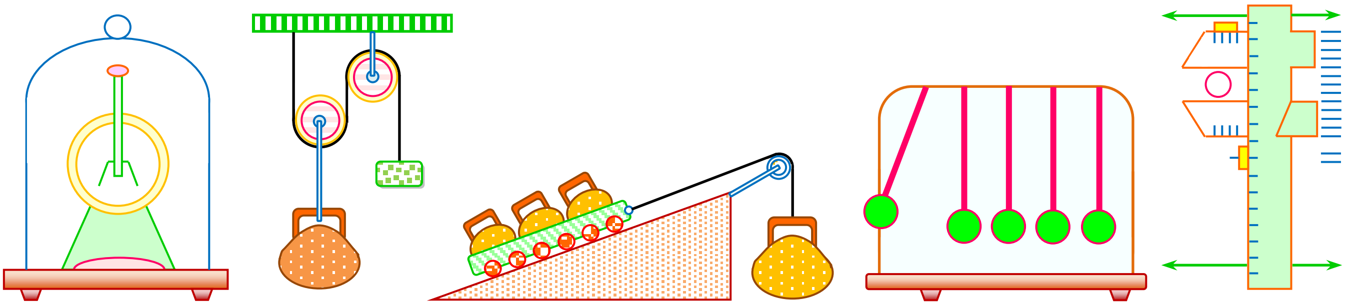
DUAL NATURE OF RADIATION AND MATTER

PHYSICS XII

Key Features

- All-in-one Study Material (for Boards/IIT/Medical/Olympiads)
- Multiple Choice Solved Questions for Boards and Entrance Examinations
- Concise, Conceptual & Trick-based Theory
- Magic Trick Cards for Quick Revision and Understanding
- NCERT & Advanced Level Solved Examples



MODERN PHYSICS

1 THE HYDROGEN ATOM

By the end of nineteenth century most of the efforts of Physicists were directed towards the analysis of the discrete spectrum of radiation emitted when electrical discharges were passed in gases. The hydrogen atom being composed of a nucleus and one electron has the simplest spectrum of all the elements. It was found that various lines in optical and nonoptical regions were systematically spaced in various series. Interestingly it turned out that all the wavelengths of atomic hydrogen were given by a single empirical relation, the Rydberg formula.

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right), \text{ where } R = 1.0967758 \times 10^7 \text{ m}^{-1}$$

where $n_1 = 1$ and $n_2 = 2, 3, 4, \ldots$ gives the Lyman series (ultraviolet region)
$n_1 = 2$ and $n_2 = 3, 4, 5 \ldots$ gives the Balmer series (optical region)
$n_1 = 3$ and $n_2 = 4, 5\ 6, \ldots$ gives the Paschen series (infrared region)
$n_1 = 4$ and $n_2 = 5, 6, 7, \ldots$ gives the Bracket series (for infrared region)
and so on for other series lying in farthest infrared.

The Bohrs theory of hydrogen atom: In 1913 Niels Bohr developed a physical theory of atomic hydrogen from which the Rydberg formula could be derived. Bohr's model for atomic hydrogen is based on certain assumptions, which are as follows:

(i) In the hydrogen atom electron revolves around the nucleus in circular orbits.

(ii) Electron revolves only in those orbits around nucleus where the angular momentum of electron is an integral multiple of $\frac{h}{2\pi}$. These orbits are called stationary orbits. This assumption is called Bohr's quantization rule.

(iii) The energy of electron can take only definite values in a given stationary orbit. The electron can jump from one stationary orbit to other. If it jumps from an orbit of higher energy to an orbit of lower energy it emits a photon of radiation. Similarly an electron can take energy from a source and jumps from a lower energy orbit to a higher energy orbit.

In both the cases energy of radiation involved is given by the Einstein-Planck equation.

$$\Delta E = \frac{hc}{\lambda}$$

Energy of a hydrogen atom: Let the mass of electron be m and it is revolving in an orbit of radius r, then using the quantization rule we get

$$mvr = n\frac{h}{2\pi}, \quad \text{where } n \text{ is a positive integer} \quad \ldots \text{(i)}$$

Also, from the equation of motion of electron we have

$$\frac{Ze^2}{4\pi\varepsilon_0 r^2} = \frac{mv^2}{r} \qquad \text{... (ii)}$$

Though $Z = 1$ for hydrogen, however generally we leave Z in the equation, as the theory is equally applicable to other atoms with all but one of their electrons are removed.

Solving (i) & (ii) we get

$$v = \frac{Ze^2}{2\varepsilon_0 hn} \qquad \text{... (iii)}$$

and $$r = \frac{\varepsilon_0 h^2 n^2}{\pi m Z e^2} \qquad \text{... (iv)}$$

So allowed radii are proportional to n^2. Putting $Z = 1$ and $n = 1$ the quantity $\frac{\varepsilon_0 h^2}{\pi m e^2}$ = 0.53 Å is called **Bohr's radius** and is radius of smallest circle allowed to the electron. Using equation (iii) we write kinetic energy of the electron in n^{th} orbit is

$$K = \frac{1}{2} mv^2 = \frac{mZ^2e^4}{8\varepsilon_0^2 h^2 n^2} \qquad \text{... (v)}$$

The potential energy of the atom is

$$U = -\frac{Ze^2}{4\pi\varepsilon_0 r} = -\frac{mZ^2e^4}{4\varepsilon_0^2 h^2 n^2}$$

So total energy of the atom is

$$E = K + U$$

$$E = -\frac{mZ^2e^4}{8\varepsilon_0^2 h^2 n^2} \qquad \text{... (vi)}$$

In deriving the energy of an atom we have considered kinetic energy of electron and potential energy of the electron nucleus pair.

From (vi), the total energy of the atom in the state $n = 1$ is $E_1 = -\frac{mZe^4}{8\varepsilon_0^2 h^2}$

For hydrogen atom $Z = 1$ and we get

E_1 = –13.6 eV, this is the energy of electron when it moves in the smallest allowed orbit. It is also evident from equation (vi) that energy of the atom in the n^{th} energy state is proportional to $\frac{1}{n^2}$. So we can write.

$$E_n = -\frac{13.6}{n^2}\, eV$$

So we get energy in the state $n = 2$ is – 3.4 eV. In the state $n = 3$ it is – 1.5 eV etc. The state of an atom with the lowest energy is called its ground state and states with higher energies are called excited states.

Important results for a hydrogen like atom are

$$V = \frac{Ze^2}{2\varepsilon_0 hn} = \frac{C}{137}\frac{Z}{n}\text{m/s} \qquad \text{... (1)}$$

$$r = \frac{\varepsilon_0 h^2 n^2}{\pi m Z e^2} = \frac{0.53 n^2}{Z}\ \text{Å} \qquad \text{... (2)}$$

$$E = -\frac{mZ^2e^4}{8\pi\varepsilon_0 h^2 n^2} = -\frac{13.6 Z^2}{n^2}\ \text{eV} \qquad \text{... (3)}$$

Hydrogen spectra: Now on the basis of Bohr's model of hydrogen atom it is possible to explain the spectra of hydrogen. If an electron jumps from m^{th} orbit to the n^{th} orbit, the energy of the atom changes from E_m to E_n. The extra energy $E_m - E_n$ is emitted as a photon of electromagnetic radiation. The corresponding wavelength λ is given by

$$\frac{1}{\lambda} = \frac{E_m - E_n}{hc} = \frac{mZ^2e^4}{8\varepsilon_0^2h^3c}\left(\frac{1}{n^2} - \frac{1}{m^2}\right) = RZ^2\left(\frac{1}{n^2} - \frac{1}{m^2}\right) \qquad \text{... (4)}$$

where $R = \dfrac{me^4}{8\varepsilon_0^2h^3c}$ is called the Rydberg constant. Putting the values of different constant, the Rydberg constant R comes out to be 1.0973×10^7 m^{-1}.

So on the basis of energy levels involved in the transition we can divide the entire hydrogen spectrum in various series.

Lyman series: When an electron jumps from any of the higher states to the ground state ($n = 1$), the series of spectral lines emitted fall in *uv* region and is called as Lyman series. The wavelength λ of any line of the series can be given by

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{1^2} - \frac{1}{n^2}\right), \qquad n = 2, 3, 4, \ldots$$

Balmer series: When an electron makes a transition from any of the higher states to the state with $n = 2$ (first excited state), the series of spectral lines emitted fall in visible region and is called Balmer series. The wavelength of any of Balmer lines is given by

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{2^2} - \frac{1}{n^2}\right), \qquad n = 3, 4, 5, \ldots$$

Paschen series: When an electron jumps from any of the higher states to the state with $n = 3$ (2^{nd} excited state), the series of spectral lines emitted fall in near infra-red region and is called Paschen series. The wavelength λ for any of the line of Paschen series is given by

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{3^2} - \frac{1}{n^2}\right), \qquad n = 4, 5, 6, \ldots$$

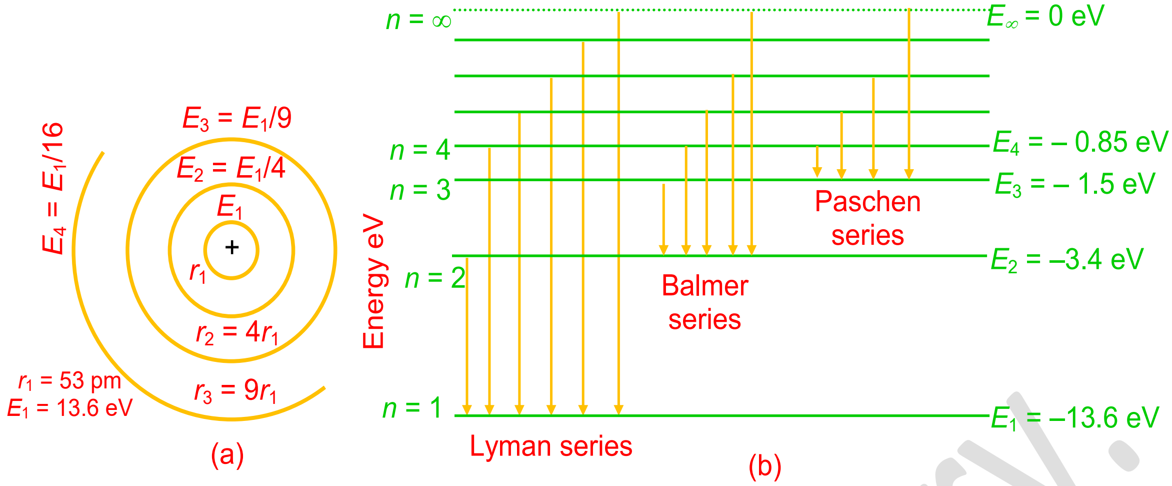
Bracket Series: When an electron jumps from any of the higher states to the state with $n = 4$, (3^{rd} excited state) the series of spectral lines emitted fall in far infrared region and constitute Bracket series. The wavelength λ of any spectral lines of Bracket series is given by

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{4^2} - \frac{1}{n^2}\right), \qquad n = 4, 5, 6, 7, \ldots$$

Pfund series: Pfund series is constituted by spectral lines emitted when electron jumps from any of the higher energy states to the state with $n = 5$ (4^{th} excited state).

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{5^2} - \frac{1}{n^2}\right), \qquad n = 6, 7, 8, \ldots$$

Figure below shows schematically the allowed orbits together with the energies of the hydrogen atom. It also shows the allowed energies separately.



Ionization potential: Negative total energy of hydrogen atom mean that hydrogen nucleus and electron constitute a bounded system. Therefore a positive or zero energy of hydrogen atom would mean that electron is not bound to the nucleus i.e., atom is ionised. The minimum energy needed to ionise an atom is called ionisation energy, and the potential difference through which an electron should be accelerated to acquire this energy is called ionisation potential. The ionisation energy of hydrogen atom in ground state is 13.6 eV and ionization potential is 13.6 V.

Binding Energy: Binding energy of a system is defined as energy liberated when its constituents are brought from infinity to form the system. For hydrogen atom binding energy is same as its ionization energy.

Excitation potential: The energy required to take an atom from its ground state to an excited state is called excitation energy of that excited state, and the potential through which the electron should be accelerated to acquire this, is called excitation potential.

Illustration 1

Question: **The longest wavelength in the Lyman series for hydrogen is 1215Å. Calculate the Rydberg constant in a unit where 1 unit = 10^{-6}Å^{-1} .**

Solution:

$$\frac{1}{\lambda} = R\left(\frac{1}{n_l^2} - \frac{1}{n_u^2}\right)$$

For the Lyman series $n_l = 1$; the longest wavelength will correspond to the value $n_u = 2$.

$$\frac{1}{1215Å} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$

or $R = 1097 \times 10^{-6}$ Å^{-1} = **1097 unit**

Illustration 2

Question: **How many different photons can be emitted by hydrogen atom that undergo transition to the ground state from the n = 5 state?**

Solution: Consider the problem for arbitrary n. If $n_u > n_l$ is any pair of unequal integers in the range 1 to n, it is clear that there is at least one route from state n down to the ground state that includes the transition $n_u \to n_l$. Thus, the number of photons is equal to the number of such pairs, which is

$$^nC_2 = \frac{n\,(n-1)}{2}$$

For $n = 5$, there are 5(4)/2 = 10 photons.

The above reasoning fails if there is "degeneracy," i.e., if two different pairs of quantum numbers correspond to the same energy difference. In that case the number of distinct photons is smaller than $n(n-1)/2$.

Illustration 3

Question: **In a transition to a state of excitation energy 10.19 eV, a hydrogen atom emits a 4890Å photon. Determine the binding energy of the initial state in milli electron volt (meV).**

Solution: The energy of the emitted photon is

$$h\nu = \frac{hc}{\lambda} = \frac{12.40\times10^3 \text{eV}.\text{Å}}{4.89\times10^3 \text{Å}} = 2.536 \text{ eV} = 2536 \text{ meV}$$

The excitation energy (E_x) is the energy to excite the atom to a level above the ground state. Therefore, the energy of the level is

$$E_n = E_1 + E_x = -13.6 \text{ eV} + 10.19 \text{ eV} = -3.41 \text{ eV} = -3410 \text{ meV}$$

The photon arises from the transition between energy states such that $E_u - E_l = h\nu$; hence

$$E_u - (-3410 \text{ meV}) = 2536 \text{ meV} \quad \text{or} \quad E_u = \mathbf{-874 \text{ meV}}$$

Therefore, the binding energy of an electron in the state is **874 meV**.

Note that the transition corresponds to

$$n_u = \sqrt{\frac{E_1}{E_u}} = \sqrt{\frac{13.6\text{eV}}{0.874 \text{ eV}}} = \mathbf{4} \quad \text{and}$$

$$n_l = \sqrt{\frac{E_1}{E_l}} = \sqrt{\frac{13.6\text{eV}}{3.41\text{eV}}} = \mathbf{2}$$

PROFICIENCY TEST– I

The following questions deal with the basic concepts of this section. Answer the following briefly. Go to the next section only if your score is at least 80%. Do not consult the Study Material while attempting these questions.

1. The energy of an electron in an excited hydrogen atom is – 3.4 eV. Calculate the angular momentum of the electron (in a unit where 1 unit = 10^{-36}J-s) according to Bohr's theory. Planck's constant $h = 6.626 \times 10^{-34}$ J-s

2. If the series limit of Balmer series for hydrogen is 3646 Å, calculate the atomic number of the element which gives K-series wavelengths down to 0.1 nm.

3. Find the quantum number n corresponding to the excited state He^+ ion if on transition to the ground state that ion emits two photons in succession with wavelengths 108.5 nm and 30.4 nm. The ionisation energy of the hydrogen atom is 13.6 eV.

4. The wavelength of the first line of Lyman series for hydrogen is identical to that of the second line of Balmer series for some hydrogen-like ion X. Calculate energy required in eV for transition from $n = 1$ to $n = 2$ in ion X. (Given: Ground state binding energy of hydrogen atom is 13.6 eV).

5. A hydrogen atom moving at speed v collides with another hydrogen atom kept at rest. Find the minimum value of v in km/s for which one of the atoms may get ionized. The mass of a hydrogen atom = 1.67×10^{-27} kg.

ANSWERS TO PROFICIENCY TEST– I

1. 211 unit
2. 31
3. $n = 5$
4. 41 eV
5. 72 km/s

2 WAVE PARTICLE DUALITY

Nearly two decades after the 1905 discovery of the particle properties of wave, Louis de-Broglie proposed that moving object have wave as well as particle characteristics. de-Broglie ideas soon received respectful attention despite a complete lack of experimental mandate. The existence of de-Broglie waves was experimentally demonstrated by 1927 and the duality principle they represent provided the starting point for successful development of quantum mechanics.

de-Broglie suggested that a moving body behaves in certain ways as though it has a wave nature. A photon of light of frequency ν has a momentum

$$p = \frac{h\nu}{C} = \frac{h}{\lambda} \quad \text{... (5)}$$

The wavelength of a photon is therefore specified by its momentum as

$$\lambda = \frac{h}{p} \quad \text{... (6)}$$

de-Broglie suggested that equation (6) is a completely general one that applied to material particles as well as photons. The momentum of a particle of mass m and velocity v is $p = mv$, and its de-Broglie wavelength is accordingly.

$$\lambda = \frac{h}{mv} \quad \text{... (7)}$$

The greater the particle's momentum; the shorter is its wavelength. In equation (7) m is the relativistic mass, which is given by

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$ where m_0 is the rest mass of the particle.

The wave and particle aspects of moving bodies can never be observed at the same time. So one can not ask which is the correct description. All that can be said is that in certain situations a moving body resembles a wave and in others it resembles a particle. Which set of properties is most conspicuous depends on how its de-Broglie wavelength compares with its dimensions and the dimensions of whatever it interacts with.

Illustration 4

Question: **Find the de Broglie wavelengths of (a) a 46-g golf ball with a velocity of 30 m/s (in a unit where 1 unit = 10^{-36} m) and (b) an electron with a velocity of 10^7 m/s (in a unit where 1 unit = 10^{-12} m).**

Solution: (a) since $v << c$, we can let $m = m_0$.

Hence $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}\,\text{Js}}{(0.046\text{ kg})(30\text{ m/s})}$

$= 4.80 \times 10^{-34}$ m

= **480 unit**

The wavelength of the golf ball is so small compared with its dimensions that we would not except to find any wave aspects in its behavior.

(b) Again $v << c$, so with $m = m_0 = 9.1 \times 10^{-31}$ kg,

we have $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}\text{ J.s}}{(9.1\times10^{-31}\text{kg})(10^7\text{m/s})}$

$= 7.28 \times 10^{-11}$ m = **728 unit**

The dimensions of atoms are comparable with this figure – the radius of the hydrogen atom, for instance is 5.3×10^{-11} m. It is therefore not surprising that the wave character of moving electrons is the key to understanding atomic structure and behaviour.

3 PHOTOELECTRIC EFFECT

When light of sufficiently small wavelength is incident on a metal surface, electrons are ejected from the metal. This phenomenon is called photoelectric effect and the electrons ejected are called photoelectrons. An experimental setup was arranged to study photoelectric effect, and the results obtained from the experiment are

(i) When light of sufficiently small wavelength falls a metal surface, the metal emits photoelectrons. This emission of photoelectrons is instantaneous.

(ii) The photoelectric current i.e., the number of photoelectrons emitted per second depends on the intensity of the incident light.

(iii) The maximum kinetic energy with which electrons come out of the metal depends only on frequency of incident light and is independent of intensity of light.

(iv) There is a threshold wavelength for a given metal such that if the wavelength of incident light is greater than the threshold, there will be no emission of photoelectrons.

Einstein's theory of photoelectric effect: Soon after the publication of results of photoelectric effect, efforts were made to explain the result. Wave theory which considered light as wave failed on all counts to explain photoelectric effect. The main cause for this failure was inability of wave theory to consider the energy of light quantised and not distributed continuously. In 1900 Planck proposed that radiation from a hot body consists of small packets of energy called 'quantas'. The energy of a quanta is given by $h\nu$ (ν being frequency of radiation). Einstein getting a hint from this proposed theory that light wave also consists of packets of energy or quantas whose energy is also given by '$h\nu$'. He called these quantas as photons.

Einstein postulated that a photon of incident light interacts with a metal electron and transfers its energy to electron in two ways. A part of the energy of the incident photon is used up in liberating the metal electron against the attractive forces of surrounding ions inside the metal; the remaining energy is spent in giving kinetic energy to ejected photoelectrons. If ν be the frequency of incident light W_0 be the minimum energy required to liberate an electron from the surface and E_K be the maximum kinetic energy of the emitted free electrons, then

$$h\nu = W_0 + E_K \qquad \dots (8)$$

W_0 is called the work function and it obviously depends on the nature of metal. Equation (8) is called **Einstein photoelectric equation.**

Stopping potential: This is the smallest magnitude of anode potential which just stops the electron with maximum kinetic energy from reaching the anode.

As $K.E_{max.} = h\nu - W_0$

So, if stopping potential for a given photoelectric emission is V_0 then $eV_0 = KE_{max} = h\nu - W_0$

$$V_0 = \left(\frac{h}{e}\right)\nu - \frac{W_0}{e} \qquad \dots (9)$$

If we plot a curve between V_0 and ν we can get the value of Planck's constant by measuring slope.

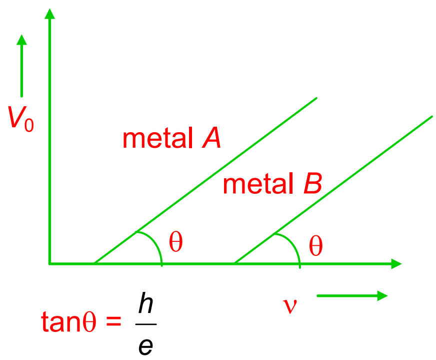


Illustration 5

Question: **The emitter in a photoelectric tube has a threshold wavelength of 6000Å. Determine the wavelength of the light in Å incident on the tube if the stopping potential for this light is 2.5V.**

Solution: The work function is

$$W_0 = h\nu_{th} = \frac{hc}{\lambda_{th}} = \frac{12.4\times10^3\ \text{eV.Å}}{6000Å} = 2.07\ \text{eV}$$

The photoelectric equation then gives

$$eV_s = h\nu - W_0 = \frac{hc}{\lambda} - W_0$$

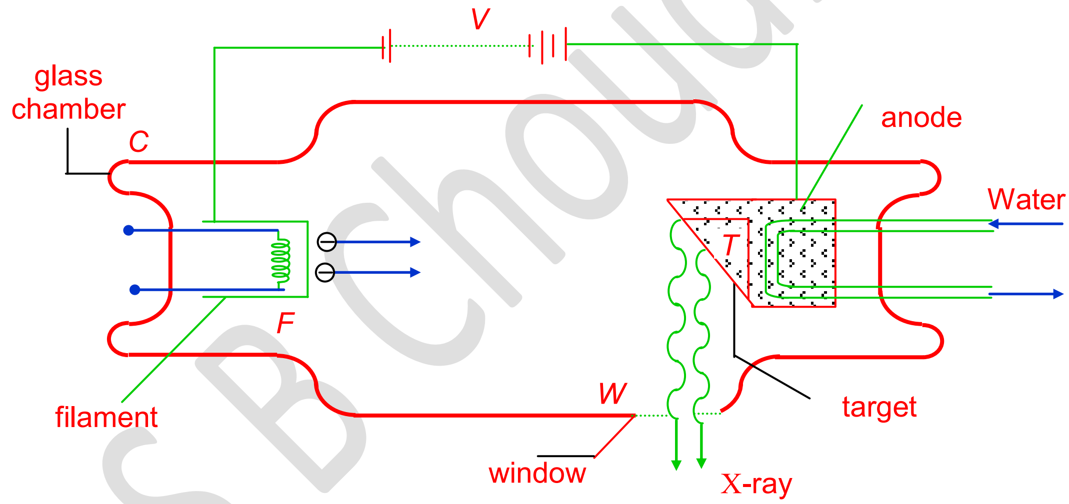
or $$2.5\ \text{eV} = \frac{12.4\times10^3\ \text{eV.Å}}{\lambda} - 2.07\ \text{eV}$$

Solving , λ = **2713 Å.**

4 X-RAYS

PRODUCTION OF X-RAYS

When highly energetic electrons are made to strike a metal target, electromagnetic radiation comes out. A large part of this radiation has wavelength of the order of 1Å and is called X-rays. The device which is used to produce X-rays is called Coolidge tube as shown below.



A filament *F* and a metallic target *T* are fixed in an evacuated glass chamber *C*. The filament is heated electrically and emits electrons by thermionic emission. A constant potential difference of several kilovolts is maintained between the filament and the target using a DC power supply so that the target is at a higher potential than the filament. The electrons emitted by the filament are, therefore, accelerated by the electric field set up between the filament and the target and hit the target with a very high speed. These electrons are stopped by the target and in the process X-rays are emitted. These X-rays are brought out of the tube through a window *W* made of thin mica or mylar or some such material which does not absorb X-rays appreciably. In process, large amount of heat is developed, and thus an arrangement is provided to cool down the tube continuously by running water.

4.1 CONTINUOUS AND CHARACTERISTIC X-RAYS

When X-rays coming from a Coolidge tube are investigated for the wavelength present. We find that X-rays can be divided in two categories based on the mechanism of their generation. These X-rays are called continuous and characteristic X-rays. These X-rays have their origin in the manner in which the highly energetic electron loses its kinetic energy. As the fast moving electrons enter metal target, they starts losing their energy by collisions with the atoms of metal target. At each such collision either of the following two processes take place.

(i) Electron loses its kinetic energy and a part of this lost kinetic energy is converted into a photon of electromagnetic radiation and the increases the kinetic energy of the target atoms, which ultimately heats up the target. This electromagnetic radiation is nothing but continuous X-rays. The fraction of kinetic energy converting into energy of photon varies from one collision to the other and the energy of such photon will be maximum when electron converts all its energy into a photon in the first collision itself.

If electrons are accelerated through a potential difference V, then maximum energy of emitted photon could be

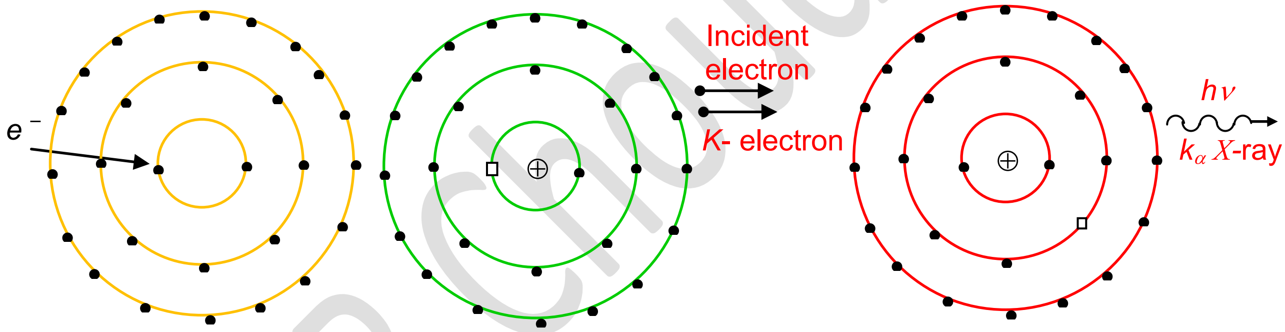
$$E_{max} = eV$$

$$\frac{hc}{\lambda_{min}} = eV$$

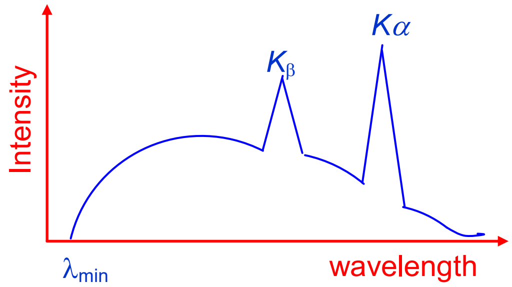
$$\lambda_{min} = \frac{hc}{eV} \quad \text{... (10)}$$

λ_{min} is also called cut off wavelength. Since electron may loose very small energy in a given collision, the upper value of λ will approach to infinity. However both the cases e.g. electron converting all its energy in one go and loosing very small energy will have very small probability. That explains the origin of continuous X-ray. We can also see from the discussion, which we have had on continuous X-rays that λ_{min} depends only on accelerating voltage applied on the electron and not on the material of the target.

(ii) The electron knocks out an inner shell electron of the atom with which it collides. Let us take a hypothetical case of a target atom whose K- shell electron has been knocked out as shown.



This will create a vacancy in K-shell. Sensing this vacancy an electron from a higher energy state may make a transition to this vacant state. When such a transition takes place the difference of energy is converted into photon of electromagnetic radiation, which is called characteristic X-rays. Now depending upon which shell electron makes a transition to K-shell we may have different K X-rays e.g. if electron from L shell jumps to K shell we have $K\alpha$, if electron from M shell jumps to K shell we have K_β X-ray and so on. Similarly if vacancy has been caused in L shell we may have L_α, L_β X-ray etc depending upon, whether we have transition of electron from M shell or N shell. Since emission of characteristic X-ray involves the inner material energy levels of target atom, hence the wavelength of characteristic X-ray will depend on the target. If we plot curve between intensity of different wavelength component of X-ray coming out of a Coolidge tube, and, wavelength, it is like figure given below



As we can see from the curve, at certain clearly defined wavelengths the intensity of X-rays is very large. These X-rays are known as characteristic X-rays. It is also clear from the curve that $\lambda_{K\beta}$ is less than $\lambda_{K\alpha}$, however intensity of K_α transition is more as compared to the intensity of K_β transition, it is primarily because transition probability of K_α is more as compared to transition probability of K_β. At other wavelengths intensity varies gradually and these are called continuous X-rays.

Moseley's law: Moseley conducted many experiments on characteristic X-rays, the findings of which played an important role in developing the concept of atomic number. Moseley's observations can be expressed as

$$\sqrt{\nu} = a(Z-b) \qquad \ldots (11)$$

where a and b are constants. Z is the atomic number of target atom and ν is the frequency of characteristic X-rays. Moseley's law can be easily understood on the basis of Bohr's atomic model. Let us consider an atom from which an electron from K–shell has been knocked out, an L shell electron which is about to make transition to the vacant site will find the charge of nucleus is screeened by the spherical cloud of remaining one electron in the K shell. If the effect of outer electrons and other L-electrons are neglected then electron making the transition will find a charge $(Z\text{-}1)e$ at the centre. Hence we may expect Bohr's model to give expected result if we replace Z by $(Z\text{-}1)$.

According to Bohr's model, the energy released during a transition from $n = 2$ to $n = 1$ is given by

$$\Delta E = Rhc\,(Z-1)^2\left(\frac{1}{1^2}-\frac{1}{2^2}\right)$$

$$h\nu = Rhc\left(\frac{3}{4}\right)(Z-1)^2$$

$$\nu = \sqrt{\frac{3Rc}{4}}\,(Z-1)$$

Which is same as Moseley's equation with $b = 1$ & $a = \sqrt{\frac{3Rc}{4}}$.

4.2 PROPERTIES OF X-RAYS

(i) X-rays being an electromagnetic wave travel with a speed equal to the speed of light.
(ii) X-rays are not responsive to electric or magnetic field.
(iii) X-rays when pass through gases, produce ionisation.
(iv) X-rays affect photographic plates and exhibit the phenomenon of fluorescence.

Illustration 6

Question: **An experiment measuring the K_α lines for various elements yields the following data:**
Fe : 1.94Å Co : 1.79Å Ni : 1.66Å Cu : 1.54Å
Determine the atomic number of each of the elements from these data.

Solution: The Moseley relation gives

$$\nu^{1/2} = (4.97\times10^7\ \text{Hz}^{1/2})(Z-1)$$

or $$Z = 1+\frac{\nu^{1/2}}{4.97\times10^7\,\text{Hz}^{1/2}}$$

and using $\nu = c/\lambda$ we obtain

$$Z = 1+\frac{c^{1/2}}{\lambda^{1/2}}\left(\frac{1}{4.97\times10^7\,\text{Hz}^{1/2}}\right) = 1+\frac{34.85}{\lambda^{1/2}} \quad (\lambda \text{ in Å})$$

The results are given in Table.

Element	λ , Å	Z
Fe	1.94	26.02 ≈ 26
Co	1.79	27.04 ≈ 27
Ni	1.66	28.04 ≈ 28
Cu	1.54	29.08 ≈ 29

Before Moseley's work, Ni whose atomic weight is 58.69, was listed in the periodic table before Co, whose atomic weight is 58.94, and it was believed that the atomic numbers for Ni and Co were 27 and 28, respectively. By using the above experimental data, Moseley showed that this ordering and the corresponding atomic numbers should be reversed.

Illustration 7

Question: **When 50Å X-rays strike a material, the photoelectrons from the *K* shell are observed to move in a circle of radius 23 mm in a magnetic field of 2 × 10^{-3} T. What is the binding energy of *K*-shell electrons?**

Solution: The velocity of the photoelectrons is found from $F = ma$:

$$evB = m\frac{v^2}{R}$$

or $$v = \frac{e}{m}BR$$

The kinetic energy of the photoelectrons is then

$$K = \frac{1}{2}mv^2 = \frac{1}{2}\frac{e^2B^2R^2}{m}$$

$$= \frac{1}{2}\frac{(1.6\times10^{-19}\text{ C})^2\ (2\times10^{-3}\text{ T})^2\ (23\times10^{-3}\text{ m})^2}{(9.11\times10^{-31}\text{kg})} = 2.97\times10^{-17}\text{ J}$$

or $$K = (2.97\times10^{-17}\text{ J})\frac{1\text{ eV}}{1.6\times10^{-19}\text{ J}} = 186\text{ eV}$$

The energy of the incident photon is

$$E_v = \frac{hc}{\lambda} = \frac{12400\text{ eV.Å}}{50\text{Å}} = 248\text{ eV}$$

The binding energy is the difference between these two values:

$BE = Ev - K = 248\text{ eV} - 186\text{ eV} = \mathbf{62\ eV}$

Illustration 8

Question: **Stopping potentials of 24, 100, 110 and 115 kV are measured for photoelectrons emitted from a certain element when it is irradiated with monochromatic X–ray. If this element is used as a target in an X-ray tube, what will be the wavelength of the *K*α line (in a unit where 1 unit = 10^{-13} m)?**

Solution: The stopping potential energy, eV_s, is equal to the difference between the energy of the incident photon and the binding energy of the electron in a particular shell:

$$eV_s = E_p - E_B$$

The different stopping potentials arise from electrons being emitted from different shells, with the smallest value (24 kV) corresponding to ejection of a *K*-shell electron. Subtracting the expression for the two smallest stopping potentials, we obtain

$$eV_{sL} - eV_{sK} = (E_p - E_{BL}) - (E_p - E_{BK}) = E_{BK} - E_{BL}$$

or $100\text{ keV} - 24\text{ keV} = E_{BK} - E_{BL}$

The difference, 76 keV, is the energy of the K_α line. The corresponding wavelength is

$$\lambda = \frac{hc}{E_{BK} - E_{BL}} = \frac{12.4\text{ keV.Å}}{76\text{ keV}}$$

$= 0.163$ Å

$= 163 \times 10^{-13}$ m

$=$ **163 unit**

PROFICIENCY TEST– II

The following questions deal with the basic concepts of this section. Answer the following briefly. Go to the next section only if your score is at least 80%. Do not consult the Study Material while attempting these questions.

1. The maximum kinetic energy of photoelectrons emitted from a certain metallic surface is 30 eV when monochromatic radiation of wavelength λ falls on it. When the same surface is illuminated with light of wavelength 2λ, the maximum kinetic energy of photo-electrons is observed to be 10 eV. Calculate the wavelength λ ($h = 6.62 \times 10^{-34}$ J-s, $c = 3 \times 10^8$ m/s).

2. The photoelectric work function of potassium is 2.0 eV. If light having a wavelength 3600Å falls on potassium, find (i) the stopping potential in milli volt (mV), (ii) the kinetic energy in milli electron volt (meV) of the most energetic electrons ejected. ($c = 3 \times 10^8$ m/s)

3. A metallic surface is illuminated alternatively with light of wavelengths 3000 Å and 6000 Å. It is observed that the maximum speed of the photoelectrons under these illuminations are in the ratio 3 : 1. Calculate the work function of the metal in meV.

4. The stopping potential for the photoelectrons emitted from a metal surface of work-function 1.7 eV is 10.4 volt. Find the wavelength of radiations used.

5. When the voltage applied to an X-ray tube is increased from V_1 = 10 kV to V_2 = 20 kV , the wavelength interval between the K_α line and the short wave cut off of the continuous X-ray spectrum increases by a factor of 3. Find the element of which target of the tube is made. ($R = 10^7$ m^{-1})

ANSWERS TO PROFICIENCY TEST– II

1. 310 Å

2. 1440 mV, 1440 meV

3. 1808 meV

4. 1026 Å

5. 29

5 NUCLEAR PHYSICS

So far the only knowledge of nucleus we have as a tiny positively charged object whose primary contributions are to provide the atom with most of its mass and to hold its electrons in captivity. The chief properties of atoms, molecules, solids and liquids can all be traced to the behaviour of atomic electrons not to the behaviour of nuclei. However, the nucleus turns out to be of paramount importance in the grand scheme of things. To start with the very existence of the various elements is due to the ability of nuclei to possess multiple electric charge. Furthermore, the energy involved in almost all natural processes can be traced to nuclear reactions and transformations. In the following sections we will study about the nucleus and phenomenon associated with nucleus.

