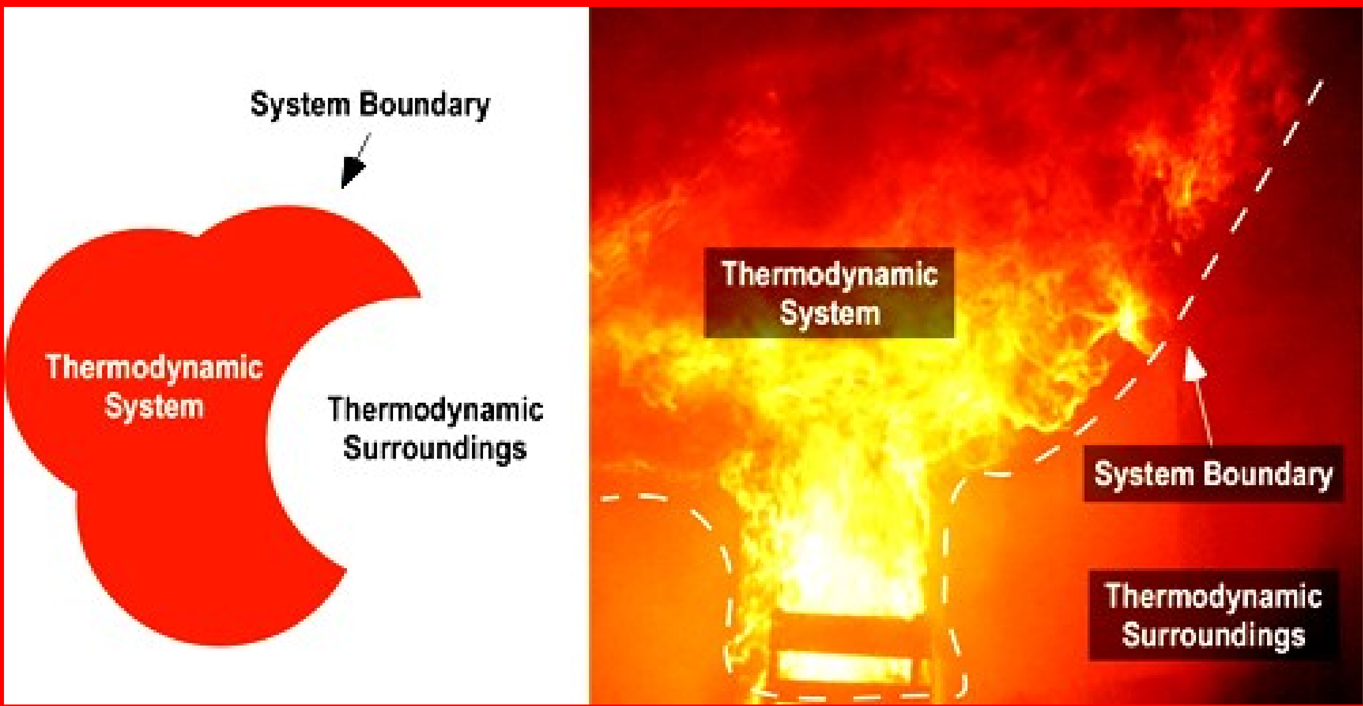
PHYSICS

for JEE, NEET & BOARD

11th

HEAT & THERMODYNAMICS



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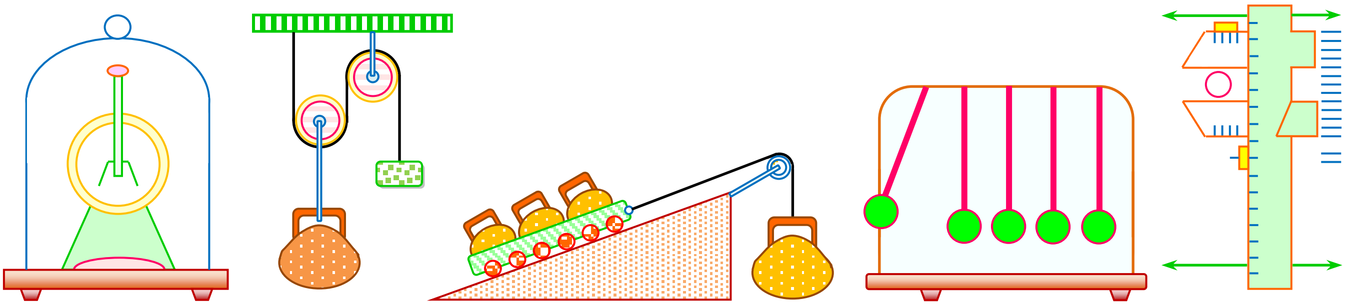

PHYSICS BOOKLET FOR JEE NEET & BOARDS

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THERMAL PHYSICS

1 THERMAL EXPANSION

Most of the substances expand on heating; this thermal expansion takes place in all the dimensions, length, breadth and height. For a linear object, for a small change in temperature dT, the fractional change in length (dl/l) is directly proportional to dT i.e.

$$\frac{dl}{l} = \alpha\, dT \qquad (1)$$

where α is known as the thermal coefficient of linear expansion and it depends on the material of the rod. If the initial length of the object is l_0 and change in temperature is ΔT then equation (1) will give us the new length of the rod, which is

$$l = l_0 e^{\alpha \Delta T} \qquad \ldots (2)$$

If $\alpha\Delta T$ is very small as compared to 1 then

$$l = l_0 (1 + \alpha\Delta T) \qquad \ldots (3)$$

Similar expressions can be written for change in area for a two-dimensional object and change in volume for a three dimensional object.

$$S = S_0 \; (1 + \beta\Delta T\,)$$

and $$V = V_0\, (1 + \gamma\Delta T)$$

where β and γ are coefficients of superficial expansion and coefficient of cubical expansion respectively.

The relation between α, β and γ for an isotropic solid is $\alpha : \beta : \gamma :: 1 : 2 : 3$.

1.1 THERMAL STRESS

When a rod is held between two fixed supports and its temperature is increased, the fixed supports do not allow the rod to expand, which results in a stress which is called thermal stress.

Let a rod of length l is held between two fixed supports and its temperature is increased by ΔT, then change in length of the rod

$$\Delta l = l\, \alpha\Delta T$$

where α is thermal coefficient of linear expansion for the material of the rod.

If Y is the Young's modulus for the material of the rod and A is the area of cross-section of the rod then mechanical compression in the rod.

$$\Delta l' = \left(\frac{F}{A}\right)\frac{l}{Y}$$

Since support is rigid

$\Delta l + \Delta l' = 0$, which gives

$$\frac{F}{A} = -\alpha Y \Delta T$$

This is thermal stress, – ive sign indicates that thermal stress is compressive in nature.

1.2 EXPANSION OF LIQUIDS

Liquids like solids expand on heating. The liquids have no definite shape and they experience volume expansion only. As the liquid is contained in a vessel, the observed expansion of liquid is less than the real expansion, because the capacity of vessel containing liquid increases with temperature. If C is the coefficient of real expansion of liquid and C' the coefficient of apparent expansion of liquid and α coefficient of linear expansion of solid container then

$$C = C' + 3\alpha$$

The expansion of gases we will cover in section II.

Illustration 1

Question: **The design of some physical instrument requires that there be a constant difference in length of 6 cm between an iron rod and copper rod laid side by side at all temperatures. Find their lengths.**
($\alpha_{Fe} = 11 \times 10^{-6}\ {}^0C^{-1}$, $\alpha_{Cu} = 17 \times 10^{-6}\ {}^\circ C^{-1}$)

Solution: Since the $\alpha_{CU} > \alpha_{Fe}$ so length of iron rod should be greater than the length of copper rod.
Let the initial lengths of iron and copper rods be l_1 and l_2 , then

$$l_1 - l_2 = 6 \text{ cm} \qquad \dots \text{(i)}$$

also since the difference has to be constant at all the temperatures, so

$$\Delta l = l_1\,\alpha_{Fe}\,\Delta T = l_2\alpha_{Cu}\,\Delta T$$

$$\frac{l_1}{l_2} = \frac{\alpha_{Cu}}{\alpha_{Fe}} \qquad \dots \text{(ii)}$$

Solving (i) & (ii) we get

l_1 = **17 cm** and l_2 = **11 cm**

Illustration 2

Question: **The height of mercury column measured at $t°= 40^0$ C with a metallic scale which gives correct reading H_1 = 100 cm at 0°C. What height H_0 will the liquid column have at 0°C? The coefficient of linear expansion of brass is $\alpha = 0.03/\ {}^0C$ and the coefficient of volume expansion of mercury is $\gamma = 0.05\ /\ {}^0C$.**

Solution: H_1 at t°C = H_1 $(1 + \alpha\, t)$ actually since pressure is same, so

$\rho_0\, gH_0 = \rho_t\, gH_1\,(1 + \alpha t)$

$$H_0 = H_1\,(1 + \alpha t)\,\frac{\rho t}{\rho_0} = H_1\,(1 + \alpha t)\,(1 + \gamma t)^{-1}$$

$$H_0 = H_1\,[1 + (\alpha - \gamma)\,t] = 100[1 + (0.03 - 0.05)40] = \textbf{20 cm}$$

Illustration 3

Question: **A sphere of diameter 7.0 cm and mass 266.5 g floats in a bath of liquid. As the temperature is raised, the sphere begins to sink at a temperature of 35°C. If the density of the liquid is 1.527 g/cm^3 at 0°C, find the coefficient of cubical expansion (in μ/^{0}C) of the liquid. Neglect the expansion of the sphere.**

Solution: It is given that the expansion of the sphere is negligible as compared to the expansion of the liquid. At 0°C, the density of the liquid is ρ_0 = 1.527 g/cm^3. At 35°C, the density of the liquid equals the density of the sphere. Thus,

$$\rho_{35} = \frac{266.5\,g}{\frac{4}{3}\pi(3.5\,\text{cm})^3}$$

$$= 1.484 \text{ g/cm}^3$$

We have $\frac{\rho_\theta}{\rho_0} = \frac{V_0}{V_\theta} = \frac{1}{(1+\gamma\theta)}$

Or, $\rho_\theta = \frac{\rho_0}{1+\gamma\theta}$

Thus, $\gamma = \frac{\rho_0 - \rho_{35}}{\rho_{35}\,(35°C)} = \frac{(1.527 - 1.484)\,\text{g/cm}^3}{(1.484\ \text{g/cm}^3)\,(35°C)}$

$= \mathbf{828\ \mu/°C.}$

2 THERMOMETRY

The zeroth law of thermodynamics states that, if two bodies *A* and *B* are separately in thermal equilibrium with a third body *C*, then *A* and *B* are in thermal equilibrium with each other.

If two bodies are left for a long time so that they reach thermal equilibrium, the property that becomes common to the two bodies is temperature.

Thermometry is the branch of Physics that deals with the measurement of temperature. The device which is used to measure temperature is called thermometer.

2.1 TEMPERATURE SCALES

Defining a temperature scale involves

(i) Choosing the thermometric substance
(ii) The choice of the thermometric property of the substance.
(iii) Choosing the upper fixed point and lower fixed point.
(iv) Choosing the number of divisions between the two fixed points.

Let *N* be the number of divisions between the fixed upper and fixed lower point. If measure of the thermodynamic property at the upper fixed point be x_N and that at lower fixed point is x_0 then if temperature at the lower fixed point is t_o and at an unknown temperature *t* the measure of the thermometric property is *x* then,

$$t = \frac{x - x_0}{x_N - x_0} N + t_0$$

This equation defines temperature *t*. Some of the most common thermometric properties are the length of the liquid column (like mercury) in a glass capillary tube, the electrical resistance of the coil, the emf of a thermocouple etc.