5.1 NUCLEAR CHARACTERISTICS

(i) Nuclear mass: It was observed in Rutherford's α-particle scattering experiment that mass of an atom is concentrated within a very small positively charged region at the centre called nucleus. The total mass of nucleons in the nucleus is called as nuclear mass.

Nuclear mass = mass of protons + mass of neutrons

(ii) Size and shape of the nucleus: The nucleus is nearly spherical. Hence its size is usually given in terms of radius. The radius of nucleus was measured by Rutherford and it was found to have following relation

$$R = R_0 A^{1/3}$$

where $R_0 = 1.1$ fm $= 1.1 \times 10^{-15}$ m and A is mass number of particular element.

(iii) Nuclear charge: Nucleus is made of protons and neutrons. Protons have positive charge of magnitude equal to that of electron and neutrons are uncharged. So, nuclear charge = Ze

(iv) Nuclear density: The ratio of the mass of the nucleus to its volume is called nuclear density. As the masses of proton and neutron are roughly equal, the mass of a nucleus is roughly proportional to A.

As volume of a nucleus is

$$V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R_0^3 A$$

$$V \propto A$$

density within a nucleus is independent of A.

5.2 DIFFERENT TYPES OF NUCLEI

There are different types of nuclei depending upon the number of protons or the total number of nucleons in them.

(a) Isotopes: The atoms of an element having same atomic number but different mass number are called isotopes of that element i.e. different isotopes of the same element have same number of protons inside the nucleus but different number of neutrons inside the nucleus. Though isotopes have same chemical properties but their nuclear properties are highly different. Examples of isotopes are $_1H^1$, $_1H^2$, $_1H^3$ and $_8O^{16}$, $_8O^{17}$, $_8O^{18}$ etc.

(b) Isotones: Atoms whose nuclei have same number of neutrons are called isotones. For them, both the atomic number Z and atomic mass A are different but the value of difference $(A - Z)$ is same. Examples of isotones are $_1H^3$, and $_2He^4$, $_1H^2$, and $_2He^3$ etc.

(c) Isobars: Atoms of same mass number but different atomic number are called isobars examples of isobars are $_1H^3$ and $_2He^3$, $_6C^{14}$ and $_7N^{14}$ etc.

5.3 NUCLEAR FORCES

The strong forces of attraction, which firmly hold the nucleons in the nucleus, are known as nuclear forces. Though the exact theory of nuclear forces is still to be understood completely, yet it is undoubtedly established that these forces exist between the nucleons i.e. between a neutron and a proton, between two protons and between two neutrons. The stability of nucleus is due to the presence of these forces. Nuclear forces have following important characteristics.

(i) They are attractive i.e. nucleons exert attractive force on each other hence they are also called **cohesive forces**.

(ii) They are extremely strong. These forces are strongest possible force in nature.

(iii) They are charge independent.

(iv) They are short-range forces i.e. they act only over a short range of distances.

(v) They are spin dependent i.e. nuclear forces acting between two nucleons depend on the mutual orientation of the spins of the nucleons.

(vi) They are saturated i.e. their magnitude does not increase with the increase in the number of nucleons, beyond a certain number.

5.4 EINSTEIN'S MASS ENERGY EQUIVALENCE PRINCIPLE

Before the discovery of Einstein's mass energy equivalence principle, mass and energy were considered independent physical quantities. Einstein on the basis of theory of relativity showed that mass of a body is not independent of energy but they are inter convertible. According to Einstein if a substance loses an amount Δm of its mass, an equivalent amount ΔE of energy is produced, where $\Delta E = (\Delta m)\, c^2$

where c is the speed of light. This is called Einstein's mass-energy equivalence principle. In nuclear physics mass is usually represented in terms of energy according to the conversion formula $E = mc^2$. For example the mass of an electron is 9.1×10^{-31} kg and the equivalent energy is 511 KeV/c^2. Similarly, the mass of a proton is 938 MeV/c^2, and the mass of a neutron is 939 MeV/c^2. The energy corresponding to the mass of a particle when it is at rest is called its rest mass energy. Another useful unit of mass in nuclear physics is unified atomic mass unit, denoted by the symbol u. It is $(1/12)^{th}$ of the mass of a neutral carbon atom in its lowest energy state which has six protons, six neutrons and six electrons. We have

$$1u = 1.67 \times 10^{-27}\text{ kg} = 931.478\text{ MeV/c}^2$$

5.5 BINDING ENERGY OF NUCLEUS

(i) The total energy required to liberate all the nucleons from the nucleus (i.e., the disintegrate the nucleus completely into its constituent particles) is called binding energy of the nucleus. Clearly, this is the same energy with which the nucleons are held together within the nucleus. The origin of binding energy results from strong nuclear exchange forces. In other words, we may think of existence of binding energy in other useful way also. A nucleus is made by the coming together of various nucleons. It has been observed experimentally that the mass of the nucleus is always less than the sum of the masses of its constituents when measured in free state. For example, deutron ($_1H^2$) is composed of one proton and 1 neutron. The question arises where the difference in mass has gone? The answer is that this decrease in mass has been converted into energy binding the nucleons together according to the following relation:

$$\Delta E = \Delta mc^2$$

where, ΔE = binding energy of nucleus, Δm = decrease in mass, called mass defect and c = velocity of light.

Hence in the formation of stable nucleus, the following equation holds good.

Mass of protons + Mass of neutrons = Mass of nucleus + Binding energy

Example: Consider a deutron ($_1H^2$) nucleus. It is the nucleus of heavy hydrogen or deuterium ($_1H^2$). It contains 1 proton and 1 neutron. We shall compare the mass of one free proton and one free neutron with their mass when combined to form deutron and thus find out mass defect and binding energy of deutron.

Mass one free neutron	=	1.675×10^{-27} kg = 1.008665 a.m.u
Mass of one free proton	=	1.673×10^{-27} kg = 1.007825 a.m.u.
Their total	=	3.348×10^{-27} = 2.01649 a.m.u.
Mass of deutron	=	3.348×10^{-27} = 2.014103 a.m.u.
∴ Mass defect, Δm	=	0.002387 a.m.u.

It shows that when a proton and a neutron come together to form a deutron, a small mass of 0.002387 disappears. In fact, this mass is converted into binding energy according to the following relation:

$$\Delta E = \Delta mc^2 = \frac{0.002387 \times 1.66 \times 10^{-27} \times (3 \times 10^8)^2}{1.6 \times 10^{-19}} = 2.22 \times 10^6 \text{ eV} = 2.22 \text{ MeV}$$

Binding energy curve

(i) Expression for binding energy per nucleon: In order to compare the stability of various nuclei, we calculate binding energy per nucleon. Higher is the binding energy per nucleon more stable is the nucleus.

We have seen that the mass defect during the formation of a nucleus:

$\Delta m = Zm_p + (A - Z)\, m_n - m$, where m_p, m_n and m are masses of proton, neutron and nucleus respectively.

∴ Total binding energy of nucleus

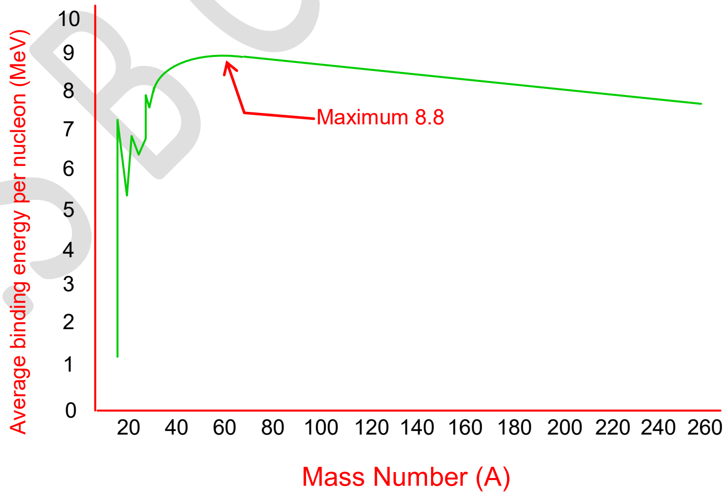
$$\Delta E = \Delta mc^2 = [Zm_p + (A - Z)\, m_n - m] \times c^2$$

∴ Mean binding energy per nucleon

$$= \frac{\Delta E}{A} = \frac{\Delta mc^2}{A} = \left[\frac{Z}{A}(m_p - m_n) + m_n - \frac{m}{A}\right] \times c^2$$

If the mass m of the nucleas is found experimentally, we can find mean binding energy per nucleon since all other factors are known to us.

(ii) Binding energy curve: A graph between the binding energy per nucleon and the mass number of nuclei is called as the binding energy curve.



The following points may be noted from the biding energy curve:

(a) The binding energy per nucleon is maximum (≈ 8.8 MeV) for the nucleus having mass number 56. So, this nucleus is most stable i.e. iron is the most stable element of periodic table.

(b) The light nuclei with $A < 20$ are least stable.

(c) The curve has certain peaks indicating that certain nuclei like ${}^4_2He$, ${}^{12}_6C$ and ${}^{16}_8O$ are much more stable than the nuclei in their vicinity.

(d) For atomic number $Z > 56$, the curve takes a downside turn indicating lesser stability of these nuclei.

(e) Nuclei of intermediate mass are most stable. This means maximum energy is needed to break them into their nucleons.

(f) The binding energy per nucleon has a low value for both very light and very heavy nuclei. Hence, if we break a very heavy nucleus (like uranium) into comparatively lighter nuclei then the binding energy per nucleon will increase. Hence a large quantity of energy will be liberated in this process. This phenomenon is called nuclear fission.

(g) Similarly, if we combine two or more very light nuclei (e.g. nucleus of heavy hydrogen $_1H^2$) into a relatively heavier nucleus (e.g. $_2He^4$), then also the binding energy per nucleon will increase i.e., again energy will be liberated. This phenomenon is called nuclear fusion.

5.6 NUCLEAR FISSION

The phenomenon of breaking a heavy nucleus into two light nuclei of almost equal masses along with the release of huge amount of energy is called nuclear fission. The process of nuclear fission was first discovered by German Scientists Otto Hahn and Strassman is 1939. They bombared uranium nucleus ($_{92}U^{235}$) with slow neutrons and found that $_{92}U^{236}$ was split into two medium weight parts with the release of enormous energy. These fragments has atomic numbers far less than the target nucleus ($_{92}U^{235}$). The nuclear fission of $_{92}U^{235}$ is given by the following nuclear reaction:

$$_{92}U^{235} + {_0n^1} \longrightarrow [_{92}U^{236}] \longrightarrow {_{56}Ba^{144}} + {_{36}Kr^{89}} + 3{_0n^1} + \text{energy.}$$

The fission of $_{92}U^{235}$ nucleus when bombarded with a neutron takes place in following manner. When a neutron strikes $_{92}U^{235}$ nucleus, it is absorbed by it, producing a highly unstable $_{92}U^{236}$ nucleus. Instead of emitting α or β particles or γ rays, this unstable nucleus is split into two middle weight parts viz $_{56}Ba^{144}$ and krypton ($_{36}Kr^{89}$). During this fission, three neutrons are given out and a small mass defect occurs which is converted into enormous amount of energy. The following points are worth noting about nuclear fission process:

(a) The energy released in the fission of uranium is about 200 MeV per nucleus. This can be easily verified. If we obtain atomic mass unit values of reactants and products in the fission of $_{92}U^{235}$ nucleus, we find that there occurs a mass defect of 0.214 a.m.u. Which is converted into energy. Energy released per fission of $_{92}U^{235}$ nucleus = 0.214×931.
$\approx$ 200 MeV

(b) The products of uranium fission are not always barium and krypton. Sometimes, they are Strontium and Xenon. There are other pairs as well. However, in each case, neutrons are emitted and tremendous amount of energy is released.

(c) Energy is released in the form of kinetic energy of fission fragments. Some of the energy is also released in the form of γ-rays, heat energy sound energy and light energy.

(d) The pressure and temperature is very high in fission process.

5.7 NUCLEAR FUSION

The process of combining two light nuclei to form a heavy nucleus is known as nuclear fusion. An important feature of nuclear fusion is that there is a release of huge amount of energy in the process. This can be easily understood. When two light nuclei are combined to form a heavy nucleus there occurs a small mass defect. This small mass defect results in the release of huge amount of energy according to the relation $\Delta E = mc^2$. For example by the fusion of two nuclei of heavy hydrogen, the following reaction is possible.

$$_1H^2 + {_1H^2} \longrightarrow {_1H^3} + {_1H^1} + \Delta E_1$$

The nucleus of tritium ${}_1^3\text{H}$ so formed can again fuse with a deuterium nucleus.

$${}_1^3H + {}_1^2H \longrightarrow {}_2^4He + {}_0^1n + \Delta E_2$$

Nuclear fusion is a very difficult process to achieve. This is because when positively charged nuclei come close to each other for fusion they required very high energy to counter repulsive force between them. So a high temperature is required for fusion. Though the energy output in the process of nuclear fission is much more than in a nuclear fusion the energy liberated by the fusion of a certain mass of heavy hydrogen is much more than the energy liberated by the fission of equal mass of uranium.

6 RADIOACTIVITY

The phenomenon of **spontaneous emission of radiations** from radioactive substances is known as Radioactivity. This is exhibited naturally by certain heavy elements like uranium, radium, thorium, etc is called natural radioactivity. However it was later established that it can be induced in lighter elements as well using modern techniques and this is called induced radioactivity.

Rutherford analysed the radiations coming from radioactive sources and showed that this consists of three types of rays namely α, β and γ rays. The prime reason for the emission of these rays is that nucleus can have excited states; these excited states can decay by the emission of high-energy photons (γ rays) to the ground states, directly or via lower energy states. In addition nuclei in both excited and ground states can spontaneously emit other particles (αand β) to reach lower energy configuration.

α-decay: In alpha decay an α particle is ejected from a nucleus and the parent nucleus loses two protons and two neutrons. Therefore its atomic number z decreases by two units and its mass number A decreases by four units, so that the daughter D and parent P, are different chemical elements. Applying conservation of charge and nucleons we can write alpha decay symbolically as

$$^{A}_{Z}P \rightarrow {}^{A-4}_{Z-2}D + {}^{4}_{2}He$$

β-decay: It is possible for a nuclear process to occur where the charge Ze of a nucleus changes but the number of nucleons remains unchanged. This can happen with a nucleus emitting an electron (β-decay), emitting a positron (β-decay) or capturing an inner atomic electron (electron capture). In each of these processes either a proton is converted into a neutron or vice-versa. It is also found that in each of these processes an extra particle called a neutrino appears as one of the decay products. The properties of a neutrino are electric charge = O, rest mass ≈ O, intrinsic spin, $\frac{1}{2}$, and, as with all massless particles it has speed C (speed of light)

γ- decay: a gamma ray emission does not affect either the charge or the mass number

The statistical radioactive law: In a typical radioactive decay an initially unstable nucleus called the parent, emits a particle and decays into a nucleus called the daughter, effectively, the birth of the daughter arises from the death of the parent. The daughter may be either the same nucleus in a lower energy state, as in the case of a γ-decay or an entirely new nucleus as arises from α and β decays. No matter what types of particles are emitted all nuclear decays follow the same radioactive decay law. If there are initially no unstable parents nuclei present, the number N of parents that will be left after a time t is

$$N = N_0 e^{-\lambda t} \quad \text{... (12)}$$

The constant λ is called the decay constant or disintegration constant and depends on the particular decay process.

Equation (1) is statistical, not a deterministic, law, it gives the expected number N of parent that survive after a time t. However for a large number of unstable nuclei, the actual number and expected number of survivors will almost certainly differ by no more than an insignificant fraction The rapidity of decay of a particular radioactive sample is usually measured by the half life $T_{1/2}$, defined as the time interval in which the number of parent nuclei at the beginning of the interval is reduced by a factor of one half. The half-life is readily obtained in terms of λ as :

$$T_{1/2} = \frac{\ln 2}{\lambda} \quad \text{... (13)}$$

Another quantity that measures the rapidity of decay is the average or mean lifetime of a nucleus, T_{av}, is given by

$$T_{av} = \frac{1}{\lambda} = \frac{T_{1/2}}{\ln 2} \quad \text{... (14)}$$

$\therefore$ Average life $= 1.44$ times the half-life.

Activity of a radioactive substance

The activity of a radioactive substance is the rate of decay or the number of disintegrations per second. It is denoted by A.

$$\therefore \quad A = \frac{dN}{dt} \qquad \text{... (15)}$$

$$= \frac{d}{dt}(N_0 e^{-\lambda t})$$

$$= -\lambda N_0 e^{-\lambda t}$$

$$\therefore \quad A = -\lambda N$$

Also, $A = A_0 e^{-\lambda t}$ **... (16)**

The activity of a sample is measured in unit called Curie. A Curie is defined as that quantity of radioactive substance in which the number of disintegrations per second is 3.7×10^{10}. This is also equal to the activity of one gram of radium.

The activity at time t is given by $A = \dfrac{A_0}{2^{t/T_{1/2}}}$.

Illustration 9

Question: **Determine the approximate density of a nucleus in a unit where 1 unit = 10^{17} kg/m^3.**

Solution: If the nucleus is treated as a uniform sphere,

$$\text{Density} = \frac{\text{mass}}{\text{volume}} \approx \frac{A \times (\text{mass of a nucleon})}{\frac{4}{3}\pi R^3}$$

$$= \frac{A(1.67 \times 10^{-27}\,\text{kg})}{\frac{4}{3}\pi(1.1 \times 10^{-15} A^{1/3} m)^3}$$

$$= 3 \times 10^{17}\,\frac{\text{kg}}{\text{m}^3}$$

= 3 unit

Illustration 10

Question: **What is the activity of one gram of $^{226}_{88}\text{Ra}$, (in a unit where 1 unit = 10^{12} disintegration per second) whose half-life is 1622 years?**

Solution: The number of atoms in 1g of radium is

$$N = (1\text{g})\left(\frac{1\text{g}-\text{mole}}{226\text{ g}}\right)\left(6.023 \times 10^{23}\,\frac{\text{atoms}}{\text{g}-\text{mole}}\right) = 2.665 \times 10^{21}$$

The decay constant is related to the half-life by

$$\lambda = \frac{0.693}{T_{1/2}} = \left(\frac{0.693}{1622\,y}\right)\left(\frac{1\,y}{365\,d}\right)\left(\frac{1\,d}{8.64 \times 10^4\,s}\right) = 1.355 \times 10^{-11}\,s^{-1}$$

The activity is then found from

Activity = $\lambda N = (1.355 \times 10^{-11}\,\text{s}^{-1})(2.665 \times 10^{21}) = 3.61 \times 10^{10}$ disintegration/s = **361 unit**

The definition of the curie is 1 Ci = 3.7×10^{10} disintegration/s. This is approximately equal to the value found above.

Illustration 11

Question: **An unstable element is produced in nuclear reactor at a constant rate R. If its half-life for β^- decay is $T_{1/2}$, how much time, in terms of $T_{1/2}$, is required to produce 50% of the equilibrium quantity?**

Solution: We have

Rate of increase of element =

$$\frac{\text{number of nuclei produced by reactor}}{s} - \frac{\text{number of nuclei decaying}}{s}$$

$$\frac{dN}{dt} = R - \lambda N \quad \text{or} \quad \frac{dN}{dt} + \lambda N = R$$

The solution to this is the sum of the homogeneous solution, $N_h = ce^{-\lambda t}$, where c is a constant, and a particular solution, $N_p = \frac{R}{\lambda}$.

$$N = N_h + N_p = ce^{-\lambda t} + \frac{R}{\lambda}$$

The constant c is obtained from the requirement that the initial number of nuclei be zero:

$$N(0) = 0 = c + \frac{R}{\lambda} \quad \text{or} \quad c = -\frac{R}{\lambda}$$

so that $$N = \frac{R}{\lambda}(1 - e^{-\lambda t})$$

The equilibrium value is $(t \to \infty) = R/\lambda$. Setting N equal to 1/2 of this value gives

$$\frac{1}{2}\left(\frac{R}{\lambda}\right) = \frac{R}{\lambda}(1 - e^{-\lambda t})$$

$$e^{-\lambda t} = \frac{1}{2} \Rightarrow t = \frac{\ln 2}{\lambda} = T_{1/2} = \textbf{1 half life.}$$

The result is independent of R.

PROFICIENCY TEST– III

The following questions deal with the basic concepts of this section. Answer the following briefly. Go to the next section only if your score is at least 80%. Do not consult the Study Material while attempting these questions.

1. The mean lives of a radio active substance are 1620 years and 405 years for α-emission & β-emission respectively. Find out the time during which three fourth of a sample will decay if it is decaying both by α-emission and β-emission simultaneously. ($ln\ 4 = 1.386$)

2. If λ is the decay constant of a nucleus, find the percentage of nuclei that will (a) decay in two half life and (b) will not decay in two half life.

3. Calculate the age of a wooden article if its ${}_6C^{14}$ activity is $\eta = \frac{1}{3}$ of the activity of a newly cut wood. Half life of radio active ${}_6C^{14}$ is 6000 yrs. (ln 3 = 1.1)

4. The mass of ${}_{17}Cl^{35}$ nucleus is 34.98 amu. Calculate the binding energy per nucleon of chlorine in kilo electron volt (keV). (Mass of proton = 1.008 u, mass of neutron = 1.009 u)

5. A uranium U^{235} nucleus liberates energy of 200 MeV per fission. How much energy is released when a uranium bomb of 1.5 kg is exploded (in a unit where 1 unit = 10^{11} J).

ANSWERS TO PROFICIENCY TEST– III

1. 449 yrs.
2. 75, 25
3. 9524 yrs.
4. 8459 keV
5. 1230 unit

SOLVED OBJECTIVE EXAMPLES

***Example* 1:**

A carbon radioactive substance has a half-life time period 30 days. The disintegration constant is

(a) 231 day^{-1} **(b) 231 × 10^{-2} day^{-1}** **(c) 231 × 10^{-4} day^{-1}** **(d) 2.31 × 10^{3} day^{-1}**

***Solution*:**

$$T_{1/2}=\frac{0.693}{\lambda}$$

$$\lambda=\frac{0.693}{T_{1/2}}=\frac{0.693}{30}=\frac{0.0693}{3}=0.0231 \text{ per day}=\mathbf{231\times10^{-4}\ per\ day}$$

∴ **(c)**

***Example* 2:**

1 gram of a radioactive substance takes 50 seconds to lose 1 centigram. The half-life period of substance is (ln 0.99 = –0.01005)

(a) 2914 seconds **(b) 3448 seconds** **(c) 522 seconds** **(d) 212.97 seconds**

***Solution*:**

Suppose 1 g has N_0 nuclei. After 50 seconds mass remains $=\frac{1\times1}{100}$ g.

No. of nuclei which decay = $0.01N_0$ = 0.01 g.

Remaining nuclei = $N_0-0.01N_0=0.99N_0$.

$$N=N_0e^{-\lambda t}=0.99N_0=N_0e^{-\lambda\times50}$$

$$\lambda=0.0002010$$

$$T_{1/2}=\mathbf{3448\ s}$$

∴ **(b)**

***Example* 3:**

The activity of a radioactive sample is measured as 9750 counts per minute at t = 0 and as 975 counts per minute at t = 5 minute. The decay constant is approximately (ln 10 = 2.3026)

(a) 0.230 min^{-1} **(b) 0.461 min^{-1}** **(c) 0.691 min^{-1}** **(d) 0.922 min^{-1}**

***Solution*:**

$$A=A_0e^{-\lambda t}$$

$$\lambda=\mathbf{0.461\ min^{-1}}$$

∴ **(b)**

***Example* 4:**

In a given nuclear reaction $_2He^4+{}_zX^A\longrightarrow{}_{z+2}Y^{A+3}+K$, K is

(a) electron **(b) positron** **(c) proton** **(d) neutron**

***Solution*:**

Mass number is one and atomic number is zero. Hence it is neutron.

∴ **(d)**

***Example* 5:**

In nuclear reaction, there is conservation of

(a) mass only **(b) energy only**

(c) momentum only **(d) mass, energy and momentum**

***Solution*:**

Mass, energy and momentum are conserved.

∴ **(d)**

***Example* 6:**

Moving with same velocity which of the following has largest wavelength of matter wave?

(a) Proton **(b) Neutron** **(c) Electron** **(d) Alpha particle**

***Solution*:**

$$\lambda = \frac{h}{mv} \quad \text{or} \quad \lambda \propto \frac{1}{m}$$

So the electron, having smallest mass has the largest wavelength.

$\therefore$ **(c)**

***Example* 7:**

The de Broglie wavelength of 0.08 eV neutron will be (mass of neutron = 1.67 × 10^{-27} kg)

(a) 1.01 × 10^{-16} m **(b) 1.01 × 10^{-6} m** **(c) 1.01 × 10^{-10} m** **(d) 1.01 × 10^{-12} m**

***Solution*:**

$$\lambda = \frac{h}{\sqrt{2Em}} = \frac{6.6\times10^{-34}}{\sqrt{2\times0.08\times1.6\times10^{-19}\times 1.67\times10^{-27}}}$$

$\therefore$ **(c)**

***Example* 8:**

Light of wavelength 4000 Å is incident on a metal plate where work function is 2.0 eV. The maximum kinetic energy of the emitted photoelectrons would be

(a) 2 eV **(b) 1.5 eV** **(c) 1.1 eV** **(d) 0.5 eV**

***Solution*:**

$$E_{max} = \frac{hc}{\lambda} - W_0 = \frac{12400}{4000} - 2.0 = 3.1 - 2.0 = 1.1\text{eV}$$

$\therefore$ **(c)**

***Example* 9:**

In the case of hydrogen atoms, the energy required to remove an electron from fourth orbit is

(a) 0.85 eV **(b) 13.6 eV** **(c) 3.4 eV** **(d) 1.5 eV**

***Solution*:**

$$E_n = \frac{-13.6}{n^2}\ \text{eV}$$

when $n = 4$, $E_n = \frac{-13.6}{16}$ eV

$= -0.85$ eV, so energy required is 0.85 eV

$\therefore$ **(a)**

***Example* 10:**

The ground state energy of H-atom is 13.6 eV. The energy needed to ionise H-atom from its second excited state is

(a) 1.51 eV **(b) 3.4 eV** **(c) 13.6 eV** **(d) 12.1 eV**

***Solution*:**

In the second excited state $n = 3$

$$E = \frac{13.6}{9} = \mathbf{1.51\ eV}$$

$\therefore$ **(a)**

SOLVED SUBJECTIVE EXAMPLES

***Example* 1:**

If the average life time of an excited state of hydrogen is of the order of 10^{-8} s, estimate how many thousand rotation an electron makes when it is in the state $n = 2$ and before it suffers a transition to state $n = 1$. Bohr radius = 5.3×10^{-11} m.

***Solution*:**

Velocity of electron in the n^{th} orbit of hydrogen atom

$$v_n = \frac{v_1}{n} = \frac{2.19 \times 10^6}{n} \text{ m/s}$$

If $\quad n = 2, \quad v_n = \dfrac{2.19 \times 10^6}{2}$ m/s

Radius of $n = 2$ orbit, $r_n = n^2 r_1 = 4 \times$ Bohr radius

$= 4 \times 5.3 \times 10^{-11}$ m

Number of revolutions made in 1 sec

$$= \frac{v_n}{2\pi r} = \frac{2.19 \times 10^6}{2 \times 2\pi \times 4 \times 5.3 \times 10^{-11}}$$

Number of revolutions made in 10^{-8} s $= \dfrac{2.19 \times 10^6 \times 10^{-8}}{2 \times 2\pi \times 4 \times 5.3 \times 10^{-11}}$

$= 8.22 \times 10^6$ revolution = 8220 thousand revolution

***Example* 2:**

The wavelength of the first member of the Balmer series in hydrogen spectrum is 6563 Å. What is the wavelength of the first member of Lyman series?

***Solution*:**

Balmer series

$$\frac{1}{\lambda_1} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$$

Lyman series

$$\frac{1}{\lambda_2} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3R}{4}$$

$$\frac{\lambda_2}{\lambda_1} = \frac{4}{3R} \times \frac{5R}{36} = \frac{20}{108} = \frac{5}{27}$$

$$\lambda_2 = \frac{5}{27} \times \lambda_1 = \frac{5}{27} \times 6563 = \mathbf{1215\ Å}$$

***Example* 3:**

A single electron, orbits around a stationary nucleus of charge Ze, where Z is a constant and e is the electronic charge. It requires 47.2 eV to excite the electron from the second Bohr orbit to 3rd Bohr orbit. Find,

(i) the value of Z.

(ii) the energy required to excite the electron from the third to the fourth Bohr orbit in centi-electron volt (ceV).

(iii) the wavelength of electromagnetic radiation required to remove the electron from first Bohr orbit to infinity in pico-metre (pm).

(iv) the kinetic energy (in a unit where 1 unit = 10^{-19}J) potential energy (in a unit where 1 unit = –10^{-19} J) and angular momentum (in a unit where 1 unit = 10^{-36} J-s) of the electron in the first Bohr orbit.

(v) the radius of the first Bohr orbit in a unit where 1 unit = 10^{-13} m.

(Ionisation energy of hydrogen atom = 13.6 eV.

Bohr radius = 5.3×10^{-11} m, Velocity of light = 3×10^8 m/s and

Planck's constant = 6.6×10^{-34} Js)

Solution:

(i) For a general hydrogen-like atom

$$E_{n_2} - E_{n_1} = Z^2 E_0 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \text{ eV}$$

where E_0 is the ionisation energy of hydrogen atom

$$\Delta E = Z^2 \times 13.6 \left(\frac{1}{2^2} - \frac{1}{3^2}\right) = 47.2 \quad \text{or} \quad Z^2 \times \frac{13.6}{36} \times 5 = 47.2$$

$$Z^2 = \frac{47.2 \times 36}{13.6 \times 5} = 25$$

Z = 5

(ii) $$E_4 - E_3 = 5^2 \times 13.6 \left(\frac{1}{3^2} - \frac{1}{4^2}\right) \text{eV}$$

$$= 25 \times 13.6 \times \frac{7}{144} = \mathbf{16.53\ eV}$$

Energy required to excite the electron from the third to the fourth Bohr orbit
= **1653 ceV**

(iii) $$E_\infty - E_1 = Z^2 \times 13.6 \left[\frac{1}{1^2} - \frac{1}{\infty}\right] = 13.6 \times 25 \text{ eV}$$

$$\lambda = \frac{hc}{\Delta E} = \frac{(6.6 \times 10^{-34})(3 \times 10^8)}{13.6 \times 25 \times 1.6 \times 10^{-19}} = 0.03640 \times 10^{-7} = 36.4 \times 10^{-10}$$

= **3640 pm**

The wavelength of electromagnetic radiation required to remove the electron from first Bohr orbit to infinity = **3640 pm**

(iv) K.E. of *I* Bohr orbit is numerically equal to the energy of the orbit

$$E_1 = -Z^2 E_o = -25 \times 13.6 eV$$

∴ K.E. $= 25 \times 13.6 \times 1.6 \times 10^{-19}$ J $= 544 \times 10^{-19}$ J = **544 unit**

Potential energy of electron $= -2 \times$ K.E. $= -2 \times 544 \times 10^{-19}$ J $= -1088 \times 10^{-19}$ J = **1088 unit**

Angular momentum of the electron

$$mvr = \frac{nh}{2\pi} = \frac{h}{2\pi} \quad \because n = 1$$

$$= \frac{6.6 \times 10^{-34}}{2\pi} = 105 \times 10^{-36} \text{ J-s} = \mathbf{105\ unit}$$

(v) Radius r_1 of the first Bohr orbit

$$r_n = \frac{n^2 r_o}{Z}$$

For $n = 1$,

$$r_1 = \frac{1^2 \times 5.3 \times 10^{-11}}{5} = 106 \times 10^{-13} \text{ m} = \mathbf{106\ unit}$$

Example 4:

One milliwatt of light of wavelength 4560 Å is incident on a caesium surface. Calculate the electron current liberated in nano-ampere (nA). Assume a quantum efficiency of 0.5%.

Solution:

The energy of one photon of incident light

$$E = h\nu = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{4560 \times 10^{-10}} = 4.34 \times 10^{-19} J$$

1 mW of light energy is equivalent to

$$\frac{10^{-3}}{4.34 \times 10^{-34}} = 2.30 \times 10^{15} \text{ photon/sec}$$

The quantum efficiency = 0.5%

This means that only 0.5% of these photons release photoelectrons.

∴ the number of electrons released from the surface per second

$$= 2.30 \times 10^{15} \times \frac{0.5}{100}$$

$$= 1.15 \times 10^{13} \text{ electron/sec}$$

The electron current = $1.15 \times 10^{13} \times 1.6 \times 10^{-19}$ amp

$= 1.84 \times 10^{-6}$ amp = **1840 nA.**

***Example* 5:**

Find the de Broglie wavelength in pico-metre (pm) for an electron beam of kinetic energy 100 eV.

***Solution*:**

Kinetic energy of electrons: $(E)_K = \frac{1}{2}mv^2$

⇒ velocity of electrons: $v = \sqrt{\frac{2(E)_K}{m}}$

⇒ $v = \sqrt{\frac{2 \times 100 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}} = 5.9 \times 10^6$ m/s

Momentum : $p = mv = 9.1 \times 10^{-31} \times 5.9 \times 10^6 = 5.37 \times 10^{-24}$ kg m/s

⇒ de Broglie wavelength : $\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{5.37 \times 10^{-24}} = 1.23 \times 10^{-10}$ m = **123 pm**

***Example* 6:**

The wavelength of K_α X–ray of tungsten is 0.21 Å. If the energy of a tungsten atom with an *L* electron knocked out is 11.9 keV, what will be the energy of this atom when a K electron is knocked out? (h = 4.14 × 10^{-15} eVs)

***Solution*:**

Energy of K_α photon: $E = \frac{hc}{\lambda}$

⇒ $E = \frac{4.14 \times 10^{-15} \times 3 \times 10^{18} \text{ eV}-\text{Å}}{0.21 \text{Å}} = 59.1 \text{keV}$

Let E_K = energy of the atom with a vacancy in the *K*-shell

E_L = energy of the atom with a vacancy in the *L*-shell

Then, $E_K - E_L = E \Rightarrow E_K = E + E_L = 59.1 + 11.9 =$ **71 keV**

***Example* 7:**

Radio phosphorus-32 has a half-life of 14 days. A source containing this isotope has initial activity 10 μ curie.

(a) What is the activity of the source after 42 days in nano-curie?

(b) What time elapses before the activity of the source falls to 2.5 micros curie?

***Solution*:**

(a) The number of half-lives in 42 days = $\frac{42}{14} = 3$

$A = A_0 e^{-\lambda t} = A_0 \frac{1}{2^3} = \frac{10\mu \text{ curie}}{8} =$ **1250 nano-curie**

(b) $\frac{\text{Final activity}}{\text{Initial activity}} = \frac{2.5 \mu \text{ curie}}{10 \mu \text{ curie}} = \frac{1}{4}$

Time to decay to $\frac{1}{4}$ of initial activity = 2 half-lives = **28 days**

***Example* 8:**

It is found from an experiment that the radioactive substance emits one beta particle for each decay process. Also an average of 8.4 beta particles are emitted each second by 2.5 milligram of substance. The atomic weight of substance is 230. What is its half-life in a unit where 1 unit = 10^{12} years?

***Solution*:**

The activity = 8.4 sec^{-1}

Number of atoms in kilomole (i.e., 230 kg) = 6.02×10^{26}

$$\therefore \quad N = \frac{6.02\times10^{26}}{230} \times 2.5 \times 10^{-6} = 6.54 \times 10^{18}$$

$$8.4 = \lambda N = \lambda \times 6.54 \times 10^{18}$$

$$\lambda = \frac{8.4\times10^{-18}}{6.54} = 1.28 \times 10^{-18}/\text{sec}$$

$$\text{Half-life } T = \frac{0.693}{\lambda} = \frac{0.693}{1.28\times10^{-18}} = 5.41 \times 10^{17} \text{ sec}$$

$$= \frac{5.41\times10^{17}}{3.16\times10^{7}} = 171 \times 10^{12} \text{ years} = \mathbf{171\ unit}$$

***Example* 9:**

In the deuterium-tritium fusion reaction find the rate at which deuterium and tritium are consumed to produce 1 MW (in a unit where 1 unit = 10^{-12} kg/s). The *Q*-value of deuterium-tritium reaction is 17.6 MeV. You can assume that the efficiency is 100%.

***Solution*:**

Energy released per fusion = 17.6 MeV

Number of fusion reactions to produce 1 MW

$$= \frac{10^{6}}{17.6\times1.6\times10^{-19}\times10^{6}} = 3.55 \times 10^{17}$$

In each reaction one atom of deuterium and one atom of tritium are consumed.