Based on the choice of upper and lower fixed points we define various scales e.g., Celsius scale, Farenheit scale, Requmer scale. The relation between these scales is given by the following equation.

$$\frac{C}{100} = \frac{K - 273}{100} = \frac{F - 32}{180} = \frac{R}{4}$$

Illustration 4

Question: **What is the temperature which has the same numerical value in centigrade scale and Fahrenheit Scale?**

Solution: Let x be the required temperature

Now $\frac{x-0}{100-0} = \frac{x-32}{212-32}$ or $\frac{x}{100} = \frac{x-32}{180}$ (or) $\frac{x}{5} = \frac{x-32}{9}$

$9x = 5x - 160$

$4x = -160$

$x = -40$

$\therefore$ **$-40°C$ or $-72K$**

Illustration 5

Question: **A thermometer has its lower and upper fixed points marked as 10° and 80°. When it reads 38° what is the corresponding temperature on Centigrade scale?**

Solution: Let x be the reading on Centigrade scale

$\frac{x-0}{100-0} = \frac{38-10}{80-10}$

$\frac{x}{100} = \frac{28}{70}$,

$x = \frac{28}{70} \times 100 = \frac{280}{7} =$ **40^0C**

3 CALORIMETRY

Neglecting any heat exchange with the surrounding the principle of calorimetry states that the total heat given by the hot objects equals the total heat received by the cold objects.

Heat is a form of energy. It is the energy in transit whenever temperature difference exists. Since heat is energy in transit its unit in SI is joule. Another unit of heat is calory which is used very often. The relation between the joule and calory is given as

1 calories = 4.18 joule

3.1 SPECIFIC HEAT CAPACITY AND MOLAR HEAT CAPACITY

When heat is supplied to a body the temperature of the body increases. The increase in temperature of the body depends upon the mass of the substance, heat supplied, the material of the body as well as the surrounding conditions. We write the equation.

$$Q = ms\,(\Delta\theta) \qquad \ldots (4)$$

Where $\Delta\theta$ is the change in temperature m is the mass of the body, Q is the heat supplied and s is a constant for given material under the given surrounding conditions. The constant s is called specific heat capacity of the substance.

The SI unit for specific heat capacity is J/kg – K or J/kg – °C. The specific heat capacity is also called specific heat in short. The amount of substance in the given body may also be measured in terms of number of moles. So equation (4) may be rewritten as

$$Q = nC\Delta\theta \qquad \ldots (5)$$

Where n is the number of moles in the sample. The constant C is called molar heat capacity.

3.2 MECHANICAL EQUIVALENT OF HEAT

Since we define heat as energy in transit hence it can be compared to work. In fact we do have a relation, which tells us that how much mechanical energy is equivalent to work. If mechanical work W joule produces the same temperature difference as is produced by a heat H calories then we write.

$$W = JH$$

Where J is called mechanical equivalent of heat. The unit of J is joule/calorie.

3.3 HEAT CAPACITY & WATER EQUIVALENT

The quantity ms is called heat capacity of the body. Its unit is J/K or J/°C. The mass of water having the same heat capacity as a given body is called water equivalent of the body. The unit of water equivalent is kg.

Latent Heat: Apart from raising the temperature, heat supplied to a body may cause a phase change such as solid to liquid or liquid to vapour. During the process of melting or vaporisation, the temperature remains constant. The amount of heat needed to melt a solid of mass m may be written as

$$Q = mL \qquad \ldots (6)$$

Where L is a constant for a given material for the given surrounding conditions. This constant L is called specific latent heat of fusion, commonly referred as latent heat of fusion. The equation (6) is also valid when a liquid, changes into vapour and the constant L in this case is called specific latent heat of vaporisation commonly referred as latent heat of vaporisation.

Illustration 6

Question: **A lead ball at 30°C is dropped from a height of 6.2 km. The ball is heated due to the air resistance and it completely melts just before reaching the ground. The molten substance falls slowly on the ground. Calculate the latent heat of fusion of lead. Specific heat capacity of lead = 126 J/kg–°C and melting point of lead = 330°C. Assume that any mechanical energy lost is used to heat the ball. Use g = 10 m/s².**

Solution: The initial gravitational potential energy of the ball

$= mgh$

$= m \times (10\ \text{m/s}^2)\,(6.2 \times 10^3\ \text{m})$

$= m \times (6.2 \times 10^4\ \text{m}^2/\text{s}^2) = m \times (6.2 \times 10^4\ \text{J/kg})$.

All this energy is used to heat the ball as it reaches the ground with a small velocity. Energy required to take the ball from 30°C to 330°C is

$m \times (126\ \text{J/kg–°C}) \times (300°\text{C})$

$= m \times 37800\ \text{J/kg}$

and energy required to melt the ball at 330°C = mL

where L = latent heat of fusion of lead

Thus, $m \times (6.2 \times 10^4\ \text{J/kg}) = m \times 37800\ \text{J/kg} + mL$

or, L = **24 kJ/kg.**

Illustration 7

Question: **How should one kg of water at 10°C be so divided that one part of it when converted into ice at 0°C, would by this change of state provide a quantity of heat that would be sufficient to vaporise the other part?**

Solution: Initially 1000 g of water is at 10°C.

Let m gram of it be cooled to ice at 0°C.

Heat released due to this = $(m \times 1 \times 10) + (m \times 80)$

$= 10m + 80m = 90m$ cal.

The heat required by (1000 – m) g of water at 10°C to become steam at 100°C

$= (1000 - m)(100 - 10) + (1000 - m)\,540$ cal $= (1000 - m)(90 + 540)$ cal

$= (1000 - m)(630)$ cal

Now, $90\,m = (1000 - m)\,630$ or, $720\,m = 630 \times 1000$

$$m = \frac{630 \times 1000}{720} = 875\ \text{g}$$

Hence **875 g** of water by turning into at 0°C will supply heat to evaporate **125 g** of water.

4 HEAT TRANSFER

Heat can be transferred from one place to another by three different methods, namely, conduction, convection and radiation. Conduction usually takes place in solids, convection in liquids and gases, and no medium is required for radiation.

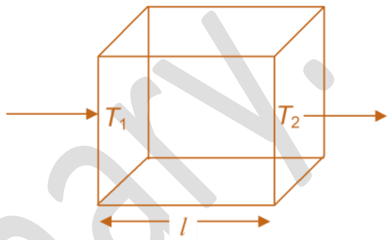
4.1 THERMAL CONDUCTION

This is the mode of heat transfer in which particles of the medium do not leave their position permanently i.e., they keep vibrating at their own places and transfer energy from one part of the medium to the other part.

4.1.1 Thermal conductivity

The ability of a material to conduct heat is measured by thermal conductivity of the material.

Consider a solid bar of thickness l and cross-sectional area A. Let the left side of the bar is at temperature T_1 and right side at T_2 where $T_1 > T_2$.



Sooner or later the temperature of each cross-section becomes constant with respect to time. This is known as steady state. If ΔQ amount of heat flows through a cross-section in time Δt under steady state conditions then the rate of heat transfer is given by

$$\frac{\Delta Q}{\Delta t} = \frac{KA(T_1 - T_2)}{l}$$

where K is a constant for the material of the rod and is called thermal conductivity of the material of the rod. It's unit is J/s-m-K or Cal/s-m-K.

If the area of cross-section is not uniform or if the steady state conditions are not reached, then the equation can only be applied to a thin layer of material perpendicular to the heat flow. If A be the area of cross-section at a place, dx be a small thickness and dT be the temperature difference across the layer of thickness dx then the rate of heat transfer is

$$\frac{dQ}{dt} = -KA\frac{dT}{dx}$$

The negative sign indicates that $\frac{dT}{dx}$ is negative along the direction of flow.

4.1.2 Thermal Resistance

In the equation

$$\frac{\Delta Q}{\Delta t} = \frac{T_1 - T_2}{\left(\frac{l}{KA}\right)}$$

If we treat $\frac{\Delta Q}{\Delta t}$ as thermal current and $T_1 - T_2$ as the temperature difference due to which the thermal current is flowing, then quantity $\frac{l}{KA}$ can be treated as somewhat similar to electrical resistance (think $i = \frac{V}{R}$, Ohm's law) and we call it thermal resistance. So thermal resistance of a body depends upon its length, area of cross-section and thermal conductivity of the material of the body.

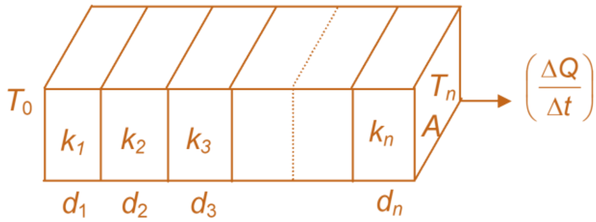
4.2 COMBINATION OF LAYERS

4.2.1 Layers in series

Let us consider a multiplayer medium consisted of layers having area of cross-section A each and width $d_1, d_2, \ldots d_n$ as shown. The thermal conductivities of various layers are $K_1, K_2 \ldots, K_n$. If a temperature difference of magnitude $T_0 - T_n$ is maintained between the near and far faces of the multiplayer (where T_o and T_n are the temperatures of the near and far faces respectively), The rate of heat flow is given by

$$\frac{\Delta Q}{\Delta t}=\frac{A(T_0-T_n)}{\frac{d_1}{k_1}+\frac{d_2}{k_2}+\ldots+\frac{d_n}{k_n}}$$

Which can be obtained directly using the concept of thermal resistance



4.2.2 Layers in parallel

Now let us consider a multiplayer, this time having same width d but different areas of cross-section A_1, A_2, … A_n as shown. The thermal conductivities of the various layers are k_1, k_2, … k_n. If a temperature difference of magnitude (T_0 – T_n) is maintained between the near and far faces of the multiplayer (where T_0 and T_n are the temperatures of near and far faces respectively, the rate of heat flow is given by

$$\frac{\Delta Q}{\Delta t}=\frac{(T_0-T_n)(k_1A_1+k_2A_2+\ldots+k_nA_n)}{d}$$

Which can be obtained directly using the concept of thermal resistance.

4.3 CONVECTION

It is the mode of heat transfer by actual motion of matter. It is therefore possible only in fluids. Convection can be natural or forced. Gravity plays an important role in natural convection. Convection involves bulk transport of different parts of the liquid. We can see many examples of heat transfer by convection in our day to day life, right from the circulation of blood in our body to the intricacies of monsoon in India are all examples of convection. However the mathematical analysis of convection is beyond the scope of IIT-JEE, so we are not discussing the mathematics of convection.

4.4 HEAT TRANSFER THROUGH RADIATION

We have already defined radiation as the mode of heat transfer from one body to other even in the absence of any medium. Before discussing the laws governing radiation we have to understand following terms.

Black body: A black body may be defined as the one that completely absorbs the radiations of all wavelengths incident on it. The concept of black body is an idealised concept and in practice no substance behaves like black body.

Emissive power (E): The emissive power of a body is defined as the energy radiated per unit area per unit time, per unit solid angle perpendicular to the area. So if energy radiated by the area ΔA of the surface in the solid angle ΔW in time Δt be ΔU the emissive power of the body is given by

As all the radiation incident on a black body is absorbed, the absorptive power of black body is unity.

4.4.1. Kirchhoff's law of radiation

Kirchhoff's law states that ratio of the emissive power to the absorptive power for the radiation of a given wavelength is same for all bodies at the same temperature and is equal to the emissive power of a perfectly black body at that temperature. Kirchhoff's law in a way tells that a good emitter is a good absorber and a good absorber is a good emitter.

So $\dfrac{E\text{ (body)}}{a\text{ (body)}}=E\text{ (black body)}$

4.4.2 Stefan's law

The energy emitted per second per unit area of a black body is proportional to the fourth power of absolute temperature of the emitter, and is given by

$$E = \sigma T^4 \quad \ldots \text{(i)}$$

where σ is a constant known as Stefan's constant and its value is 5.67×10^{-8} J/m^2-s-K^4

For any other body

$$E = e\sigma T^4 \quad \ldots \text{(ii)}$$

where e is emissivity which is defined for a surface as the ratio of the emissive power of the surface to the emissive power of black body at the same temperature. The value of e lies between 0 and 1, it is zero for perfectly reflecting surface and unity for black body.

Using Kirchhoff's law

$$\frac{E\ (\text{body})}{E\,(\text{black body})} = a$$

Using (i) and (ii) we get

$$\frac{E\ (\text{body})}{E\,(\text{black body})} = e = a$$

So emissivity and absorptive power have the same value.

Net Loss of Heat: The rate at which a body radiates energy is determined by the temperature of the body but the rate at which it absorbs energy by radiation depends on the temperature of surroundings.

So for a body at a temperature of T_1 surrounded by walls at temperature T_2 the net rate of loss of energy by radiation per unit area per second by radiation is given by

$$E_{net} = e\sigma\,(T_1^4 - T_2^4)$$

4.4.3 Newton's law of cooling

For a small temperature difference between body and surrounding, the rate of cooling of the body is directly proportional to the temperature difference. This can be easily derived taking the value of T to be really close to temperature of surrounding T_o. Mathematically rate of fall of temperature with respect to time is given as

$$\frac{dT}{dt} = -\,bA\,(T - T_0)$$

where b is a constant which depends on the nature of the surface involved and surrounding conditions A is the surface area of the body and $(T - T_0)$ is the instantaneous temperature difference between the body and the surrounding. This is known as Newton's law of cooling. The negative sign indicates that temperature decreases with time. This equation can be used in Celsius scale as difference in temperature is same for absolute as well as for Celsius scale.

4.4.4 Spectral distribution of energy in a black body radiation

A black body emits radiations of different wavelength, however the energy content of radiations of different wavelength is not equal. The relative intensities of different wavelengths depend upon the temperature of radiator. The distribution of energy among the various wavelengths in blackbody radiation was studied by Lummer and Pringsheim and following information were obtained.

(1) For a given temperature the graph between energy and wavelength is a continuous spreading from a minimum to a maximum and has a wavelength (λ_m) where the emission is maximum.

(2) As the temperature increases the wavelength at which the emission is maximum, shifts to lower values.

i.e., $\lambda_m T = b$ where b is a constant having value 2.9×10^{-3} m-K

This is called Wein's displacement law

(3) As the temperature increases, the area enclosed by the curve also increases.

(4) Area under the curve is proportional to T^4 and hence verifies Stefan's law.

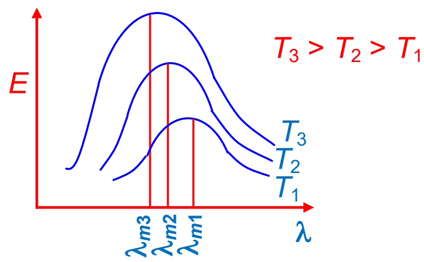
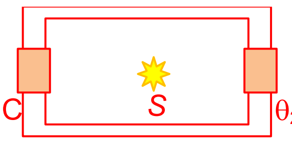


Illustration 8

Question: **A closed cubical box is made of perfectly insulating material and the only way for heat to enter or leave the box is through two solid cylindrical metal plugs, each of cross-sectional area 12 cm^2 and length 8 cm fixed in the opposite walls of the box. The outer surface of one plug is kept at a temperature of 100°C while the outer surface of the other plug is maintained at a temperature of 4°C. The thermal conductivity of the material of the plug is 2.0 W/m-°C. A source of energy generating 12 W is enclosed inside the box. Find the equilibrium temperature of the inner surface of the box assuming that it is the same at all points on the inner surface.**

Solution: The situation is shown in figure. Let the temperature inside the box be θ. The rate at which heat enters the box through the left plug is



$$\frac{\Delta Q_1}{\Delta t} = \frac{KA(\theta_1 - \theta)}{x}$$

The rate of heat generation in the box = 12 W. The rate at which heat flows out of the box through the right plug is

$$\frac{\Delta Q_1}{\Delta t} + 12\,W = \frac{\Delta Q_2}{\Delta t}$$

or, $$\frac{KA}{x}(\theta_1 - \theta) + 12\text{ W} = \frac{KA}{x}(\theta - \theta_2)$$

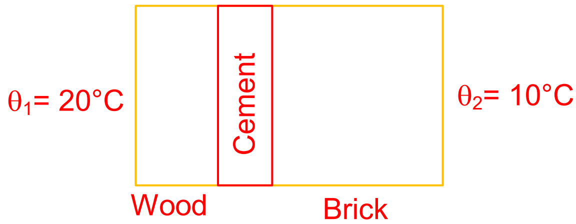
or, $$2\frac{KA}{x}\theta = \frac{KA}{x}(\theta_1 + \theta_2) + 12\text{W} \quad \text{or,} \quad \theta = \frac{\theta_1 + \theta_2}{2} + \frac{(12W)x}{2KA}$$

$$= \frac{100°C + 4°C}{2} + \frac{(12\,W) \times 0.08\,m}{2 \times (2.0\,W/m\text{–}°C)(12 \times 10^{-4}\,m^2)}$$ **= 52°C + 200°C ≈ 252°C.**

Illustration 9

Question: **An electric heater is used in a room of total wall area 137 m^2 to maintain a temperature of 20°C inside it, when the outside temperature is –10°C. The walls have three different layers of materials. The innermost layer is of wood of thickness 2.5 cm, the middle layer is of cement of thickness 1.0 cm and the outermost layer is of brick of thickness 25.0 cm. Find the power of the electric heater. Assume that there is no heat loss through the floor and the ceiling. The thermal conductivities of wood, cement and brick are 0.125 W/m-°C, 1.5 W/m-°C and 1.0 W/m–°C respectively.**

Solution: The situation is shown in figure. The thermal resistances of the wood, the cement and the brick layers are



$$R_W = \frac{1}{K}\frac{x}{A}$$

$$= \frac{1}{0.125\ \text{W/m}-°\text{C}}\ \frac{2.5\times10^{-2}\text{m}}{137\ \text{m}^2}$$

$$= \frac{0.20}{137}\ °\text{C/W}$$

$$R_C = \frac{1}{1.5\ \text{W/m}-°\text{C}}\ \frac{1.0\times10^{-2}\ \text{m}}{137\ \text{m}^2} = \frac{0.0067}{137}\ °\text{C/W}$$

and $R_B = \frac{1}{1.0\ \text{W/m}-°\text{C}}\ \frac{25.0\times10^{-2}\ \text{m}}{137\ \text{m}^2} = \frac{0.25}{137}\ °\text{C/W}$

As the layers are connected in series, the equivalent $R = R_w + R_C + R_B$

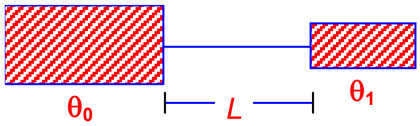
$$= \frac{0.20+0.0067+0.25}{137}\ °\text{C/W} = 3.33 \times 10^{-3}\ °\text{C/W}$$

The heat current is $i = \frac{\theta_1-\theta_2}{R} = \frac{20\ °\text{C}-(-10°\text{C})}{3.33\times10^{-3}°\text{C/W}}$ = **9000 W**

The heater must supply 9000 W to compensate the outflow of heat.

Illustration 10

Question: **The figure shows a large tank of water at a constant temperature θ_0 and a small vessel containing a mass m = 10 kg of water at an initial temperature θ_1 ($< \theta_0$). A metal rod of length L = 2m area of cross-section A = 1 m² and thermal conductivity K = 2100 w connects the two vessels. Find the time taken for the temperature of the water in the smaller vessel to become $\theta_2(\theta_1 < \theta_2 < \theta_0)$. Specific heat capacity of water is s = 4200J/kg -K and all other heat capacities are negligible.**



Solution: Suppose, the temperature of the water in the smaller vessel is θ at time t. In the next time interval dt, a heat, ΔQ is transferred to it where

$$\Delta Q = \frac{KA}{L}(\theta_0-\theta)\,dt \qquad \text{… (i)}$$

This heat increases the temperature of the water of mass m to θ + dθ where

$$\Delta Q = ms\,d\theta \qquad \text{… (ii)}$$

From (i) and (ii),

$$\frac{KA}{L}(\theta_0-\theta)\,dt = ms\,d\theta$$

or, $$dt = \frac{Lms}{KA}\ \frac{d\theta}{\theta_0-\theta}$$

or, $$\int_0^T dt = \frac{Lms}{KA}\int_{\theta_1}^{\theta_2}\frac{d\theta}{\theta_0-\theta}$$

where T is the time required for the temperature of the water to become θ_2.

Thus, $$T = \left[\frac{Lms}{KA}\ ln\ \frac{\theta_0-\theta_1}{\theta_0-\theta_2}\right]$$

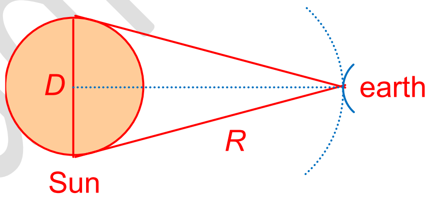
$$= \frac{2\times 1\times 4200}{2100\times 1}\ln e^2$$

$= 40 \times 2 =$ **80 sec**

Illustration 11

Question: **The earth receives solar radiation at a rate of 8.2 J/cm^2 – minute. Assuming that the sun radiates like a blackbody. Calculate the surface temperature of the sun. The angle subtended by the sun on the earth is 0.53° and the Stefan constant $\sigma = 5.67 \times 10^{-8}$ W/m^2-K^4.**

Solution: Let the diameter of the sun be D and its distance from the earth be R. From the question,



$$\frac{D}{R} \approx 0.53 \times \frac{\pi}{180}$$

$= 9.25 \times 10^{-3}$ … (i)

The radiation emitted by the surface of the sun per unit time is

$$4\pi\left(\frac{D}{2}\right)^2\sigma T^4 = \pi D^2\sigma T^4$$

At distance R, this radiation falls on an area $4\pi R^2$ in unit time. The radiation received at the earth's surface per unit time per unit area is, therefore,

$$\frac{\pi D^2\sigma T^4}{4\pi R^2} = \frac{\sigma T^4}{4}\left[\frac{D}{R}\right]^2$$

Thus, $$\frac{\sigma T^4}{4}\left[\frac{D}{R}\right]^2 = 8.2\ \text{J/cm}^2 - \text{minute}$$

or, $$\frac{1}{4}\times\left(5.67\times 10^{-8}\frac{W}{m^2-K^4}\right)T^4\times(9.25\times 10^{-3})^2$$

$$= \frac{8.2}{10^{-4}\times 60}\ \frac{\text{W}}{\text{m}^2}$$

or, $T =$ **5794 K**

PROFICIENCY TEST– I

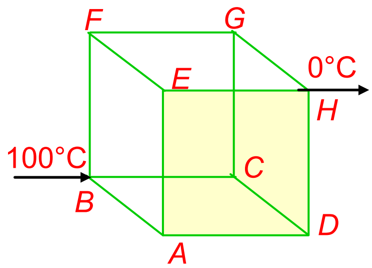
The following questions deal with the basic concepts of this section. Answer the following briefly. Go to the next section only if your score is at least 80%. Do not consult the Study Material while attempting these questions.

1. A composite slab is prepared by pasting two plates of thicknesses l_1 and l_2 and thermal conductivities K_1 and K_2. The slabs have equal cross-sectional area. Find the equivalent conductivity of the slab.

2. A pendulum clock losses 12 s a day if the temperature is 40°C and gains 4 s a day if temperature is 20°C, find the temperature at which clock will give correct time.