Mass of deuterium consumed per second

$$= \frac{2 \text{ kg}}{1 \text{ kmol}} \times \frac{1 \text{ kmol}}{6.023\times10^{26}} \times 3.55 \times 10^{17} \text{ atom/sec}$$

$$= 1179 \times 10^{-12} \text{ kg/sec} = \mathbf{1179\ unit}$$

Mass of tritium consumed per second

$$= \frac{3}{2}\times1.179\times10^{-9} = 1769 \times 10^{-12} \text{ kg/sec} = \mathbf{1769\ unit}.$$

***Example* 10:**

Two deuterium nuclei fuse to form a tritium nucleus and a proton as by product. Compute the energy released in kilo electron volt (keV)
Given: Mass of deuterium = 2.0141 U
Mass of tritium nucleus = 3.01605 U
and mass of proton = 1.00782 U

***Solution*:**

$${}_1^2H + {}_1^2H \longrightarrow {}_1^3H + {}_1^1H + \Delta E$$

Mass of reactants = 2.0141 × 2 = 4.02820 U

Mass of products = 3.01605 + 1.00782 = 4.02387 U

Mass defect = 4.0282 – 4.02387 = 0.00433 U

Energy released = 0.00433 × 931 = 4.031 MeV = **4031 keV**

MIND MAP

MODERN PHYSICS

1. Radius of allowed Bohrs orbit

$$= \frac{\varepsilon_0 h^2 n^2}{\pi m Z e^2} = 0.53\frac{n^2}{Z}\,\text{Å}$$

Energy of hydrogen atom in n^{th} energy state $= -\frac{mZ^2e^4}{8\varepsilon_0^2 h^2 n^2} = -13.6\frac{Z^2}{n^2}$

Velocity of electron Bohr orbit

$$V = \frac{Ze^2}{2\varepsilon_0 hn} = 2.191.10^6\frac{Z}{n}$$

2. The wave number of a spectral line is given by $\bar{\nu} = RZ^2\left(\frac{1}{m^2} - \frac{1}{n^2}\right)$

$m = 1, n > 2$
Corresponds to Lyman series,
$m = 2, n > 2$
Corresponds to Balmer series,
$m = 3, n > 3$
Corresponds to Paschen series,
$m = 4, n > 4$
Corresponds to Bracket series,
$m = 5, n > 5$
Corresponds to Pfund series and so on.
(n is a natural number)

3. de-Broglie wavelength of a particle of mass m and moving with velocity v is

$$\lambda = \frac{h}{mv}$$

Einstein photoelectric equation is

$h\nu = W_0 + (K.E.)_{max}$

Stopping potential

$$V_0 = \left(\frac{h}{e}\right)\nu - \frac{W_0}{e}$$

4. For continuous X-rays

$$\lambda_{min} = \frac{hc}{eV}$$

Moseley law for characteristic X-rays

$\sqrt{\nu} = a\,(Z - b)$

5. Einstein mass energy equivalence principle $\Delta E = (\Delta m)c^2$

Binding energy per nucleon

$$= \left[\frac{Z}{A}(m_P - m_n) + m_n - \frac{m}{A}\right]c^2$$

The statistical radioactive law

$N = N_0 e^{-\lambda t}$

Half life

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

Mean life,

$$T_{av} = \frac{1}{\lambda}$$

Activity $A = A_0 e^{-\lambda t}$

EXERCISE – I

CBSE PROBLEMS

1. Compare the ratio of radii of two nuclei with mass numbers 1 and 27 respectively.

2. Define atomic mass unit. Write its energy equivalent.

3. Does the ratio of neutrons to protons in a nucleus increase, decrease or remain the same after the release of an α-particle?

4. You are given two nuclides $_3X^7$ and $_3Y^6$. Which one of the two is likely to be more stable? Give reason.

5. In the series of radioactive disintegration of $^A_Z X$, first an alpha particle and then a beta particle is emitted. What is the atomic number and mass number of the new nucleus formed by these disintegrations?

6. State and explain the laws of radioactive disintegration. Hence define disintegration constant and half life period.

or

Define the terms decay constant and half life of a radio active substance. Derive the relation connecting the two.

7. Explain the term chain reaction with suitable example.

8. Explain the concept of nuclear binding energy. Draw a curve between mass number and average binding energy per nucleon. What do you conclude from this curve?

9. Which has greater ionizing power. The alpha-particle or beta particles.

10. Write a general equation that represents β- emission.

11. A beam of electrons passes undeflected through mutually perpendicular electric and magnetic field $\vec{E}$ and $\vec{B}$ respectively. If the electric field is cut-off, the electron beam moves in a circular path of radius r. Derive the expression for $\frac{e}{m}$ of electron in terms of r, E and B.

12. What is the energy (in joule) acquired by an electron when accelerated through a potential difference of 2000 V?

13. An electron of mass m and charge q is accelerated through a potential difference V. What is its maximum velocity, if it was initially at rest?

14. Explain the terms cut off potential and threshold frequency in photo electric effect.

15. If the intensity of incident radiation on a metal surface is doubled, what happens to the kinetic energy of the electrons emitted?

16. Radiation of frequency 10^{15} Hz is incident on two photosensitive surfaces P and Q. Following observations are made.
(i) Surface P : Photoemission occurs but the photoelectrons have zero kinetic energy.
(ii) Surface Q : Photoemission occurs and photoelectrons have some kinetic energy. Which of these has a higher work function? If the incident frequency is slightly reduced, what will happen to photoelectron emission in the two cases?

17. All the photoelectrons are not emitted with the same energy. The energies of photoelectrons are distributed over a certain range. Why?

18. Which photon is more energetic –violet or red?

19. Describe Davisson and Germer experiment to establish the wave nature of electrons. Draw a labeled diagram of the apparatus used.

20. Derive the expression for the de-Broglie wavelength of an electron accelerated by a potential difference of V volt.

EXERCISE – II

NEET-SINGLE CHOICE CORRECT

1. If the frequency of light in a photoelectric experiment is doubled the stopping potential will be

(a) halved (b) doubled (c) more than double (d) less than double

2. Light of wavelength 3500 Å is incident on two metals *A* and *B* whose work functions are 4.2 eV and 1.9 eV respectively. Photoelectrons will be emitted by

(a) metal *A* only (b) metal *B* only (c) both *A* and *B* (d) none

3. The ratio of the speed of the electrons in the ground state of hydrogen to the speed of light in vacuum is

(a) $\frac{1}{2}$ (b) $\frac{2}{237}$ (c) $\frac{1}{237}$ (d) $\frac{1}{137}$

4. The first member of Balmer series of H-atom has a wavelength 6561Å . The wavelength of second member will be

(a) 6860 Å (b) 5860 Å (c) 4860 Å (d) 3860 Å

5. In which of the following transitions will the wavelength be minimum in the case of hydrogen atom?

(a) $n = 5$ to $n = 4$ (b) $n = 4$ to $n = 3$ (c) $n = 3$ to $n = 2$ (d) $n = 2$ to $n = 1$

6. The X-rays coming from an X-ray tube will be

(a) monochromatic

(b) having all wavelength smaller than a certain minimum wavelength

(c) having all wavelength greater than a certain minimum wavelength

(d) having all wavelength between certain minimum and maximum wavelengths

7. Given that mass of proton = 1.00813 amu, mass of neutron is 1.00894 amu and mass of α-particle is 4.00388 amu, the binding energy of alpha particle is

(a) 28.172 MeV (b) 27.172 MeV (c) 13.52 MeV (d) 56.321 MeV

8. Nuclear radius of ${}_{8}O^{16}$ is 3 fermi. The nuclear radius of ${}_{82}Pb^{205}$ is

(a) 5.02 fermi (b) 6.02 fermi (c) 7.02 fermi (d) 8.02 fermi

9. What percentage of a radioactive substance is left after 5 half-lives

(a) 31% (b) 3.12% (c) 0.3% (d) 1%

10. A photon of energy 10.2 eV collides inelastically with a stationary hydrogen atom (in ground state). After few micro-second another photon of energy 15.0 eV collides with same hydrogen atom. Which of the following can be detected by a suitable detector?

(a) One photon of 10.2 eV and an electron of energy 1.4 eV

(b) One photon of 3.4 eV and one electron of energy 10.2 eV

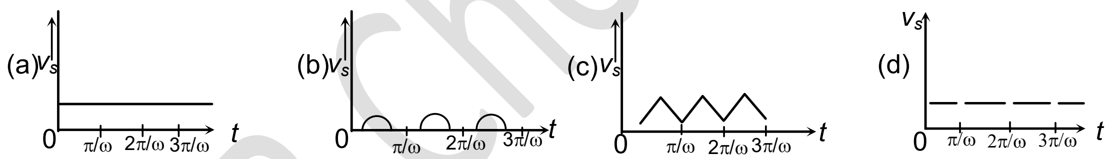
(c) Two photon of energy 10.2 eV

(d) Two photon of energy 3.4 eV

11. K_α wavelength of an element with atomic number $Z = 11$ is λ. For what value of Z wavelength becomes 4 λ?

(a) 44 (b) 11 (c) 6 (d) 4

12. A light beam coming from a monochromatic source of variable intensity $I = I_0\ |\sin \omega t|$ is incident on a metallic plate of work function w_0. The curve correctly shows minimum potential required to stop the ejection of electron from the surface with respect to time is



13. If potential energy of electron in the first excited state of hydrogen atom is taken to be zero then energy of first excited state and that of the first line of Lyman series are respectively

(a) –3.4 eV, 10.2 eV (b) 3.4 eV, 10.2 eV

(c) –3.4 eV, 3.4 eV (d) 3.4 eV, –3.4 eV

14. If λ_1, λ_2 and λ_3 are the wavelengths of K_α X-rays emitted by ^{112}Sn, ^{114}Sn and ^{116}Sn tin isotopes, then

(a) $\lambda_1 = \lambda_2 = \lambda_3$ (b) $\lambda_1 > \lambda_2 > \lambda_3$ (c) $\lambda_1 < \lambda_2 < \lambda_3$ (d) $\frac{1}{\lambda_1} + \frac{1}{\lambda_3} = \frac{2}{\lambda_2}$

15. At any instant the ratio of the amount of radioactive substances is 2 : 1. If their half-lives be respectively 12 and 16 hours, then after two days, what will be the ratio of the substances?

(a) 1 : 1 (b) 2 : 1 (c) 1 : 2 (d) 1 : 4

16. The nucleus $_6C^{12}$ absorbs an energetic neutron and emits particle β. The resulting nucleus is

(a) $_7N^{14}$ (b) $_5B^{13}$ (c) $_7N^{13}$ (d) $_6C^{13}$

17. In the reaction represented by ${}_{Z}X^{A} \rightarrow {}_{Z-2}Y^{A-4} \rightarrow {}_{Z-2}Y^{A-4} \rightarrow {}_{Z-1}K^{A-4}$. The decays in the sequence are

(a) α, β, γ (b) β, α, γ (c) γ, α, β (d) α, γ, β

18. The de Broglie wavelength of an electron in the n^{th} Bohr orbit is related to the radius R of the orbit as

(a) $n\lambda = nR$ (b) $n\lambda = \frac{3}{2}\pi R$ (c) $n\lambda = 2\pi R$ (d) $n\lambda = 4\pi R$

19. Light of wavelength λ strikes a photosensitive surface and electrons are ejected with kinetic energy E. If the KE is to be increased to $2E$, the wavelength must be changed to λ' where

(a) $\lambda' = \lambda/2$ (b) $\lambda' = 2\lambda$ (c) $\lambda' > \lambda$ (d) $\lambda/2 < \lambda' < \lambda$

20. The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6eV fall on it is 4eV. The stopping potential in volts is

(a) 2 (b) 4 (c) 6 (d) 10

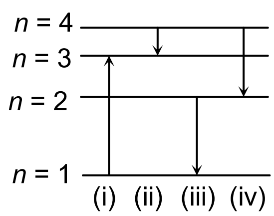
21. Three radioactive substances have their activity in the ratio 1 : 3 : 5. The substances are heated to double its temperature. Then, the activity will be

(a) 5 : 3 : 1 (b) 3 : 1 : 5 (c) 3 : 5 : 1 (d) 1 : 3 : 5

22. In Bohr's model, the atomic radius of the first orbit is r_0 ; then the radius of the third orbit is

(a) $r_0/9$ (b) r_0 (c) $9r_0$ (d) $3r_0$

23. The diagram shows the energy levels for an electron in certain hydrogen like atom. Which transition shown represents the emission of a photon with the most energy?



(a) (i) (b) (ii)
(c) (iii) (d) (iv)

24. The radius of the shortest orbit in a one electron system is 18 pm. It may be

(a) hydrogen (b) deuterium (c) He^{+} (d) Li^{++}

25. In a star, three alpha particles join in succession to form ${}_{6}C^{12}$ nucleus. How much energy is evolved in this reaction? Take mass ${}_{6}C^{12}$ = 12 amu and that of alpha particle = 4.002603 amu

(a) 15 MeV (b) 18 MeV (c) 7.27 MeV (d) 2.917 MeV

EXERCISE – III

IIT-JEE-SINGLE CHOICE CORRECT

1. Kinetic energy of a photoelectron is E and wavelength of incident light is $\frac{\lambda}{2}$. If energy becomes double when wavelength is reduced to $\lambda/3$, then work function of the metal is

(a) $\frac{3hc}{\lambda}$ (b) $\frac{hc}{3\lambda}$ (c) $\frac{hc}{\lambda}$ (d) $\frac{hc}{2\lambda}$

2. If the frequency of K_α X-ray emitted from the element with atomic number 31 is f, then the frequency of K_α X-ray emitted from the element with atomic number 51, would be (assume that screening constant for K_α is 1)

(a) $\frac{5}{3}f$ (b) $\frac{51}{31}f$ (c) $\frac{9}{25}f$ (d) $\frac{25}{9}f$

3. If the shortest wavelength of Lyman series of H atom is x, then the wavelength of first member of Balmer series of H atom will be

(a) $9x / 5$ (b) $36x / 5$ (c) $5x / 9$ (d) $5x / 36$s

4. An excited hydrogen atom emits a photon of wavelength λ while returning to the ground state. The quantum number n of the excited state is given by (R = Rydberg constant)

(a) $\sqrt{\lambda R/(\lambda R-1)}$ (b) $\sqrt{\lambda R/(\lambda R+1)}$ (c) $\sqrt{(\lambda R-1)/\lambda R}$ (d) $\frac{1}{\sqrt{\lambda R(\lambda R-1)}}$

5. Two radioactive materials X_1 and X_2 have decay constants 10 λ and λ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that of X_2 will be 1/e after a time

(a) $\frac{1}{10\lambda}$ (b) $\frac{1}{11\lambda}$ (c) $\frac{11}{10\lambda}$ (d) $\frac{1}{9\lambda}$

6. A container is filled with a radioactive substance for which the half-life is 2 days. Six days later, when the container is opened, it contains 5 grams of the substance. How many grams of the substance were initially placed in the container?

(a) 40 (b) 60 (c) 80 (d) 100

7. The radioactivity of a sample is R_1 at a time T_1 and R_2 at a time T_2. If the half-life of the specimen is T, the number of atoms that have disintegrated in the time $(T_2 - T_1)$ is proportional to

(a) $R_1T_1 - R_2T_2$ (b) $R_1 - R_2$ (c) $\frac{R_1 - R_2}{T}$ (d) $(R_1 - R_2)T$

8. The activity of a radioactive element decreases to one-third of the original activity I_0 in a period of nine years. After a further lapse of nine years its activity will be

(a) I_0 (b)(2/3) I_0 (c) $(I_0/9)$ (d) $(I_0/6)$

9. An element *A* decays into element *C* by a two step process $A \rightarrow B + {}_2He^4$, $B \rightarrow C + 2e^-$. Then

(a) *A* and *B* are isotopes (b) *A* and *B* are isobars

(c) *A* and *C* are isotopes (d) *A* and *C* are isobar

10. A light source is at a distance *d* from a photoelectric cell. The stopping potential of the photoelectrons emitted is V_0. If the distance of light source and cell is reduced to half, then the stopping potential will become

(a) $V_0/2$ (b) $2V_0$ (c) $4V_0$ (d) V_0

11. Two identical photo cathodes receive light of frequencies ν_1 and ν_2. If the velocities of the photoelectrons (of mass *m*) coming out are v_1 and v_1 respectively, then:

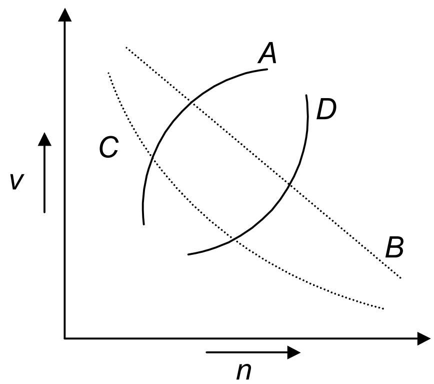
(a) $v_1 - v_2 = \left[\frac{2h}{m}(\nu_1 - \nu_2)\right]^{1/2}$ (b) $v_1^2 - v_2^2 = \frac{2h}{m}(\nu_1 - \nu_2)$

(c) $v_1 + v_2 = \left[\frac{2h}{m}(\nu_1 - \nu_2)\right]^{1/2}$ (d) $v_1^2 + v_2^2 = \frac{2h}{m}(\nu_1 - \nu_2)$

12. Which of the following curves may represent the speed of electron in a hydrogen atom as a function of principal quantum number *n*?

(a) *A* (b) *B*

(c) *C* (d) *D*



13. The momentum of an X-ray photon of wavelength 0.10 nm will be

(a) 6.62×10^{-34} kg-m/s (b) 3.31×10^{-24} kg-m/s

(c) 3.31×10^{-34} kg-m/s (d) 6.62×10^{-24} kg-m/s

14. The wave number of energy emitted when electron comes from fourth to second orbit in hydrogen is 20397 cm^{-1}. The wave number of energy for same transition in helium is

(a) 5099 cm^{-1} (b) 20497 cm^{-1} (c) 40994 cm^{-1} (d) 81588 cm^{-1}

15. If the wavelength of light incident on a photoelectric cell be reduced from 4000 Å to 3600 Å, then the change in the cut off potential will be

(a) 3.4 V (b) 0.34 V (c) 1.34 V (d) 2.34 V

16. Assuming that four protons combine to form helium atom and two positrons each of mass 0.000549 amu. Calculate the energy released. Given mass of $_1H^1$ = 1.007825 amu and mass of $_2He^4$ = 4.0026 amu

(a) 12.2 MeV (b) 25.7 MeV (c) 24 MeV (d) 40 MeV

17. An unknown atom has 30 neutrons in its nucleus. Ratio of radii of nuclei of this atom and $_2^4He$ is $(14)^{\frac{1}{3}}$. Then the atomic number of unknown atom is

(a) 28 (b) 26 (c) 30 (d) 31

18. A silver sphere (work function 4.6 eV) is suspended in a vacuum chamber by an insulating thread. Ultraviolet light of wavelength 0.2 μm strike on the sphere. The maximum electric potential of the sphere will be (hc = 12400 eVÅ)

(a) 4.6 V (b) 6.2 V (c) 1.6 V (d) 3.2 V

19. The counting rate observed from a radioactive source at t second was N_0 counts per second and at $4t$ second $\frac{N_0}{16}$ counts per second. The counting rate observed, as counts per second, at $\left(\frac{11}{2}\right)t$ second will be

(a) $\frac{N_0}{128}$ (b) $\frac{N_0}{64}$ (c) $\frac{N_0}{32}$ (d) $\frac{N_0}{256}$

20. If light of wavelength of maximum intensity emitted from a surface at temperature T_1 is used to cause photoelectric emission from a metallic surface, the maximum kinetic energy of the emitted electron is 6 eV, which is 3 times the work function of the metallic surface. If light of wavelength of maximum intensity emitted from a surface at temperature $T_2(T_2 = 2T_1)$ is used, the maximum kinetic energy of the photoelectrons emitted is

(a) 2 eV (b) 4 eV (c) 14 eV (d) 18 eV

21. A proton is bombarded on a stationary lithium nucleus. As a result of the collision two α-particles are produced. If the direction of motion of the α-particles with the initial direction of motion makes an angle $\cos^{-1}\left(\frac{1}{4}\right)$, then the kinetic energy of striking proton is (Given binding energy per nucleon of Li^7 and He^4 is 5.60 MeV and 7.06 MeV respectively).

(a) 17.28 MeV (b) 5.76 MeV (c) 11.52 MeV (d) 12.66 MeV

22. Nuclei of a radioactive element A are being produced at a constant rate α. The element has a decay constant λ. At time $t = 0$, there are N_0 nuclei of the element. The number N of nuclei of A at time t is

(a) $\frac{1}{\lambda}[\alpha-(\alpha-\lambda N_0)e^{-\lambda t}]$ (b) $\frac{1}{\lambda}[(\alpha-\lambda N_0)e^{-\lambda t}]$

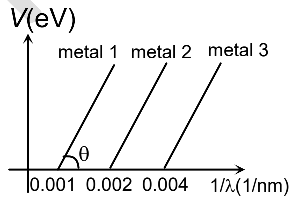
(c) $\lambda[\alpha-(\alpha-\lambda N_0)e^{\lambda t}]$ (d) $\lambda N_0 e^{-\lambda t}$

23. A beam of light having λ between 5×10^{-7} m and 6×10^{-7} m is incident on a sample of atomic hydrogen. If the atoms are in first excited state, the wavelength which will have low intensity in the transmitted beam is (Take $R = 10^7$ m^{-1})

(a) 5.11×10^{-7} m (b) 5.22×10^{-7} m

(c) 5.33×10^{-7} m (d) 5.44×10^{-7} m

24. The graph between $1/\lambda$, where λ is wavelength of incident light and stopping potential (V) of three metals having work functions ϕ_1, ϕ_2 and ϕ_3 in an experiment of photo-electric effect is plotted as shown in the figure. Which of the following statements is correct?



(a) Ratio of work functions $\phi_1 : \phi_2 : \phi_3 = 1:2:4$

(b) Ratio of work functions $\phi_1 : \phi_2 : \phi_3 = 4:2:1$

(c) $\tan\theta$ is inversely proportional to $\frac{hc}{e}$, where h is Planck's constant and c is the speed of light

(d) The violet colour light can eject photoelectrons from metals 2 and 3

25. The ratio of U^{238} to Pb^{206} nuclei in an ore is 3. The age of the ore, assuming that all the lead present in the ore is the final product of U^{238} (decay constant = λ) is

(a) $\frac{\ln 2}{\lambda}$ (b) $\frac{\ln 3}{\lambda}$ (c) $\frac{\ln\left(\frac{3}{4}\right)}{\lambda}$ (d) $\frac{\ln\left(\frac{4}{3}\right)}{\lambda}$

EXERCISE – IV

ONE OR MORE THAN ONE CHOICE CORRECT

1. During radioactive decay
(a) atomic number cannot increase
(b) atomic number may increase
(c) atomic number may decrease
(d) atomic number may remain unchanged

2. When photons of energy 4.25 eV strike the surface of a metal A, the ejected photoelectrons have maximum kinetic energy T_A eV and de Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photons of energy 4.70 eV is $T_B = (T_A - 1.50)$ eV. If the de Broglie wavelength of these photoelectrons is $\lambda_B = 2\lambda_A$, then
(a) the work function of A is 2.25 eV
(b) the work function of B is 4.20 eV
(c) $T_A = 2.00$ eV
(d) $T_B = 2.75$ eV

3. Light rays are incident on an opaque sheet. Then they
(a) exert a force on the sheet
(b) transfer an energy to the sheet
(c) transfer momentum to the sheet
(d) transfer impulse to the sheet

4. Which of the following statements is /are correct for an X-rays tube?
(a) on increasing potential difference between filament and target, photon flux of X-rays increases
(b) on increasing potential difference between filament and target, frequency of X-ray increases
(c) on increasing filament current, cut off wavelength increases
(d) on increasing filament current, intensity of X-rays increases

5. When an electron of hydrogen like atoms jumps from a higher energy level to a lower energy level
(a) angular momentum of the electron remains constant
(b) kinetic energy increases
(c) wavelength of de-Broglie wave, associated with motion of the electron decreases
(d) none of these

6. When a hydrogen atom is excited from ground state to first excited state
(a) its KE increases by 10.2 eV
(b) its KE decrease by 10.2 eV
(c) its PE increases by 20.4 eV
(d) its angular momentum increases by 1.05×10^{-34} J-s

7. Suppose the potential energy between electron and proton at a distance r is given by $-\dfrac{Ke^2}{3r^3}$.
Application of Bohr's theory of hydrogen atom in this case shows that;
(a) energy in the nth orbit is proportional to n^6
(b) energy is proportional to m^{-3} (m: mass of electron)
(c) energy in the nth orbit is proportional to n^{-2}
(d) energy is proportional to m^3 (m = mass of electron)

8. Which of the following assertions are correct?
(a) A neutron can decay to proton only inside a nucleus.
(b) A proton can change to a neutron only inside a nucleus.
(c) An isolated neutron can change into a proton.
(d) An isolated proton can change into a neutron.

9. When the nucleus of an electrically neutral atom undergoes a radioactive decay, it will remain neutral after the decay if the process is
(a) an α decay (b) a β^- decay (c) a γ decay (d) a K-capture process

10. In the Bohr model of the hydrogen atom, let *R*, *V* and *E* represent the radius of the orbit, speed of the electron and the total energy of the electron respectively. Which of the following quantities are proportional to the quantum number *n* ?
(a) VR (b) RE (c) $\frac{V}{E}$ (d) $\frac{R}{E}$

11. An electron in a hydrogen atom makes a transition from $n = n_1$ to $n = n_2$. The time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_2 are
(a) $n_1 = 4, n_2 = 2$ (b) $n_1 = 8, n_2 = 2$ (c) $n_1 = 8, n_2 = 1$ (d) $n_1 = 6, n_2 = 3$

12. Whenever a hydrogen atom emits a photon in the Balmer series,
(a) it may emit another photon in the Balmer series
(b) it must emit another photon in the Lyman series
(c) the second photon, if emitted, will have a wavelength of about 122 nm
(d) it may emit a second photon, but the wavelength of this photon cannot be predicted

13. When an electron moving at a high speed strikes a metal surface, which of the following are possible?
(a) The entire energy of the electron may be converted into an X-ray photon.
(b) Any fraction of the energy of the electron may be converted into an X-ray photon.
(c) The entire energy of the electron may get converted to heat
(d) The electron may undergo elastic collision with the metal surface

14. A radioactive sample has initial concentration N_0 of nuclei.
(a)The number of undecayed nuclei present in the sample decays exponentially with time
(b) The activity (R) of the sample at any instant is directly proportional to the number of undecaysed nuclei present in the sample at that time
(c) The number of decayed nuclei grows linearly with time.
(d) The number of decayed nuclei grows exponentially with time

15. When a monochromatic point source of light is at a distance of 0.2 m from a photoelectric cell, the cut-off voltage and the saturation current are respectively 0.6 V and 18.0 mA. If the same source is placed 0.6 m away from the photoelectric cell, then
(a) the stopping potential will be 0.2 V
(b) the stopping potential will be 0.6 V
(c) the saturation current will be 6.0 mA
(d) the saturation current will be 2.0 mA

EXERCISE –V

MATCH THE FOLLOWING

Note : Each Statement in column – I has only one match in column – II.

1. $_7N^{14} + {_2He^4} \longrightarrow {_8O^{17}} + {_1H^1}$. The masses are given as : N^{14} = 14.003 amu, $_1H^1$ = 1.0078 amu, O^{17} = 16.999 amu, $m(_0n^1)$ = 1.009 amu, $_2He^4$ = 4.002 amu, 1 amu = 931 eV
Match the quantities of column I with their values in column II.

Column I	Column II
I. Q value (MeV)	**A.** 29.42
II. Minimum K.E. of an α-particle to cause the reaction (MeV)	**B.** 7.9
III. Binding energy of α-particle (MeV)	**C.** 2.15
IV. Binding energy per nucleon of $_8O^{17}$ (MeV)	**D.** 1.675

2. The radiations emitted when an electron jumps from $n = 4$ to $n = 3$ in a lithium atom, falls on a metal surface to produce photoelectrons. The photoelectrons with maximum K.E. are allowed to move in a perpendicular magnetic field of 4×10^{-4} T. It traces out a circular path of radius 2 cm. (mass of electron = 10^{-30} kg, $R = 1.09 \times 10^7\ m^{-1}$)
Match the quantities of column I with their values in column II.

Column I	Column II
I. Wavelength of radiation (in Å)	**A.** 1280
II. Velocity of electron (in km/s)	**B.** 0.83
III. K.E. of electron (in eV)	**C.** 2097
IV. Work function of metal (in eV)	**D.** 5.12

Note: Each statement in column – I has one or more than one match in column –II.

3. The kinetic energy, the speed, the magnitude of angular momentum and orbital radius of an electron in a hydrogen atom corresponding to the quantum number n are E, v, L and r respectively. Match the quantities in the column-I with the quantities in the column-II on the basis of proportionality.

Column I	Column II
I. E/L	**A.** n
II. $\frac{r}{L}$	**B.** n^{-1}
III. $\frac{L}{Er}$	**C.** v/r
IV. $E\sqrt{r}$	**D.** n^{-3}

REASONING TYPE

Directions: Read the following questions and choose

(A) If both the statements are true and statement-2 is the correct explanation of **statement-1**.
(B) If both the statements are true but statement-2 is not the correct explanation of **statement-1**.
(C) If statement-1 is True and **statement-2** is False.
(D) If statement-1 is False **and statement-2** is True.

1. **Statement-1**: During radio active disintegration an α-particle and a β-particle can be emitted simultaneously.
Statement-2: α, β-particles are the products of radioactive decay.
(a) (A) (b) (B) (c) (C) (d) (D)

2. **Statement-1**: The process of photoelectric emission is different to that of thermionic emission.
Statement-2: The process of thermionic emission is temperature dependent but photoelectric emission is independent of temperature.
(a) (A) (b) (B) (c) (C) (d) (D)

3. **Statement-1**: In the process of photoelectric emission, all the emitted photoelectrons have the same kinetic energy.
Statement-2: The photons transfer its whole energy to the electron of the atom in photoelectric effect.
(a) (A) (b) (B) (c) (C) (d) (D)

4. **Statement-1**: Hydrogen atom consists of only one electron but its emission spectrum has many lines.
Statement-2: Only Lyman series in found in the absorption spectrum of hydrogen atom where as in the emission spectrum, all the series are found.
(a) (A) (b) (B) (c) (C) (d) (D)

5. **Statement-1**: The threshold frequency of photoelectric effect supports the particle nature of light.
Statement-2: If frequency of incident light is less than the threshold frequency, electrons are not emitted from metal surface.
(a) (A) (b) (B) (c) (C) (d) (D)

LINKED COMPREHENSION TYPE

We have two radioactive nuclei *A* and *B*. Both convert into a stable nucleus *C*. Nucleus *A* converts into *C* after emitting two α-particles and three β-particles. Nucleus *B* converts into *C* after emitting one α-particle and five β- particles. A time $t = 0$, nuclei of *A* are 4 N_0 and that of *B* are N_0. Half-life of *A* (into the conversion of *C*) is 1 minute and that of *B* is 2 minutes. Initially number of nuclei of *C* is zero.

1. If atomic numbers and mass numbers of *A* and *B* are Z_1, Z_2, A_1 and A_2 respectively. Then
(a) $Z_1 - Z_2 = 6$ (b) $A_1 - A_2 = 4$
(c) both (a) and (b) are correct (d) (a) is incorrect and (b) is correct

2. What are number of nuclei of *C*, when number of nuclei of *A* and *B* are equal?
(a) $2\,N_0$
(b) $3\,N_0$
(c) $\frac{9N_0}{2}$
(d) $\frac{5N_0}{2}$

3. At what time rate of disintegrations of *A* and *B* are equal
(a) 4 minute
(b) 6 minute
(c) 8 minute
(d) 2 minute

4. At what time activity of *A* will be double the activity of *B*
(a) 4 minute
(b) 6 minute
(c) 8 minute
(d) 2 minute

SUBJECTIVE PROBLEMS

1. A solution contains a mixture of two isotopes *A*(half life = 10 days) and *B* (half life = 5 days). Total activity of the mixture is 15×10^{10} disintegrations per second at time $t = 0$, the activity reduces to 20% in 20 days. Find the initial activities of *A* and *B* in a unit where 1 unit = 10^{10} disintegration per second.

2. Photons of energy 3eV fall on a photosensitive metal of work function 1 eV. The de-Broglie wavelength of the most energetic ejected electron is found to be $(1.09)^2\sqrt{10}$ times the wavelength of K_α *X*-ray coming from a certain element *A* when it is bombarded by fast moving electron. Find the atomic number of the element *A*.
Given plank constant $h = 6.54 \times 10^{-34}$ J –s, mass of the electron = 9×10^{-31} kg, Rydberg's constant = $1.09 \times 10^{7}\ m^{-1}$.

3. A source of radiation consisting of Be^{3+} ions excited to their third excited state is being used to have photoelectric emission on a metallic plate with work function 8 eV.
(a) What is the maximum possible energy in eV of the emitted photons from Be^{3+}?
(b) Find the minimum de-Broglie wavelength of the emitted photoelectrons in nano-metre (nm).
(Given mass of electron = 9.1×10^{-31} kg and Plank constant = 6.63×10^{-34} Js)

4. Photoelectrons are emitted when 400 nm radiation is incident on a surface of work function 1.9 eV. These photoelectrons pass through a region containing α-particle. A maximum energy electron combines with an α-particle to from a He^+ ion, emitting a single photon in this process. He^+ ions thus formed are in their fourth excited state. Find the energy in meV of the photons lying in the 2000 to 4000 meV range, that are likely to be emitted during and after the combination. (take $h = 4.14 \times 10^{-15}$ eV-s]

5. A hydrogen like atom (atomic number *Z*) is in a higher excited state of quantum number *n*. The excited atom can make a transition to the first excited state by successively emitting two photons of energy 10.2 and 17.0 eV respectively. Alternately, the atom from the same excited state can make a transition to the second excited state by successively emitting two photons of energies 4.25 eV and 5.95 eV respectively. Determine the values of *n* and *Z*. (Ionization energy of H-atom = 13.6 eV).

6. Light from a discharge tube containing hydrogen atoms falls on the surface of a piece of sodium. The kinetic energy of the fatest photoelectrons emitted from sodium is 1.18 eV. The work function for sodium is 1.82 eV. Find

(a) the energy of the photons causing the photoelectric emission.

(b) the recoil speed of the emitting atom assuming it to be at rest before the transition in mm/s. (Ionization potential of hydrogen is 13.6 V).

7. (a) An electron in a hydrogen like atom is in an excited state. It has a total energy of – 3400 meV. Calculate

(i) the kinetic energy in meV

(ii) the de-Broglie wavelength of the electron in pico-metre (pm)

(b) At a given instant there are 25% undecayed radioactive nuclei in a sample. After 10 second the number of undecayed nuclei reduces to 12.5%. Calculate the time in which the number of undecayed nuclei will further reduce 6.25% of the reduced number.

8. When a beam of 10.6 eV photons of intensity 2.0 W/m^2 falls on a platinum surface of area 1.0 × 10^{-4} m^2 and work function 5.6 eV, 0.53% of the incident photons eject photoelectrons. Find the number of photoelectrons emitted per second (in a unit where 1 unit = 10^9 s^{-1}) and their minimum and maximum energies (in eV). Take 1 eV = 1.6 × 10^{-19} J.

9. In a photoelectric effect set-up a point source of light of power 3.2 × 10^{-3} W emits monoenergetic photons of energy 5.0 eV. The source is located at a distance of 0.8m from the centre of a stationary metallic sphere of work function 3.0 eV and a radius 8.0 × 10^{-3} m. The efficiency of photoelectron emission is one for every 10^6 incident photons. Assume that the sphere is isolated and initially neutral and that photoelectrons are instantly swept away after emission.

(a) Calculate the number of photoelectrons emitted per milli-second.

(b) Find the ratio of the wavelength of incident light to the de-Broglie wavelength of the fastest photoelectrons emitted in nearest whole number.

(c) Evaluate the time t in which the photo electron emission stops after the light source is switched on.

10. Assume that the de-Broglie wave associated with an electron can form a standing wave between the atoms arranged in a one dimensional array with nodes at each of the atomic sites. If it found that one such standing wave is formed if the distance d between the atoms of the array is 4 Å. A similar standing wave is again formed if d is increased to 5 Å but not for any intermediate value of d. Find the energy of the electron in eV and the least value of d (in Å) for which the standing wave of the type described above can form.

ANSWERS

EXERCISE – II

NEET-SINGLE CHOICE CORRECT

1. (c)	2. (b)	3. (d)	4. (c)	5. (d)
6. (c)	7. (a)	8. (c)	9. (b)	10. (a)
11. (c)	12. (d)	13. (b)	14. (a)	15. (a)
16. (c)	17. (d)	18. (c)	19. (d)	20. (b)
21. (d)	22. (c)	23. (c)	24. (d)	25. (c)

EXERCISE – III

IIT-JEE - SINGLE CHOICE CORRECT

1. (c)	2. (d)	3. (b)	4. (a)	5. (d)
6. (a)	7. (d)	8. (c)	9. (c)	10. (d)
11. (b)	12. (c)	13. (d)	14. (d)	15. (b)
16. (b)	17. (b)	18. (c)	19. (b)	20. (c)
21. (a)	22. (a)	23. (c)	24. (a)	25. (d)

EXERCISE – IV

MORE THAN ONE CHOICE CORRECT

1. (b,c,d)	2. (a,b,c)	3. (a,b,c,d)	4. (b,d)	5. (b,c)
6. (b,c,d)	7. (a,b)	8. (b,c)	9. (c,d)	10. (a,c)
11. (a,d)	12. (b,c)	13. (a,b,c)	14. (a,b,d)	15. (b,d)

EXERCISE –V

MATCH THE FOLLOWING

1. I – D, II – C, III – A, IV – B

2. I – C, II – A, III – D, IV – B

3. I – C, D, II – A, III – A, IV – B

REASONING TYPE

1. (d)	2. (a)	3. (d)	4. (b)	5. (b)

LINKED COMPREHENSION TYPE

1. (b)	2. (c)	3. (b)	4. (a)	

SUBJECTIVE PROBLEMS

1. 11 unit, 4 unit

2. 24

3. (a) 204 eV (b) 878 nm

4. 3376 meV during combination and 3868 meV and 2644 meV after combination.

5. 6, 3

6. (a) 3 eV (b) 814 mm/s

7. (a) (i) 3400 meV (ii) 663 pm (b) 40 s

8. 625 unit, 0 eV, 5 eV

9. (a) 100 $(ms)^{-1}$ (b) 285 (c) 111 s

10. 38 eV, 1 Å

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 1

Q.1 Which of the following is not the property of atomic nucleus ?
(1) Definite charge
(2) Definite number of nucleons
(3) Characteristic atomic number
(4) Sharp boundary

Q.2 The radius of the nucleus with nucleon number 2 is 1.5×10^{-15}m, then the radius of nucleus with nucleon number 54 will be -
(1) 3×10^{-15} m (2) 4.5×10^{-15}m
(3) 6×10^{-15} m (4) 9.5×10^{-15} m

Q.3 The mass number of a nucleus is -
(1) always less than its atomic weight
(2) always greater than its atomic weight
(3) equal to its atomic weight
(4) sometimes greater than and sometimes equal to its atomic weight

Q.4 If there are N nucleons in a nucleus of radius R, then the number of nucleons in a nucleus of radius 2R will be -
(1) N (2) 2N (3) 8N (4) $2^{1/3}$N

Q.5 The radius of $_{29}Cu^{64}$ nucleus will be -
(1) 1.2×10^{-15} m (2) -2.4×10^{-15} m
(3) 3.6×10^{-15} m (4) 4.8×10^{-15} m

Q.6 Of the three basic forces, gravitational, electrostatic and nuclear, which are able to provide an attractive force between two neutrons -
(1) electrostatic and gravitational only
(2) electrostatic and nuclear only
(3) electrostatic, nuclear and gravitational
(4) nuclear and gravitational only

Q.7 Attractive nuclear forces exist between -
(1) neutron - neutron (2) proton - proton
(3) neutron - proton (4) all of the above

Q.8 Force that acts between proton and proton in the nucleus is -
(1) attractive (2) gravitational
(3) repulsive (4) electro-magnetic

Q.9 The correct statements about nuclear forces is
(1) these are the strongest among forces
(2) these are short range forces
(3) these are charge independent forces
(4) all of the above

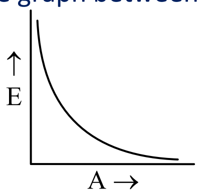
Q.10 If F_{pp}, F_{pn} and F_{nn} are the magnitudes of nuclear force between proton-proton, proton-neutron and neutron-neutron respectively, then-
(1) $F_{pp} = F_{pn} = F_{nn}$ (2) $F_{pp} < F_{pn} = F_{nn}$
(3) $F_{pp} > F_{pn} > F_{nn}$ (4) $F_{pp} < F_{pn} < F_{nn}$

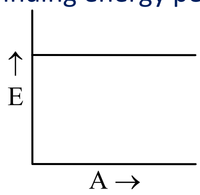
Q.11 Two protons are kept at a separation of 50Å. F_n is the nuclear force and F_e is the electrostatic force between them, then -
(1) $F_n >> F_e$ (2) $F_n = F_e$
(3) $F_n << F_e$ (4) $F_n \approx F_e$

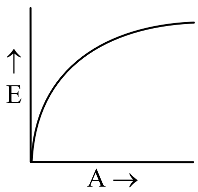
Q.12 In most stable nuclei neutron number N and proton number Z has the relation -
(1) $N < Z$ (2) $N = Z$
(3) $N > Z$ (4) $N \geq Z$

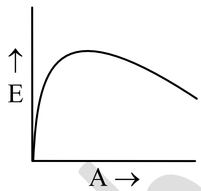
Q.13 The correct relation between the packing fraction f and mass number A is -
(1) $f = \frac{M-A}{A}$ (2) $f = \frac{M+A}{A}$
(3) $f = \frac{A}{M-A}$ (4) $f = \frac{A}{M+A}$

Q.14 The graph between the binding energy per nucleon (E) and atomic mass number (A) is as-

(1) 

(2) 

(3) 

(4) 

Q.15 The value of binding energy per nucleon is -
(1) more for light nuclei
(2) more for heavy nuclei
(3) more for medium nuclei
(4) equal for all nuclei

Q.16 The binding energy per nucleon for a radioactive element in comparison to that for a stable element is -
(1) less
(2) more
(3) having no definite relation
(4) none of the above

Q.17 Binding energies of nuclei $_1H^2$, $_2He^4$, $_{25}Fe^{56}$ and $_{92}U^{235}$ are 2.22, 28.3, 492 and 1786 respectively. Most stable nucleus is -
(1) $_{26}Fe^{56}$ (2) $_1H^2$ (3) $_{92}H^{235}$ (4) $_2He^4$

Q.18 The value of binding energy per nucleon is maximum for the elements having the mass number -
(1) more then 10 (2) between 50 to 100
(3) more than 100 (4) between 100 to 200

Q.19 Masses of nucleus, neutron an protons are M, m_n and m_p respectively. If nucleus has been divided in to neutrons and protons, then -
(1) $M = (A - Z)\, m_n + Zm_p$
(2) $M = Zm_n + (A - Z)m_p$
(3) $M < (A - Z)m_n + Zm_p$
(4) $M > (A - Z) \ + Zm_p$

Q.20 The wrong statement about binding energy is -
(1) It is the sum of the rest mass energies of nucleus minus the rest mass energy of the nucleus
(2) It is the energy released when the nucleons combine to from a nucleus
(3) It is the energy required to break a given nucleus into its constituent nucleus
(4) It is the sum of the kinetic energies of all the nucleons in the nucleus

Q.21 As the mass number A increases, which of the following quantities related to a nucleus do not change -
(1) mass (2) volume
(3) density (4) binding energy

Q.22 Mass defect of an atom refers to -
(1) packing fraction of the atom
(2) increase in mass over total mass of its constituents to bind the atoms
(3) mass annihilated to produce energy to bind the nucleons
(4) error in the measurement of atomic masses

Q.23 Most of the stable nuclides have -
(1) even number of protons and even number of neutrons
(2) odd number of proton and odd number of neutrons
(3) even number of protons and odd number of neutrons
(4) odd number of protons and even number of neutrons

Q.24 Calculate the mass defect for helium-4 nucleus, given M(He) = 4.0015084, Mp = 1.007276 u, mn = 1.008665u -
(1) 0.03074
(2) 0.030384
(3) 0.030374
(4) 0.30374

Q.25 The binding energy of a deuterium nucleus is about 1.115 MeV per nucleon. Then the mass defect of the nucleus is about -
(1) 2.23 u (2) 0.0024 u
(3) 2077 u (4) None of the above

Q.26 The energy equivalent to 1 kilogram of matter is approximately -
(1) 10^{11} joule (2) 10^{14} joule
(3) 10^{17} joule (4) 10^{20} joule

Q.27 In nuclear reactions -
(1) mass and momentum both are conserved
(2) energy and momentum both are conserved
(3) charge and momentum both are conserved
(4) energy and charge both are conserved

Q.28 When do two protons attract each other ?
(1) the distance between them is 1 Å
(2) the distance between them is 1 mm
(3) the distance between them is 10^{-15} m
(4) this will never happen

Q.29 If two nuclei of mass number A_1 and A_2 fuse together to form a nucleus of mass number A, then -
(1) $A = A_1 + A_2$ (2) $A > A_1 + A_2$
(3) $A < A_1 + A_2$ (4) $A \le A_1 + A_2$

Q.30 If there is a mass defect of 0.1% in nuclear fission, then the energy released in the fission of 1 kg mass would be -
(1) 2.5×10^5 kWH (2) 2.5×10^7 kWH
(3) 2.5×10^9 kWH (4) 2.4×10^{-7} kWH

Q.31 Thermal neutron means :
(1) neutron being heated
(2) the energy of these neutrons is equal to the energy of neutrons in a heated atom.
(3) these neutrons have energy of neutron in a neutron gas at normal temperature
(4) such neutrons gather energy released in the fission process

Q.32 10^{14} fissions per second are taking place in a nuclear reactor having efficiency 40%. The energy released per fission is 250 MeV. The power output of the reactor is -
(1) 2000 W (2) 4000 W
(3) 1600 W (4) 3200 W

Q.33 Two lighter nuclei are fused together to form another nucleus an energy is released in the process because -
(1) binding energy of lighter nucleus is more
(2) binding energy per nucleon of lighter nucleus is more
(3) binding energy per nucleon is more for medium nucleus
(4) energy is always released when two nuclei are combined

Q.34 Atomic reactor is based on -
(1) controlled chain reaction
(2) uncontrolled chain reaction
(3) nuclear fission
(4) nuclear fusion

Q.35 If the energy required to eject an electron from an atom is E_e and the energy required to eject a nucleon from a nucleus is E_n, then -
(1) $E_n < E_e$
(2) $E_e < E_n$
(3) $E_e = E_n$
(4) nothing can be stated

Q.36 The critical mass of fissionable material is -
(1) 75 kg (2) 1 kg
(3) 20 kg (4) 10 kg

Q.37 In fission the percentage of mass converted into energy is about -
(1) 0.01% (2) 0.1%
(3) 1% (4) 10%

Q.38 A radon nucleus $_{86}R^{224}$ of mass 3.6×10^{-25}kg undergoes α-decay. α-particle has mass 6.7×10^{-27}kg and energy 8.8×10^{-13} J. The resulting nucleus is -
(1) $_{84}Sr^{220}$
(2) $_{84}Po^{220}$
(3) $_{84}Sn^{220}$
(4) none of the above

Q.39 Which of the following materials is used for controlling the fission -
(1) heavy water
(2) graphite
(3) cadmium
(4) Berilium oxide

Q.40 Which of the following is a fusion reaction ?
(1) ${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He$
(2) ${}^{1}_{0}n + {}^{14}_{7}N \rightarrow {}^{14}_{6}C + {}^{1}_{1}H$
(3) ${}^{1}_{0}n + {}^{238}_{92}U \rightarrow {}^{239}_{93}Np + \beta^{-} + \gamma$
(4) ${}^{3}_{1}H \rightarrow {}^{3}_{2}He + \beta^{-} + \gamma$

Q.41 Which element is used for making atom bomb-
(1) Ra^{226} (2) U^{234}
(3) U^{238} (4) Pu^{239}

Q.42 For a chain nuclear fission of U^{235} the moderation of neutron is a must because very high energy neutron -
(1) will collide in elastically with the nucleus and so there is no fission
(2) will collide elastically with the nucleus and so there is no fission
(3) will be trapped in the nucleus and hence no fission
(4) replied by nucleus

Q.43 In an atomic reactor fast moving neutrons are slowed down to thermal energies by colliding them with -
(1) oxygen atoms of heavy water
(2) lead atoms
(3) paraffin-Hydrogen
(4) cadmium-atoms

Q.44 Neutron ratio (available/used) r per fission in atomic reactor an atom bomb are -
(1) r > 1 in atomic reactor and r < 1 in bomb
(2) r = 1 in atomic reactor and r > 1 in bomb
(3) r > 1 in both atomic reactor and bomb
(4) r < 1 in both atomic reactor and bomb

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 2

Q.1 For nuclei with A > 100, mark the incorrect statement -
(1) the binding energy per nucleon decreases on the average as A increases
(2) if the nucleus breaks into two roughly equal parts, energy is released
(3) if two nuclei fuse to form a bigger nucleus energy is released
(4) the nucleus with Z > 83 are generally unstable

Q.2 If the mass of proton = 1.008 a.m.u. and mass of neutron = 1.009 a.m.u., then binding energy per nucleon for $_4Be^9$ (mass = 9.012 amu) would be -
(1) 0.065 MeV (2) 60.44 MeV
(3) 67.2 MeV (4) 6.72 MeV

Q.3 200 MeV energy is released due to fission of U^{235} by slow neutrons. If the output power from a atomic reactor is 1.6 MW, then rate of fission will be -
(1) $5 \times 10^{16} s^{-1}$ (2) $10 \times 10^{16} s^{-1}$
(3) $15 \times 10^{16} s^{-1}$ (4) $20 \times 10^{16} s^{-1}$

Q.4 The binding energies per nucleon of deutron and α-particles are x_1 and x_2 respectively. The energy released in the following reaction will be : $_1H^2 + {_1H^2} = {_2He^4} + Q$
(1) $(x_1 + x_2)$ (2) $(x_2 - x_1)$
(3) $4(x_1 + x_2)$ (4) $4(x_2 - x_1)$

Q.5 If the binding energy per nucleon in ^7Li and ^4He nuclei are 5.60 MeV and 7.06 MeV, then energy of the reaction $^7Li + {^1H} \longrightarrow 2\ {^4_2He}$ is -
(1) 19.6 MeV (2) 2.4 MeV
(3) 8.4 MeV (4) 17.3 MeV

Q.6 A nuclear fission is represented by the following reaction :
$$U^{236} = X^{111} + Y^{122} + 3n$$
If the binding energies per nucleon of X^{111}, Y^{122} and U^{236} are 8.6MeV, 8.5 MeV and 7.6 MeV respectively, then the energy released in the reaction will be -
(1) 200 MeV (2) 202 MeV
(3) 195 MeV (4) 198 MeV

Q.7 If mass of the fissionable material is less than the critical mass, then -
(1) fission and chain reactions both are impossible
(2) fission is possible but chain reaction is impossible
(3) fission is impossible but chain reaction is possible
(4) fission and chain reaction both are possible

Q.8 A positron of 1 MeV collides with an electron of 1 MeV and gets annihilated and the reaction produces two γ-ray photons. If the effective mass of each photon is 0.0016 amu, then the energy of each γ-ray photon is about -
(1) 1.5 MeV (2) 3 MeV
(3) 6 MeV (4) 2 MeV

Q.9 If the rest mass of electron or positron is 0.51 MeV, then the kinetic energy of each particle in the electron-positron pair production by a γ-photon of 2.42 MeV will be -
(1) 0.3 MeV (2) 1.9 MeV
(3) 0.7 MeV (4) 1.5 MeV

Q.10 An electron and a positron may annihilate one another producing two γ-ray photons of equal energy. The minimum energy of each of these photon is -
(1) 8.2×10^{-14} MeV (2) 8.2×10^{-14} J
(3) 16.4×10^{-14} MeV (4) 16.4×10^{-14} J

Q.11 The amount of U^{235} in kg which is to be used per hour in a nuclear reactor of capacity 100 kW (E = 200 MeV/fission) -
(1) 0.45×10^{-5} (2) 4.5×10^{-5}
(3) 4.5×10^{5} (4) 45×10^{5}

Q.12 The binding energies of two nuclei X^n and Y^{2n} are P and Q joules respectively, where P > Q/2. In the reaction $X^n + X^n \to Y^{2n}$
(1) energy will be released
(2) energy will be absorbed
(3) energy will be neither released nor absorbed
(4) release or absorption of energy, will depends upon n

Q.13 In a fast breeder atomic reactor -
(1) fast neutrons convert natural uranium into fissionable fuel and released energy.
(2) thermal neutrons cause fission of enriched uranium and released energy
(3) fast neutrons cause fission of enriched uranium and release more energy
(4) thermal neutron cause fission of natural uranium and produce energy

Q.14 A fusion reaction takes place at very high temperature because -
(1) atoms get ionized at high temperature
(2) molecules get decomposed at high temperature
(3) nuclei get decomposed at high temperature
(4) due to their high energy nuclei overcome their mutual repulsion and combines.

Q.15 The binding energies of two nuclei P^n and Q^{2n} are x and y joules. If 2x > y then the energy released in the reaction :
$P^n + P^n \to Q^{2n}$, will be -
(1) 2x + y (2) 2x – y
(3) –(2x – y) (4) x + y

Q.16 Consider the fission reaction ${}_{92}U^{236} \to X^{117} + Y^{117} + {}_0n^1 + {}_0n^1$ i.e. two nuclei of same mass number 117 are formed plus two neutrons. The binding energy per nucleon of X and Y is 8.5 MeV where as of U^{236} is 7.6 MeV. The total energy liberated will be about -
(1) 2 MeV (2) 20 MeV
(3) 200 MeV (4) 2000 MeV

Q.17 Two deuterons are moving towards each other with equal speeds. What should be their initial kinetic energies so that the distance of closest approach between them is 2 fm?
(1) 0.36 MeV (2) 0.51 MeV
(3) 1.02 MeV (4) 7.8 MeV

Q.18 A stationary ^{238}U nucleus decays by α emission generating a total kinetic energy T
$${}^{238}_{92}U \to {}^{234}_{90}Th + {}^{4}_{2}\alpha$$
What is the kinetic energy of the α particle ?
(1) slightly less than T/2
(2) T/2
(3) slightly less than T
(4) slightly greater than T

Q.19 The rest mass of the deuteron, ${}_1^2H$, is equivalent to an energy of 1876 MeV, the rest mass of a proton is equivalent to 939 MeV and that of a neutron to 940 MeV. A deuteron may disintegrate to a proton and a neutron if it -
(1) emits a γ-ray photon of energy 2 MeV
(2) captures a γ-ray photon of energy 2 MeV
(3) emits a γ-ray photon of energy 3 MeV
(4) captures a γ-ray photon of energy 3 MeV

Q.20 In the nuclear fusion reaction ${}_1^2H + {}_1^3H \rightarrow {}_2^4H + n$, given that the repulsive potential energy between the two nuclei is – 7.7×10^{-14} J, the temperature at which the gases must be heated to initiate the reaction is nearly
[Boltzman's constant k = 1.38×10^{-23} J/K]
(1) 10^9 K (2) 10^7 K
(3) 10^5 K (4) 10^3 K

Q.1 A deutron is bombarded on $_{8}O^{16}$ nucleus then α-particle is emitted then product nucleus is -
(1) $_{7}N^{13}$ (2) $_{5}B^{10}$ (3) $_{4}Be^{9}$ (4) $_{7}N^{14}$

Q.2 The nuclei of which one of the following pairs of nuclei are isotones -
(1) $_{34}Se^{74}$, $_{31}Ga^{71}$ (2) $_{38}Sr^{84}$, $_{38}Sr^{86}$
(3) $_{42}Mo^{92}$, $_{40}Zr^{92}$ (4) $_{20}Ca^{40}$, $_{16}S^{32}$

Q.3 Which one of the following is a possible nuclear reaction ?
(1) ${}^{10}_{5}B + {}^{4}_{2}He \rightarrow {}^{13}_{7}N + {}^{1}_{1}H$
(2) ${}^{23}_{11}Na + {}^{1}_{1}H \rightarrow {}^{20}_{10}Ne + {}^{4}_{2}He$
(3) ${}^{239}_{93}Np \rightarrow {}^{239}_{94}Pu + \beta^{-} + \overline{\nu}$
(4) ${}^{11}_{7}N + {}^{1}_{1}H \rightarrow {}^{12}_{6}C + \beta^{-} + \nu$

Q.4 For nuclear reaction
$_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{56}Ba^{144} + ... + 3\ {}_{0}n^{1}$
(1) $_{26}Kr^{89}$ (2) $_{36}Kr^{89}$ (3) $_{26}Sr^{90}$ (4) $_{38}Sr^{89}$

Q.5 For the given reaction, the particle X is -
$_{6}C^{11} \rightarrow {}_{5}B^{11} + \beta^{+} + X$
(1) Neutron (2) Anti neutrino
(3) Neutrino (4) Proton

Q.6 M_n and M_p represent the mass of neutron and proton respectively. An element having mass M has N neutron and Z-protons, then the correct relation will be -
(1) $M < \{N.\ M_n + Z.\ M_p\}$
(2) $M > \{N.\ M_n + Z.\ M_p\}$
(3) $M = \{N.\ M_n + Z.\ M_p\}$
(4) $M = N\ \{M_n + M_p\}$

Q.7 Energy is released in nuclear fission is due to-
(1) Few mass is converted into energy
(2) Total binding energy of fragments is more than the B.E. of parallel element
(3) Total B.E. of fragments is less than the B.E. of parental element
(4) Total B.E. of fragments is equals to the B.E. of parental element is

Q.8 Which of the following are suitable for the fusion process ?
(1) Light nuclei
(2) Heavy nuclei
(3) Element must be lying in the middle of the periodic table
(4) Middle element, which are lying on binding energy curve

Q.9 The volume occupied by an atom is greater than the volume of the nucleus by a factor of about -
(1) 10^{1} (2) 10^{5}
(3) 10^{10} (4) 10^{15}

Q.10 The mass of proton is 1.0073 u and that of neutron is 1.0087 u(u = atomic mass unit). The binding energy of ${}^{4}_{2}He$ is -
(1) 0.0305 J (2) 0.0305 erg
(3) 28.4 MeV (4) 0.061 u
(Given : Helium nucleus mass = 4.0015 u)

Q.11 The mass number of a nucleus is -

(1) always less than its atomic number
(2) always more than its atomic number
(3) sometimes equal to its atomic number
(4) sometimes less than and sometimes more than its atomic number

Q.12 A nuclear reaction given by-
$_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} + {}_{-1}e^{0} + \bar{\nu}$ represents
(1) β-decay (2) γ-decay
(3) fusion (4) fission

Q.13 If in a nuclear fusion process the masses of the fusing nuclei be m_1 and m_2 and the mass of the resultant nucleus be m_3, then -
(1) $m_3 = |m_1 - m_2|$ (2) $m_3 < (m_1 + m_2)$
(3) $m_3 > (m_1 + m_2)$ (4) $m_3 = m_1 + m_2$

Q.14 A nucleus represented by the symbol ${}_{Z}^{A}X$ has-
(1) Z protons and A – Z neutrons
(2) Z protons and A neutrons
(3) A protons and Z – A neutrons
(4) Z neutrons and A – Z protons

Q.15 M_p denotes the mass of a protons and M_n that of a neutron. A given nucleus, of binding energy B, contains Z protons and N neutrons. The mass M (N, Z) of the nucleus is given by (c is velocity of light) -
(1) $M(N, Z) = NM_n + ZM_p + Bc^2$
(2) $M(N, Z) = NM_n + ZM_p - B/c^2$
(3) $M(N, Z) = NM_n + ZM_p + B/c^2$
(4) $M(N, Z) = NM_n + ZM_p - Bc^2$

Q.16 In the reaction ${}_{1}^{2}H + {}_{1}^{3}H \rightarrow {}_{2}^{4}He + {}_{0}^{1}n$. If the binding energies of ${}_{1}^{2}H$, ${}_{1}^{3}H$ and ${}_{2}^{4}He$ are respectively a, b and c (in MeV), then the energy (in MeV) released in this reaction is-
(1) a + b + c (2) c + a – b
(3) c – a – b (4) a + b + c

Q.17 In any fission process the ratio $\frac{\text{mass of fission products}}{\text{mass of parent nucleus}}$ is -
(1) Greater than 1
(2) Depends on the mass of the parent nucleus
(3) Equal to 1
(4) Less than 1

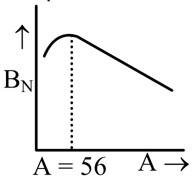
Q.18 Fission of nuclei is possible because the binding energy per nucleon in them -
(1) Decreases with mass number at low mass numbers
(2) Increases with mass number at low mass number
(3) Decreases with mass number at high mass number
(4) Increases with mass number at high mass number

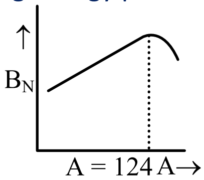
Q.19 The binding energy of deuteron is 2.2 MeV and that of ${}_{2}^{4}He$ is 28 MeV. If two deuterons are fused to form one ${}_{2}^{4}He$ then the energy released is -
(1) 25.8 MeV (2) 23.6 MeV
(3) 19.2 MeV (4) 30.2 MeV

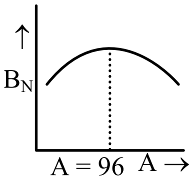
Q.20 The radius of Germanium (Ge) nuclide is measured to be twice the radius of ${}^{9}_{4}Be$. The number of nucleons in Ge are -
(1) 73 (2) 74 (3) 75 (4) 72

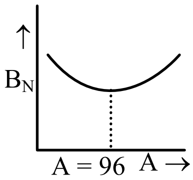
Q.21 Nuclear fusion is possible -
(1) only between light nuclei
(2) only between heavy nuclei
(3) between both light and heavy nuclei
(4) only between nuclei which are stable against β-decay.

Q.22 The dependence of binding energy per nucleon (B_N) on the mass number (A), is represented by-

(1) 

(2) 

(3) 

(4) 

Q.23 The operation of a nuclear reactor is said to be critical, if the multiplication factor (k) has a value -
(1) 1 (2)1.5 (3) 2.1 (4) 2.5

Q.24 The number of β-particles emitted by a radioactive substance is twice the number of alpha particles emitted by it. The resulting daughter is an -
(1) isotope of parent (2) isobar of parent
(3) isomer of parent (4) isotone of parent

Q.25 Which one of the following is used as a moderator in nuclear reaction ?
(1) Uranium (2) Heavy water
(3) Cadmium (4) Plutonium

Q.26 The reaction responsible for the production of light energy from the sun will be -
(1) fission (2) fusion
(3) nuclear (4) none of these

Q.27 Consider the following nuclear reaction
$X^{200} \rightarrow A^{110} + B^{90} + \text{Energy}$
If the binding energy per nucleon for X, A and B are 7.4 MeV, 8.2 MeV and 8.2 MeV respectively, the energy released will be-
(1) 90 MeV
(2) 110 MeV
(3) 200 MeV
(4) 160 MeV

Q.28 In each fission of ${}_{92}U^{235}$ releases 200 MeV, how many fissions must occur per second to produce power of 1 kW ?
(1) 1.25×10^{18} (2) 3.125×10^{13}
(3) 3.2×10^{18} (4) 1.25×10^{13}

Q.29 The function of heavy water in a nuclear reactor to-
(1) slow down the neutrons
(2) increase the neutrons
(3) stop the electrons
(4) none of the above

Q.30 Which one of the following has the highest neutrons ratio ?
(1) ${}_{92}U^{235}$ (2) ${}_{8}O^{16}$
(3) ${}_{2}He^{4}$ (4) ${}_{26}Fe^{56}$

Q.31 In an atom bomb, the energy is released because of the-
(1) chain reaction of neutrons and ${}_{92}U^{238}$
(2) chain reaction of neutrons and ${}_{92}U^{235}$
(3) chain reaction of neutrons and ${}_{92}U^{236}$
(4) chain reaction of neutrons and ${}_{92}U^{240}$

Q.32 Nuclear fusion is possible-
(1) only between light nuclei
(2) only between heavy nuclei
(3) between both light and heavy nuclie
(4) only between nuclei which are stable against β-decay

Q.33 When an electron-positron pair annihilates, the energy released is about-
(1) 0.8×10^{-13} J (2) 1.6×10^{-13} J
(3) 3.2×10^{-13} J (4) 4.8×10^{-13} J

Q.34 In the nuclear reaction, there is a conservations of-
(1) momentum (2) mass
(3) energy (4) all of these

Q.35 The energy released by fission of one atom of ${}_{92}U^{235}$ is 200 MeV the number of fission required per second to produce a power of 1 kW is-
(1) 3.125×10^{9} (2) 3.125×10^{12}
(3) 3.125×10^{13} (4) 3.125×10^{11}

Q.36 A nucleus disintegrates into two nuclear parts which have their velocities in the ratio 8 : 1. The ratio of their nuclear sizes will be-
(1) 1 : 8 (2) 8 : 1 (3) 2 : 1 (4) 1 : 2

Q.37 When ${}_{92}U^{235}$ undergoes fission, 0.2 % of its original mass is changed into energy. How much energy is released if 1 gram of ${}_{92}U^{235}$ undergoes fission ? (Energy released per fission reaction = 200 MeV)
(1) 11.9×10^{20} MeV (2) 5.1×10^{20} MeV
(3) 2.5×10^{20} MeV (4) 1.5×10^{10} MeV

Q.38 Atoms having different atomic number as well as different mass number but having same number of neutrons-
(1) isotopes (2) isobars
(3) isotones (4) isodiaphers

Q.39 In fission of U-235, the percentage of mass converted into energy is about-
(1) 0.1 % (2) 0.25 %
(3) 0.3 % (4) 2 %

Q.40 The main source of sun's energy is-
(1) nuclear fusion
(2) nuclear fission
(3) gravitational contraction
(4) combustion

Q.41 Which of the following is most unstable ?
(1) Electron (2) Proton
(3) Neutron (4) α-particle

Q.42 The fission of ^{235}U can be triggered by the absorption of a slow neutron by a nucleus. Similarly a slow proton can also be used. This statement is-
(1) correct
(2) wrong
(3) information is insufficient
(4) none of the above

Q.43 When a sample of solid lithium is placed in a flask of hydrogen gas then following reaction happened $_1H^1 + {}_3Li^7 \rightarrow {}_2He^4 + {}_2He^4$
This statement is-
(1) True
(2) False
(3) May be true at a particular pressure
(4) None of the above

Q.44 The mass of a ^7_3Li nucleus is 0.042 u less than the sum of the masses of all its nucleons. The binding energy per nucleon of ^7_3Li nucleus is nearly –
(1) 46 MeV (2) 5.6 MeV
(3) 3.9 MeV (4) 23 MeV

Q.45 An alpha nucleus of energy $\frac{1}{2}$ mv^2 bombards a heavy nuclear target of charge Ze. Then the distance of closest approach for the alpha nucleus will be proportional to –
(1) $\frac{1}{Ze}$ (2) v^2
(3) $\frac{1}{m}$ (4) $\frac{1}{v^4}$

Q.46 The binding energy per nucleon in deutorium and helium nuclei are 1.1 MeV and 7.0 MeV, respectively. When two deuterium nuclei fuse to form a helium nucleus the energy released in the fusion is -
(1) 2.2 MeV (2) 28.0 MeV
(3) 30.2 MeV (4) 23.6 MeV

Q.47 The power obtained in a reactor using U^{235} disintegration is 1000 kW. The mass decay of U^{235} per hour is :
(1) 1 microgram (2) 10 microgram
(3) 20 microgram (4) 40 microgram

Q.48 Fusion reaction takes place at high temperature because :
(1) molecules break up at high temperature
(2) nuclei break up at high temperature
(3) atomic get ionised at high temperature
(4) kinetic energy is high enough to overcome the coulomb repulsion between nuclei

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 4

Q.1 The energy radiated by a red giant star is produces by-
(1) Fission process
(2) Fusion process
(3) Chemical burning of hydrogen
(4) Gravitational contraction

Q.2 A γ ray photon produces an electron positron pair, if the rest mass energy of electron is 0.51 MeV and the total kinetic energy of electron-positron pair is 0.78 MeV then the energy of γ-ray photon in MeV is-
(1) 0.78 (2) 1.8 (3) 1.28 (4) 0.28

Q.3 In the process of atomic explosion, the maximum energy is present in which form-
(1) γ-rays
(2) Kinetic energy of products
(3) Infra red region
(4) Visible light

Q.4 Assuming that 200 MeV of energy is released per fission of ${}_{92}U^{235}$ atom. Find the number of fission per second required to release 1 kW power-
(1) 3.125×10^{13} (2) 3.125×10^{14}
(3) 3.125×10^{15} (4) 3.125×10^{16}

Q.5 Energy liberated in nuclear reaction is-
(1) Change of potential energy in to kinetic energy
(2) Kinetic energy of resultant nucleus
(3) Energy equivalent to mass lost
(4) None of the above

Q.6 The energy is liberated when two deutron nuclei combines to form a nucleus of helium, because the mass of helium nucleus is-
(1) Less than the sum of masses of two deutron nuclei
(2) More than the sum of masses of two deutron nuclei
(3) Equal to the sum of masses of two deutron nuclei
(4) None of the above

Q.7 Masses of nucleus, neutron and protons are M, M_n and M_p respectively, then-
(1) $M = (A - Z)M_n + ZM_p$
(2) $M = ZM_n + (A - Z)M_p$
(3) $M > (A-Z)M_n + ZM_p$
(4) $M < (A-Z)M_n + ZM_p$

Q.8 When four hydrogen nuclei combine to form a helium nucleus-
(1) Energy is absorbed
(2) Energy is released
(3) Energy is absorbed or released depending on temperature
(4) Energy is nither released nor absorbed

Q.9 Binding energy per nucleon of deutron is 1.112 MeV and binding energy per nucleon of an α particle is 7.07 MeV, then in following process energy Q is : $2({}_1H^2) \rightarrow {}_2He^4 + Q$
(1) 1 MeV (2) 11.9 MeV
(3) 23.8 MeV (4) 931 MeV

Q.10 Electron-positron pair can be created by γ-rays. In this process the minimum energy of γ-rays should be-
(1) 5.0 MeV (2) 4.02 MeV
(3) 15.0 MeV (4) 1.02 MeV

Q.11 200 MeV of energy can be obtained by per fission. In a reactor generating 1000 kW find the number of nuclei under going the fission per second-
(1) 1000 (2) 2×10^8
(3) 3.125×10^{16} (4) 931

Q.12 In nuclear fission the percentage of mass converted into energy is about-
(1) 0.1 % (2) 1 % (3) 10 % (4) 0.01 %

Q.13 Mass equivalent to energy 931 MeV is-
(1) 6.02×10^{-27} kg (2) 1.66×10^{-27} kg
(3) 16.66×10^{-26} kg (4) 6.02×10^{-26} kg

Q.14 Which has highest penetrating power-
(1) γ-rays (2) β-rays
(3) α-rays (4) Cathode rays

Q.15 Which one of the following is unstable-
(1) α-ray (2) γ-ray
(3) Proton (4) Neutron

Q.16 Which of the following is weakest force-
(1) Gravitational force
(2) Electric force
(3) Magnetic force
(4) Nuclear force

Q.17 Force acting on proton-proton is-
(1) Nuclear force > Electric force
(2) Electric force > Nuclear force
(3) Gravitational force > Nuclear force
(4) None of the above

Q.18 In the nuclear fusion reaction $^2_1\mathrm{H} + ^3_1\mathrm{H} \rightarrow ^4_2\mathrm{H} + n$,
given that the repulsive potential energy between the two nuclei is ~ 7.7×10^{-14} J, the temperature at which the gases must be heated to initiate the reaction is nearly –
(Boltzman constant : K = 1.38×10^{-23} J/K)
(1) 10^5 K (2) 10^3 K
(3) 10^9 K (4) 10^7 K

Q.19 A nucleus disintegrates into two nuclear parts which have their velocities in the ratio of 2 : 1. The ratio of their nuclear sizes will be –
(1) $3^{1/2} : 1$ (2) $1 : 2^{1/3}$
(3) $2^{1/3} : 1$ (4) $1 : 3^{1/2}$

Q.20 The binding energy per nucleon of deuteron ($^2_1$H) and helium nucleus ($^4_2$He) is 1.1 MeV and 7 MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then the energy released is –
(1) 23.6 MeV (2) 26.9 MeV
(3) 13.9 MeV (4) 19.2 MeV

Q.21 If radius of the $^{27}_{13}\text{Al}$ nucleus is estimated to be 3.6 Fermi then the radius of $^{125}_{52}\text{Te}$ nucleus be nearly -
(1) 6 fermi (2) 8 fermi
(3) 4 fermi (4) 5 fermi

Q.22 A nuclear transformation is denoted by X(n, α) ^7_3Li. Which of the following is the nucleus of element of X ?
(1) $^{12}C_6$ (2) $^{10}_5\text{B}$
(3) ^9_5B (4) $^{11}_4\text{Be}$

Q.23 When $_3Li^7$ nuclei are bombarded by protons, and the resultant nuclei are $_4Be^8$, the emitted particles will be –
(1) gamma photons (2) neutrons
(3) alpha particles (4) beta particles

Q.24 An alpha nucleus of energy $\frac{1}{2}mv^2$ bombards a heavy nuclear target of charge Ze. Then the distance of closest approach for the alpha nucleus will be proportional to –
(1) $1/v^4$ (2) 1/Ze (3) v^2 (4) 1/m

Q.25 If the binding energy per nucleon in ^7_3Li and ^4_2He nuclei are 5.60 MeV and 7.06 MeV respectively, then in the reaction p + $^7_3\text{Li} \rightarrow 2\ ^4_2\text{He}$ energy of proton must be –
(1) 1.46 MeV (2) 39.2 MeV
(3) 28.24 MeV (4) 17.28 MeV

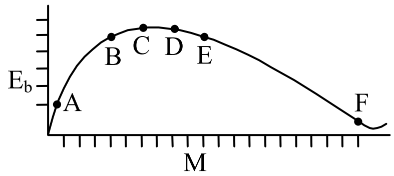
Q.26 If M_0 is the mass of an oxygen isotope $_8O^{17}$, Mp and M_N are the masses of a proton and a neutron respectively, the nuclear binding energy of the isotope is -
(1) $(M_0 - 8M_P)\ C^2$
(2) $(8M_P + 9M_N - M_O)\ C^2$
(3) M_0C^2
(4) $(M_0 - 17\ M_N)\ C^2$

Q.27 In gamma ray emission from a nucleus
(1) both the neutron number and the proton number change
(2) there is no change in the proton number and the neutron number
(3) only the neutron number changes
(4) only the proton number changes

Q.28 This question contains Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.
Statement-1 :
Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion.
and

Statement-2 :
For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing Z.
(1) Statement-1 is true, Statement-2 is true; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is true, Statement-2 is true; Statement-2 is not a correct explanation for Statement-1
(3) Statement-1 is true, Statement-2 is false
(4) Statement-1 is false, Statement-2 is true

Q.29 The above is a plot of binding energy per nucleon E_b, against the nuclear mass M; A, B, C, D, E, F correspond to different nuclei. Consider four reactions.