3. Find the final temperature when 150 gm of ice at 0°C is mixed with 300 gm of water at 50°C. Specific heat of water = 1 cal/gm/°C. Latent heat of fusion of ice = 80 cal/gm

4. Twelve identical conducting rods form a uniform cube of side l. In steady state the ends B and H are at 100°C & 0°C. Find the temperature of the junction A.



5. The emissivity of tungsten is 0.35. A tungsten sphere 1 cm in radius is suspended within a large evacuated enclosure whose walls are at 300 K. What power input is required to maintain the sphere at a temperature of 300 K, if heat conduction along the supports is neglected? ($\sigma = 5.67 \times 10^{-8}$ SI units)

ANSWERS TO PROFICIENCY TEST– I

1. $\dfrac{K_1K_2(L_1+L_2)}{L_1K_2+L_2K_1}$

2. 25°C

3. 6.7°C

4. 60°

5. 0.2020 Watt

5 THERMODYNAMICS

5.1 FUNDAMENTAL ASSUMPTIONS OF KINETIC THEORY OF GAS

1. All gases are made of molecules moving randomly in all directions.
2. The size of a molecule is much smaller than the average separation between the molecules.
3. No forces of attraction or repulsion are exerted on a gas molecule by other molecules or by the container except during collisions. This implies that energy of gas is purely kinetic.
4. Collisions between two molecules or between a molecule and a wall are perfectly elastic. The time spent during a collision is assumed to be negligibly small.
5. The molecules follow Newton's laws of motion.
6. In the steady state molecular density remains uniform throughout the gas and does not change with time.

A gas which satisfies all the above assumptions of kinetic theory of gases under all set of temperature and pressure is called an ideal gas or perfect gas. In our present discussion we will always consider only ideal gases.

5.2 INTERNAL ENERGY OF AN IDEAL GAS

In case of an ideal gas, according to kinetic theory of gases we assume no force of interaction between molecules. Hence internal potential energy is zero. Internal energy of an ideal gas is purely kinetic and it depends only on temperature. Needless to say internal energy of an ideal gas is a state function.

5.3 EXPANSION OF GASES

The state of a given mass of a gas is determined by the values of three parameters, the pressure *P*, the volume *V* and the temperature *T*. Since the three quantities are related to one another according to a certain law, a change in one causes change in others. If relation between any two of them is required, the third has to be constant. Three such relations can be obtained.

Boyle's law gives a relation between pressure and volume when temperature is kept constant. At constant temperature the pressure of a given mass of gas is inversely proportional to its volume i.e.,

$$P \propto \frac{1}{V} \quad \text{or} \quad PV = \text{constant}$$

Charle's law gives the relation between temperature and volume at constant pressure. The volume of a given mass of a gas is directly proportional to absolute temperature of the gas.

$$V \propto T \text{ when } P \text{ is constant}$$

or $$\frac{V}{T} = \text{constant}$$

The pressure of a given mass of gas at constant volume varies directly as its Kelvin temperature.

$$\frac{P}{T} = \text{constant (at constant volume)}$$

Charle's law of pressure says that at a given volume, the pressure of a given mass of a gas a proportional to its absolute temperature. i.e.,

$$(P)_{\text{constant volume}} \propto T$$

5.4 IDEAL GAS EQUATION

For n moles of an ideal gas at pressure P, absolute temperature T, occupying a volume V, the ideal gas equation is given by

$$PV = nRT$$

This is called equation of the state of the gas, and this equation gives a relation between pressure P, volume V and temperature T of the gas at any given state of the system.

5.5 OTHER IMPORTANT LAWS OF AN IDEAL GAS

Avagadro's law say that at the same temperature and pressure, equal volumes of all gases contain equal number of molecules.

Graham's law of diffusion says that when two gases at the same pressure and temperature are allowed to diffuse into each other, the rate of diffusion of each gas is inversely proportional to the square root of the density of the gas i.e.,

$$\text{rate of diffusion} \propto \sqrt{\frac{1}{\text{Density of gas}}}$$

Dalton's law of Partial Pressure says that the pressure exerted by a mixture of several gases equals the sum of the pressures exerted by each gas occupying the same volume as that of the mixture i.e., if P_1, P_2, … P_n are the pressures exerted by individual gases of the mixture, then pressure of the mixture of the gas is

$$P = P_1 + P_1 + \ldots + P_n$$

5.6 THE FIRST LAW OF THERMODYNAMICS

The first law of thermodynamics states that the heat supplied to a thermodynamics system gets used in increasing the internal energy and doing external work. Mathematically this law can be expressed as

$$\Delta Q = \Delta U + \Delta W$$

where ΔQ is the heat given to the gas and ΔW is the work done by the gas. The total energy of the gas must be conserved. The conventions which we follow for ΔQ and ΔW are,

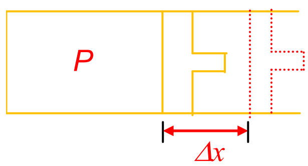
(a) if work is done by the system it is positive

(b) if work is done on the system it is negative

(c) if heat is given to the system it is positive

(d) if heat is given by the system it is negative

Work done by a gas: Consider a gas contained in a cylinder of cross-sectional area A fitted with a movable piston. Let the pressure of the gas is p. The force exerted by the gas on the piston is pA in the outward direction. If the gas expands by a small distance Δx then the work done by the gas on the piston is



$$\Delta W = (PA)(\Delta x) = P\Delta V$$

where ΔV is the change in volume of the gas. We can divide the entire process of expansion in small steps and add work done in each step. So the total work done by the gas in the process is

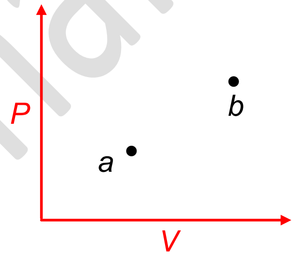
$$W = \int_{V_1}^{V_2} P dV$$

If we show the process in a diagram, the work done is equal to the area bounded by the P-V curve, V-axis and ordinates at V_1 & V_2.

Specific heat capacities for gases: The specific heat capacity of a substance is defined as the heat supplied per unit mass of the substance for the unit rise in the temperature. If an amount ΔQ of heat is given to a mass m of the substance and its temperature rises by ΔT then the specific heat capacity is given by

$$S = \frac{Q}{m\Delta T}$$

This definition applied for all substances. Let us consider one mole (it is convenient to describe amount of gas in mole) of an ideal gas at pressure P_1, volume V_1, and temperature T_1. We represent the state of the gas by the point a in the P-V diagram as shown in the figure. Let us consider another point b in the P-V diagram at which the pressure is P_2, volume is V_2 and temperature is $(T_1 + 1)$. If we stick to our definition, then amount of heat given to gas to take it from a to b is specific heat of the gas. Now according to 1st law of thermodynamics



$$\Delta Q = \Delta U + \Delta W$$

Since ΔU depends only on temperature difference it will be a constant irrespective of the path the gas takes in reaching from a to b. ΔW being path dependent will be different for different processes.

So in order to increase the temperature by 1°C, the heat supplied will be different for different processes. So we conclude that specific heat of a gas is path dependent. In order to define specific heat for gases we will first have to define the path. So specific heat for a gas can have infinite number of values depending upon the process by which temperature increase has been accomplished. So we can say that a gas can have infinite number of specific heats based on the processes. However the most common processes in which temperature increase takes place are defined as process at constant volume. So specific heat for unit mass of gas at constant pressure is defined as c_p and at constant volume c_V. Let the volume of a gas of mass m is kept constant and heat ΔQ is given to it. If its temperature rises by ΔT, the specific heat capacity is given by

$$C_V = \left(\frac{\Delta Q}{m\Delta T}\right)_{\text{constant volume}}$$

and is called specific heat capacity of the gas at constant volume. Now suppose the pressure of the gas is constant, if temperature of m mass of a gas is increased by ΔT by giving heat ΔQ, then specific heat capacity is given by

$$C_p = \left(\frac{\Delta Q}{m\Delta T}\right)_{\text{constant pressure}}$$

and is called specific heat capacity of the gas at constant pressure. If we take the amount of the gas 1 mole instead of its mass m then corresponding quantities are called molar specific heat of the gas at constant volume and at constant pressure respectively. These quantities are represented by C_P and C_V and $C_P - C_V = R$ where R is universal gas constant. The unit of specific heat capacity is J/kg – K and that of molar heat capacity is J/mol – K.

6 DEGREES OF FREEDOM

The degrees of freedom of a system is the number of independent quantities which must be known to specify the position and configuration of the system completely

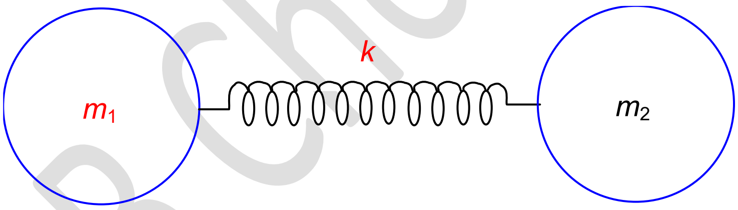
For example, if an ant moves along straight line we say that it has one degree of freedom. If the same ant moves in a plane surface, it has two degrees of freedom since we require x and y co-ordinates to specify its position at any instant. A bird moving in free space has 3 degrees of freedom.

A monatomic gas molecule has three degrees of freedom. As a point mass it can move along any of three mutually perpendicular directions viz x, y or z axis. Its kinetic energy is the sum of the three terms $\frac{1}{2}mv_x^2+\frac{1}{2}mv_y^2+\frac{1}{2}mv_z^2$

Let us consider a rigid body (not a point mass). Its moment of inertia about each of the three mutually perpendicular axes passing through its centre of mass is not negligible. Then it has six degrees of freedom (a) its centre of mass has three translational degrees of freedom of motion. (b) In addition to the translational motion it can rotate about any of the three mutually perpendicular axes and hence it has three degrees of freedom of rotational motion. Its total kinetic energy is the sum of six terms.

$$K.E.=\frac{1}{2}mv_x^2+\frac{1}{2}mv_y^2+\frac{1}{2}mv_z^2+\frac{1}{2}I_x\omega_x^2+\frac{1}{2}I_y\omega_y^2+\frac{1}{2}I_z\omega_z^2$$

In addition to the above it is possible for a body to have vibrational motion about its centre of mass.



Let us consider two spheres of masses m_1 and m_2 connected by a spring of spring constant k. The two spheres can vibrate about their common centre of mass. Its potential energy of vibrations is $\frac{1}{2}kx^2$ and the kinetic energy is $\frac{1}{2}\mu v^2$, where $\mu=\frac{m_1m_2}{m_1+m_2}$ is its reduced mass. This type of body has three degrees of freedom of translational motion, two degrees of freedom of rotational motion and one degree of freedom of vibrational motion. The number of degrees of freedom of rotational motion is two and not three because its moment of inertia about a line passing the centres of the two spheres in small compared to the moment of inertia about the other two axes.

If the two spheres are connected by a rigid rod instead of a spring the total number of degrees of freedom is five i.e. three translational and two rotational. Diatomic molecules can be considered as two spheres joined by a rigid rod just like a dumb-bell. This has five degrees of freedom, three translational and two rotational.

For a triatomic molecule, the number of degrees of freedom could be five or six, three translational and two rotational or three translational and three rotational depending on whether the atoms are arranged linearly or not.

7 LAW OF EQUIPARTITION OF ENERGY

For a system in equilibrium at absolute temperature T, the average energy per molecule corresponding to each degrees of freedom is $\frac{1}{2}kT$.

Where k is Boltzman constant.

Since we already know that internal energy of an ideal gas is entirely the kinetic energy of its molecules.