(i) A + B $\rightarrow$ C + ε
(ii) C $\rightarrow$ A + B + ε
(iii) D + E $\rightarrow$ F + ε and
(iv) F $\rightarrow$ D + E + ε
Where ε is the energy released ? In which reactions is ε positive -
(1) (i) and (iv) (2) (i) and (iii)
(3) (ii) and (iv) (4) (ii) and (iii)

Q.30 In the nuclear process, $^{11}_{6}C \longrightarrow {}^{11}_{5}B + \beta^{+} + X$, X stands for -
(1) neutrino
(2) γ-particle
(3) α-particle
(4) neutron

Q.31 Which of the following statement (s) is (are) correct ?
(1) The rest mass of a stable nucleus is less than the sum of the rest masses of its separated nucleons.
(2) The rest mass of a stable nucleus is greater than the sum of the rest masses of its separated nucleons.
(3) In nuclear fusion, energy is released by fusing two nuclei of medium mass (approximately. 100 amu)
(4) None of these

Q.32 Fast neutrons can easily be slowed down by -
(1) The use of lead shielding
(2) Passing them through water
(3) Elastic collisions with heavy nuclei
(4) Applying a strong electric field

Q.33 Masses of two isobars $_{29}Cu^{64}$ and $_{30}Zn^{64}$ are 63.9298 amu and 63.9292 amu respectively. It can be concluded from these data that -
(1) Both the isobars are stable
(2) Zn^{64} is radioactive, decaying to Cu^{64} through β-decay
(3) Cu^{64} is radioactive, decaying to Zn^{64} through γ-decay
(4) Cu^{64} is radioactive, decaying to Zn^{64} through β-decay

Q.34 Consider the following reaction :

$$^{2}H_1 + {}^{2}H_1 = {}^{4}He_2 + Q$$

Mass of the deuterium atom = 2.0141 amu
Mass of helium atom = 4.0024 amu
This is a nuclear .... reaction in which the energy Q released is .... MeV
(1) Fusion, 24
(2) Fission, 24
(3) Fusion, 30
(4) Fission, 30

Q.35 In the following, column I lists some physical quantities and the column II gives approximate energy values associated with some of them. Choose the appropriate value of energy from column II for each of the physical quantities in column I and write the corresponding letter (a), (b), (c) etc. against the number (i), (ii), (iii), etc of the physical quantity in the answer book. In your answer, the sequence of column I should be maintained.

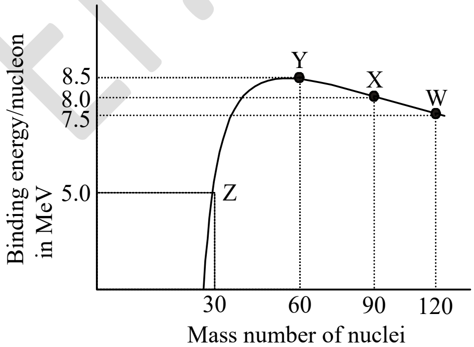
Column I	**Column II**
(i) Energy of thermal neutrons	(a) 0.025 eV
(ii) Energy of X-rays	(b) 0.5 eV
(iii) Binding energy per nucleon	(c) 3 eV
(iv) Photoelectric threshold of metal	(d) 20 eV
	(e) 10 keV
	(f) 8 MeV

(1) (i) a (ii) e (iii) f (iv) c
(2) (i) e (ii) a (iii) f (iv) c
(3) (i) a (ii) e (iii) c (iv) f
(4) None of these

Q.36 Le m_p be the mass of a proton, m_n the mass of neutron, M_1 the mass of a $_{10}Ne^{20}$ nucleus and M_2 the mass of a $_{20}Ca^{40}$ nucleus. Then -
(1) $M_2 = 2M_1$ (2) $M_2 > 2M_1$
(3) $M_2 < 2M_1$ (4) $M_1 < 10\,(m_n + m_p)$

Q.37 Order of magnitude of density of Uranium nucleus is,[$m_p = 1.67 \times 10^{-27}$ kg]
(1) 10^{20} kg/m^3 (2) 10^{17} kg/m^3
(3) 10^{14} kg/m^3 (4) 10^{11} kg/m^3

Q.38 Binding energy per nucleon versus mass number curve for nuclei is shown in the figure. W, X, Y and Z are four nuclei indicated on the curve. The process that would release energy is-



(1) $Y \rightarrow 2Z$ (2) $W \rightarrow X + Z$
(3) $W \rightarrow 2Y$ (4) $X = Y + Z$

Q.39 The volume and mass of a nucleus are related as -

(1) $v \propto m^3$ (2) $v \propto \sqrt[3]{m}$

(3) $v \propto m$ (4) $v \propto \frac{1}{m}$

Q.40 In a star all Helium nuclei are converted into oxygen. If atomic mass of M_{He} = 4.0026U and atomic mass of oxygen M_0 = 15.9994U, then the reaction energy per atom of oxygen -

(1) 10.26 MeV (2) 0 MeV

(3) 5.24 MeV (4) 20.4 MeV

Q.41

Column-I	**Column-II**
(a) Nuclear Fusion	(p) Some matter converted into energy
(b) Nuclear Fission	(q) Generally having occurs in nuclei low atomic number
(c) β-decay	(r) Generally occurs in nuclei having higher atomic number.
(d) Exothermic reaction	(s) Essentially occurs due to weak nuclear force.

(1) (a) p, q (b) p, r (c) p, s (d) p, q, r

(2) (a) p, r (b) p, s (c) q, s (d) p, q, s

(3) (a) p, s (b) p, q (c) q, r (d) p, s, r

(4) None of these

Q.42 In the options given below, let E denote the rest mass energy of a nucleus and n a neutron. The correct option is -

(1) $E\left({}^{236}_{92}U\right) > E\left({}^{137}_{53}I\right) + E\left({}^{97}_{39}Y\right) + 2E(n)$

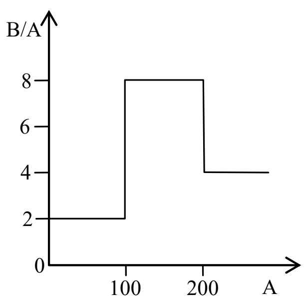
(2) $E\left({}^{236}_{92}U\right) < E\left({}^{137}_{53}I\right) + E\left({}^{97}_{39}Y\right) + 2E(n)$

(3) $E\left({}^{236}_{92}U\right) < E\left({}^{140}_{56}Ba\right) + E\left({}^{94}_{36}Kr\right) + 2E(n)$

(4) $E\left({}^{236}_{92}U\right) = E\left({}^{140}_{56}Ba\right) + E\left({}^{94}_{36}Kr\right) + 2E(n)$

Q.43 Assume that the nuclear binding energy per nucleon (B/A) versus mass number (1) is as shown in the figure. Use this plot to choose the correct choice(s) given below.

Figure :



(1) Fusion of two nuclei with mass numbers lying in the range of 1 < A < 50 will release energy

(2) Fusion of two nuclei with mass numbers lying in the range of 51 < A < 100 will release energy

(3) Fission of a nucleus lying in the mass range of 100 < A < 200 will release energy when broken into two equal fragments

(4) Fission of a nucleus lying in the mass range of 200 < A < 260 will release energy when broken into two equal fragments

Paragraph for Question Nos. 44 to 46

Scientists are working hard to develop nuclear fusion reactor. Nuclei of heavy hydrogen, ^2_1H, known as deuteron and denoted by D, can be thought of as a candidate for fusion reactor. The D-D reaction is $^2_1H + ^2_1H \rightarrow ^3_2H + n +$ energy. In the core of fusion reactor, a gas of heavy hydrogen is fully ionized into deuteron nuclei and electrons. This collection of ^2_1H nuclei and electrons is known as plasma. The nuclei move randomly in the reactor core and occasionally come close enough for nuclear fusion to take place. Usually, the temperatures in the reactor core are too high and no material wall can be used to confine the plasma. Special techniques are used which confine the plasma for a time t_0 before the particles fly away from the core. If n is the density (number/volume) of deuterons, the product nt_0 is called Lawson number. In one of the criteria, a reactor is termed successful if Lawson number is greater than 5×10^{14} s/cm^3. It may be helpful to use the following. Boltzmann constant

$k = 8.6 \times 10^{-5}$ eV/K; $\frac{e}{4\pi\varepsilon_0} = 1.44 \times 10^{-9}$ eVm.

Q.44 In the core of nuclear fusion reactor, the gas becomes plasma because of –
(1) Strong nuclear force acting between the deuterons
(2) Coulomb force acting between the deuterons
(3) Coulomb force acting between deuteron-electron pairs
(4) the high temperature maintained inside the reactor core

Q.45 Assume that two deuteron nuclei in the core of fusion reactor at temperature T are moving towards each other, each with kinetic energy 1.5 kT, when the separation between them is large enough to neglect Coulomb potential energy. Also neglect any interaction from other particles in the core. The minimum temperature T required for them to reach a separation of 4×10^{-15} m is in the range –
(1) 1.0×10^9 K < T < 2.0×10^9 K
(2) 2.0×10^9 K < T < 3.0×10^9 K
(3) 3.0×10^9 K < T < 4.0×10^9 K
(4) 4.0×10^9 K < T < 5.0×10^9 K

Q.46 Results of calculations for four different designs of a fusion reactor using D-D reaction are given below. Which of these is most promising based on Lawson criterion ?
(1) deuteron density = 2.0×10^{12} cm^{-3}, confinement time = 5.0×10^{-3} s
(2) deuteron density = 8.0×10^{14} cm^{-3}, confinement time = 9.0×10^{-1} s
(3) deuteron density = 4.0×10^{23} cm^{-3}, confinement time = 1.0×10^{-11} s
(4) deuteron density = 1.0×10^{24} cm^{-3}, confinement time = 4.0×10^{-12} s

These questions of two statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.
(A) If both Assertion & Reason are true & the Reason is a correct explanation of the Assertion.
(B) If both Assertion and Reason are true but Reason is not a correct explanation of the Assertion.
(C) If Assertion is true but the Reason is false.
(D) If Assertion & Reason both are false.

Q.1 **Assertion :** In nuclear reactor moderator is used to slow down the fast neutrons.
Reason : Fast neutrons are absorbed by U^{238} nuclei.
(1) A (2) B (3) C (4) D

Q.2 **Assertion :** Nuclear binding energy per nucleon is in the order ${}_4^9\text{Be} > {}_3^7\text{Li} > {}_2^4\text{He}$.
Reason : Binding energy per nucleon increases linearly with difference in number of neutrons and protons.
(1) A (2) B (3) C (4) D

Q.3 **Assertion :** Energy is released in nuclear fission.
Reason : Total binding energy of the fission fragments is larger than the total binding energy of the parent nucleus.
(1) A (2) B (3) C (4) D

Q.4 **Assertion :** It is not possible to use ^{35}Cl as the fuel for fusion energy.
Reason : The binding energy of ^{35}Cl is too small.
(1) A (2) B (3) C (4) D

Q.5 **Assertion :** The binding energy per nucleon, for nuclei with atomic mass number A > 100, decreases with A.
Reason : The nuclear forces are weak for heavier nuclei.
(1) A (2) B (3) C (4) D

Q.6 **Assertion :** Heavy water is preferred over ordinary water as a moderator in reactor.
Reason : Heavy water, used for slowing down the neutrons, has lesser absorption probability of neutrons than ordinary water.
(1) A (2) B (3) C (4) D

Q.1 Radioactivity is a -
(1) nuclear process (2) atomic process
(3) chemical process (4) physical process

Q.2 The value of decay constant of last element of radioactive series is -
(1) infinite
(2) much less
(3) zero
(4) equal to the decay constant of first element

Q.3 If the pressure on a radioactive material is increased three times, then the mean life of the element -
(1) does not change
(2) will become three times
(3) will becomes $\frac{1}{3}$rd
(4) will depend on the initial pressure

Q.4 A radioactive material emits 20 β-particles per sec at 10ºC. If the temperature is increased to 20ºC then the emission rate of β-particles per sec is -
(1) 20 (2) 40
(3) 30 (4) 1

Q.5 What will be the effect of dissolving a radioactive material in HNO_3?
(1) Its radioactive properties will remain unchanged
(2) Its radioactive properties will change
(3) The state of material cannot be predicted
(4) None of these

Q.6 The particles emitted by a radioactive substance are deflected in a magnetic field. The particle may be -
(1) neutrons
(2) electrons
(3) protons
(4) hydrogen atoms

Q.7 What will happen when a radioactive substance with mean life 2×10^5 years is dissolved in H_2SO_2 ?
(1) it will dissociate into H^+ and SO_2 ions
(2) it will be converted into SO_2 gas
(3) it will be converted into H_2 gas
(4) it will remain unchanged

Q.8 The half life of a radioactive material is 20 days. If it is heated to 10000 K, then its half life will become -
(1) 20×10000 days (2) 20/10000 days
(3) 9800 days (4) 20 days

Q.9 The following is not an application of radioactive material -

(1) to locate cracks in welding or castings
(2) to find the thickness of material
(3) in cigarette factory
(4) in photography

Q.10 SI unit of radioactivity is -
(1) curie (2) rutherfored
(2) rontgen (4) bacqueral

Q.11 The graph between remaining radioactive atoms and time for a radioactive decay is -
(1) straight line (2) parabola
(3) exponential (4) ellipse

Q.12 Number of active atoms in m gram material is :
(M $\rightarrow$ atomic weight)
(1) Mm × 6.02 × 10^{23}
(2) (M/m) × 6.02 × 10^{23}
(3) 6.02 × 10^{23}/Mm
(4) (m/M) × 6.02 × 10^{23}

Q.13 The activity of a radioactive element (decay constant λ) becomes $\frac{1}{3}$ of initial activity A_0 in 9 years then the decay constant after 9 years will -
(1) λ (2) $\lambda/3$
(3) $\lambda/9$ (4) $2\lambda/3$

Q.14 A radioactive sample contains two elements P and Q. The mass of each is 10^{-3}kg. The ratio of their atomic weights is 1 : 3. Their half lives are 4s and 8s respectively. The mass of P and Q after 16s will respectively be -
(1) 1.25 × 10^{-5} kg and 2.5 × 10^{-4} kg
(2) 6.25 × 10^{-5} kg and 2.5 × 10^{-4} kg
(3) 6.25 × 10^{-5} kg and 1.25 × 10^{-4} kg
(4) 2.25 × 10^{-5} kg and 6.25 × 10^{-4} kg

Q.15 A fraction of $\frac{5}{9}$ of a radioactive substance decays in time t. What fraction of the substance would had been active after time $\frac{t}{2}$ -
(1) 1/2 (2) 2/3 (3) 3/4 (4) 4/5

Q.16 What percentage of the atoms in a sample will remain undecayed in a time equal to mean life ?
(1) 100% (2) 63%
(3) 50 % (4) 37%

Q.17 If the quantity of radioactive material reduces by 10% in 5 days, then the quantity that remains after 20 days will be -
(1) 70% (2) 75 %
(3) 65 % (4) 60%

Q.18 The half life of a radioactive substance is 23.10 minute. If 10^{23} atoms of the substance are active at any instant of time, then the activity of the substance will be - (in dps)
(1) 1 × 10^{19} (2) 3 × 10^{19}
(3) 5 × 10^{19} (4) 7 × 10^{19}

Q.19 We get N_1 and N_2 β-particles per second from two specimens of a radioactive specimen, then the ratio of number of atoms present in the samples is -
(1) N_2/N_1 (2) N_1/N_2
(3) N_1^2/N_2^2 (4) None of these

Q.20 A radio active substance has $t_{1/2}$ = 60 min. After 3 hrs, what percentage of radioactivity will remain -
(1) 50% (2) 17.5%
(3) 12.5% (4) 25%

Q.21 When 64 gms of a radioactive element are carried from Jaipur to Jodhpur in 2 hours, then 1 gm of active element remains. The half life of the element is -
(1) 2 hours (2) 30 minute
(3) 20 minute (4) 1 hour

Q.22 The number of active atoms of a radio active element decreases from 1024 to 128 in 6 hours. The half life of the element is -
(1) 6 hours (2) 4 hours
(3) 3 hours (4) 2 hours

Q.23 The weight based ratio of U^{238} and Pb^{226} in a sample of rock is 4 : 3. If the half life of U^{238} is 4.5 × 10^9 years, then the age of rock is -
(1) 9.0 × 10^9 years (2) 6.3 × 10^9 years
(3) 4.5 × 10^9 years (4) 3.78 × 10^9 years

Q.24 The rate of decay of radioactive element at a given instant of time is 10^3 disintegration per second. If the half life of this element is 1 second, then the rate of decay after 3 second will be -
(1) 12 per sec (2) 50 per sec
(3) 500 per sec (4) 125 per sec

Q.25 A radioactive isotope X with a half-life of 1.37 × 10^9 years decays to Y which is stable. A sample of rock from the moon was found to contain both the elements X and Y which were in the ratio 1 : 7. The age of the rocks is -
(1) 1.96 × 10^8 years (2) 3.85 × 10^9 years
(3) 4.11 × 10^9 years (4) 9.59 × 10^9 years

Q.26 Two radioactive substance X and Y initially contain equal number of nuclei. X has a half life of 1 hours and Y has half of 2 hours. After two hours t he ratio of the activity of X to the activity of Y is
(1) 1 : 4 (2) 1 : 2 (3) 1 : 1 (4) 2 : 1

Q.27 The radioactivity of a sample is R_1 at a time T_1 and R_2 at a time T_2 If the half-life of the specimen is T, the number of atoms that have disintegrated in the time $(T_2 - T_1)$ is proportional to -
(1) $(R_1 T_1 - R_2 T_2)$ (2) $(R_1 - R_2)$
(3) $(R_1 - R_2)$ T (4) $(R_2 - R_1) / T$

Q.28 The counting rate observed from radioactivity source at t = 0 second was 1600 counts per second and at t = 8 seconds it was 100 counts per second. The counting rate observed, as counts per second at t = 6 seconds will be -
(1) 400 (2) 300 (3) 200 (4) 150

Q.29 A radioactive sample at any instant has its disintegration rate 5000 disintegrations per minute. After 5 minutes, the rate is 1250 disintegrations per minute. Then, the decay constant (per minute) is -
(1) 0.8 ln 2 (2) 0.4 ln 2
(3) 0.2 ln 2 (4) 0.1 ln 2

Q.30 The fraction of a radioactive material which remains active after time t is 9/16. The fraction which remains active after time t/2 will be -
(1) 4/5 (2) 7/8 (3) 3/5 (4) 3/4

Q.31 One curie is the activity of one gram of -
(1) Uranium (2) Radium
(3) Polonium (4) Radon

Q.32 In one average - life -
(1) Half the active nuclei decay
(2) Less than half the active nuclei decay
(3) More than half the active nuclei decay
(4) All the nuclei decay

Q.33 A radioactive element, with mass 8 gm and half life 100 second, after 5 minutes will reduce to -
(1) 1.5 gram (2) 4 gram
(3) 1 gram (4) 2 gram

Q.34 A specimen of radioactive material contains 10^6 radioactive nuclei. Its half life is 20 second. How many nuclei will remain undecayed after 10 second ?
(1) 7.07 (2) 7.07×10^5
(3) 79 (4) 709

Q.35 The rate of decay of a radioactive element at any instant is 10^3 disintegrations per second. If the half life of the element is 1 second then the rate of decay after one second will be -
(1) 500 per sec (2) 1000 per sec
(3) 250 per sec (4) 2000 per sec

Q.36 The particles not emitted by a radioactive substance are -
(1) γ-rays
(2) electrons
(3) protons
(4) helium nuclei

Q.37 The α-particles will get deflected in electric and magnetic fields -
(1) towards negative plate and outside the magnetic pole
(2) towards negative plate and towards north pole
(3) towards positive plate and towards north pole
(4) towards positive plate and towards south pole

Q.38 γ-rays are produced ...... α or β-decay.
(1) after
(2) before
(3) without
(4) none of the above

Q.39 The β^--particle obtained by radioactive decay and the electrons obtained by thermionic emission have -
(1) different charges
(2) same velocity
(3) same penetrating power
(4) velocity much less than that of β^--particles

Q.40 The particle emitted in the nuclear reaction $_{Z}X^{A} = {}_{Z+1}Y^{A} + ...$ will be -
(1) α particle (2) β^- particle
(3) β^+ particle (4) Photon

Q.41 By neutrino hypothesis which conservation law for β-decay can be explained -
(1) energy conservation
(2) angular momentum conservation
(3) both of the above
(4) momentum conservation

Q.42 Which of the following particle is emitted along with β-emission after considering the conservation laws ?
(1) electron (2) proton
(3) positron (4) neutrino

Q.43 The following conservation law/laws could be obeyed in β-decay with the help of neutrino hypothesis -
(1) energy conservation
(2) angular momentum conservation
(3) energy and linear momentum conservation
(4) energy and angular momentum conservation

Q.44 In negative β-decay -
(1) electrons are emitted by an atom
(2) electrons are emitted by a nucleus which are initially present in the nucleus
(3) electrons are emitted by a nucleus which are formed by neutron decay
(4) some part of the binding energy of the nucleus changes into electron.

Q.45 In which of the following we don't use a radioactive isotope -
(1) growth process of plants
(2) in cure of dysentery
(3) to divide chromosomes
(4) treatment by X-rays

Q.46 The leaves of the Gold leaf spectroscope carry negative charge. If radiations emitted by a radioactive source fall on the spectroscope, then the divergence of the leaves decreases. Therefore the radiation can be -
(1) α (2) β^+
(3) γ (4) all of the above

Q.47 A nucleus with Z = 92 emits the following in a sequences :
$\alpha, \beta^-, \beta^-, \alpha, \alpha, \alpha, \alpha, \alpha, \beta^-, \beta^-, \beta^+, \alpha, \beta^+, \alpha$.
The Z of the resulting nucleus is -
(1) 74 (2) 76
(3) 78 (4) 82

Q.48 A nucleus, with mass number m and atomic number n, emits one α-particle and one β-particle. The mass number and atomic number of the resulting nucleus will respectively be-
(1) (m – 2), n
(2) (m – 4), (n – 1)
(3) (m – 4), (n–2)
(4) (m + 4) (n –1)

Q.49 A neutron decays to -
(1) one proton, one neutron and one γ
(2) one β^+ and one ν
(3) one p, one β^- and one $\overline{\nu}$
(4) one p, one β^+ and one ν

Q.50 The nucleus $_{92}X^{234}$ decays by emitting 3α and $1\beta^-$ particle. Final product is -
(1) $_{87}Y^{228}$
(2) $_{84}Z^{228}$
(3) $_{87}Y^{222}$
(4) $_{84}Z^{222}$

Q.51 Which quantity is different for a neutrino and a photon -
(1) mass
(2) charge
(3) spin
(4) effect of magnetic field

Q.52 After radioactive γ-decay of an element, the change occurs -
(1) only in atomic number
(2) only in mass number
(3) in atomic number and mass number both
(4) neither in atomic number nor in mass number

Q.53 In the radioactive decay process of uranium the initial nuclide is $_{92}U^{238}$ and the final nuclide is $_{82}Pb^{206}$. When uranium nucleus decays to lead, then the number of α and β-particles emitted will respectively be -
(1) 8, 6 (2) 8, 4
(3) 6, 8 (4) 4, 8

Q.54 The intensity of γ-rays from a source (I_0) reduces to $I_0/8$ after passing through 48 mm thick sheet of lead. The thickness of the sheet for obtaining intensity equal to $I_0/2$ will be -
(1) 48 mm (2) 24 mm
(3) 16 mm (4) 8 mm

Q.55 The intensity of gamma radiation from a given source is I_0. On passing through 37.5 mm of lead it is reduced to $I_0 / 8$. The thickness of lead which will reduce it to $I_0 / 2$ is -
(1) $(37.4)^{1/3}$ mm (2) $(37.5)^{1/4}$ mm
(3) $(37.5/3)$ mm (4) $(37.5/4)$ mm

Q.56 Which of the following processes represents a gamma decay ?
(1) $^AX_Z + \gamma \rightarrow {}^AX_{Z-1} + a + b$
(2) $^AX_Z + {}^1n_0 \rightarrow {}^{A-3}X_{Z-2} + c$
(3) $^AX_Z \rightarrow {}^AX_Z + f$
(4) $^AX_Z + e_{-1} \rightarrow {}^AX_{Z-1} + g$

Q.57 The reason of origin of γ-rays is -
(1) Transition between the levels of atom
(2) Transition between the levels of nucleus
(3) Binding energy
(4) Nuclear reaction

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 7

Q.1 If $\frac{15}{16}$ of portion of radioactive nuclei decays in $\frac{15}{16}$ minute then determine the half life period -

(1) $\frac{15}{64}$ sec (2) $\frac{225}{16}$ sec

(3) $\frac{15}{16}$ sec (4) $\frac{15}{32}$ sec

Q.2 The half life of that radioactive substance, which reduces to 1/64 of its initial value in 15 hours, will be -

(1) 5 hours (2) 2 hours

(3) 2.50 hours (4) 4 hours

Q.3 The radiations emitted by a radioactive substance with half life 30 minutes, are measured by a Geiger-Muller counter. If the count rate reduces to 5 per second in two hours, then the initial count rate will be -

(1) 200 s^{-1} (2) 100 s^{-1}

(3) 80 s^{-1} (4) 40 s^{-1}

Q.4 The half life of a radioactive substance is 1 hour. The radiations emitted by it are measured by a GM counter. The count rate was measured to be 2 dps after 4 hours. The initial count rate in dps was -

(1) 80 (2) 32

(3) 16 (4) 8

Q.5 When a U^{238} nucleus originally at rest, decays by emitting an alpha particle having a speed 'u', the recoil speed of the residual nucleus is -

(1) $-\frac{4u}{238}$ (2) $\frac{4u}{238}$

(3) $-\frac{4u}{234}$ (4) $\frac{4u}{234}$

Q.6 If the half lives of a radioactive element for α and β decay are 4 year and 12 years respectively, then the percentage of the element that remains after 12 year will be -

(1) 6.25% (2) 5.25%

(3) 4.25% (4) 3.50%

Q.7 Equal masses of two samples A and B of charcoal are burnt and the activity of resulting carbon-di-oxide from two samples is measured. The gas from sample A gives 10^4 counts per month and that from sample B gives 2.5×10^3 counts per month. The age difference of two samples is - (Half life of C^{14} is 5730 years) -

(1) 5730 Y

(2) 11460 Y

(3) 17190 Y

(4) 22920 Y

Q.8 The radioactive carbon gets produced by the process of -

(1) reaction of radium rays on simple carbon

(2) reaction of cosmic rays on simple carbon

(3) reaction of high energy neutrons on nitrogen

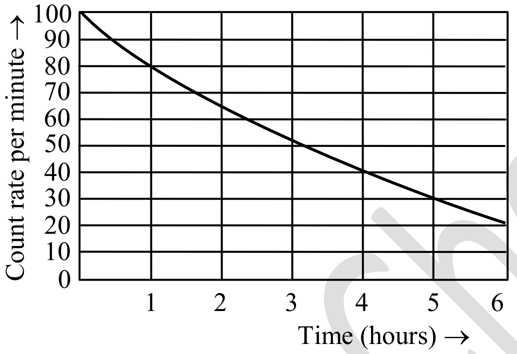
(4) reaction of cosmic rays on oxygen.

Q.9 The half life of a radioactive element X is 2 hours. This element decays to another stable element. The ratio of the atoms of X and Y was found to be 1:4 after time t. The value of t in hours will be -
(1) 2 hours
(2) 4 hours
(3) 6 hours
(4) between 4 hours and 6 hours

Q.10 Which of the following statements is correct ?
(1) λ, T and τ depends on physical changes
(2) λ, T and τ depends on chemical changes
(3) λ is a constant and T, τ depends on physical and chemical changes
(4) λ, T and τ are constants and depend on the nature of the material

Q.11 If the half life of one gram radioactive element of molecular weight M gram of is T, then the half life of M gm will be -
(1) T (2) T/M
(3) TM (4) TM/2

Q.12 The count rate of 10 gms of a radioactive material was measured at different instants of time and is represented in the following graph. The half life of the material is -



(1) 1 hours (2) 2 hours
(3) 3 hours (4) 4 hours

Q.13 A nucleus $_ZX^A$ emits 2 α - particles and 3 β-particles. The ratio of total protons and neutrons in the final nucleus is -
(1) $\frac{Z-7}{A-Z+7}$ (2) $\frac{Z-1}{A-Z-8}$
(3) $\frac{Z-1}{A-Z-7}$ (4) $\frac{Z-3}{A-Z+3}$

Q.14 The half life of a radioactive material is 8 hours. Its 20% fraction remains active after time t. Its 10% fraction will remain active after -
(1) (t + 2) hours (2) (t + 4) hours
(3) (t + 6) hours (4) (t + 8) hours

Q.15 The half-life of a radioactive material is 5 years. The probability of disintegration of a nucleus of this material after 10 years will be -
(1) 0.50 (2) 0.75
(3) 0.25 (4) none of the above

Q.16 The percentage of quantity of a radioactive material that remains after 5 half lives will be -
(1) 31% (2) 3.125%
(3) 0.3% (4) 1%

Q.17 A sample of radioactive element has a mass of 10 g at an instant t = 0. The approximate mass of this element in the sample after two mean lives is -
(1) 1.35 g (2) 2.50 g
(3) 3.70 g (4) 6.30 g

Q.18 n α-particles per second are being emitted by N atoms of a radioactive element. The half life of the element will be -
(1) $\frac{n}{N}$ s (2) $\frac{N}{n}$ s
(3) $\frac{0.693N}{n}$ (4) $\frac{0.693n}{N}$

Q.19 Samples of two radioactive nuclides, X and Y, each have equal activity A_0 at time t = 0. X has a half-life of 24 years and Y a half-life of 16 years. The samples are mixed together. What will be the total activity of the mixture at t = 48 years ?
(1) $\frac{1}{12}A_0$ (2) $\frac{1}{4}A_0$
(3) $\frac{3}{16}A_0$ (4) $\frac{3}{8}A_0$

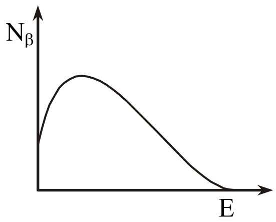
Q.20 The decay constants of a radioactive substance for a and b emission are λ_a and λ_b respectively. If the substance emits α and β simultaneously, the average half life of the material will be -
(1) $T_\alpha - T_\beta$ (2) $T_\alpha + T_\beta$
(3) $\frac{T_\alpha T_\beta}{T_\alpha + T_\beta}$ (4) none of these

Q.21 The decay constant of an element is λ and the number of its active atoms is N_0. Its rate of disintegration at the time when active atoms are N, will be -
(1) λN_0 (2) λN
(3) $\frac{\lambda}{(N_0 - N)}$ (4) $\lambda\left(\frac{N_0}{N}\right)$

Q.22 The decay constants of a radioactive substance for a and b emission are λ_a and λ_b respectively. If the substance emits α and β simultaneously, then the average decay constant of the material will be-
(1) $\lambda_\alpha - \lambda_\beta$ (2) $\lambda_\alpha + \lambda_\beta$
(3) $\frac{\lambda_\alpha \lambda_\beta}{\lambda_\alpha + \lambda_\beta}$ (4) none of these

Q.23 In different samples of different elements of same amount the number of atoms disintegrated in a definite time :
(1) always remain constant
(2) depends on the temperature
(3) depends on the physical changes
(4) are different because it is random process

Q.24 The curve representing the energy spectrum of β-particles is -

(1)


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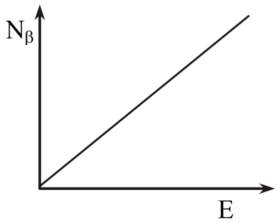

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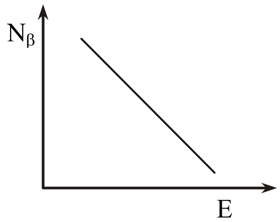

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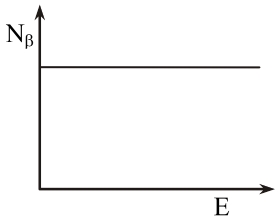


Q.25 The particles emitted in the nuclear reaction are respectively -

${}_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} \rightarrow {}_{Z-1}R^{A-4} \rightarrow {}_{Z-1}R^{A-4}$

(1) β, γ, α (2) α, β, γ
(3) β, α, γ (4) γ, α, β

Q.26 The mean lives for α-and β-decay of radioactive substance are 1620 years and 405 years respectively. In how much time its $\frac{3}{4}$th fraction will decay, if it simultaneously emits α-and β-particles?

(1) 449 years (2) 199 years
(3) ∞ (4) 99 years

Q.27 The electron emitted in beta radiation originates from -

(1) Inner orbits of atoms
(2) Free electrons existing in nuclei
(3) Decay of a neutron in a nucleus
(4) Photon escaping from the nucleus

Q.28 10^{-3} kg of radioactive isotope (atomic mass 226) emits 3.72×10^{10} α-particles in a second. The half-life of the isotope will be -

(1) 5570 years (2) 1571 years
(3) 1200 years (4) 1350 years

Q.29 Ten grams of ^{57}Co kept in an open container Beta-decays with a half-life of 270 days. The weight of the material inside the container after 540 days will be very nearly -

(1) 10 g (2) 5 g
(3) 2.5 g (4) 1.25 g

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 8

Q.1 Half life period of two elements are 40 minute and 20 minute respectively, then after 80 minute ratio of the remaining nuclei will be- (Initially both have equal active nuclei)
(1) 4 : 1 (2) 1 : 2
(3) 8 : 1 (4) 16 : 1

Q.2 A radio-active elements emits one α and β particles then mass number of daughter element is-
(1) Decreased by 4 (2) Increased by 4
(3) Decreased by 2 (4) Increased by 2

Q.3 The half life of a radio nuclide is 77 days then its decay constant is-
(1) 0.003/day (2) 0.006/day
(3) 0.009/day (4) 0.012/day

Q.4 The relation between λ and $T_{1/2}$ as :- ($T_{1/2} \rightarrow$ half life, $\lambda \rightarrow$ decay constant)
(1) $T_{1/2} = \frac{\ell n\, 2}{\lambda}$ (2) $T_{1/2}\, \ell n2 = \lambda$
(3) $T_{1/2} = \frac{1}{\lambda}$ (4) $(\lambda + T_{1/2}) = \frac{\ell n\, 2}{2}$

Q.5 Which rays contain (+ve) charged particle-
(1) α-rays (2) β-rays
(3) γ-rays (4) X-rays

Q.6 X(n, α) ${}^{7}_{3}\text{Li}$, then X will be-
(1) ${}^{10}_{5}\text{B}$ (2) ${}^{9}_{5}\text{B}$ (3) ${}^{11}_{4}\text{Be}$ (4) ${}^{4}_{2}\text{He}$

Q.7 Half life of radioactive element is 12.5 Hour and its quantity is 256 gm. After how much time its quantity will remain 1 gm-
(1) 50 Hrs
(2) 100 Hrs
(3) 150 Hrs
(4) 200 Hrs

Q.8 A sample of radioactive element containing 4×10^{16} active nuclei. Half life of element is 10 days, then number of decayed nuclei after 30 days-
(1) 0.5×10^{16} (2) 2×10^{16}
(3) 3.5×10^{16} (4) 1×10^{16}

Q.9 A deutron is bombarded on ${}_{8}O^{16}$ nucleus then α-particle is emitted then product nucleus is-
(1) ${}_{7}N^{13}$ (2) ${}_{5}B^{10}$
(3) ${}_{4}Be^{9}$ (4) ${}_{7}N^{14}$

Q.10 A sample of radioactive element has a mass of 10gm at an instant t = 0. The approximate mass of this element in the sample after two mean lives is-
(1) 1.35 gm (2) 2.50 gm
(3) 3.70 gm (4) 6.30 gm

Q.11 The half life of radium is about 1600 years. Of 100 g of radium existing now. 25g will remain unchanged after-
(1) 6400 years (2) 2400 years
(3) 3200 years (4) 4800 years

Q.12 In a radioactive material the activity at time t_1 is R_1 and at a later time t_2, it is R_2. If the decay constant of the material is λ, then-

(1) $R_1 = R_2\ e^{-\lambda(t_1-t_2)}$ (2) $R_1 = R_2\, e^{\lambda(t_1-t_2)}$

(3) $R_1 = R_2(t_2/t_1)$ (4) $R_1 = R_2$

Q.13 A radioactive substance decays to $1/16^{th}$ of its initial activity in 40 days. The half-life of the radioactive substance expressed in days is-

(1) 2.5 (2) 5

(3) 10 (4) 20

Q.14 Carbon dating is best suited for determining the age of fossils if their age in years is of the order of-

(1) 10^3 (2) 10^4

(3) 10^5 (4) 10^6

Q.15 ${}^{238}_{92}U$ emits 8 α-particle and 6 β-particles. The neutron/proton ratio in the product nucleus is-

(1) 60/41 (2) 61/40

(3) 62/41 (4) 61/42

Q.16 A radioactive material has a half life of 10 days. What fraction of the material would remain after 30 days-

(1) 0.5 (2) 0.25

(3) 0.125 (4) 0.33

Q.17 ${}^{238}_{92}U$ has 92 protons and 238 nucleons. It decays by emitting an Alpha particle and becomes-

(1) ${}^{234}_{92}U$ (2) ${}^{234}_{90}Th$

(3) ${}^{235}_{92}U$ (4) ${}^{237}_{93}Np$

Q.18 The fossil bone has a ${}^{14}C$: ${}^{12}C$ ratio, which is $\left(\frac{1}{16}\right)$ of that in a living animal bone. If the half-life of ${}^{14}C$ is 5730 years, then the age of the fossil bone is-

(1) 11460 years (2) 17190 years

(3) 22920 years (4) 45840 years

Q.19 Which one of the following is a possible nuclear reaction-

(1) ${}^{10}_{5}B + {}^{4}_{2}He \rightarrow {}^{13}_{7}N + {}^{1}_{1}H$

(2) ${}^{23}_{11}Na + {}^{1}_{1}H \rightarrow {}^{20}_{10}Ne + {}^{4}_{2}He$

(3) ${}^{239}_{93}Np \rightarrow {}^{239}_{94}Pu + \beta^- + \bar{\nu}$

(4) ${}^{11}_{7}N + {}^{1}_{1}H \rightarrow {}^{12}_{6}C + \beta^- + \bar{\nu}$

Q.20 For nuclear reaction

${}_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{56}Ba^{144} + \ldots\ldots + 3\ {}_{0}n^{1}$

(1) ${}_{26}Kr^{89}$ (2) ${}_{36}Kr^{89}$

(3) ${}_{26}Sr^{90}$ (4) ${}_{38}Sr^{89}$

Q.21 The total energy of an electron is 3.555 MeV, then its kinetic energy is-

(1) 3.545 MeV

(2) 3.045 MeV

(3) 3.5 MeV

(4) None

Q.22 For the given reaction, the particle X is -

${}_6C^{11} \rightarrow {}_5B^{11} + \beta^+ + X$

(1) Neutron (2) Anti neutrino
(3) Neutrino (4) Proton

Q.23 The activity of a radioactive sample is 1.6 curie and its half-life is 2.5 days. Then activity after 10 days will be-

(1) 0.16 curie (2) 0.8 curie
(3) 0.1 curie (4) 0.4 curie

Q.24 Half-life of a substance is 20 minute, then the time between 33% and 67% decay will be-

(1) 20 minute (2) 40 minute
(3) 50 minute (4) 10 minute

Q.25 When radioactive substance emits an α-particle, then its position in the periodic table is lowered by-

(1) two places (2) three places
(3) five places (4) one place

Q.26 A radioactive substance decays to (1/16)th of its initial activity in 40 days. The half-life of the radioactive substance expressed (in days) is-

(1) 2.5 (2) 5 (3) 10 (4) 20

Q.27 Radioactive nuclei that are injected into a patient collected at certain sites within its body, undergoing radioactive decay and emitting electromagnetic radiation. These radiations can then be recorded by a detector. This procedure provides an important diagnostic tool called-

(1) gamma camera
(2) CAT scan
(3) radiotracer technique
(4) gamma ray spectroscopy

Q.28 In a material medium, when a positron meets an electron both the particles annihilate leading to the emission of two gamma ray photons. This process forms the basis of an important diagnostic procedure called-

(1) MRI (2) PET
(3) CAT (4) SPECT

Q.29 Carbon dating is best suited for determining the age of fossils if their age in years is of the order of-

(1) 10^3 (2) 10^4 (3) 10^5 (4) 10^6

Q.30 A nucleus of mass number A, originally at rest, emits an α-particle with speed v. The daughter nucleus recoils with a speed-

(1) $\frac{2v}{A+4}$ (2) $\frac{4v}{A+4}$
(3) $\frac{4v}{A-4}$ (4) $\frac{2v}{A-4}$

Q.31 In radioactive decays process, the negatively charged emitted β-particles are-

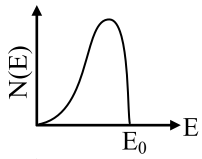
(1) the electrons present inside the nucleus
(2) the electrons produced as a result of the decay of neutrons inside the nucleus
(3) the electrons produced as a result of collisions between atoms
(4) the electrons orbiting around the nucleus

Q.32 Two radioactive substance A and B have decay constants 5λ and λ respectively. At t = 0, they have the same number of nuclei. The ratio of number of nuclei of A to those of B will be $(1/e)^2$ after a time interval-

(1) $\frac{1}{4\lambda}$ (2) 4λ

(3) 2λ (4) $\frac{1}{2\lambda}$

Q.33 The energy spectrum of β-particles [number N(E) as a function of β-energy E] emitted from a radioactive source is-

(1)


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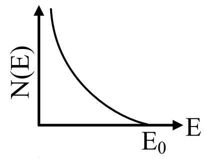

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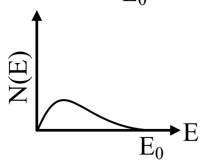

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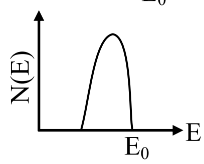


Q.34 Mass spectrometric analysis of potassium and argon atoms in a Moon rock sample shows that the ratio of the number of (stable) ^{40}Ar atoms present to the number of (radioactive) ^{40}K atoms is 10.3. Assume that all the argon atoms were produced by the decay of potassium atoms, with a half-life of 1.25×10^9 yr. How old is the rock ?

(1) 2.95×10^{11} yr (2) 2.95×10^9 yr

(3) 4.37×10^9 yr (4) 4.37×10^{11} yr

Q.35 Starting with a sample of pure ^{66}Cu, 7/8 of it decays into Zn in 15 min. The corresponding half-life is-

(1) 10 min (2) 15 min

(3) 5 min (4) $7\frac{1}{2}$ min

Q.36 A radioactive material decays by simultaneous emission of two particles with respective half lives 1620 yr and 810 yr. The time (in years) after which one-fourth of the material remains is-

(1) 1080 (2) 2430

(3) 3240 (4) 4860

Q.37 The half-life of a radioactive material is 3 hour. If the initial amount is 300g, then after 18 hour, how much of it will remain ?

(1) 4.68 g (2) 46.8 g

(3) 9.375 g (4) 93.75 g

Q.38 The activity of a sample of radioactive material is A_1 at time t_1 and A_2 at time $t_2 (t_2 > t_1)$. If its mean life is T, then-

(1) $A_1 t_1 = A_2 t_2$ (2) $A_1 - A_2 = t_2 - t_1$

(3) $A_2 = A_1 e^{(t_1 - t_2)/T}$ (4) $A_2 = A_1 e^{(t_1/t_2)T}$

Q.39 A β-particle is emitted by a radioactive nucleus at the time of conversion of a –

(1) neutron into a proton

(2) proton into a neutron

(3) nucleon into energy

(4) positron into energy

Q.40 In which sequence, the radioactive radiations are emitted in the following nuclear reaction
$_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} \rightarrow {}_{Z-1}K^{A-4} \rightarrow {}_{Z-1}K^{A-4}$
(1) γ, α and β (2) α, β and γ
(3) β, α and γ (4) β, γ and α

Q.41 Energy transferred to a person through gamma rays is measured in units of-
(1) curie (2) rutherford
(3) roentgen (4) none of these

Q.42 A radioactive material decays by simultaneous emission of two particles with respective half lives 1620 year and 810 year. The time, after which one fourth of the material remains, is-
(1) 3860 year (2) 4240 year
(3) 2380 year (4) 1080 year

Q.43 The end product of the decay of $_{90}Th^{232}$ is $_{82}Pb^{208}$. The number of alpha and beta particles emitted are, respectively-
(1) 3, 3 (2) 6, 4 (3) 6, 0 (4) 3, 2

Q.44 After 2 hour 1/16th of initial amount of a certain radioactive isotope remains undecayed. The half life of the isotope is-
(1) 15 minute (2) 30 minute
(3) 45 minute (4) 60 minute

Q.45 Three fourth of the active nuclei present in a radioactive sample decay in $\frac{3}{4}$ s. The half life of the sample is-
(1) 1 s (2) $\frac{1}{2}$ s (3) $\frac{3}{8}$ s (4) 3 s

Q.46 Half-lives of two radioactive substances A and B are respectively 20 minute and 40 minute. Initially the sample of A and B have equal number of nuclei. After 80 minute the ratio of remaining number of A and B nuclei is-
(1) 1 : 16 (2) 4 : 1 (3) 1 : 4 (4) 1 : 1

Q.47 Activity of a radioactive sample decreases to (1/3)rd of its original value in 3 days. Then, in 9 days its activity will become-
(1) (1/27) of the original value
(2) (1/9) of the original value
(3) (1/18) of the original value
(4) (1/3) of the original value

Q.48 Two radioactive materials A and B contain same number of nuclei. If the decay constants of A and B are $5\lambda s^{-1}$ and $3\lambda s^{-1}$ respectively, the ratio of number of nuclei undecayed of A to that of B will be 1/e after a time-
(1) $\frac{1}{2\lambda}$s (2) $\frac{1}{5\lambda}$s (3) 2λs (4) $\frac{1}{3\lambda}$s

Q.49 What is not released in nuclear disintegration ?
(1) Electrons (2) Protons
(3) Helium nucleus (4) γ rays

Q.50 The activity of a radioactive sample is measured as N_0 counts per minute at t = 0 and N_0/e counts per minute at t = 5 minutes. The time (in minutes) at which the activity reduces to half its value is

(1) $\log_e 2/5$ (2) $\frac{5}{\log_e 2}$

(3) $5 \log_{10} 2$ (4) $5 \log_e 2$

Q.51 The decay constant of a radio isotope is λ. If A_1 and A_2 are its activities at times t_1 and t_2 respectively, the number of nuclei which have decayed during the time $(t_1 - t_2)$ –

(1) $A_1 - A_2$ (2) $(A_1 - A_2) / \lambda$

(3) $\lambda (A_1 - A_2)$ (4) $A_1t_1 - A_2t_2$

Q.52 A radioactive nucleus of mass M emits a photon of frequency ν and the nucleus recoils. The recoil energy will be –

(1) $h\nu$ (2) $Mc^2 - h\nu$

(3) $h^2\nu^2/2Mc^2$ (4) Zero

Q.53 The half life of radioactive isotope 'X' is 50 years. It decays to another element 'Y' which is stable. The two elements 'X' and 'Y' were found to be in the ratio of 1 : 15 in a sample of a given rock. The age of the rock was estimated to be :

(1) 100 years (2) 150 years

(3) 200 years (4) 250 years

Q.54 A nucleus $^{m}_{n}X$ emits one α particle and two β^- particles. The resulting nucleus is :

(1) $^{m-4}_{n-2}Y$ (2) $^{m-6}_{n-4}Z$

(3) $^{m-6}_{n}Z$ (4) $^{m-4}_{n}X$

Q.55 Two radioactive nuclei P and Q, in a given sample decay into a stable nucleus R. At time t = 0, number of P species are 4 N_0 and that of Q are N_0. Half-life of P (for conversion to R) is 1 minute where as that of Q is 2 minutes. Initially there are no nuclei of R present in the sample. When number of nuclei of P and Q are equal, the number of nuclei of R present in the sample would be

(1) $2N_0$ (2) $3N_0$ (3) $\frac{9N_0}{2}$ (4) $\frac{5N_0}{2}$

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 9

Q.1 The activity of radio active material is-

(1) $\frac{-dN}{dt}$

(2) $\frac{\lambda dN}{dt}$

(3) $\frac{1}{\lambda}\frac{dN}{dt}$

(4) $N\frac{dN}{dt}$

Q.2 Consider the following two reactions, then atomic number and mass number of nucleus X and Y -

(i) $_{92}U^{235} + {}_0n^1 \rightarrow X + {}_{35}Br^{85} + 3\ {}_0n^1$

(ii) $_3Li^6 + {}_1H^2 \rightarrow Y + {}_2He^4$

(1) (i) 57,148 (ii) 2, 4

(2) (i) 57, 151 (ii) 4, 4

(3) (i) 60, 148 (ii) 4, 2

(4) (i) 60, 15 (ii) 3, 4

Q.3 The β rays which are emitted from a radioactive material are-

(1) Electro-magnetic radiations

(2) Orbital electrons

(3) Electrons or positrons emitted by a nucleons

(4) Neutral particle emitted by nucleons

Q.4 When a neutron is disintegrated, it gives-

(1) One proton, one electron and one anti neutrino

(2) One positron, one electron and one neutrino

(3) One proton, one positron and one neutrino

(4) One proton, γ-rays and one neutrino

Q.5 When $_{90}Th^{238}$ changes into $_{83}Bi^{222}$, then the number of emitted α and β-particles are-

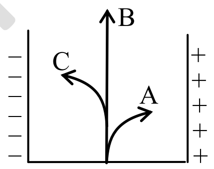
(1) $8\alpha, 7\beta$

(2) $4\alpha, 7\beta$

(3) $4\alpha, 4\beta$

(4) $4\alpha, 1\beta$

Q.6 A radioactive source is kept in an uniform electric field α, β and γ-particle are emitting α, β, γ are respectively-



(1) A, B, C (2) A, C, B

(3) C, A, B (4) C, B, A

Q.7 A radioactive nucleus decay as follows : $X \xrightarrow{\alpha} X_1 \xrightarrow{\beta} X_2 \xrightarrow{\alpha} X_3 \xrightarrow{\gamma} X_4$,
if the atomic number and the mass number of X are 72 and 180 then the mass number and atomic number of X_4 is-

(1) 172, 70 (2) 171, 69

(3) 172, 69 (4) 172, 68

Q.8 The rate of disintegration of a radioactive sample can be increased by-
(1) increasing the temperature
(2) increasing the pressure
(3) chemical reaction
(4) it is not possible

Q.9 In a radioactive decay, neither the atomic number nor the mass number changes. Which of the following would be emitted in the decay process-
(1) Proton (2) Neutron
(3) Electron (4) Photon

Q.10 The decay constant of a radioactive sample is λ. The respective values of its half life and mean life are-
(1) $\frac{1}{\lambda}$ and ($\log_e 2$) (2) $\frac{\log_e 2}{\lambda}$ and $\frac{1}{\lambda}$
(3) λ ($\log_e 2$) and $\frac{1}{\lambda}$ (4) $\frac{2}{\lambda}$ and $\frac{1}{\lambda}$

Q.11 For the given reaction, the particle 'X' is :
${}_6C^{11} \rightarrow {}_5B^{11} + \beta^+ + X$
(1) Neutron (2) Antinutrino
(3) Neutrino (4) Proton

Q.12 If ${}_a^bX$ emits a positron, two α and two β^- and in last one α is also emit and converts in ${}_d^cY$, correct relation-
(1) c = b – 12, d = a – 5
(2) a = c – 8, d = b – 1
(3) a = c – 6, d = b – 0
(4) a = c – 4, a = b – 2

Q.13 The half life of a radioactive material is 5 years in his element probability of nucleus disintegration during 10 years is-
(1) 0.50 (2) 0.25
(3) 0.60 (4) 0.75

Q.14 If $N_t = N_0e - \lambda t$, then number of disintegrated atoms between t_1 to t_2 ($t_2 > t_1$) will be-
(1) $N_0[e^{\lambda t_2} - e^{\lambda t_1}]$
(2) $N_0[-e^{-\lambda t_2} - e^{-\lambda t_1}]$
(3) $N_0[-e^{-\lambda t_1} - e^{-\lambda t_2}]$
(4) None

Q.15 The half life of a radioactive isotope is 2 hour, after which time it remains 1/64 times of its initial value-
(1) 6 hour (2) 12 hour
(3) 24 hour (4) 3 hour

Q.16 1/16 part of a radioactive material is left after one hour. It's half life is-
(1) 45 min. (2) 30 min.
(3) 20 min. (4) 15 min.

Q.17 The half life of a radioactive material is T. After T/2 time, the material left is-
(1) 1/2 (2) 3/4
(3) $\frac{1}{\sqrt{2}}$ (4) $(\sqrt{2}-1)/\sqrt{2}$

Q.18 The half life of a radioactive element is 30 days, in 90 days the percentage of disintegrated part is-
(1) 13.5 % (2) 46.5 %
(3) 87.5 % (4) 90.15 %

Q.19 At some instant two radioactive substance are having amount in ratio of 2 : 1. Their half lives are 12 hrs and 16 hrs then after two days the ratio of their quantities is-
(1) 1 : 1 (2) 2 : 1
(3) 1 : 2 (4) 1 : 4

Q.20 The half life of radium is 1600 yrs. After 4800 yrs what fraction of it remains active-
(1) 1/8 (2) 1/10
(3) 7/8 (4) 15/16

Q.21 The half life of a radioactive element is 10 days. If the mass of the specimen reduces to (1/10)th then the time taken is-
(1) 100 days (2) 50 days
(3) 33 days (4) 16 days

Q.22 N atoms of a radioactive element emits n alpha particles per second. The half life of the element is-
(1) n/N secs
(2) N/n secs
(3) 0.693 N/n secs
(4) 0.693 n/N secs

Q.23 The half life of radioactive material is 30 days, number of radioactive atoms after 90 days is-
(1) 1/3 of the initial number
(2) 1/4 of the initial number
(3) 1/8 of the initial number
(4) 1/1 of the initial number

Q.24 'Rn' decays into 'Po' by emitting α-particle with half life of 4 days, A sample contains 6.4×10^{10} atoms of Rn. After 12 days, the number of atoms of 'Rn' left in the sample will be-
(1) 3.2×10^{10} (2) 0.53×10^{10}
(3) 2.1×10^{10} (4) 0.8×10^{10}

Q.25 In a mean life of a radioactive sample-
(1) About 1/3 of substance disintegrate
(2) About 2/3 of substance disintegrate
(3) About 90% of the substance disintegrate
(4) Almost all the substance disintegrates

Q.26 10.38 gm radioactive substance of half life 3.8 days, than after 19 days, remaining quantity is-
(1) 0.151 gm (2) 0.32 gm
(3) 1.51 gm (4) 0.16 gm

Q.27 In N_0 is the original mass of the substance of half-life period $t_{1/2}$ = 5 years, then the amount of substance left after 15 years is -
(1) $\frac{N_0}{8}$ (2) $\frac{N_0}{16}$ (3) $\frac{N_0}{2}$ (4) $\frac{N_0}{4}$

Q.28 At a specific instant emission of radioactive compound is deflected in a magnetic field. The compound can emit -
(1) Electrons (2) Protons
(3) He^{2+} (4) Neutrons

Q.29 A radioactive sample at any instant has its disintegration rate 5000 disintegrations per minute. After 5 minutes, the rate is 1250 disintegrations per minute. Then, the decay constant (per minute) is -

(1) $0.2 \ell n 2$ (2) $0.1 \ell n 2$

(3) $0.8 \ell n 2$ (4) $0.4 \ell n 2$

Q.30 Which of the following cannot be emitted by radioactive substances during their decay ?

(1) Neutrinos (2) Helium nuclei

(3) Electrons (4) Protons

Q.31 Which of the following radiations has the least wavelength ?

(1) β-rays (2) α-rays

(3) X-rays (4) γ -rays

Q.32 When a U^{238} nucleus originally at rest, decay by emitting an alpha particle having a speed 'u' the recoil speed of the residual nucleus is -

(1) $-\frac{4u}{234}$ (2) $\frac{4u}{234}$

(3) $-\frac{4u}{238}$ (4) $\frac{4u}{238}$

Q.33 A nucleus with Z = 92 emits the following in a sequence : $\alpha, \beta^-, \beta^-, \alpha, \alpha, \alpha, \alpha, \alpha, \beta^-, \beta, \alpha, \beta^+, \beta^+, \alpha$ The Z of the resulting nucleus is -

(1) 78 (2) 82 (3) 74 (4) 76

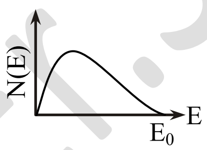
Q.34 The intensity of gamma radiation from a given source is I. On passing through 36 mm of lead, it is reduced to I/8. The thickness of lead which will reduce the intensity to I/2 will be -

(1) 6 mm (2) 9 mm (3) 18 mm (4) 12 mm

Q.35 Starting with a sample of pure ^{66}Cu, 7/8 of it decays into Zn in 15 minutes. The corresponding half-life is -

(1) 10 min (2) 15 min (3) 5 min (4) 7½ min

Q.36 The energy spectrum of β-particles [number N(E) as a function of β-energy E] emitted from a radioactive source is -

(1)


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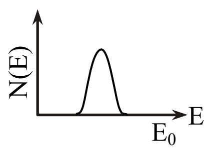

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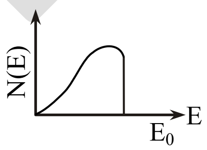

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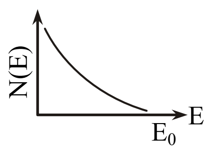


Q.37 The 'rad' is the correct unit used to report the measurement of -

(1) the biological effect of radiation

(2) the rate of decay of a radioactive sourced

(3) the ability of a beam of gamma ray photons to produce ions in a target

(4) the energy delivered by radiation to a target

Q.38 The half-life period of a radio-active element X is same as the mean life time of another radio-active element Y. Initially they have the same number of atoms. Then -
(1) X will decay faster than Y
(2) Y will decay faster than X
(3) X and Y have same decay rate initially
(4) X and Y decay at same rate always

Q.39 In the nuclear process, ${}_{6}^{11}C \rightarrow {}_{5}^{11}B + \beta^{+} + X$, X stands for -
(1) neutrino (2) γ particle
(3) α particle (4) neutron

Q.40 Consider α particles, β particles and γ-rays, each having an energy of 0.5 MeV. In increasing order of penetrating powers, the radiations are -
(1) α, β, γ (2) α, γ, β
(3) β, γ, α (4) γ, β, α

Q.41 Masses of two isobars ${}_{29}Cu^{64}$ and ${}_{30}Zn^{64}$ are 63.9298 amu and 63.9292 amu respectively. It can be concluded from these data that –
(1) Both the isobars are stable
(2) Zn^{64} is radioactive, decaying to Cu^{64} through β-decay
(3) Cu^{64} is radioactive, decaying to Zn^{64} through γ-decay
(4) Cu^{64} is radioactive, decaying to Zn^{64} through β-decay

Q.42 The half-life of ${}^{131}I$ is 8 days. Given a sample of ${}^{131}I$ at time t = 0, we can assert that -
(1) No nucleus will decay before t = 4 days
(2) No nucleus will decay before t = 8 days
(3) All nuclei will decay before t = 16 days
(4) A given nucleus may decay at any time after t = 0

Q.43 Which of the following is a correct statement ?
(1) Beta rays are same as cathode rays
(2) Gamma rays are high energy neutrons
(3) Alpha particles are singly ionized helium atoms
(4) Protons and neutrons have exactly the same mass

Q.44 ${}^{22}Ne$ nucleus, after absorbing energy, decays into two α-particles and an unknown nucleus. The unknown nucleus is -
(1) Nitrogen
(2) Carbon
(3) Boron
(4) Oxygen

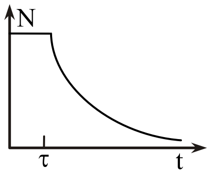
Q.45 The half-life period of a radioactive element X is same as the mean-life time of another radioactive element Y. Initially both of them have the same number of atoms. Then -
(1) X and Y have the same decay rate initially
(2) X and Y decay at the same rate always
(3) Y will decay at a faster rate than X
(4) X will decay at a faster rate than Y

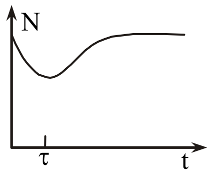
Q.46 Two radioactive materials X_1 and X_2 have decay constants 10λ and λ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 and that of X_2 will be 1/e after a time -
(1) $1/(10\lambda)$ (2) $1/(11\lambda)$

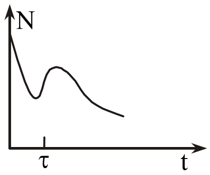
(3) 11/ (10 λ) (4) 1/ (9 λ)

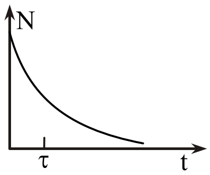
Q.47 The electron emitted in beta radiation originates from -
(1) inner orbits of atoms
(2) Free electrons existing in nuclei
(3) Decay of a neutron in a nucleus
(4) Photon escaping from the nucleus

Q.48 A radioactive sample consists of two distinct species having equal number of atoms initially. The mean life time of one species is τ and that of the other is 5τ. The decay products in both cases are stable. A plot is made of the total number of radioactive nuclei as a function of time. Which of the following figure best represents the form of this plot ?

(1) 

(2) 

(3) 

(4) 

Q.49 The half-life of ^{215}At is 100 μs. The time taken for the radioactivity of a sample of ^{215}At to decay to 1/16th of its initial value is -
(1) 400 μs (2) 6.3 μs (3) 40 μs (4) 300 μs

Q.50 Which of the following processes represents a gamma-decay ?
(1) ${}^{A}X_{Z} + \gamma \rightarrow {}^{A}X_{Z-1} + a + b$
(2) ${}^{A}X_{Z} + {}^{1}n_{0} \rightarrow {}^{A-3}X_{Z-2} + c$
(3) ${}^{A}X_{Z} \rightarrow {}^{A}X_{Z} + f$
(4) ${}^{A}X_{Z} + e_{-1} \rightarrow {}^{A}X_{Z-1} + g$

Q.51 The nucleus of element X (A = 220) undergoes α-decay. If Q-value of the reaction is 5.5 MeV, then approximate kinetic energy of α-particle is -
(1) 5.6 MeV (2) 5.4 MeV
(3) 4.9 MeV (4) 6.5 MeV

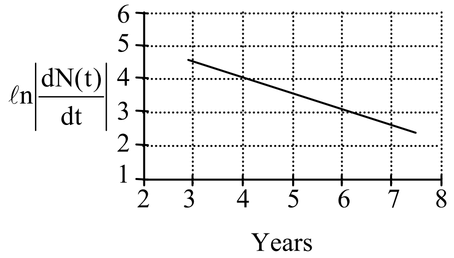
Q.52 Activity of a radioactive substance after 280 days was 6000 d/s. It decreases to 3000 d/s after next 140 days. Its original activity was -
(1) 12000 d/s (2) 9000 d/s
(3) 20,000 d/s (4) 24000 d/s

Q.53 Half life of a radioactive sample is 4 days. Find the probability that a particular nucleus of the radioactive material decays after 2 half life is -
(1) 1 (2) $\frac{1}{2}$
(3) $\frac{3}{2}$ (4) $\frac{3}{4}$

Q.54 A radio active sample S_1 having an activity of 5μCi has twice the number of nuclei as another sample S_2 which has an activity of 10μCi. The half lives of S_1 and S_2 can be -
(1) 20 years and 5 years, respectively (2) 20 years and 10 years, respectively

(3) 10 years each (4) 5 years each

Q.55 To determine the half life of a radioactive element, a student plots a graph of $\ell n\left|\frac{dN(t)}{dt}\right|$ versus t. Here $\frac{dN(t)}{dt}$ is the rate of radioactive decay at time t. If the number of radioactive nuclei of this element decreases by a factor of p after 4.16 years, the value of p is -



(1) 2 (2) 4 (3) 6 (4) 8

Directions: Questions number 56 – 57 are based on the following paragraph.

A nucleus of mass M + Δm is at rest and decays into two daughter nuclei of equal mass $\frac{M}{2}$ each. Speed of light is c.

Q.56 The speed of daughter nuclei is -

(1) $c\sqrt{\frac{\Delta m}{M+\Delta m}}$ (2) $c\frac{\Delta m}{M+\Delta m}$

(3) $c\sqrt{\frac{2\Delta m}{M}}$ (4) $c\sqrt{\frac{\Delta m}{M}}$

Q.57 The binding energy per nucleon for the parent nucleus is E_1 and that for the daughter nuclei is E_2. Then –

(1) $E_1 = 2E_2$ (2) $E_2 = 2E_1$

(3) $E_1 > E_2$ (4) $E_2 > E_1$

Q.58 A radioactive nucleus (initial mass number A and atomic number Z) emits 3 α-particles and 2 positrons. The ratio of number of neutrons to that of protons in the final nucleus will be –

(1) $\frac{A-Z-4}{Z-2}$ (2) $\frac{A-Z-8}{Z-4}$

(3) $\frac{A-Z-4}{Z-8}$ (4) $\frac{A-Z-12}{Z-4}$

Q.59 The half life of a radioactive substance is 20 minutes. The approximate time interval $(t_2 - t_1)$ between the time t_2 when $\frac{2}{3}$ of it has decayed an time t_1 when $\frac{1}{3}$ of it had decayed is :

(1) 7 min (2) 14 min (3) 20 min (4) 28 min

Q.60 **Statement-1**

A nucleus having energy E_1 decays by β^- emission to daughter nucleus having energy E but β^- rays emitted with a continuous energy spectrum having end point energy $E_1 - E_2$.

Statement-2

To conserve energy and momentum in β-decay at least three particles must take part in the transformation.

(1) Statement-1 is correct but statement-2 is not correct

(2) Statement-1 and statement-2 both are correct and statement-2 is the correct explanation of statement-1

(3) Statement-1 is correct, statement-2 is correct and statement-2 is not the correct explanation of statemet-1

(4) Statement-1 is incorrect, statement-2 is correct.

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 10

These questions of two statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.
(A) If both Assertion & Reason are true & the Reason is a correct explanation of the Assertion.
(B) If both Assertion and Reason are true but Reason is not a correct explanation of the Assertion.
(C) If Assertion is true but the Reason is false.
(D) If Assertion & Reason both are false.

Q.1 **Assertion :** Speed of radioactive α-rays is a characteristic property.
Reason : Speed of α-rays depends upon the kind of the nucleus.
(1) A (2) B (3) C (4) D

Q.2 **Assertion :** Nucleus may emit negative charged particles.
Reason : Nucleus contains negative charge also.
(1) A (2) B (3) C (4) D

Q.3 **Assertion :** $^{22}_{11}\mathrm{Na}$ emits a positron giving $^{22}_{12}\mathrm{Mg}$.
Reason : In β^+ emission neutron is transformed into proton.
(1) A (2) B (3) C (4) D

Q.4 **Assertion :** Neutrons penetrate matter more readily as compared to protons.
Reason : Neutrons slightly more massive than protons.
(1) A (2) B (3) C (4) D

Q.5 **Assertion :** Radioactive nuclei emit β^- particles.
Reason : Electrons exist inside the nucleus.
(1) A (2) B (3) C (4) D

Q.6 **Assertion :** $_ZX^A$ undergoes 2α-decays, 2β-decays and 2γ-decays and the daughter product is $_{Z-2}Y^{A-8}$.
Reason : In α-decay, the mass number decreases by 4 and atomic number decreases by 2. In β-decay, the mass number remains unchanged, but atomic number increases by 1 only.
(1) A (2) B (3) C (4) D

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 11

Q.1 Photoelectric effect was discovered by -
(1) Hallwachs (2) Einstein
(3) Planck (4) Bohr

Q.2 Photoelectric effect was explained by -
(1) Newton (2) Einstein
(3) Planck (4) Bohr

Q.3 A surface ejects electrons when illuminated by blue light but none with green light. Then photo emission is possible by light of which of the following colours -
(1) violet (2) red
(3) yellow (4) infra-red

Q.4 Dual nature of radiation is shown by -
(1) diffraction and reflection
(2) refraction and diffraction
(3) photo-electric effect alone
(4) photo electric effect and diffraction

Q.5 If the work-function of the metal is ϕ and the frequency of incident light is ν, there is no emission of photoelectrons when -
(1) $\nu < (\phi/h)$ (2) $\nu = (\phi/h)$
(3) $\nu > (\phi/h)$ (4) $\nu \geq (\phi/h)$

Q.6 In photoelectric equation $h\nu = h\nu_0 + \frac{1}{2}mv^2$ of Einstein which classical law is followed -
(1) conservation of momentum (2) conservation of energy
(3) conservation of charge (4) conservation of mass

Q.7 In photoelectric effect, emitted electrons are -
(1) those which are moving in a shell near to the nucleus
(2) those which are present in the nucleus
(3) those which are moving freely in the inter atomic distance
(4) those which are produced from neutron disintegration

Q.8 The work-function of a photo-electric material is 3.3 eV. The threshold frequency will be equal to
(1) 8×10^{14} Hz (2) 5×10^{36} Hz
(3) 8×10^{10} Hz (4) 4×10^{11} Hz

Q.9 Photo electrons emitted from the surface of sodium metal are -
(1) of equal frequency
(2) of equal kinetic energy
(3) of equal De-Broglie's wavelength
(4) having velocities which changes from zero to a fixed maximum value

Q.10 The photoelectric effect can not be explained by the wave theory of light because -
(1) the energy carried by the light waves is not given to a particular electron of the metal, rather it is distributed among all the electrons present on the surface of metal
(2) waves do not have energy
(3) energy of the waves becomes zero as it strikes the metal surface

(4) waves do not have sufficient energy which is required for electron emission

Q.11 Which of the following statement is wrong ?
(1) photoelectric current depends on intensity
(2) the maximum kinetic energy of emitted electrons can be equal to eV_s where V_s is stopping potential
(3) at stopping potential on increasing the intensity of light photoelectric current increases
(4) the maximum energy of photoelectron does not depend on the intensity of light

Q.12 Energy of a photon is 20eV then its momentum is -
(1) 5.33×10^{-27} kg-m/sec
(2) 10.66×10^{-25} kg-m/sec
(3) 10.66×10^{-27} kg-m/sec
(4) 5.33×10^{-30} kg-m/sec

Q.13 Two photons of 2.5eV are incident on the surface of metal. If the work functions of metal is 4.5 eV then from surface -
(1) one electron is emitted
(2) two electron are emitted
(3) no electron is emitted
(4) more than two electrons are emitted

Q.14 Photocell is a device to -
(1) store photons
(2) measure light intensity
(3) convert photon energy into electrical energy
(4) store electrical energy for replacing storage batteries

Q.15 Light of frequency 1.5 times the threshold frequency is incident on photo-sensitive material. If the frequency is halved and intensity is doubled, the photo-current becomes -
(1) quadrupled
(2) doubled
(3) halved
(4) zero

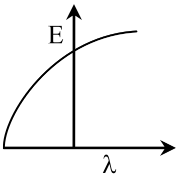
Q.16 Let n_r and n_b be respectively the number of photons emitted by a red bulb and a blue bulb of equal power in a given time -
(1) $n_r = n_b$
(2) $n_r < n_b$
(3) $n_r > n_b$
(4) the information is insufficient to get a relation between n_r and n_b

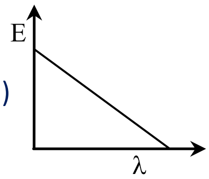
Q.17 Four elements A, B, C, D have work function 2, 2.4, 2.8, 3.2 eV. Light of wavelength 4000 Å is incident on them. The elements which emit photo electrons are -
(1) A, B, C, D
(2) A, B, C
(3) A, B
(4) A

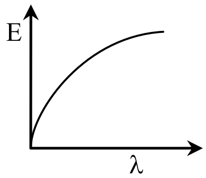
Q.18 The equation E = pc is valid -
(1) for an electron as well as for photon
(2) for an electron but not for a photon

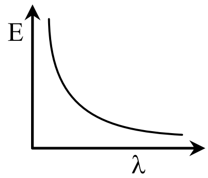
(3) for a photon but not for an electron
(4) neither for an electron nor for a photon

Q.19 The graph between the energy of photoelectrons (E) and the wavelength of incident light (λ) is -

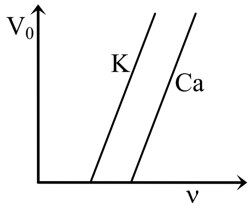
(1)


(2)


(3)


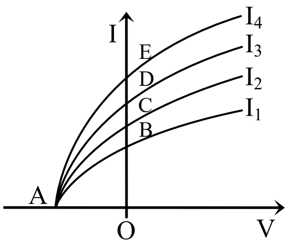
(4)


Q.20 In the diagram, graph are drawn between stopping potential V_0 and frequency ν for the elements K and Ca. According this to diagram-



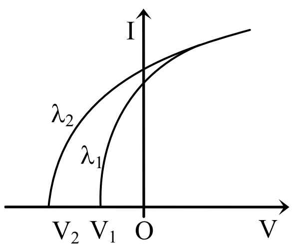
(1) the work functions of K and Ca are equal
(2) the work function of K is greater than that of Ca
(3) the work function of K is less than that of Ca
(4) no information can be obtained about the work function

Q.21 In the following figure the curves have been drawn between the photoelectric current and the potential difference applied at the cathode with respect to anode at four different intensities, the stopping potential is represented by -



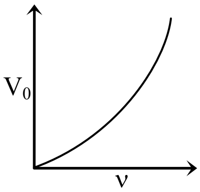
(1) OA (2) OB
(3) OC (4) OD

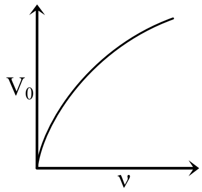
Q.22 In the given diagram if V represent the stopping potential and wavelength of incident light is λ. If $V_2 > V_1$ then -