So internal energy of one mole of an ideal gas having f degrees of freedom.

$$U = Nf\frac{1}{2}kT = \frac{1}{2}fRT$$

Where $R = kN$ where N is Avagadro number. If the gas is heated at constant volume until its temperature rises by dT. Then heat given

$$dQ = (1)\,C_V\,dT$$

Since $dQ = dU$, as volume is constant hence $dW = 0$

So $dU = C_v\,dT$

$$C_V = \frac{dU}{dT} = \frac{1}{2}fR$$

$$C_P = C_V + R = \left(\frac{f}{2}+1\right)R$$

Ratio of the specific heat $\gamma = \dfrac{\left(\frac{f}{2}+1\right)R}{\frac{f}{2}R} = 1+\dfrac{2}{f}$

For a monoatomic gas which has only 3 (translational) degrees of freedom $f = 3$

$$C_V = \frac{3}{2}R$$

$$C_P = \left(1+\frac{3}{2}\right)k = \frac{5}{2}R$$

$$\gamma = 1+\frac{2}{f} = \frac{5}{3} = 1.67$$

For a diatomic gas which has 5 degrees of freedom (3 translational and 2 rotational), as moment of inertia about the line joining the two atoms is negligibly small and so is the rotational energy about that axis is zero So $f = 5$

$$C_V = \frac{5}{2}R$$

$$C_P = \left(1+\frac{5}{2}\right)R = \frac{7}{2}R$$

$$\gamma = 1 + \frac{2}{f} = 1.40$$

For a polyatomic gas which has 6 degrees of freedom (3 translational and 3 rotational)

$$f = 6$$

$$C_V = 3R$$

$$C_P = (3R + R) = 4R$$

$$\gamma = \frac{4}{3} = 1.33$$

However if the atoms of the molecule are arranged linearly like the molecule of CO_2, then degrees of freedom are again 5 and its C_V, C_P and γ will be similar to those of the diatomic gases.

However if the atoms of the molecule are arranged linearly like the molecule of CO_2, then degrees of freedom are again 5 and its C_V, C_P and γ will be similar to those of the diatomic gases.

8 THERMODYNAMIC PROCESSES

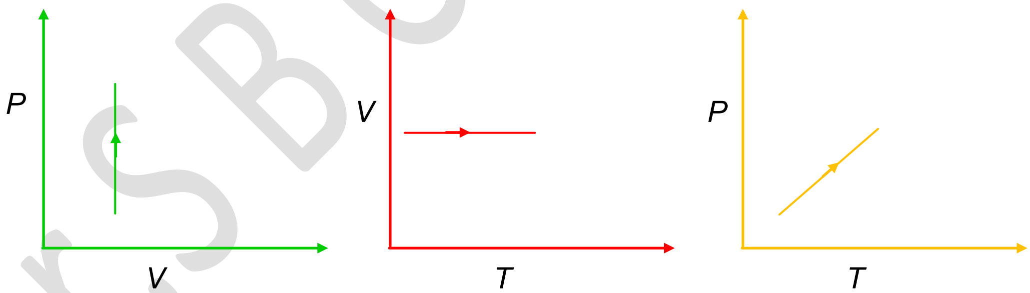
8.1 ISOCHORIC PROCESS

Isochoric process is the process in which volume of the gas remains constant. Since in this process volume remains constant, the work done in this process is equal to zero. Applying the 1st law of thermodynamics to this process we get

$$\Delta Q = \Delta U + \Delta W = \Delta U$$

So heat exchange in this process takes place at the expense of the internal energy of the system.

The P-V, V-T and P-T diagram for Isochoric process will be like the curves given below



8.2 ISOBARIC PROCESS

Isobaric process is the process in which the pressure of the gas remains constant. In this case the work done by the gas in changing its volume from V_1 to V_2 at constant pressure P is given by

$$W = \int_{V_1}^{V_2} P\,dV = P\int_{V_1}^{V_2} dV = P(V_2 - V_1)$$

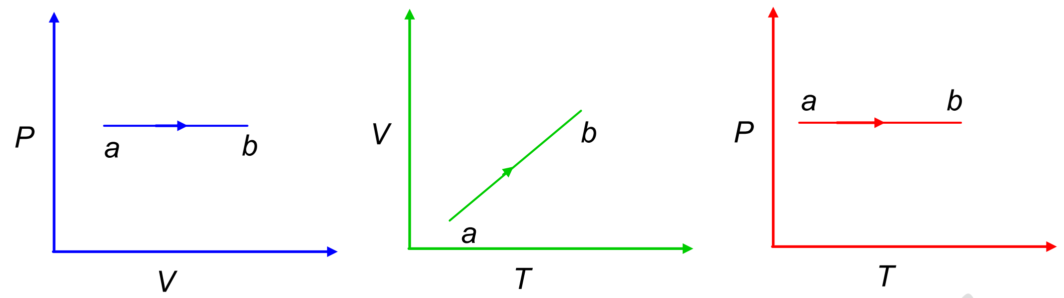
Applying 1st law of thermodynamics to isobaric processes we get

$$\Delta Q = \Delta U + \Delta W$$

$$\Delta Q = \Delta U + P\int_{V_1}^{V_2} dV$$

$\Delta Q = \Delta U + P\,(V_2 - V_1)$

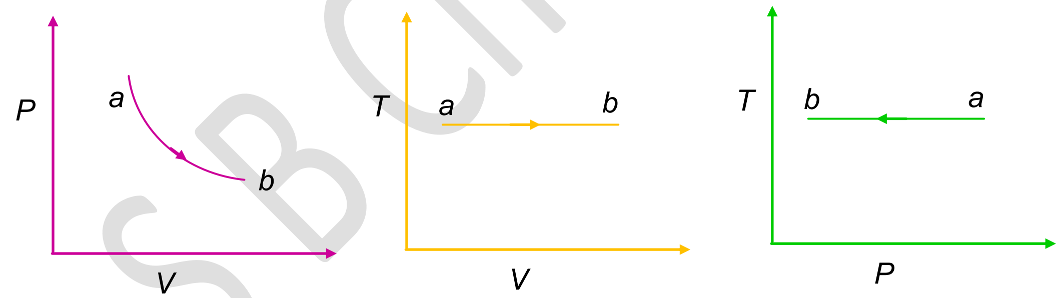
The *P-V V-T* and *P-T* diagram for Isobaric process will be like the curves given below



8.3 ISOTHERMAL PROCESS

An expansion or contraction of a gas, which occurs without change of temperature, is said to be isothermal. During isothermal process, the temperature T remains constant while the volume V and pressure P change. Since at constant temperature, there is no change in the internal energy of the gas the quantity ΔU in the equation, $\Delta Q = \Delta U + \Delta W$ is zero and hence $\Delta Q = \Delta W$ for an isothermal process. So heat supplied during an isothermal expansion is equal to the work done by the gas in expanding. Similarly, during an isothermal compression there must be a continual transfer of heat away from the gas in order to keep the temperature constant and the heat transferred is equal to the work done in compressing the gas. Isothermal changes usually take place very slowly. The equation representing an isothermal process is PV = constant or $P_1V_1 = P_2V_2$

The *P-V*, *T-V* and *T-P* diagram for Isothermal process will be like the curves given below

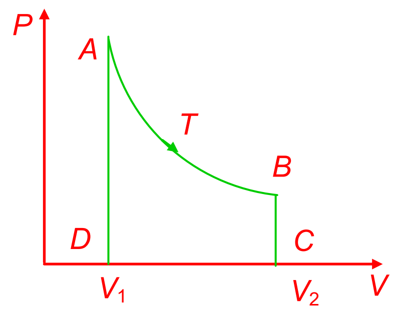


8.3.1 Work done during Isothermal Process

From the equation of an isothermal process we know, $PV = nRT$ (constant). The work dW done during a small expansion dV can be written as $dW = P\,dV = \frac{nRT}{V}\,dV$ and consequently during a finite expansion from a volume V_1 to volume V_2 the work done is given by

$$W = \int P\,dV = nRT \int_{V_1}^{V_2} \frac{dV}{V}$$

$$= nRT\,ln\left(\frac{V_2}{V_1}\right),$$ where n is the number of moles of gas involved.



When converted from natural logarithms to those of base 10, the expression for the work done by a gas during an isothermal expansion becomes

$$W = 2.303\ nRT\log_{10}\left(\frac{V_2}{V_1}\right)$$

Since $\frac{V_2}{V_1} = \frac{P_1}{P_2}$ $\quad W = 2.303\, nRT\log_{10}\left(\frac{P_1}{P_2}\right)$

Applying first law of thermodynamics to Isothermal processes we get

$\Delta Q = \Delta U + \Delta W$, but $\Delta U = 0$ for Isothermal processes.

Hence, $\Delta Q = \Delta W$ for Isothermal processes.

$$\Delta Q = = 2.303\ nRT\log_{10}\left(\frac{V_2}{V_1}\right)$$

8.4 ADIABATIC PROCESS

When a gas expands or contracts without exchanging heat with the surrounding the process is called adiabatic. Such a process is possible if the gas contained in a cylinder is completely insulated by a perfect heat insulator so that no heat is absorbed from the surroundings during expansion or given off to the surroundings during compression. In the relation, for an adiabatic change

$$\Delta Q = \Delta U + \Delta W$$
$$\Delta Q = 0 \text{ and hence}$$
$$-\Delta U = \Delta W$$

The reduction in the internal energy of the gas (due to which the temperature falls) is equal to the work done during an adiabatic expansion. Again during an adiabatic compression the work done on the gas causes its temperature rise. Adiabatic processes are generally very fast.

8.4.1 Equations of Adiabatic Process

Consider one mole of an ideal gas undergoing adiabatic process. For the process we can write

$$\Delta U + \Delta W = 0$$

$$C_V dT + PdV = 0 \quad \ldots \text{(i)}$$

Since equation of state for one mole of an ideal gas is given by

$$PV = RT \quad \ldots \text{(ii)}$$

where P, V, T are pressure, volume and temperature of the gas.

Differentiating (ii) we get

$$dT = \frac{PdV + VdP}{R}$$

So $\quad C_V\left(\frac{PdV + VdP}{R}\right) + PdV = 0$

$\Rightarrow \quad PdV\left(1+\frac{C_V}{R}\right)+VdP\left(\frac{C_V}{R}\right)=0$

$\Rightarrow \quad C_P\frac{dV}{V}+C_V\frac{dP}{P}=0$

$\Rightarrow \quad C_P\frac{dV}{V}+C_V\frac{dP}{P}=0$

$\Rightarrow \quad \frac{Cp}{Cv}\frac{dV}{V}+\frac{dP}{P}=0$

$\Rightarrow \quad \gamma\frac{dV}{V}+\frac{dP}{P}=0$

Integrating we get

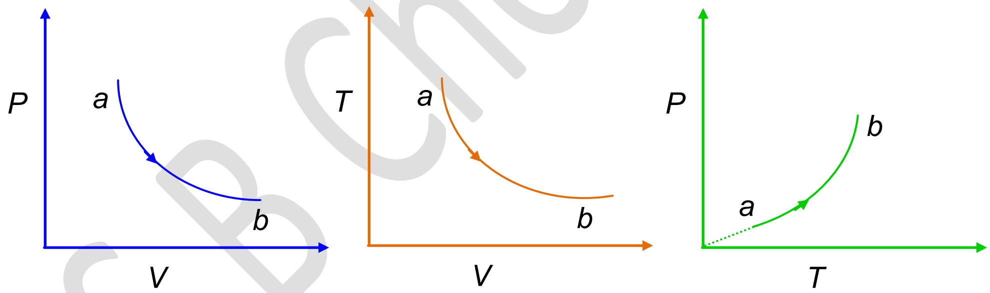
$\gamma \, lnV + lnP =$ constant

or $\quad PV^{\gamma} =$ constant

which is the equation of adiabatic process. Putting $P=\frac{RT}{V}$

we get $TV^{\gamma-1}$ = constant which is the equation of adiabatic process in terms of temperature and volume.

The *P-V, T-V* and *P-T* diagrams for adiabatic process will be like the curves given below



8.4.2 Work done during an Adiabatic Process

The work done by *n* moles of an ideal gas during adiabatic expansion is equal to the loss of its internal energy

$$nC_V(T_1-T_2) = \frac{nR}{\gamma-1}(T_1-T_2) = \frac{P_1V_1-P_2V_2}{\gamma-1}$$

where C_v is the molar heat capacity at constant volume.

Applying 1st law of thermodynamic to adiabatic processes we get

$\Delta Q = \Delta U + \Delta W$, but $\Delta Q = 0$ for adiabatic processes

Hence, $\Delta U = -\Delta W$

8.5 ISOTHERMAL AND ADIABATIC CURVES

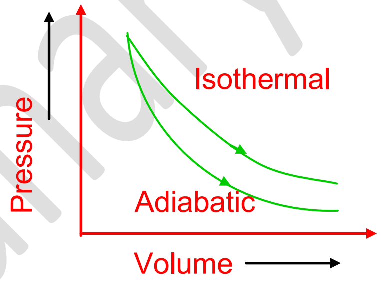
The relation between the pressure and volume of a gas can be represented graphically. The curve for an isothermal process is called isothermal curve or an isotherm and there are different isotherms for different temperatures for a given gas. A similar curve for an adiabatic process is called an adiabatic curve or adiabatic.

Since $\left(\frac{dP}{dV}\right)_{\text{isothermal}} = -\frac{P}{V}$ and $\left(\frac{dP}{dV}\right)_{\text{adiabatic}} = -\gamma\frac{P}{V}$

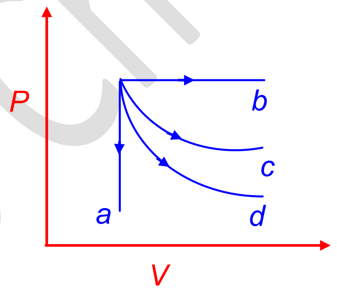
So $\left(\frac{dP}{dV}\right)_{\text{adiabatic}} = \gamma\left(\frac{dP}{dV}\right)_{\text{isothermal}}$

Since $\gamma > 1$, so adiabatic curve is steeper than the isothermal curve.

To permit comparison between isothermal and adiabatic process an isothermal curve and an adiabatic curve of the gas are drawn on the same pressure-volume diagram starting from the same point.



Note: *The work done in different processes can also be compared by drawing the P-V diagram for various process as shown below.*



where a is isochoric process, b is isobaric process, c is isothermal process and d is adiabatic process. Needless to say work done in an isobaric process is maximum and in adiabatic process it is minimum, for a given change in volume.

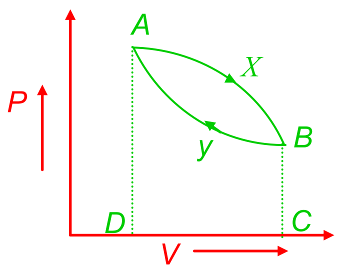
8.6 CYCLIC PROCESS AND EFFICIENCY CALCULATION

When a system after passing through various intermediate steps returns to its original state, then it is called a ***cyclic process***.

Suppose a gas enclosed in a cylinder is expanded from initial state A to final state B along the path AXB as shown in the figure.

If W_1 be the work done by the system during expansion, then

$$W_1 = + \text{Area } AXBCDA$$



Now let the gas be compressed from state B to state A along the path BYA, so as to return the system to the initial state. If W_2 be the work done on the system during compression, then

$$W_2 = -\text{ Area } BYADCB$$

According to sign convention, work done on the system during compression is negative. So net work done in the cyclic process $AXBYA$

$$W = \text{Area } AXBCDA - \text{Area } BYADCB = \text{Area } AXBYA$$

Which is a positive quantity and hence net work will be done by the system.

So the net amount of work done during a cyclic process is equal to the area enclosed by the cyclic path. It is also evident from the figure that if the cyclic path is being traced in anticlockwise direction, the expansion curve will be below the compression curve and net work done during the process will be negative. This implies that the net work will now be done on the system. Applying first law of thermodynamics to cyclic process we get

$$\Delta Q = \Delta U + \Delta W$$

but $\Delta U = 0$ for a cyclic process

So $\Delta Q = \Delta W$

Sometimes in numerical problems we have to deal with efficiency calculation in cyclic process. Since efficiency of process is given as

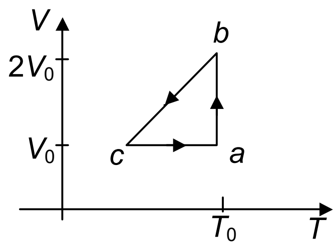
$$\eta = \frac{\text{work done}}{\text{Heat taken}}$$

We can solve the problem quickly by replacing work done by net heat exchanged, as for a cyclic process $\Delta Q = W$. So if we can calculate heat exchanged in individual processes, there is no need to calculate work done separately.

Illustration 12

Question: **A sample of an ideal gas has pressure $P_0 = 100$ N/m^2 volume $V_0 = 10$ m^3 and temperature T_0. It is isothermally expanded to twice its original volume. It is then compressed at constant pressure to have the original volume V_0. Finally, the gas is heated at constant volume to get the original temperature (a) show the process in a V-T diagram (b) Calculate the heat absorbed in the process.**

Solution: (a) The V-T diagram for the process is shown in figure. The initial state is represented by the point a. In the first step, it is isothermally expanded to a volume $2V_0$. This is shown in ab. Then the pressure is kept constant and the gas is compressed to the volume V_0. From the ideal gas equation, V/T is constant at constant pressure. Hence, the process is shown by a line bc which passes through the origin. At point c, the volume is V_0. In the final step, the gas is heated at constant volume to a temperature T_0. This is shown by ca. The final state is the same as the initial state.



(b) The process is cyclic so that the change in internal energy is zero. The heat supplied is, therefore, equal to the work done by the gas. The work done during *ab* is

$$W_1 = nRT_0 \ln \frac{2V_0}{V_0} = nRT_0 \ln 2 = P_0V_0 \ln 2$$

Also from the ideal gas equation,

$$P_aV_a = P_bV_b \qquad \text{Or, } P_b = \frac{P_aV_a}{V_b} = \frac{P_0V_0}{V_b} = \frac{P_0V_0}{2V_0} = \frac{P_0}{2}$$

In the step *bc*, the pressure remains constant. Hence the work done is,

$$W_2 = \frac{P_0}{2}(V_0 - 2V_0) = -\frac{P_0V_0}{2}$$

In the step *ca*, the volume remains constant and so the work done is zero. The net work done by the gas in the cyclic process is

$$W = W_1 + W_2 = P_0V_0[\ln 2 - 0.5]$$

$$= 0.193\ P_0V_0 = 0.193 \times 100 \times 10 = 193\ \text{J}$$

Hence, the heat supplied to the gas is **193 J**.

Illustration 13

Question: **An experiment is performed to measure the molar heat capacity of a gas at constant pressure using Regnault's method. The gas is initially contained in a cubical reservoir of size 40 cm × 40 cm × 40 cm at 600 kPa at 27°C. A part of the gas is brought out, heated to 100°C and is passed through a calorimeter at constant pressure. The water equivalent of the calorimeter and its contents is 100 g. The temperature of the calorimeter and its contents increases from 20°C to 30°C during the experiment and the pressure in the reservoir decreases to 525 kPa. Specific heat capacity of water = 4200 J/kg-K. Calculate the molar heat capacity C_p from these data.**

Solution: We have $PV = nRT$ or, $n = \frac{PV}{RT}$. The amount of the gas in the reservoir is $n_1 = \frac{P_1V}{RT}$ before the gas is taken out and $n_2 = \frac{P_2V}{RT}$ after the gas is taken out. The amount taken out is

$$\Delta n = n_1 - n_2 = (P_1 - P_2)\frac{V}{RT}$$

$$= \frac{(600-525)\times 10^3\ \text{N/m}^2 \times (40\times 10^{-2}\ \text{m})^3}{(8.3\ \text{J/mol-K})\times(300\ \text{K})} = 1.925\ \text{mol.}$$

The gas is heated to 100°C and it cools down as it passes through the calorimeter. The average final temperature of the gas is $\frac{20°C + 30°C}{2}$ = 25°C. Thus, the average decrease in temperature of the gas is

$$\Delta T = (100°\text{C} - 25°\text{C}) = 75°\text{C}$$

or $\Delta T = 75\ \text{K}$

The heat lost by the gas is

$$\Delta Q = \Delta n\ C_p\ \Delta T$$

The heat gained by the calorimeter and its contents is (100g) (4200 J/kg –K) (30 – 20)°C = 4200 J

Thus, $\Delta n\, C_p \Delta T = 4200$ J

Or, $C_p = \dfrac{4200\text{ J}}{(1.925\text{ mol})\ (75\text{K})}$ = **29 J/mol-K**

Illustration 14

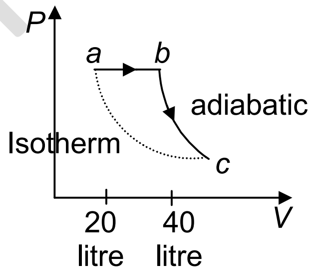
Question: **Two moles of helium gas (γ = 5/3) are initially at 27°C and occupy a volume of 20 litres. The gas is first expanded at constant pressure until the volume is doubled. Then it undergoes an adiabatic change until the temperature returns to its initial value. (a) Sketch the process in a *p – V* diagram. (b) What is the final volume and pressure of the gas? (c) What is the work done by the gas?**

Solution: (a) The process is shown in figure. During the part *ab*, the pressure is constant.

we have, $\dfrac{p_a V_a}{T_a} = \dfrac{p_b V_b}{T_b}$

or, $T_b = \dfrac{V_b}{V_a} T_a = 2T_a$ = **600 K**

During the part *bc*, the gas is adiabatically returned to the temperature T_a. The point *a* and the point *c* are on the same isotherm. Thus, we draw an adiabatic curve from *b* and an isotherm from *a* and look for the point of intersection *c*. That is the final state.



(b) From the isotherm *ac*,

$P_a V_a = P_c V_c$ … (i)

and from the adiabatic curve *bc*,

$P_b V_b^{\gamma} = P_c V_c^{\gamma}$

or $P_a (2V_a)^{\gamma} = P_c V_c^{\gamma}$. … (ii)

Dividing (ii) by (i),

$2^{\gamma}(V_a)^{\gamma-1} = (V_c)^{\gamma-1}$

or, $V_c = 2^{\gamma/(\gamma-1)}\, V_a = 4\sqrt{2}\ V_a = 113$ litres.

From (i), $P_c = \dfrac{P_a V_a}{V_c} = \dfrac{nRT_a}{V_c}$

$= \dfrac{2\text{ mol} \times (8.3\text{ J/mol} - \text{K}) \times (300\text{K})}{113 \times 10^{-3}\text{ m}^3}$ = **4.4 × 10⁴ Pa.**

(c) Work done by the gas in the part *ab*

$= P_a (V_b - V_a)$

$= nRT_2 - nRT_1$

= 2 mol × (8.3 J/mol-K) × (600 K – 300 K) = 4980 J

The work done in the adiabatic part *bc* $= \dfrac{P_b V_b - P_c V_c}{\gamma - 1}$

$= \dfrac{nR(T_2 - T_1)}{\gamma - 1} = \dfrac{4980\,J}{5/3 - 1}$ = 7470 J

The net work done by the gas

= 4980 J + 7470 J

= **12450 J**

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. An amount Q of heat is added to a monatomic ideal gas in a process in which the gas performs a work $\frac{Q}{2}$ on its surrounding. Find the molar heat capacity for the process.

2. Two ideal gases have the same value of $C_P/C_V = \gamma$. What will be the value of this ratio for a mixture of the two gases in the ratio 1 : 2

3. When the state of a thermodynamical system changes from A to B adiabatically the work done on the system is 322 Joule. If the state of the same system is changed from A to B by another process and 100 calories of heat is required then find the work done on the system in this process.