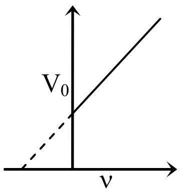


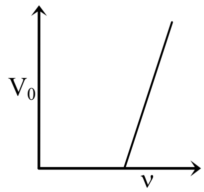
(1) $\lambda_1 = \lambda_2$ (2) $\lambda_1 > \lambda_2$
(3) $\lambda_1 < \lambda_2$ (4) none of these

Q.23 For a photoelectric cell, the graph showing the variation of cut off voltage (V_0) with frequency (ν) of incident light is -

(i)


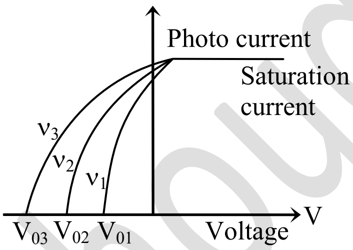
(ii)


(iii)


(iv)


(1) (i) (2) (ii) (3) (iii) (4) (iv)

Q.24 Photoelectric current as a function of voltage V for different light frequencies is shown here. Then the correct relation is -



(1) $\nu_1 = \nu_2 = \nu_2$ (2) $\nu_1 > \nu_2 > \nu_3$
(3) $\nu_1 < \nu_2 < \nu_3$ (4) none of the above

Q.25 The graph between the frequency of incident light and the stopping potential is -
(1) parabolic
(2) elliptical
(3) a straight line passing through origin
(4) a straight line not passing through the origin

Q.26 The graph between the stopping potential V_0 and frequency (n) of incident photons for photocell is a straight line with a slope -
(1) h (2) eh (3) e/h (4) h/e

Q.27 The work function of a metal is 1 eV. On making light of wavelength 3000Å incident on this metal, the velocity of photoelectrons emitted from the metal, in m/s will be -
(1) 10^2 (2) 10^3 (3) 10^6 (4) 10^4

Q.28 The threshold wavelength for photoelectric emission in tungsten is 230 nm. What wavelength of light must be used in order for electrons to be ejected with a maximum kinetic energy 1.5 eV ?
(1) 179 nm (2) 180 nm
(3) 169 nm (4) 170 nm

Q.29 If the wavelength of incident light decreases from λ_1 to λ_2 in photoelectric cell then corresponding charges in stopping potential will be -
(1) an increase of (hc/e) $(1/\lambda_2 - 1/\lambda_1)$
(2) a decrease of (hc/e) $(1/\lambda_2 - 1/\lambda_1)$

(3) an increase of (hc) $(1/\lambda_2 - 1/\lambda_1)$
(4) a decrease of (hc) $(1/\lambda_2 - 1/\lambda_1)$

Q.30 The retarding potential for having zero photoelectron current -
(1) Is proportional to the wavelength of incident light
(2) Increases uniformly with the increase in the wavelength of incident light
(3) Increases uniformly with the increase in the frequency of incident light wave
(4) Is proportional to the frequency of incident light

Q.31 In photoelectric effect work function of any metal is 2.5 eV. Emitted electrons are stopped by the potential of –1.5 volt then -
(1) energy of incident photons is 4 eV
(2) energy of incident photons is 1 eV
(3) photoelectric current increases when we use photons of high frequency
(4) none of the above

Q.32 If the wavelength of incident light changes from 4000 Å to 3600 Å, change in stopping potential will be -
(1) + 0.35V (2) –0.35 V
(3) + 0.40V (4) –0.40V

Q.33 Silver has a work function of 4.7 eV. When ultraviolet light of wavelength 100 nm is incident upon it, a potential of 7.7 volt is required to stop the photoelectrons from reaching the collector plate. The potential required to stop photo electrons when light of wavelength 200 nm is incident upon silver is -
(1) 1.5 V (2) 1.85 V
(3) 1.95 V (4) 2.37 V

Q.34 The K.E. of the photoelectrons is E when the incident wavelength is $\lambda/2$. The K.E. becomes 2E when the incident wavelength is $\lambda/3$. The work function of the metal is -
(1) $\frac{hc}{\lambda}$ (2) $\frac{2hc}{\lambda}$
(3) $\frac{3hc}{\lambda}$ (4) $\frac{hc}{3\lambda}$

Q.35 Electrons of 0.5 eV energy are emitted from a metal surface when photons of wavelength 3000Å are incident. The energy of electrons, when photons of 2000Å are incident will be -
(1) equal to 0.5 eV (2) higher then 0.5 eV
(3) less then 0.5 eV (4) none of the above

Q.36 If the frequency of light in a photoelectric experiment is doubled, the stopping potential will -
(1) be doubled
(2) be halved
(3) become more than double
(4) become less than double

Q.37 The stopping potential for photo electrons does not depend on -
(1) the intensity of incident light
(2) the nature of stopping electrode
(3) distance between photo cathode and the stopping electrode
(4) all of the above

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 12

Q.1 A freshly cleaned zinc plate is connected to the top of a positively charged gold leaf electroscope. If the plate is now illuminated with ultraviolet radiation, then -
(1) the separation between gold leaves increase
(2) the separation between gold leaves decreases
(3) nothing happens
(4) sparking between leaves occur

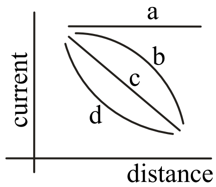
Q.2 What is the maximum K.E. with which electrons are released if the photoelectric current stops when the collecting wire in the photo cell is one volt negative with respect to the emitting metal ?
(1) 1 joule (2) 1.6×10^{-19} joule
(3) 1 erg (4) 1×10^{-7} erg

Q.3 The threshold frequency for a certain metal is ν_0. When frequency of incident radiation is $2\nu_0$, the maximum velocity of photoelectrons is 3×10^6 ms^{-1}. If the frequency of incident radiation is increased to $10\nu_0$, then the maximum velocity of photoelectrons will be -
(1) 3×10^6 ms^{-1} (2) 6×10^6 ms^{-1}
(3) 9×10^6 ms^{-1} (4) 12×10^6 ms^{-1}

Q.4 The frequency and intensity of a light source are both doubled. consider the following statements -
(i) The saturation photocurrent remains almost the same
(ii) The maximum kinetic energy of the photoelectrons is doubled
(1) both (i) and (ii) are true
(2) (i) is true but (ii) is false
(3) (i) is false but (ii) is true
(4) Both (i) and (ii) are false

Q.5 Two radiations containing photons of energy twice and five times the work function of a metal are incident successively on the metal surface. The ratio of the maximum velocities of the emitted electrons in the two cases will be -
(1) 1 : 3
(2) 1 : 4
(3) 1 : 2
(4) 1 : 1

Q.6 A point source causes photoelectric effect from a small metal plate. Which of the following curves may represent the saturation photocurrent as a function of the distance between the source and the metal ?

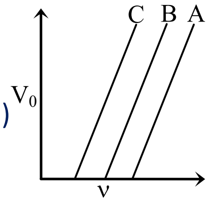


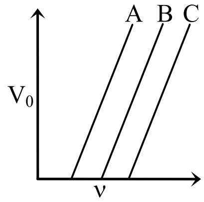
(1) a (2) b (3) c (4) d

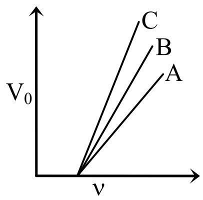
Q.7 For a certain metal ν is twice ν_0 & electrons come out with a maximum velocity of 4×10^8 cm/sec. If the value of ν is $5\nu_0$ the maximum velocity of the photoelectrons in cm/sec will be -

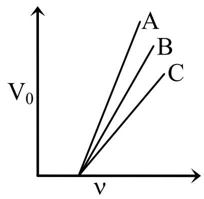
(1) $\frac{4}{5} \times 10^8$ (2) 2×10^7
(3) 8×10^8 (4) 20×10^8

Q.8 The work functions for three different metals A,B,C, are W_A,W_B and W_C respectively with $W_A > W_B > W_C$. The graphs between stopping potential (v_0) and frequency (ν) for them would look like -

(1)


(2)


(3)


(4)


Q.9 Light from a hydrogen discharge tube is incident on the cathode of a photoelectric cell. The work function of the cathode surface is 4.2 eV. In order to reduce the photocurrent to zero, the voltage of the anode relative to the cathode must be made -
(1) –4.2 V (2) –9.4 V
(3) –17.8 V (4) +9.4 V

Q.10 A nonmonochromatic light is used in an experiment on photoelectric effect. The stopping potential
(1) is related to the mean wavelength
(2) is related to the longest wavelength
(3) is related to the shortest wavelength
(4) is not related to the wavelength

Q.11 Tick the incorrect statement -
(1) One photon of incident light when absorbed, one electron is ejected out of metal surface
(2) The number of electrons emitted in photoelectric effect must be equal to the number of photons falling on the surface
(3) Work function of different metals is different
(4) The photoelectric effect is explained on the basis of quantum theory of radiation.

Q.12 When stopping potential is applied in an experiment on photoelectric effect, no photocurrent is observed. This means that -
(1) the emission of photoelectrons is stopped
(2) the photoelectrons are emitted but are reabsorbed by the emitter metal
(3) the photoelectrons are accumulated near the collector plate
(4) the photoelectrons are dispersed from the sides of the apparatus

Q.13 When the intensity of a light source is increased -
(1) the number of photons emitted by the source in unit time increases
(2) the total energy of the photons emitted per unit time increases
(3) more energetic photons are emitted
(4) faster photons are emitted
(1) a,b (2) a,c (3) a,d (4) b,d

Q.14 The cathode of a photoelectric cell is changed such that the work function changes from W_1 to W_2 ($W_2 > W_1$). If the current before and after changes are I_1 and I_2 all other conditions remaining unchanged, then (assuming $h\nu > W_2$) -

(1) $I_1 = I_2$ (2) $I_1 < I_2$
(3) $I_1 > I_2$ (4) $I_1 < I_2 < 2I_1$

Q.15 A photon of energy $h\nu$ is absorbed by a free electron of a metal having work function $\phi < h\nu$ -

(1) The electron is sure to come out
(2) The electron is sure to come out with a kinetic energy $h\nu - \phi$
(3) Either the electron does not come out or it comes out with a kinetic energy $h\nu - \phi$
(4) It may come out with a kinetic energy less than $h\nu - \phi$

Q.16 Two identical metal plates show photoelectric effect. Light of wavelength λ_A falls on plate A and λ_B falls on plate B. $\lambda_A = 2\lambda_B$. The maximum K.E. of the photoelectrons are K_A and K_B respectively. Which one of the following is true ?

(1) $2K_A = K_B$ (2) $K_A = 2K_B$
(3) $K_A < K_B/2$(4) $K_A > 2K_B$

Q.17 Mark the wrong statement -

(1) One photon of frequency greater than the threshold may eject two photo electrons from a metal surface
(2) the number of photo electrons emitted from a metal surface is always equal to the number of photons of frequency above threshold falling on the metal surface
(3) Work function of a metal surface does not depend on surface impurities and temperature
(4) all of the above are wrong

Q.18 In a photoelectron experiment, the stopping potential for the photoelectrons is 2V for the incident light of wavelength 400 nm. If the incident light is changed to 300 nm, the cut off potential is -

(1) 2V (2) greater than 8/3 V
(3) 8/3 V (4) zero

Q.19 A parallel beam of monochromatic light of wavelength 663 nm is incident on a totally reflecting plane mirror. The angle of incidence is 60° and the number of photons striking the mirror per second is 1×10^{19}. The force exerted by the light beam on the mirror will be -

(1) 1×10^{-6} N (2) 1×10^{-7} N
(3) 1×10^{-8} N (4) 1×10^{-9} N

Q.20 Light of wavelength 5000 Å and intensity 3.98 mW/cm^2 is incident on a light sensitive surface. If 1% photons of incident light cause emission of the photoelectrons, then how many electrons will be emitted from 1m^2 area of the surface in one second ?

(1) 10^{16} (2) 10^{18}
(3) 10^{20} (4) 10^{22}

Q.21 The electric field associated with a light wave is $E = E_0 \sin [1.57 \times 10^7 (x - ct)]$ where x is in metre and t is in second. If this light is used to produce photoelectric emission from the surface of a metal of work function 1.9 eV, then the stopping potential will be -

(1) 1.2 V (2) 1.5 V
(3) 1.75 V (4) 1.9 V

Q.22 When light of intensity 1 W/m^2 and wavelength 5×10^{-7} m is incident on a surface. It is completely absorbed by the surface. If 100 photons emit one electron and area of the surface is 1 cm^2, then the photoelectric current will be -

(1) 2m A (2) 0.4 μA
(3) 4.0 mA (4) 4 μA

Q.23 Photoelectrons of energy 2eV are emitted from a metal surface when photons of energy 5eV are incident on it. What will be the energy of emitted photoelectrons when photons of energy 6eV are incident on it ?

(1) 3eV (2) 4 eV
(3) 2 eV (4) 5 eV

Q.24 When a light source is placed at a distance of 1m from the emitter, it emits electrons of energy 4 eV. If the distance is changed to 0.5 m, then -

(1) the number of electrons emitted will be same but their energy will become double
(2) the number of electrons emitted will be same but their energy will become four times
(3) it will emit twice the number of electrons of same enrgy
(4) it will emit four times the number of electrons in earlier case with same energy

Q.25 If 5% of the energy supplied to a bulb is radiated as visible light, how many quanta are emitted per sec by a 100 watt lamp? Assume wavelength of visible light as 5.6×10^{-5} cm -

(1) 1.4×10^{19} (2) 2.0×10^{-4}
(3) 1.4×10^{-19} (4) 2.0×10^{4}

Q.26 The threshold wavelength of light ray emitting photoelectrons from a metal surface is 5800Å. If the wavelength of incident light is 4500Å, then the maximum kinetic energy of photoelectrons will be -

(1) 0.62 eV (2) 26 eV
(3) 62 eV (4) 0.26 eV

Q.27 The threshold wavelength of lithium is 8000Å. When light of wavelength 9000Å is made incident on it, then the photoelectrons -

(1) Will not be emitted
(2) Will be emitted
(3) Will sometimes be emitted and sometimes not
(4) Nothing can be said

Q.28 The work function of Na metal is 2.3 eV, then the threshold wavelength lies in the following region of EM spectrum -

(1) Ultraviolet (2) X-ray
(3) Violet (4) Yellow

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 13

Q.1 Which of the following statement is correct-
(1) The current in a photocell decreases with increasing frequency of light
(2) The photocurrent is proportional to applied voltage
(3) The photocurrent increases with increasing intensity of light
(4) The stopping potential increases with increasing intensity of incident light

Q.2 If the light of wavelength λ is incident on metal surface, the ejected fastest electron has speed v. If the wavelength emitted electron will be-
(1) Smaller than $\sqrt{\frac{4}{3}}$ v
(2) Greater than $\sqrt{\frac{4}{3}}$ v
(3) 2 v
(4) Zero

Q.3 Work function of a metal surface is ϕ = 1.5eV. If a light of wavelength 5000 Å falls on it then the maximum K.E. of ejected electron will be-
(1) 1.2 eV (2) 0.98 eV
(3) 0.45 eV (4) 0 eV

Q.4 A light of amplitude A and wavelength λ is incident on a metallic surface, then saturation current flows is proportional to- (assume cut off wavelength = λ_0)
(1) A^2, if $\lambda > \lambda_0$ (2) A^2, if $\lambda < \lambda_0$
(3) A, if $\lambda > \lambda_0$ (4) A, if $\lambda < \lambda_0$

Q.5 Light of wavelength 3000 Å in photoelectric effect gives electron of maximum K.E. 0.5 eV. If wavelength change to 2000 Å then maximum K.E. of emitted electrons will be-
(1) Less than 0.5 eV
(2) 0.5 eV
(3) Greater than 0.5 eV
(4) PEE does not occurs

Q.6 By photo electric effect, Einstein proved-
(1) E = hν (2) KE = $\frac{1}{2}mv^2$
(3) E = mc^2 (4) E = $\frac{-Rhc^2}{n^2}$

Q.7 Which one among shows particle nature of light-
(1) P.E.E. (2) Interference
(3) Refraction (4) Polarization

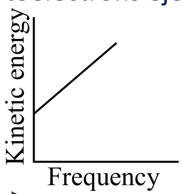
Q.8 A photo-cell is illuminated by a source of light, which is placed at a distance 'd' from the cell. If the distance become d/2, then number of electrons emitted per second will be-
(1) Remain same (2) Four times
(3) Two times (4) One-fourth

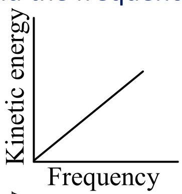
Q.9 The value of plank's constant is-
(1) 6.63×10^{-34} J/s
(2) 6.63×10^{-34} kg-m^2/s
(3) 6.63×10^{-34} kg-m^2
(4) 6.63×10^{-34} J-s

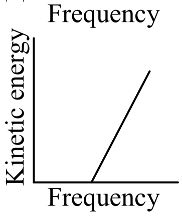
Q.10 When ultraviolet rays incident on metal plate then photoelectric effect does not occur, it occurs by incidence of-
(1) Infrared rays (2) X-rays
(3) Radio wave (4) Light wave

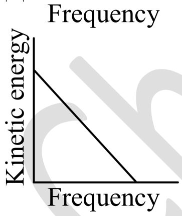
Q.11 A photoelectric cell is illuminated by a point source of light 1 m away. When the source is shifted to 2m then-
(1) each emitted electron carries one quarter of the initial energy
(2) number of electrons emitted is half the initial number
(3) each emitted electron carries half the initial energy
(4) number of electrons emitted is a quarter of the initial number

Q.12 According to Einstein's photoelectric equation, the graph between the kinetic energy of photoelectrons ejected and the frequency of incident radiation is-

(1) 

(2) 

(3) 

(4) 

Q.13 The work functions for metals A, B and C are respectively 1.92 eV, 2.0 eV and 5eV. According to Einstein's equation, the metals which will emit photo electrons for a radiation of wavelength 4100 Å is/are-
(1) None (2) A only
(3) A and B only (4) All the three metals

Q.14 A photosensitive metallic surface has work function, $h\nu_0$. If photons of energy $2h\nu_0$ fall on this surface, the electrons come out with a maximum velocity of 4×10^6 m/s. When the photon energy is increased to $5h\nu_0$, then maximum velocity of photo electrons will be-
(1) 2×10^7 m/s (2) 2×10^6 m/s
(3) 8×10^5 m/s (4) 8×10^6 m/s

Q.15 A photo-cell employs photoelectric effect to convert -
(1) Change in the frequency of light into a change in electric voltage
(2) Change in the intensity of illumination into a change in photoelectric current
(3) Change in the intensity of illumination into a change in the work function of the photocathode
(4) Change in the frequency of light into a change in the electric current

Q.16 When photons of energy $h\nu$ fall on an aluminium plate (of work function E_0), photoelectrons on maximum kinetic energy K are ejected. If the frequency of the radiation is doubled, the maximum kinetic energy of the ejected photoelectrons will be-
(1) $K + E_0$ (2) 2K

(3) K (4) K + hν

Q.17 The momentum of a photon of energy 1MeV in kg m/s, will be-
(1) 0.33×10^{6} (2) 7×10^{-24}
(3) 10^{-22} (4) 5×10^{-22}

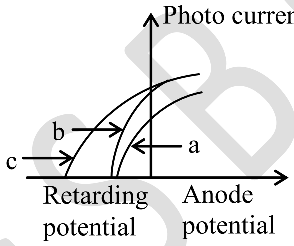
Q.18 A photon of energy 4 eV is incident on a metal surface whose work function is 2eV. The minimum reverse potential to be applied for stopping the emission of electrons is-
(1) 2V (2) 4V (3) 6V (4) 8V

Q.19 In photoelectric effect, the electrons are ejected from metals if the incident light has a certain minimum-
(1) wavelength (2) frequency
(3) amplitude (4) angle of incidence

Q.20 The number of photo electrons emitted for light of a frequency ν (higher than the threshold frequency ν_0) is proportional to-
(1) Frequency of light (ν)
(2) $\nu - \nu_0$
(3) threshold frequency (ν_0)
(4) intensity of light

Q.21 Monochromatic light of wavelength 667 nm is produced by a helium neon laser. The power emitted is 9 mW. The number of photons arriving per sec on the average at a target irradiated by this beam is-
(1) 3×10^{19} (2) 9×10^{17}
(3) 3×10^{16} (4) 9×10^{15}

Q.22 The figure shows a plot of photo current versus anode potential for a photo sensitive surface for three different radiations. Which one of the following is a correct statement ?



(1) curves (b) and (c) represent incident radiations of same frequency having same intensity
(2) curves (a) and (b) represent incident radiations of different frequencies and different intensities
(3) curves (a) and (b) represent incident radiations of same frequency but of different intensities
(4) curves (b) and (c) represent incident radiations of different frequencies and different intensities

Q.23 The mean free path of electrons in a metal is 4×10^{-8} m. The electric field which can give on an average 2eV energy to an electron in the metal will be in units of V/m -
(1) 5×10^{7} (2) 8×10^{7}
(3) 5×10^{-11} (4) 8×10^{-11}

Q.24 Particle nature and wave nature of electromagnetic waves and electrons can be represented by-
(1) photo electricity and electron microscopy
(2) light is refracted and diffracted
(3) X-rays is diffracted, reflected by thick metal sheet
(4) electrons have small mass, deflected by the metal sheet

Q.25 The surface of zone material is radiated in turn, by waves of λ = 350 nm and 540 nm respectively. The ratio of the stopping potential in the two cases is 2 : 1. The work function of the material is-
(1) 4.20 eV (2) 0.15 eV
(3) 2.10 eV (4) 1.05 eV

Q.26 Which one of the following does not support the wave nature of light ?
(1) Photoelectric effect (2) Interference
(3) Polarization (4) Diffraction

Q.27 Light of wavelength 4000 Å is incident on a metal plate whose work function is 2 eV. What is maximum kinetic energy of emitted photoelectron ?
(1) 0.5 eV (2) 1.1 eV
(3) 2.0 eV (4) 1.5 eV

Q.28 A photon of energy 4 eV is incident on a metal surface whose work function is 2 eV. The minimum reverse potential to be applied for stopping the emission of electrons is-
(1) 2 V (2) 4 V (3) 6 V (4) 8 V

Q.29 The pressure exerted by an electromagnetic wave of intensity I (watt/m^2) on a non-reflecting surface is-
[c is the velocity of light]
(1) Ic (2) Ic^2 (3) I/c (4) I/c^2

Q.30 Energy from the sun is received on earth at the rate of 2 cal per cm^2 per minute. If average wavelength of solar light be taken at 5500 Å then how many photons are received on the earth per cm^2 per minute ?
($h = 6.6 \times 10^{-34}$ Js, 1 cal = 4.2 J)
(1) 1.5×10^{13} (2) 2.9×10^{13}
(3) 2.3×10^{19} (4) 1.75×10^{19}

Q.31 In a photoemissive cell with executing wavelength λ, the fastest electron has speed v. If the exciting wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will be-
(1) $v(3/4)^{1/2}$ (2) $v\left(\frac{4}{3}\right)^{1/2}$
(3) less than $v\left(\frac{4}{3}\right)^{1/2}$ (4) greater than $v\left(\frac{4}{3}\right)^{1/2}$

Q.32 Einstein work on photoelectric effect gives support to -
(1) $E = mc^2$ (2) $E = h\nu$
(3) $h\nu = \frac{1}{2}mv^2$ (4) $E = \frac{h}{\lambda}$

Q.33 The work function of aluminium is 4.2 eV. If two photons each of energy 3.5 eV strike an electron of aluminium, then emission of electron will be-
(1) depended upon the density of the surface
(2) data is incomplete
(3) not possible
(4) possible

Q.34 The energy of an X-ray photon is 2 keV then the frequency is-
(1) 3.2×10^{-6} Hz (2) 5×10^{17} Hz

(3) 2×10^{17} Hz (4) 2×10^{18} Hz

Q.35 Which of the following waves have the maximum wavelength ?
(1) Infrared rays (2) UV-rays
(3) Radio waves (4) X-rays

Q.36 Photoelectric effect shows-
(1) wave nature of electrons
(2) particle nature of light
(3) both (1) and (2)
(4) none of the above

Q.37 According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photoelectrons from a metal versus the frequency of the incident radiation gives a straight line whose slope-
(1) depends on the intensity of the radiation
(2) depends on the nature of the metal used
(3) depends both on the intensity of the radiation and the metal used
(4) is the same for all metals and independent of the intensity of the radiation

Q.38 For photoelectric emission, tungsten requires light of 2300 Å. If light of 1800 Å wavelength is incident then emission-
(1) takes place
(2) doesn't take place
(3) may or may not take place
(4) depends on frequency

Q.39 The magnitude of saturation photoelectric current depends upon-
(1) frequency (2) intensity
(3) work function (4) stopping potential

Q.40 When light of wavelength 300 nm falls on a photoelectric emitter, photoelectrons are liberated. For another emitter, light of wavelength 600 nm is sufficient for liberating photoelectrons. The ratio of the work function of the two emitters is-
(1) 1 : 2 (2) 2 : 1
(3) 4 : 1 (4) 1 : 4

Q.41 The work function of a metallic substance is 5eV. The threshold frequency is approximately-
(1) 1.6×10^{7} Hz (2) 8.68×10^{15} Hz
(3) 9.68×10^{17} Hz (4) 1.2×10^{15} Hz

Q.42 A source S_1 is producing, 10^{15} photons per second of wavelength 5000 Å. Another source S_2 is producing 1.02×10^{15} photons per second of wavelength 5100 Å.
Then, (power of S_2)/(power of S_1) is equal to –
(1) 1.00 (2) 1.02 (3) 1.04 (4) 0.98

Q.43 The potential difference that must be applied to stop the fastest photo electrons emitted by a nickel surface, having work function 5.01 eV, when ultraviolet light of 200 nm falls on it, must be -
(1) 2.4 V (2) – 1.2 V
(3) – 2.4 V (4) 1.2 V

Q.44 When monochromatic radiation of intensity I falls on a metal surface, the number of photoelectron and their maximum kinetic energy are N and T respectively. If the intensity of

radiation is 2I, the number of emitted electrons and their maximum kinetic energy are respectively-
(1) 2N and T (2) 2N and 2T]
(3) N and T (4) N and 2T

Q.45 The electrons in the hydrogen atom jumps from excited state (n = 3) to its ground state (n = 1) and the photons thus emitted irradiate a photosensitive matieral. If the work function of the material is 5.1 eV, the stopping potential is estimated to be (the energy of the electron in n^{th} state $E_n = -\frac{13.6}{n^2}$ eV) –
(1) 12.1 V (2) 17.2 V
(3) 7 V (4) 5.1 V

Q.46 In photoelectric emission process from a metal of work function 1.8 eV, the kinetic energy of most energetic electrons is 0.5 eV. The corresponding stopping potential is :
(1) 2.3 V (2) 1.8 V
(3) 1.3 V (4) 0.5 V

Q.47 Light of two different frequencies whose photons have energies 1 eV and 2.5 eV respectively illuminate a metallic surface whose work function is 0.5 eV successively. Ratio of maximum speeds of emitted electrons will be :
(1) 1 : 5 (2) 1 : 4
(3) 1 : 2 (4) 1 : 1

Q.48 Photoelectric emission occurs only when the incident light has more than a certain minimum:
(1) frequency (2) power
(3) wavelength (4) intensity

Q.49 The threshold frequency for a photosensitive metal is 3.3×10^{14} Hz. If light of frequency 8.2×10^{14} Hz is incident on this metal, the cut-off voltage for the photoelectric emission is nearly :
(1) 1 V (2) 2 V (3) 3 V (4) 5 V

Q.50 An electron in the hydrogen atom jumps from excited state n to the ground state. The wavelength so emitted illuminates a photosensitive material having work function 2.75 eV. If the stopping potential of the photoelectron is 10V, then the value of n is :
(1) 2 (2) 3 (3) 4 (4) 5

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 14

Q.1 The slope of graph drawn between stopping potential and frequency of incident light for a given surface will be-
(1) h (2) h/e (3) eh (4) e

Q.2 When a point source of monochromatic light is at a distance of 0.2 m from a photoelectric cell, the cut-off voltage and the saturation current are 0.6 volt and 18 mA respectively. If the same source is placed 0.6 m away from the photoelectric cell, then-
(1) The stopping potential will be 0.2 V
(2) The stopping potential will be 0.6 V
(3) The saturation current will be 6 mA
(4) The saturation current will be 18 mA

Q.3 As the intensity of the given source increases-
(1) Photoelectric current increases
(2) Photoelectric current decreases
(3) Kinetic energy of emitted photoelectrons increases
(4) Kinetic energy of emitted photoelectrons decreases

Q.4 What is the momentum of a photon having frequency 1.5×10^{13} Hz-
(1) 3.3×10^{-29} kg m/s
(2) 3.3×10^{-34} kg m/s
(3) 6.6×10^{-34} kg m/s
(4) 6.6×10^{-30} kg m/s

Q.5 The energy of a photon of light of wavelength 450 nm is-
(1) 4.4×10^{-19} J (2) 2.5×10^{-19} J
(3) 1.25×10^{-17} J (4) 2.5×10^{-17} J

Q.6 What is the stopping potential when the metal of work function 0.6 eV is illuminated by the light of 2 eV -
(1) 2.6 V (2) 3.6 V (3) 0.8 V (4) 1.4 V

Q.7 The photoelectric threshold wavelength of a certain metal is 3000 Å. If the radiation of 2000Å is incident on the metal-
(1) Electrons will be emitted
(2) Positrons will be emitted
(3) Protons will be emitted
(4) Electrons will not be emitted

Q.8 A monochromatic source of 25 watt emit photons of wavelength 6000 Å then number of photons emitted per second are-
(1) 8.645×10^{17} (2) 6.143×10^{18}
(3) 3.762×10^{19} (4) 7.546×10^{19}

Q.9 Wavelength of emitted light from a monochromatic source is 6000 Å then energy of photon is-
(1) 1.5 eV (2) 2 eV (3) 2.5 eV (4) 3 eV

Q.10 Work function of silver is 5.75×10^{-18} Joule. Then threshold wavelength is-
(1) 736.7 Å (2) 760.7 Å
(3) 301 Å (4) 344.4 Å

Q.11 Light intensity depends on its-
(1) Amplitude (2) Frequency
(3) Wavelength (4) Velocity

Q.12 Quantum nature of light can be explained by-
(1) Photo electric effect (2) Interference
(3) Diffraction (4) Polarization

Q.13 Which of the following is true for photon-
(1) $E = \frac{hc}{\lambda}$ (2) $E = \frac{1}{2}mv^2$
(3) $P = \frac{E}{2V}$ (4) $E = \frac{1}{2}mc^2$

Q.14 Graph is plotted between maximum kinetic energy of electron with frequency of incident photon in photo electric effect. The slope of curve will be-
(1) Charge of electron
(2) Work function of metal
(3) Planck's constant
(4) Ratio of planck constant and charge of electron

Q.15 Photon of energy 6 eV is incident on a metal surface of work function 4 eV. Maximum K.E. of emitted photo electrons will be-
(1) 0 eV (2) 1 eV (3) 2 eV (4) 10 eV

Q.16 Light of frequency ν is incident on a metal of threshold frequency ν_0. Then work function of metal will be-
(1) $h\nu$ (2) $h\nu_0$
(3) $h(\nu - \nu_0)$ (4) $h(\nu + \nu_0)$

Q.17 A photoelectric cell is lightened by a light source, situated at a distance d from the cell. If distance becomes d/2 then number of electrons emitted per sec will be-
(1) Remains same (2) Four times
(3) Two times (4) One fourth

Q.18 The work function of a photo electric material is 3.3 eV. Its threshold frequency will be-
(1) 4×10^{23} Hz (2) 8×10^{12} Hz
(3) 4×10^{11} Hz (4) 8×10^{14} Hz

Q.19 Work function of a metal is 2 eV. The maximum wavelength of photons required to emit electrons from its surface is-
(1) 6200 Å (2) 6000 Å
(3) 5700 Å (4) 5900 Å

Q.20 The work function of a metal is-
(1) The energy for the electron to enter into the metal

(2) The energy for producing X-ray
(3) The energy for the electron to come out from metal surface
(4) None of these

Q.21 The number of photons emitted in one second by a 100 watt red light source, assuming for simplicity the average wavelength for each photon is 694 nm, is-
(1) 3.49×10^{20} (2) 4.49×10^{20}
(3) 3.49×10^{18} (4) 4.49×10^{18}

Q.22 Two separate monochromatic light beams A and B of the same intensity are falling normally on a unit area of a metallic surface. Their wavelength are λ_A and λ_B respectively. Assuming that all the incident light is used in ejecting the photoelectrons, the ratio of the number of photoelectrons from the beam A to that from B is-
(1) $(\lambda_A/\lambda_B)^2$
(2) λ_A/λ_B
(3) λ_B/λ_A
(4) 1

Q.23 Threshold wavelength for photoelectric emission from a metal surface is 5200 Å. Photoelectrons will be emitted when this surface is illuminated with monochromatic radiation from-
(1) 1 W IR lamp (2) 50 W UV lamp
(3) 50 W IR lamp (4) 10 W IR lamp

Q.24 According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photoelectrons from a metal v/s the frequency of the incident radiations gives a straight line whose slope-
(1) depends on the intensity of the radiation
(2) depends of the nature of the metal used
(3) depends both on the intensity of the radiation and the metal used
(4) is the same for all metals and independent of the intensity of the radiation

Q.25 If the energy of a photon corresponding to a wavelength of 6000 Å is 3.32×10^{-19} J, the photon energy for a wavelength of 4000 Å will be-
(1) 1.4 eV (2) 4.9 eV
(3) 3.1 eV (4) 1.6 eV

Q.26 Photons of energy 5.5 eV fall on the surface of the metal emitting photoelectrons of maximum kinetic energy 4.0 eV. The stopping voltage required for these electrons are-
(1) 5.5 V (2) 1.5 V
(3) 9.5 V (4) 4.0 V

Q.27 Momentum of photon of wavelength λ will be-
(1) $n\lambda$ (2) $\frac{h}{\lambda}$
(3) $\frac{\lambda}{h}$ (4) $\frac{h}{c\lambda}$

Q.28 Momentum of a particle is p and plank constant is h, then associated wavelength will be-

(1) $\frac{h}{p}$ (2) $\frac{p}{h}$
(3) h × p (4) None

Q.29 The work functions of potassium and sodium are 4.5eV and 2.3eV respectively. The approximate ratio of their threshold wavelength will be -
(1) 1 : 2 (2) 2 : 1 (3) 1 : 3 (4) 3 : 1

Q.30 Two identical photocathode receive light of frequencies f_1 and f_2 . If the velocities of the photo electrons (of mass m) coming out are respectively v_1 and v_2, then –

(1) $v_1 + v_2 = \left[\frac{2h}{m}(f_1 + f_2)\right]^{1/2}$

(2) $v_1^2 + v_2^2 = \frac{2h}{m}(f_1 + f_2)$

(3) $v_1 - v_2 = \left[\frac{2h}{m}(f_1 - f_2)\right]^{1/2}$

(4) $v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$

Q.31 A radiation of energy E falls normally on a perfectly reflecting surface. The momentum transferred to the surface is –
(1) E/c (2) 2E/c (3) E/c (4) E/c^2

Q.32 According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photo electrons from a metal **Vs** the frequency, of the incident radiation gives a straight line whose slope –
(1) depends both on the intensity of the radiation and the metal used
(2) depends on the intensity of the radiation
(3) depends on the nature of the metal used
(4) is the same for all metals and independent of the intensity of the radiation

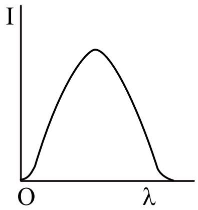
Q.33 The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately -
(1) 310 nm (2) 400 nm
(3) 540 nm (4) 220 nm

Q.34 A photocell is illuminated by a small bright source placed 1 m away. When the same source of light is placed 1/2 m away, the number of electrons emitted by photocathode would -
(1) decrease by a factor of 4
(2) increase by a factor of 4
(3) decrease by a factor of 2
(4) increase by a factor of 2

Q.35 The threshold frequency for a metallic surface corresponds to an energy of 6.2 eV and the stopping potential for a radiation incident on this surface is 5 V. The incident radiation lies in –
(1) visible region (2) X-ray region
(3) ultra-violet region (4) infra-red region

Q.36 The time taken by a photoelectron to come out after the photon strikes is approximately –
(1) 10^{-16} s (2) 10^{-1} s (3) 10^{-4} s (4) 10^{-10} s

Q.37 The anode voltage of a photocell is kept fixed. The wavelength λ of the light falling on the cathode is gradually changed. The plate current I of the photocell varies as follows –

(1)


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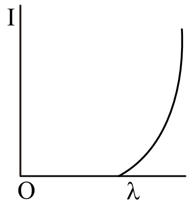

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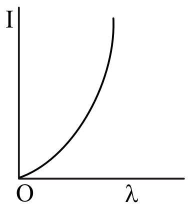
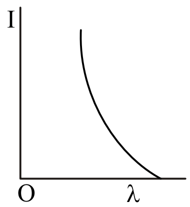


(4)


Q.38 The surface of a metal is illuminated with the light of 400 nm. The kinetic energy of the ejected photoelectrons was found to be 1.68 eV. The work function of the metal is –
(hc = 1240 eV. nm)
(1) 3.09 eV (2) 1.41 eV
(3) 1.51 eV (4) 1.68 eV

Q.39 **Statement- 1:** When ultraviolet light is incident on a photocell, its stopping potential is V_0 and the maximum kinetic energy of the photoelectrons is K_{max}. When the ultraviolet light is replaced by X-rays, both V_0 and K_{max} increase.
Statement – 2 : Photoelectrons are emitted with speeds ranging from zero to a maximum value because the range of frequencies present in the incident light.
(1) Statement-1 is true, Statement-2 is false.
(2) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1
(3) Statement-1 is true, Statement-2 is true; Statement-2 is ***not*** the correct explanation of Statement-1.
(4) Statement-1 is false, Statement-2 is true.