4. A vessel containing 1 gm oxygen at a pressure of 10 atm and a temperature of 47°C. It is found that because of a leak, the pressure drops to $\frac{5}{8}$th of its original value and temperature falls to 27°C. Find the volume of the vessel and the mass of oxygen that has leaked out.

5. For an ideal gas if the molar heat capacity varies as $C = C_V + 3aT^2$. Find the equation of the process in terms of temperature T and volume V. Where a is a constant.

ANSWERS TO PROFICIENCY TEST– II

1. $3R$

2. γ

3. 98 J

4. 0.082 litre, 0.33 gm

5. $V.e^{-\left(\frac{3a}{2R}\right)T^2}$ = constant

SOLVED OBJECTIVE EXAMPLES

***Example* 1:**

Two Identical rectangular strips one of the copper and the other of steel are riveted together to form a bimetallic strip. On heating, the strip will

(a) remain straight **(b) bend with copper on convex side**

(c) bend with steel on convex side **(d) get twisted**

***Solution*:**

The linear expansivity of copper is greater than that of steel and hence on heating there will be differential expansion, copper having more than that of steel. This will make copper strip to form the outer convex edge of the arc.

∴ **(b)**

***Example* 2:**

540 g of ice at 0° C is mixed with 540 g of water at 80° C. The final temperature of the mixture in °C is

(a) 0 **(b) 40** **(c) 80** **(d) 25**

***Solution*:**

The possible quantity of heat that will be released by 540g of water at 80°C cooling down to 0°C, is 540 x 1 x 80 = 540 x 80 cal. To melt 540 g of ice at 0°C heat required = 540 x 80 cal. Hence the mixture will remain as water at 0°C.

∴ **(a)**

***Example* 3:**

Two rods of different materials having coefficients of thermal expansion a_1, a_2 and Young's module Y_1, Y_2 respectively are fixed between two rigid massive walls. The rods are heated such that they undergo the same increase in temperature. There is no bending of the rods. If $a_1 : a_2 = 2 : 3$, the thermal stressed developed in the two rods are equal provided $Y_1 : Y_2$ is equal to

(a) 2 : 3 **(b) 1 : 1** **(c) 3 : 2** **(d) 4 : 9**

***Solution*:**

$$\Delta L_1 = La_1\Delta T$$

$$\Delta L_2 = La_2\Delta T$$

$$\frac{\Delta L_1}{\Delta L_2} = \frac{a_1}{a_2} = \frac{2}{3}$$

For thermal stresses to be equal,

$Y_1 \dfrac{\Delta L_1}{L} = Y_2 \dfrac{\Delta L_2}{L}$, $\dfrac{Y_1}{Y_2} = \dfrac{\Delta L_2}{\Delta L_1} = \dfrac{3}{2}$

∴ **(c)**

***Example* 4:**

If the temperature of a radiating body increases by 50%, the increase in its radiation is

(a) 50% **(b) 100%** **(c) 200%** **(d) 400%**

***Solution*:**

$E = \sigma T^4$

T becomes 1.5 T.

∴ $E' = \sigma(1.5T)^4 = \sigma T^4 \, x \, (1.5)^4 = 5.06\sigma T^4$

i.e., $E' - E = 4.06 = 406\%$

∴ increase in radiation is about **400%**

∴ **(d)**

***Example* 5:**

If a body takes 6 minutes to cool from 80°C to 70°C, how long will it take to cool from 60°C to 50°C, if the surrounding temperature is 25°C?

(a) 6 min **(b) 8 min** **(c) 10.min** **(d) 12 min**

***Solution*:**

As per Newton's law of cooling,

$\dfrac{80+70}{2} - 25 \propto$ Rate of cooling R_1

$\dfrac{60+50}{2} - 25 \propto$ Rate of cooling R_2

$R_1 \propto 50$; $R_2 \propto 30$

$\dfrac{R_1}{R_2} = \dfrac{5}{3}$

But time of cooling is proportional to $\dfrac{1}{R}$

∴ $\dfrac{R_1}{R_2} = \dfrac{t_2}{t_1} = \dfrac{5}{3} (i.e.,) t_2 = \dfrac{5}{3} t_1 = \dfrac{5}{3} x \, 6$

= **10 min**

∴ **(c)**

***Example* 6:**

In an arbitrary scale of temperature, water freezes at 40° and boils at 290°. What is the boiling point of a liquid in this scale if it boils at 62°C?

(a) 219° **(b) 144°** **(c) 150°** **(d) 195°**

***Solution*:**

$$\frac{\chi - 40}{290 - 40} = \frac{62}{100} x\, 250 + 40 \quad = 155 + 40 = \mathbf{195^o}$$

∴ **(d)**

***Example* 7:**

The amount of heat conducted out per second through a window, when inside temperature is 10°C and outside temperature is -10°C, is 750 J. Same heat will be conducted through the window when outside temperature is -13°C and inside temperature is

(a) 230 K **(b) 240 K** **(c) 280 K** **(d) 286 K**

***Solution*:**

Outside temperature = –13°C = 260K

Temperature difference for same heat transfer = 10 – (–10)

= 20°C (or 20 K)

∴ **(b) & (c)**

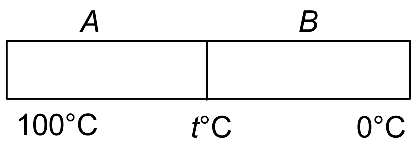
***Example* 8:**

Two metal rods *A* and *B* of equal lengths and equal cross-sectional areas are joined end-to-end. The coefficients of thermal conductivities of *A* and *B* are in the ratio 2 : 3. When the free end of *A* is maintained at 100°C and the free end of *B* is maintained at 0°C, the temperature of the junction is

(a) 30°C **(b) 40°C** **(c) 50°C** **(d) 60°C**

***Solution*:**

Let the temperature of the junction be '*t* '.



Under thermal equilibrium,

$$K_A(100^\circ - t) = K_B(t - 0^\circ)$$

⇒ $2\,(100° - t) = 3\,(t)$

⇒ $t =$ **40°C**

∴ **(b)**

Example 9:

70 J of heat is required to raise the temperature of an ideal diatomic gas at constant pressure from 30°C to 35°C. The amount of heat required (in joules) to raise the temperature of the same gas through the same range (30°C to 35°C) at constant volume is

(a) 30 **(b) 50** **(c) 70** **(d) 90**

Solution:

Heat required at constant pressure to raise the temperature by ΔT: $Q_1 = nC_p\Delta T$

Heat required at constant volume for the same rise in temperature: $Q_2 = nC_v\Delta T$

$$\therefore \quad \frac{Q_2}{Q_1} = \frac{nC_v\Delta T}{nC_p\Delta T} = \frac{C_v}{C_p} = \frac{1}{\gamma} = \frac{5}{7}$$

$$\Rightarrow \quad Q_2 = \frac{5}{7} \times Q_1 = \frac{5}{7} \times 70 = \mathbf{50\ J}.$$

$\therefore$ **(b)**

Example 10:

Molar specific heat at constant pressure for a diatomic gas is

(a) $\frac{5}{2}R$ **(b)** $\frac{7}{2}R$ **(c)** $4R$ **(d)** $\frac{3}{2}R$

Solution:

(b)

Example 11:

A closed vessel is initially evacuated and then a vapour is injected into it at a uniform rate. The pressure in the vessel

(a) first increases and then decreases

(b) increases continuously

(c) first increases and then becomes constant

(d) first decreases and then increases continuously

Solution:

As the vapour is injected, the pressure gradually increases till it reaches the saturation value. Subsequently excess vapour condenses and the pressure remains at saturation vapour pressure.

$\therefore$ **(c)**

Example **12:**

A given quantity of gas can be taken from a state p_1, V_1 to a state p_2, V_2 by two different processes. Let ΔQ and ΔW represent the heat supplied to the gas and the work done by the gas respectively. Which of the following must be a constant for both processes?

(a) $\Delta Q + \Delta W$ **(b)** ΔQ **(c)** ΔW **(d)** $\Delta Q - \Delta W$

***Solution*:**

As initial and final temperatures are fixed, ΔU = constant

$$\Delta Q = \Delta W + \Delta U \Rightarrow \Delta U = \Delta Q - \Delta W = \text{constant}$$

$\therefore$ **(d)**

Example **13:**

A monatomic gas initially at $17^\circ C$ is suddenly compressed to one eighth of its original volume. The temperature after compression is

(a) 887 K **(b) 36.25 K** **(c) 2320 K** **(d) 1160 K**

***Solution*:**

Sudden compression is adiabatic for which $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$

$$\Rightarrow \quad T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1} = 290 \times 8^{\frac{2}{3}} = 290 \times 4 = \mathbf{1160\ K}$$

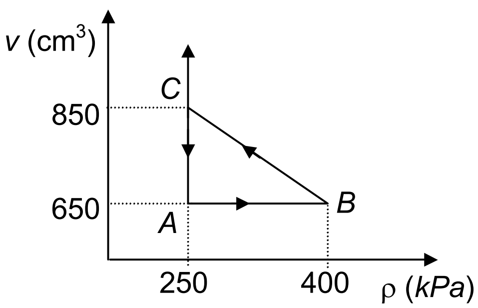
$\therefore$ **(d)**

Example **14:**

A gas is taken through a cyclic process *ABCA* as shown in the Figure. If 3.6 calories of heat is given in the process, one calorie is equivalent to

(a) 4.20 J **(b) 4.19 J**

(c) 4.18 J **(d) 4.17 J**



***Solution*:**

Heat given = Work done in the process

$$= \frac{1}{2} \times (400 - 250) \times 10^3 \times (850 - 650) \times 10^{-6}$$

$$= \frac{1}{2} \times 150 \times 200 \times 10^{-3} = 15\ \text{J} \equiv 3.6\ \text{cal.}$$

$\Rightarrow \quad 1 \text{ cal} = \frac{15}{3.6} = \mathbf{4.17 \text{ J.}}$

$\therefore$ **(d)**

***Example* 15:**

A quantity of oxygen $(\gamma = 1.4)$ is compressed isothermally until its pressure is doubled. It is then allowed to expand adiabatically until its original volume is restored. The final pressure in terms of initial pressure P_1 is

(a) $1.2P_1$ (b) P_1 (c) $0.8P_1$ (d) $0.5P_1$

***Solution*:**

For an isothermal process,

$$P_1V_1 = P_2V_2 = 2P_1V_2$$

$$V_2 = \frac{V_1}{2}$$

For an adiabatic process,

$$P_2V_2^{\gamma} = P_3V_3^{\gamma}$$

$$2P_1\left(\frac{V_1}{2}\right)^{\gamma} = P_3(V_1)^{\gamma}$$

Final pressure, $P_3 = 2^{1-\gamma}P_1 = 2^{(1-1.4)}P_1 = \frac{P_1}{2^{0.4}} = \mathbf{0.8\ P_1.}$

$\therefore$ **(c)**

SOLVED SUBJECTIVE EXAMPLES

Example **1:**

The metal scale of a barometer gives correct reading at 0°C. Coefficient of thermal expansion of brass is 0.00246914. The barometer reads 75 cm at 27°C. What is the correct atmospheric pressure at 27°C?