Q.40 When a monochromatic point source of light is at a distance of 0.2 m from a photoelectric cell, the cut off voltage and the saturation current are respectively 0.6 volt and 18.0 mA. If the same source is placed 0.6 m away from the photoelectric cell, then -
(1) the stopping potential will be 0.1 volt
(2) the stopping potential will be 0.6 volt
(3) the saturation current will be 6.0 mA
(4) the saturation current will be 2.0 mA

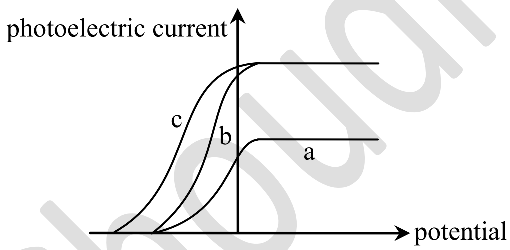
Q.41 When photons of energy 4.25 eV strike the surface of a metal A, the ejected photoelectrons have maximum kinetic energy, T_A (expressed in eV) and de Broglie wavelength λ_A. The maximum kinetic

energy of photoelectrons liberated from another metal B by photons of energy 4.70 eV is T_B = (T_A – 1.50 eV). If the de Broglie wavelength of these photoelectrons is $\lambda_B = 2\lambda_A$, then -
(1) the work function of A is 2.25 eV
(2) the work function of B is 4.20 eV
(3) T_A = 2.00 eV
(4) All of these

Q.42 The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6 eV fall on it is 4 eV. The stopping potential in volts is -
(1) 2 (2) 4 (3) 6 (4) 10

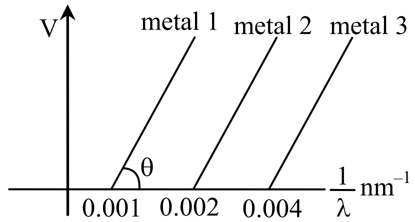
Q.43 The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photo electron emission from this substance is approximately -
(1) 540 nm (2) 400 nm
(3) 310 nm (4) 220 nm

Q.44 In photoelectric experiment the plot between anode potential and photoelectric current is shown photoelectric current. Which of the following is correct ?



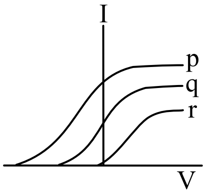
(1) Frequency of light corresponding to "a" is same as that of "b" and intensity corresponding to "b" is the same that corresponding to "c"
(2) Frequency of light corresponding to "a" is different from "b" & intensities are the same
(3) Frequency corresponding to "b" is same as that of "c", but intensities are different
(4) Frequency corresponding to "b" is different from that of "c", but intensities are different

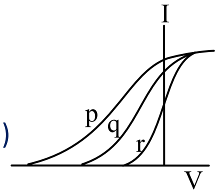
Q.45 The graph between $\frac{1}{\lambda}$ and stopping potential (V) of three metal having work functions ϕ_1, ϕ_2 and ϕ_3 in an experiment of photo electric effect is plotted as shown in the figure which of the following statement(s) is/are correct ?
(λ represents wavelength of the incident ray.)



(1) Ratio of work functions $\phi_1 : \phi_2 : \phi_3$ = 1: 2 : 4
(2) Ratio of work functions $\phi_1 : \phi_2 : \phi_3$ = 4:2 : 1
(3) tan θ is directly proportional to hc/e, where h is plank's constant and c is the speed of light
(4) the violet color can eject photoelectrons from metal 2 & 3

Q.46 Photoelectric effect experiments are performed using three different metal plates p, q and r having work functions ϕ_p = 2.0 eV, ϕ_q = 2.5 eV and ϕ_r = 3.0 eV, respectively. A light beam containing wavelengths of 550 nm, 450 nm and 350 nm with equal intensities illuminates each of the plates. The correct I-V graph for the experiment is : [Take hc = 1240 eV nm]

(1)


(2)


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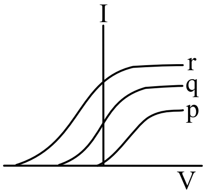

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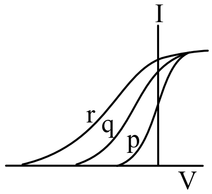


Q.47 This question has Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.

Statement – 1 :

A metallic surface is irradiated by a monochromatic light of frequency $\nu > \nu_0$ (the threshold frequency). The maximum kinetic energy and the stopping potential are K_{max} and V_0 respectively. If the frequency incident on the surface is doubled, both the K_{max} and V_0 are also doubled.

Statement -2 :

The maximum kinetic energy and the stopping potential of photoelectrons emitted from a surface are linearly dependent on the frequency of incident light.

(1) Statement -1 is true, Statement -2 is false

(2) Statement -1 is true, Statement -2 is true and Statement -2 is the correct explanation for Statement -1.

(3) Statement -1 is true, Statement -2 is true and Statement -2 is the correct explanation of Statement -1.

(4) Statement -1 is false, Statement -2 is true.

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 15

These questions of two statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.

(A) If both Assertion & Reason are true & the Reason is a correct explanation of the Assertion.

(B) If both Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

(C) If Assertion is true but the Reason is false.

(D) If Assertion & Reason both are false.

Q.1 **Assertion :** Photoelectric effect demonstrates the wave nature of light.
Reason : The number of photo electrons is proportional to the frequency of light.
(1) A (2) B (3) C (4) D

Q.2 **Assertion :** At saturation, photoelectric current is maximum.
Reason : At saturation, all the electrons emitted from cathode are able to reach at anode.
(1) A (2) B (3) C (4) D

Q.3 **Assertion :** In photoelectric effect, at stopping potential emission of photoelectrons is stopped.
Reason : Increase in intensity of given light increases the kinetic energy of photoelectron.
(1) A (2) B (3) C (4) D

Q.4 **Assertion :** Work function of a metal is 8 eV. Two photons each having energy 5 eV can't eject the electron from the metal.
Reason : More than one photon can't collide simultaneously with an electron.
(1) A (2) B (3) C (4) D

Q.5 **Assertion :** Photo electric current increases if the distance between cathode and anode is increased.
Reason : Momentum of photon is directly proportional to its wavelength.
(1) A (2) B (3) C (4) D

Q.6 **Assertion :** A photon is not a material particle. It is a quanta of energy.
Reason : Photoelectric effect demonstrate wave nature of radiation.
(1) A (2) B (3) C (4) D

Q.7 **Assertion :** The energy (E) and momentum (p) of a photon are related by $p = E/c$.
Reason : The photon behaves like a particle.
(1) A (2) B (3) C (4) D

Q.8 **Assertion :** The photoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies.
Reason : The work function of the metal varies as a function of depth from the surface.
(1) A (2) B (3) C (4) D

Q.9 **Assertion :** Kinetic energy of photoelectrons emitted by a photosensitive surface depends upon the intensity of incident photon.
Reason : The ejection of electrons from metallic surface is possible with frequency of incident photon below the threshold frequency.
(1) A (2) B (3) C (4) D

Q.10 **Assertion :** If the speed of charged particle increases both the mass as well as charge increases.
Reason : If m_0 = rest mass and m be mass at velocity v then $m = \frac{m_0}{\sqrt{1+\frac{v^2}{c^2}}}$
where c = speed of light.
(1) A (2) B (3) C (4) D

Q.11 **Assertion :** Mass of moving photon varies inversely as the wavelength.
Reason : Energy of the particle = mass × $(\text{speed of light})^2$
(1) A (2) B (3) C (4) D

Q.12 **Assertion :** Photoelectric emission is an instantaneous process.
Reason : There is no time lag between incidence of light and emission of photoelectron.
(1) A (2) B (3) C (4) D

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 16

Q.1 If the value of Planck's constant is more than its present value then the De-Broglie wavelength associated with a material particle will be -
(1) more
(2) less
(3) same
(4) more for light particles and less for heavy particles

Q.2 A moving car of 2000 kg mass and velocity of 30 m/sec has associated de-Broglie wavelength given is -
(1) 10^{-38}m (2) 6.62×10^{-34} m
(3) 1.1×10^{-38}m (4) 1.1×10^{-38}cm

Q.3 A particle of rest mass m_0 moves with a speed c. The de-Broglie wavelength associated with it will be -
(1) zero (2) infinite
(3) $\frac{h}{m_0 c}$ (4) $\frac{m_0 c}{h}$

Q.4 The wave associated with each moving material particle are -
(1) probability waves
(2) mechanical waves
(3) electromagnetic waves
(4) imaginary waves

Q.5 The wave nature of electron was verified by -
(1) photoelectric effect
(2) Compton effect
(3) the incidence of electron on metallic surface
(4) diffraction of electron by crystal

Q.6 The waves associated with electrons revolving in various Bohr orbits in an atom are -
(1) transverse (2) longitudinal
(3) progressive (4) stationary

Q.7 The mass of a particle is m kg. If mass is increased nine times keeping its energy constant, then the de-Broglie wavelength associated with it will
(1) Remain unchanged
(2) become half
(3) become one third
(4) become nine times

Q.8 The velocity at which the mass of a particle becomes twice its rest mass, will be -

(1) $\frac{2c}{3}$ (2) $\frac{c}{2}$ (3) $\frac{c\sqrt{3}}{2}$ (4) $\frac{3c}{4}$

Q.9 The mass of electron varies with -
(1) Electron velocity
(2) The size of cathode ray tube
(3) Variation of g
(4) The size of electron

Q.10 If E and p are the respective energy and momentum of a photon, then on reducing the wavelength of the photon,
(1) both p and E will decrease
(2) both p and E will increase
(3) p will increase but E will decrease
(4) p will decrease but E will increase

Q.11 The momentum of photon of energy 1 MeV will approximately be -
(1) 10^{-22} Kg-m/s
(2) 5×10^{-22} Kg-m/s
(3) 3×10^{6} Kg-m/s
(4) 0

Q.12 The frequency of a photon of momentum p will be -
(1) $\frac{pc}{h}$ (2) $\frac{ph}{c}$ (3) $\frac{mh}{c}$ (4) $\frac{mc}{h}$

Q.13 If the energy of a photon of light of frequency ν is E and its momentum is P, then the velocity of light is –
(1) EP (2) E/P
(3) P/E (4) 1/EP

Q.14 The momentum of photon of wavelength 0.01 Å will be -
(1) h (2) 10^{-2} h
(3) 10^{12} h (4) 10^{2} h

Q.15 The energy of a photon (in eV) of wavelength 5000 Å will be -
(1) 2.48 eV (2) 8.42 eV
(3) zero (4) 4.82 eV

Q.16 The wavelength of a photon of momentum 6.6×10^{-24} Kg-m/s will be -
(1) 10 Å (2) 1 Å (3) 100 Å (4) 1000 Å

Q.17 The momentum of photon of frequency 10^{9} Hz will be -
(1) 31 Kg m/s (2) 7.3×10^{-28} Kg-m/s
(3) 2.2×10^{-33} Kg-m/s (4) 6.6×10^{-26} kg-m/s

Q.18 Through what potential difference should an electron be accelerated so that its de Broglie wavelength become 0.4 Å –
(1) 9410 V (2) 94.10 V
(3) 9.140 V (4) 941.0 V

Q.19 The energy of an α-particle, whose de-Broglie wavelength is 0.004 Å will be -
(1) 1270 eV (2) 1200 KeV
(3) 1200 MeV (4) 1200 GeV

Q.20 The study of diffraction of electrons from a target, gives the wavelength associated as 0.65Å. The energy of the electrons will be -
(1) 40eV (2) 100 eV
(3) 356 eV (4) 1000 eV

Q.21 The energies of an photon and an electron of mass m are same. The ratio of wavelengths associated with them will be -
(1) c $\sqrt{E/2m}$ (2) $\sqrt{2mc/E}$
(3) c $\sqrt{2m/E}$ (4) $\sqrt{E/2mc}$

Q.22 Two particles of mass m_1 and m_2 respectively are identically charged and are accelerated by same potential. If de-Broglie wavelength associated with them are λ_1 and λ_2 then -
(1) $\frac{\lambda_1}{\lambda_2} = \frac{m_2}{m_1}$ (2) $\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_2}{m_1}}$
(3) $\frac{\lambda_1}{\lambda_2} = \frac{m_1}{m_2}$ (4) $\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_1}{m_2}}$

Q.23 An electron is 2000 times lighter than a proton. An electron and a proton are moving with such a velocity that de-Broglie wave associated with them is 1Å. The ratio of their K.E. will be -
(1) 1 : 2000 (2) 2000 : 1
(3) 1 : 1 (4) 1 : (4.0106)

Q.24 A double slit interference experiment is performed by a beam of electrons of energy 100 eV and the fringe spacing is observed to be β. Now if the electrons energy is increased to 10 keV, then the fringe spacing -
(1) remains the same (2) becomes 10β
(3) becomes 100β (4) becomes β/10

Q.25 An electron beam of energy 10 keV is passed through a slit of width 1 mm. The observed phenomenon will be -
(1) interference
(2) diffraction
(3) rectilinear propagation
(4) polarisation

Q.26 If E_1, E_2 and E_3 are the respective kinetic energies of an electron, an alpha particle and a proton, each having the same de Broglie wavelength, then -
(1) $E_1 > E_3 > E_2$ (2) $E_2 > E_3 > E_1$
(3) $E_1 > E_2 > E_3$ (4) $E_1 = E_2 = E_3$

Q.27 The de-Broglie wavelength of a particle of mass m and charge e, accelerated through potential V will be -
(1) h/ $\sqrt{2meV}$ (2) $\sqrt{hmeV}$
(3) m/ $\sqrt{2heV}$ (4) None of the above

Q.28 The electron of a H-atom moves in n^{th} orbit. If the length of the orbit is L and de-Broglie wavelength is λ, then the relation between them is -

(1) $L = \lambda/n$ (2) $\lambda = n/L$
(3) $L = n\lambda$ (4) $L = nh\lambda$

Q.29 If the momentum of electron is changed by P_m then the De Broglie wavelength associated with it changes by 0.50 % . The initial momentum of electron will be -
(1) $\frac{P_m}{200}$ (2) $\frac{P_m}{100}$
(3) 200 P_m (4) 400 P_m

Q.30 When the momentum of a proton is changed by an amount P_0, the corresponding change in the de-Broglie wavelength is found to be 0.25%. Then the original momentum of the proton was -
(1) P_0 (2) 100 P_0
(3) 400 P_0 (4) 4 P_0

Q.31 The thermal energy of a particle at temperature TºK is kT, then the associated de-Broglie wavelength will be -
(1) h/mkT (2) $\frac{h}{\sqrt{2mkT}}$
(3) $\frac{h}{2mkT}$ (4) $\frac{2h}{mkT}$

Q.32 The average thermal energy of neutrons each of mass m at temperature T kelvin is (3/2) kT. Then the de-Broglie wavelength of neutrons corresponding to this energy is -
(1) $h / \sqrt{3mkT}$ (2) $\sqrt{3mkT}$ /h
(3) $h/ \sqrt{2mkT}$ (4) none of the above

Q.33 The de Broglie wavelength associated with a nitrogen molecule at atmospheric pressure and temperature 27ºC will be nearly -
(1) 0.1 Å (2) 0.2 Å
(3) 0.3 Å (4) 0.4 Å

Q.34 What potential must be applied on an electron microscope so that it may produce an electron of wavelength 1 A° ?
(1) 50 V (2) 100 V
(3) 150.5 V (4) 200 V

Q.35 The potential in an electron microscope is increased from 30KV to 90KV. If the initial resolving power of the microscope is R, then its new resolving power will be -
(1) R (2) 2R
(3) $\sqrt{3}$ R (4) $\sqrt{5}$ R

Q.36 On which of the following principles electron microscope is based ?
(1) the particle concept
(2) the concept of matter waves
(3) the uncertainty principle
(4) all of the above

Q.37 Wrong statement in connection with Davisson-Germer experiment is -
(1) The inter-atomic distance in nickel crystal is of the order of the de-Broglie wavelength
(2) Electrons of constant energy are obtained by the electron gun
(3) Nickel crystal acts as a three dimensional diffracting grating
(4) Davission-Germer experiment is an interference experiment

Q.38 In Davisson-Germer experiment maximum intensity is observed at -
(1) 50º and 54 volt (2) 54º and 50 volt
(3) 50º and 50 volt (4) 65º and 50 volt

Q.39 The interatomic distance between atoms in a crystal is 2.8Å. Then if such a crystal is used in Davisson-Germer experiment, the maximum order of diffraction that can be observed for a beam of electrons accelerated by 100V shall be -
(1) n = 1 (2) n = 2
(3) n = 10 (4) n = ∞

Q.40 The angle between the incident and the diffracted electron in the Davisson-Germer experiment is called as -
(1) angle of incidence (2) angle of diffraction
(3) angle of scattering (4) none of the above

Q.41 In Davisson-Germer experiment, an electron beam of 60 eV energy falls normally to the surface of the crystal and maximum intensity is obtained at an angle of 60º to the direction of incident beam. The inter-atomic distance in the lattice plane of the crystal is -
(1) 18Å (2) 3.6Å
(3) 1.8 Å (4) 0.18Å

Q.42 In Davisson-Germer experiment Ni crystal acts as -
(1) an ideal reflector
(2) three dimensional diffraction grating
(3) an ideal absorber
(4) two dimensional diffraction grating

Q.43 In Davisson-Germer experiment the relation between Bragg's angle ϕ and diffraction angle θ is -
(1) $\theta = 90º - \phi$ (2) $\theta = \frac{90^o - \phi}{2}$
(3) $\theta = 180º - \phi$ (4) $\phi = \left(\frac{180^o - \theta}{2}\right)$

Q.44 The distance between two consecutive atoms of the crystal lattice is 1.227Å. The maximum order of diffraction of electrons accelerated through 10^4 volt will be -
(1) 10 (2) $\frac{1}{10}$
(3) 100 (4) $\frac{1}{100}$

Q.45 The ionization chamber used is Davission-Germer experiment, acts as -
(1) emitter
(2) collector
(3) source
(4) radiator

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 17

Q.1 X-rays are also called -
(1) Becquere rays (2) Rontgen rays
(3) neutron rays (4) cathode rays

Q.2 The nature of the target used for the production of X-rays should be -
(1) solid of high atomic number
(2) solid of low atomic number
(3) solid of high melting point
(4) solid of high atomic number and high melting point

Q.3 Which of the following are used for the study of structure of crystals ?
(1) infrared rays (2) visible light rays
(3) ultraviolet rays (4) X-rays

Q.4 Bragg's law of X-ray is correct for -
(1) refraction (2) reflection
(3) diffraction (4) polarisation

Q.5 X-rays are not used in radar because -
(1) they damage the target
(2) they are electromagnetic waves
(3) they are not reflected by the target
(4) they are completely absorbed by air

Q.6 X-rays were discovered by -
(1) Rontgen (2) Becquerel
(3) De-Broglie (4) Rutherford

Q.7 In a Coolidge tube X-rays are produced by
(1) positive rays
(2) cathode rays
(3) electromagnetic rays
(4) a proton beam

Q.8 X-ray is an electromagnetic radiation, so X-ray photons carry -
(1) an electric charge
(2) a magnetic moment
(3) both the electric charge and magnetic moment
(4) neither electric charge nor magnetic torque

Q.9 X-rays and γ-rays both are electromagnetic waves. Which of the following statements is correct ?
(1) the wavelength of X-rays is greater than that of γ-rays

(2) the wavelength of X-rays is less than that of γ-rays
(3) the frequency of γ-rays is less than that of X-rays
(4) the frequency and wavelength of X-rays are more than those of γ-rays

Q.10 The nature X-rays is similar to -
(1) cathode rays (2) neutron beam
(3) α-rays (4) γ-rays

Q.11 Which of the following characteristics of X-rays increases on increasing the number of electrons striking the anticathode ?
(1) Hardness (2) Wavelength
(3) Penetrating power (4) Intensity

Q.12 The velocity of X-rays is equal to the velocity of -
(1) sound waves (2) elastic waves
(3) ultrasonic waves (4) light waves

Q.13 The wavelength of the most energetic X-ray emitted when a metal target is bombarded by 40 keV electron is approximately -
(1) 300 Å (2) 10 Å
(3) 4 Å (4) 0.31 Å

Q.14 X-rays are diffracted by -
(1) a single slit
(2) a double slit
(3) a diffraction grating
(4) a crystal

Q.15 If X-rays are deflected from their path then its cause may be -
(1) electric field
(2) magnetic field
(3) electric and magnetic field both
(4) none of the above

Q.16 X-rays travel a long distance in a material if their -
(1) wavelength is low
(2) wavelength is high
(3) frequency is low
(4) not depend on wavelength and frequency

Q.17 In majority of crystals the value of lattice constant is of the order of 3Å. The proper X-rays with which the crystal structure can be studied are -
(1) 50Å to 100 Å (2) 10Å to 50 Å
(3) 5Å to 10 Å (4) 0.1Å to 2.7 Å

Q.18 The distance between two successive atomic planes of a calcite crystal is 0.3 Å. The minimum angle for Bragg scattering of 0.3 Å X-rays will be -
(1) 1.5º (2) 30º
(3) 2.86° (4) 60º

Q.19 X-rays of frequency ν are used to irradiate sodium and copper surface in two separate experiments and the stopping potential determined. Then :
(1) the stopping potential is more for copper than for sodium

(2) the stopping potential is more for sodium than for copper
(3) the stopping potential is same for copper and for sodium
(4) none of the above

Q.20 The lattice spacing in a crystal is 0.5Å. The maximum wavelength of X-rays for which diffraction can be observed will be
(1) 0.5Å (2) 1.0Å
(3) 2.0Å (4) 5.0 Å

Q.21 X-rays do not penetrate -
(1) wood (2) meat
(3) Al (4) $BaSO_4$

Q.22 If X-rays are passing through different material of same thickness then its absorption is minimum in -
(1) copper (2) gold
(3) air (4) lead

Q.23 In X-ray tube, the percentage of energy of electron converted into X-rays is -
(1) nearly 50%
(2) nearly 10%
(3) less than 1%
(4) almost 100%

Q.24 An X-ray tube operates at 30 kV. Then the speed of the electrons when they hit the target is about
(1) 10^8 m/s (2) 10^7 m/s
(3) 10^6 m/s (4) 10^9 m/s

Q.25 A metal block is exposed to beam of X-rays of different wavelengths. X-rays of which wavelength penetrates most.
(1) 2 Å (2) 4 Å
(3) 6 Å (4) 8 Å

Q.26 Difference between soft and hard X-rays is -
(1) of frequency
(2) of velocity
(3) of penetration power and frequency
(4) of intensity and velocity

Q.27 Which of the following statements is correct for hard X-rays ?
(1) Penetrating power is more and wavelength is less than that of soft X-rays
(2) Penetrating power is more and wavelength is more that of soft X-rays
(3) Penetrating power is equal to that of soft X-rays and wavelength is less than that of soft X-rays
(4) Penetrating power is equal to that of soft X-rays and wavelength is more than that of soft X-rays

Q.28 The cause of characteristic X-rays is -
(1) transition of valence electrons from higher to lower orbits
(2) transition of inner shell electrons from higher to lower orbits
(3) transition of atomic nuclei electrons from higher to lower energy states
(4) none of these

Q.29 The energy of a continuous X-ray photon comes from -
(1) the kinetic energy of the free electrons of target

(2) the atomic transition in the target
(3) the kinetic energy of the striking electron
(4) none of these

Q.30 The energy of a characteristic X-ray photon comes from -
(1) the kinetic energy of the free electrons of target
(2) the atomic transition in the target
(3) the kinetic energy of the striking electron
(4) none of these

Q.31 If potential difference of 10,000 volt is applied in an X-ray tube, then minimum wavelength of X-rays produced will be -
(1) 1.24Å (2) 12.4Å
(3) 0.124Å (4) 1.24×10^{-6}A

Q.32 The minimum wavelength of X-rays in the continuous spectrum is λ_{min}, then -
(1) $\lambda_{min} = \frac{hV}{ec}$ (2) $V = \frac{hc}{e\lambda_{min}}$
(3) $V = \frac{ec}{h\lambda_{min}}$ (4) $\lambda_{min} = \frac{eh}{cV}$

Q.33 When accelerated electron knock out electrons of inner shell of target atoms then we get -
(1) continuous spectrum
(2) characteristic spectrum
(3) β-spectrum
(4) γ-spectrum

Q.34 Characteristic spectrum is -
(1) linear
(2) continuous
(3) continuous and linear
(4) uncertain

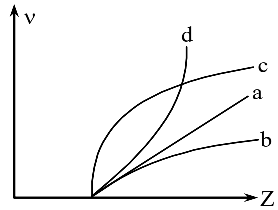
Q.35 Spectrum of X-rays is -
(1) continuous
(2) linear
(3) continuous and linear
(4) band spectrum

Q.36 The characteristic X-ray radiation is emitted when -
(1) the electrons are accelerated to a fixed energy
(2) the source of electrons emits a mono energetic beam
(3) the bombarding electrons knock out electrons from the inner shell of the target atoms and one of the outer electrons falls into this vacancy
(4) the valence electrons in the target atoms are removed as a result of the collision

Q.37 The minimum energy of electrons required to emit K_α line from molybdenum target (Z = 42) will be -
(1) 0.2399 KeV (2) 2.399 KeV
(3) 23.99 KeV (4) 239.9 KeV

Q.38 In the Mosley's law for characteristic X-rays $\sqrt{\nu} = a(Z - b)$ -
(1) both the constant a and b depend on the nature
(2) a depends on the nature of material whereas b does not
(3) b depends on the nature of material whereas a does not
(4) both the constants a and b do not depend on the nature of the material

Q.39 Which of the following curves best represents the Moseley law ?



(1) a (2) b (3) c (4) d

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 18

Q.1 Positively charged rays/particles are may be-
(1) Electron
(2) Neutron
(3) Ions
(4) Electro magnetic radiation

Q.2 In Thomson mass spectrograph an electron beam passes undeflected. If we apply mutually perpendicular E & B fields perpendicular to electron's velocity. Then the velocity of electron will be-
(1) eE/B (2) eB/E
(3) EB (4) E/B

Q.3 In a mass spectrograph O^{++}, C^{+}, He^{++} and H^{+} are projected on a photographic plate with same velocity, then which will strike the plate farthest-
(1) O^{++} (2) C^{+}
(3) He^{++} (4) H^{+}

Q.4 In Thomson experiment singly ionized Ne^{20} is represented by a parabola $y = 10z^2$, then the equation of parabola for its isotope Ne^{22} will be-
(1) $y = 5\,z^2$ (2) $y = 11\,z^2$
(3) $y = 5.5\,z^2$ (4) $y = 10\,z^2$

Q.5 In a mass spectrograph mass number and charge of ion A are 24 and +2e respectively. Mass number and charge of ion B are 22 and +e. If radius of path traced by ion A is 24 cm then radius of path traced by ion B will be-
(1) 5.5 cm (2) 11 cm
(3) 44 cm (4) 24 cm

Q.6 The atomic weight of two isotopes of chlorine are 35 and 37. If average atomic weight of chlorine is 35.5, then ratio of these two isotopes will be-
(1) 2 : 1 (2) 3 : 1
(3) 4 : 1 (4) 1 : 3

Q.7 In a mass spectrometer used for measuring the masses of ions. The ions are initially accelerated by an electric potential V and then made to describe semicircular paths of radius R using a magnetic field B. If V and B are kept constant, the ratio $\left(\frac{\text{charge on the ion}}{\text{mass of the ion}}\right)$ will be proportional to-
(1) $\frac{1}{R^2}$ (2) R^2

(3) R (4) $\frac{1}{R}$

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 19

Q.1 The specific charge of electron was first measured by-
(1) Millikan (2) Maxwell
(3) Thomson (4) Hallwach

Q.2 Which statement is not true for positive rays-
(1) They are electromagnetic waves
(2) They ionize the gas through which they pass
(3) They carry energy and momentum
(4) They are deflected by electric and magnetic fields

Q.3 As the speed of the electron increases the value of its specific charge-
(1) Increases
(2) Remains the same
(3) Decreases
(4) Nothing can be predicted

Q.4 In Thomson's experiment if the value of q/m is the same for all positive ions striking the photographic plate, then the trace would be-
(1) Straight line (2) Parabolic
(3) Circular (4) Elliptical

Q.5 When cathode rays (tube voltage ~10 kV) collide with the anode of high atomic weight then we get-
(1) Positive rays (2) X-rays
(3) Gamma rays (4) Cosmic rays

Q.6 Which of the following is not true for positive rays-
(1) They are deflected by electric and magnetic fields
(2) They travel in straight lines
(3) When they fall on metal plate, X-rays are emitted
(4) Their q/m ratio is less than q/m of an electron

Q.7 The specific charge for positive rays is much less than the specific charge for cathode rays. This is because-
(1) positive rays are positively charged
(2) charge on positive rays is less
(3) positive rays comprise ionised atoms whose mass is much larger than electron
(4) experimental method for determination is imprecise

Q.8 In Bainbridge mass spectrograph electric field E, magnetic field B and velocity V of the moving particles were in mutually perpendicular directions. Then velocity selector allows particles of velocity V to pass undeflected when-

(1) V = BE (2) V = E/B
(3) V = B/E (4) $V = B^2/E$

Q.9 The electric and magnetic fields in the velocity selector of Bainbridge mass spectrograph are-
(1) Perpendicular to each other, but electric field parallel to the velocity of ions
(2) perpendicular to each other and also perpendicular to the velocity of ions
(3) parallel to each other but perpendicular to the velocity of ions
(4) parallel to each other and also parallel to the velocity of ions

Q.10 The Bainbridge mass spectrograph is better than the Thomson spectrograph, because it has-
(1) A linear scale
(2) A higher resolving power
(3) Sharp traces
(4) All of the above

Q.11 Which of the following rays are used to determine mass of atoms in a mass spectro graph-
(1) Cathode rays (2) Positive rays
(3) Cosmic rays (4) X-rays

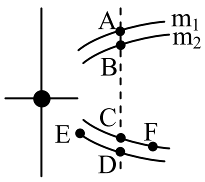
Q.12 Cathode rays can be deflected by-
(1) Magnetic field only
(2) Electric field only
(3) Both type of fields
(4) None of the fields

Q.13 Positive rays are-
(1) Electromagnetic waves
(2) Ions of gas
(3) Electrons
(4) Neutrons

Q.14 Three particles having charges in the ratio of 1 : 2 : 3 produce the same point on the photographic film in the Thomson experiment. Their masses are in the ratio of-
(1) 1 : 2 : 3 (2) 3 : 2 : 1
(3) $1 : \sqrt{2} : \sqrt{3}$ (4) $\sqrt{3} : \sqrt{2} : 1$

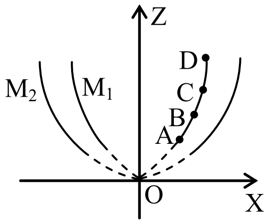
Q.15 The ratio of specific charge of an electron to that of a hydrogen ion is- (about)
(1) 1 : 1 (2) 1840 : 1
(3) 1 : 1840 (4) 2 : 1

Q.16 For figure the q/m is the same for ions reaching points-



(1) E and F (2) C and D
(3) C and F (4) C, D, E and F

Q.17 In Thomson mass spectrograph experiment two parabola as shown in diagram are observed, then the relation between velocities of positive ions will be-



(1) $V_A > V_B > V_C > V_D$
(2) $V_A = V_E = V_C = V_D$
(3) $V_D > V_C > V_B > V_A$
(4) $V_D > V_A$ and $V_B = V_C$

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 20

These questions consists of two statements each, printed as Assertion and Reason. While answering these questions you are required to choose any one of the following four responses.
(A) If both Assertion & Reason are true & the Reason is a correct explanation of the Assertion.
(B) If both Assertion and Reason are true but Reason is not a correct explanation of the Assertion.
(C) If Assertion is true but the Reason is false.
(D) If Assertion & Reason both are false.

Q.1 **Assertion :** Cathode rays get deflected by electric or magnetic fields but light rays remain unaffected by these fields.
Reason : Light rays are electromagnetic waves which are not charged particles but cathode rays are charged particles.
(1) A (2) B (3) C (4) D

Q.2 **Assertion :** An electron is not deflected on passing through certain region of space. This observation confirms that there is no magnetic field in that region.
Reason : The deflection of electron does not depend on angle between velocity of electron and direction of magnetic field.
(1) A (2) B (3) C (4) D

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 1 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	3	4	4	4	1	4	1	3	4	1	4	3	1	1	2	3	4
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	3	3	1	3	2	3	3	3	1	2	3	3	3	1	2	4	2	2	3	1
Q.No.	41	42	43	44																
Ans.	4	2	3	2																

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 2 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	4	1	4	4	4	2	1	3	2	1	2	1	4	3	3	1	3	4	1

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 3 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	1	3	2	3	1	2	1	4	3	3	1	2	1	2	3	4	3	2	4
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	1	1	1	2	2	4	2	1	1	2	1	2	1	3	4	1	3	1	1
Q.No.	41	42	43	44	45	46	47	48												
Ans.	3	2	2	2	3	4	4	4												

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 4 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	2	2	2	1	3	1	4	2	3	4	3	1	2	1	4	1	1	3	2	1
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	1	4	4	2	2	3	1	1	1	2	4	1	1	3,4	2	3	3	1
Q.No.	41	42	43	44	45	46														
Ans.	1	1	2,4	4	1	2														

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 5 (ANSWERS)

Q.No.	1	2	3	4	5	6
Ans.	1	4	1	3	3	1

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 6 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	3	1	1	1	2	4	4	4	4	3	4	1	2	2	4	3	3	2	3
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	3	4	4	4	3	3	3	3	2	4	2	3	3	2	1	3	1	1	4	2
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57			
Ans.	3	4	4	3	2	4	3	2	3	3	3	4	1	3	3	3	2			

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 7 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	2	3	3	2	4	1	2	3	4	4	1	3	3	4	2	2	1	3	4	3
Q.No.	21	22	23	24	25	26	27	28	29											
Ans.	2	2	4	1	3	1	3	2	1											

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 8 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	3	1	1	1	2	3	4	1	3	1	3	2	3	3	2	3	3	2
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	3	3	1	1	3	4	2	2	3	2	4	3	3	3	1	1	3	1	3
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55					
Ans.	3	4	2	2	3	3	1	1	2	4	2	3	3	4	3					

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 9 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	3	1	4	3	3	4	4	2	3	1	4	3	2	4	3	3	1	1
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	3	3	3	4	2	2	1	1	4	4	4	2	1	4	3	1	4	2	1	1
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	4	1	2	3	4	3	4	1	3	2	4	4	1	4	3	4	3	3	2

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 10 (ANSWERS)

Q.No.	1	2	3	4	5	6
Ans.	1	3	4	2	3	1

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 11 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	1	2	1	4	1	2	3	1	4	1	3	3	3	3	4
Q.No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	3	2	3	4	3	1	2	4	3	4	4	3	1	1	3
Q.No.	31	32	33	34	35	36	37								
Ans.	1	1	1	1	2	3	4								

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 12 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	1	2	3	2	3	4	3	1	2	3	2	2	1	1	4
Q.No.	16	17	18	19	20	21	22	23	24	25	26	27	28		
Ans.	3	4	2	3	2	1	2	1	4	1	1	1	1		

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 13 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	3	2	2	2	3	1	1	2	2	2	4	3	3	4	2
Q.No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	4	4	1	2	4	3	3	1	1	4	1	2	1	3	3
Q.No.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	4	2	3	2	3	2	4	1	2	2	2	1	4	1	3
Q.No.	46	47	48	49	50										
Ans.	4	3	1	2	2										

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 14 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	2	2	1	1	1	4	1	4	2	4	1	1	1	3	3
Q.No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	2	2	4	1	3	1	2	2	4	3	4	2	1	1	4
Q.No.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	2	4	1	2	3	4	4	2	1	2,4	4	2	3	1	1,3
Q.No.	46	47													
Ans.	1	4													

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 15 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12
Ans.	4	1	4	1	4	3	1	3	4	4	2	1

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 16 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	1	3	1	1	4	4	3	3	1	2	2	1	2	3	1
Q.No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	2	3	4	1	3	3	2	2	4	3	1	1	3	3	3
Q.No.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	2	1	3	3	3	2	4	1	2	2	3	2	4	1	2

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 17 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	2	4	4	3	3	1	2	4	1	4	4	4	4	4	4
Q.No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	1	4	2	2	2	4	3	3	1	1	3	1	2	3	2
Q.No.	31	32	33	34	35	36	37	38	39						
Ans.	1	2	2	1	3	3	3	4	4						

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 18 (ANSWERS)

Ques.	1	2	3	4	5	6	7
Ans.	3	4	2	2	3	2	1

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 19 (ANSWERS)

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Ans.	3	1	3	2	2	3	3	2	2	4	2	3	2	1	2	3	1

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 20 (ANSWERS)

Ques.	1	2
Ans.	1	4