***Solution*:**

Since the metallic scale has expanded during increase in temperature a positive correction has to be applied equal to

$L_0\alpha\,\Delta T$ = (75 cm) (0.00246914) (27°C)

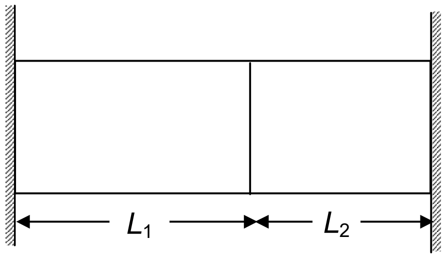
= 5 cm

The corrected reading = 75 cm + 5 cm

$\therefore$ atmospheric pressure at 27°C = **80 cm of mercury column.**

Example **2:**

Two rods of different metals having the same area of cross-section $A = 1\text{m}^2$ are placed end to end between two massive walls, as shown in the figure. The first rod has a length L_1 = 1m coefficient of linear expansion $\alpha_1 = 10^{-6}/\ ^0\text{C}$ and Young's modulus $Y_1 = 10^{12}$ N/m². The corresponding quantities for the second rod are L_2=2m, $\alpha_2 = 4 \times 10^{-6}/^0\text{C}$ and $Y_2 = 4 \times 10^{12}$ N/m².
The temperature of both the rods is now increased by T°C = 200k is $x \times 10^8$ N. Find x. The force with which the rods act on each other. Assume that there is no change in the cross-sectional area of the rods and that the rods do not bend, There is no deformation of the walls.



***Solution*:**

When the rods are heated through T°C they suffer expansion in length.

Increase in length of the first rod = $L_1\alpha_1T$

Increase in length of the second rod = $L_2\alpha_2T$

Since the rods are not allowed to expand, they develop thermal stresses which act on each other due to which they get compressed by lengths x_1 and x_2 respectively.
Let F be the force of compression exerted by first rod on second and F is also the force of compression exerted by the second rod on first. Now

$$x_1 = \frac{FL_1}{AY_1}$$

$$x_2 = \frac{FL_2}{AY_2}$$

Total compression of both rods $x_1 + x_2 = \frac{F}{A}\left(\frac{L_1}{Y_1} + \frac{L_2}{Y_2}\right)$

Total expansion of both rods to heating = $L_1\alpha_1 T + L_2\alpha_2 T$

It is given that the total length of the rods have not been changed as the walls do not yield.

∴ Total extension = Total compression

$$L_1\alpha_1 T + L_2\alpha_2 T = \frac{F}{A}\left(\frac{L_1}{Y_1} + \frac{L_2}{Y_2}\right)$$

Now, $$F = \frac{AT(L_1\alpha_1 + L_2\alpha_2)}{\frac{L_1}{Y_1} + \frac{L_2}{Y_2}} = \frac{AT(L_1\alpha_1 + L_2\alpha_2)Y_1Y_2}{L_1Y_2 + L_2Y_1}$$

$$= \frac{1 \times 200[1 \times 10^{-6} + 2 \times 4 \times 10^{-6}]10^{12} \times 4 \times 10^{12}}{1 \times 4 \times 10^{12} + 2 \times 10^{12}} = 12 \times 10^{8}\ \text{N}$$

x = **12**

***Example* 3:**

A block of wood is floating on water at 0° C with a certain volume *V* above the water level. The temperature of water is slowly raised from 0°C to 20°C. How will the volume *V* change with temperature?

***Solution*:**

When the temperature of water at 0°C is increased its density increases and at 4° C the density becomes maximum. After 4° C the density decreases with temperature.

From 0°C to 4°C the volume of displaced water gradually decreases (to keep the mass of displaced water constant) and hence *V* gradually increases.

From 4°C to 20°C the volume of displaced water increases and hence *V* decreases.

***Example* 4**

A one litre flask contains some mercury. It is found that at different temperatures the volume of air inside the flask remains the same. What is the volume of mercury in the flask? Coefficient of linear expansion of glass = 9×10^{-6} / °C. Coefficient of volume expansion of mercury = 1.8×10^{-4} /°C

***Solution*:**

It is given that the volume of air in the flask remains the same. This means the expansion in volume of the vessel is exactly equal to the expansion in volume of mercury.

Let *V* be the volume of the flask and *v* be the volume of mercury in it.

Now for a temperature rise ΔT

$$V(3 \times 9 \times 10^{-6})\Delta T = v(1.8 \times 10^{-4})\Delta T$$

$$v = \frac{V \times 27 \times 10^{-6}}{1.8 \times 10^{-4}}$$

$$= \frac{27}{180} \times 1000 (V = 1000 cm^3) = \mathbf{150\ cm^3}$$

***Example* 5:**

A calorimeter contains 0.2 kg of water at 30°C. 0.1 kg of water at 60°C is added to it, the mixture is well stirred and the resulting temperature is found to be 35°C. Find the thermal capacity of the calorimeter. Specific heat capacity of water = 4.2 kJ/kgK.

***Solution*:**

Let the thermal capacity of calorimeter be x.

The specific heat capacity of water = 4200 J/kgK.

The total thermal capacity of calorimeter + 0.2 kg of water originally contained in it

$=[x + 0.2 \times 4200]$ J/°C (or J/K)

The quantity of heat gained by calorimeter and water,

Q = Thermal capacity $\times$ rise in temperature

$= (x + 840)(35°C - 30°C) = 5(x + 840)$ J

$= 420 \times 25$ J $= 10500$ J

From the principle of mixtures, heat gained by calorimeter and contents = heat lost by hot water added to it provided there is no heat loss by conduction, radiation, etc.

$\therefore \quad 5(x + 840) = 10500$

$x + 840 = 2100$

$x = 2100 - 840 =$ **1260 J/K**

***Example* 6:**

A copper calorimeter of water equivalent 60 g contains 600 g of water at 30°C. The calorimeter and contents are given a supply of heat at the rate of 100 cal/s. No heat is lost to the surroundings from the calorimeter. Find

(i) the time taken to bring the water to its boiling point and

(ii) the time required to boil away 50 g of water. Specific heat capacity of water = 1 cal/g°C.

Latent heat of steam = 540 cal/g.

***Solution*:**

The water equivalent of calorimeter = 60 g

Calorimeter + water contained in it are together equivalent to 60 + 600 = 660 g of water.

Heat required to raise the temperature of water from 30°C to 100°C

$$Q = mc\Delta T$$

$$= 660 \times 1 \times 70 \text{ cal.}$$

Time required to get this amount of heat supply = $\frac{660 \times 70}{100}$ s = **7 min 42 s**

Now to boil away 50 g of water at its boiling point the quantity of heat required

$$= mL = 50 \times 540 \text{ cal}$$

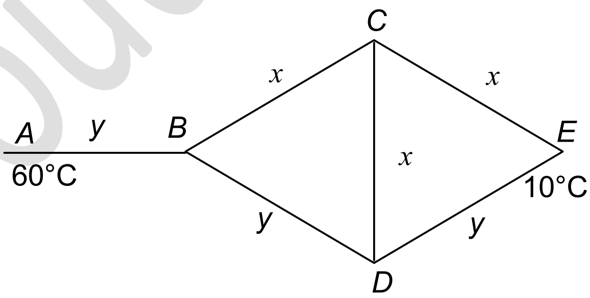
The time required for the supply of this heat = $\frac{50 \times 540}{100}$ s

$$= 270 \text{ s} = 4 \text{ min } 30 \text{ s}$$

Total time required = 7 min 42 min 42 s + 4 min 30 s = **12 min 12 s.**

***Example* 7:**

Three rods of material *x* and three rods of material *y* are connected as shown. All the rods are of identical length and cross-sectional area. If the end *A* is maintained at 60°C and the junction *E* at 10°C, calculate the temperatures of the junctions *B*, *C* and *D*. The thermal conductivity of *x* is 0.92 c.g.s. units and that of *y* is 0.46 c.g.s. units.



***Solution*:**

Since the end *A* or rod *AB* is maintained at a temperature higher than the end *B* heat is conducted from *A* to *B*.

Now the total heat-entering junction *B* is equal to the total heat leaving it (all by conduction alone).

Let the temperatures of junctions *B*, *C* and *D* be T_1, T_2 and T_3 respectively.

Let the cross-sectional area of each rod be *A* and the length of each rod be *d*.

Then, heat entering joint B per second $= \frac{k_y A(60 - T_1)}{d}$

$$= \frac{A}{d} k_y (60 - T_1)$$

Heat leaving *B* per second = heat passing trough *BC* + heat passing through *BD*

$$= K_x \cdot A \cdot \frac{(T_1 - T_2)}{d} + K_y \cdot A \cdot \frac{(T_1 - T_3)}{d}$$

Now, $\frac{A}{d}k_y(60-T_1) = \frac{A}{d}K_x\cdot(T_1-T_2)+\frac{A}{d}K_y\cdot(T_1-T_3)$

and $Kx = 2K_y$

$\therefore \quad 60-T_1 = 2(T_1-T_2)+(T_1-T_3)$

or $\quad 4T_1-2T_2-T_3 = 60$ .... (i)

Similarly for junction C

$$K_x\cdot A\cdot\frac{(T_1-T_2)}{d} = Kx\cdot A\cdot\frac{(T_2-10)}{d}+Kx\cdot A\cdot\frac{(T_2-T_3)}{d}$$

or $\quad T_1-T_2 = T_2-10+T_2-T_3$

or $\quad T_1-3T_2+T_3 = -10$ .... (ii)

For junction *D*

$$K_y\cdot A\cdot\frac{(T_1-T_3)}{d} = K_x\cdot A\cdot\frac{(T_3-T_2)}{d}+K_y\cdot A\cdot\frac{(T_3-10)}{d}$$

$$T_1-T_3 = 2(T_3-T_2)+T_3-10$$

$T_1+2T_2-4T_3 = -10$ .... (iii)

Solving equations (1), (2) and (3), we get

$T_1 = 30°C$; $T_2 = 20°C$; $T_3 = 20$ °C.

Temperature of junction *B* = **30°C**

Temperature of junction *C* = **20°C**

Temperature of junction *D* = **20°C**

***Example* 8:**

Equal volumes of two liquids *A* and *B* are allowed to cool from 80° C to 60° C the time taken being 12 minutes and 16 minutes. The relative densities of two liquids are 1.1 and 1.02 respectively. The specific heat capacity of liquid *A* is 2300 J/kg/K. Calculate the specific heat capacity of liquid *B*.

***Solution*:**

At the instant let be the temperature above that of room temperature.

Then by Newton's law of cooling $\frac{d\theta}{dt}\propto\theta$

The rate at which a mass *m* of liquid loses heat $\frac{d\theta}{dt} = -mc\frac{d\theta}{dt} = k\theta$

where c is the specific heat capacity of the liquid $-mc\dfrac{d\theta}{dt} = k\theta$

Integrating, $kt = -mc\int_{\theta_1}^{\theta_2}\dfrac{d\theta}{\theta}$

or $\quad kt = mc[\log\theta_1 - \log\theta_2]$

Let m_A, m_B represent the respective masses and c_A and c_B the respective specific heat capacities of A and B, then

$$\frac{t_A}{t_B} = \frac{m_A c_A}{m_B c_B}$$ since θ_1 and θ_2 are the same for both the liquids.

Since the volumes of both the liquids are the same

$$\frac{m_A}{m_B} = \frac{V\cdot\rho_A}{V\cdot\rho_B} = \frac{\text{Relative density of } A}{\text{Relative density of } B} = \frac{1.1}{1.02}$$

Substituting the known values

$$\frac{12}{16} = \frac{1.1}{1.02}\times\frac{2300}{c_B}$$

$$c_B = \frac{1.1}{1.02}\times 2300\times\frac{16}{12} = \mathbf{3307\ J\ kg^{-1}\ K^{-1}}$$

***Example* 9:**

A rod of length l = 0.693m with thermally insulated lateral surface consists of material whose heat conductivity coefficient varies with temperature as $k = \dfrac{2}{T}\dfrac{w}{-k}$, where T is temperature in kelvine. The ends of the rod are kept at temperature $T_1 = 400\sqrt{2}k$ and $T_2 = 200\sqrt{2}$. Find the heat flow density in J/s and temperature in Kelvin at the mid point of the rod. [ln 2 = 0.693]

***Solution*:**

The quantity of heat flowing per unit area per second $Q = \dfrac{-kdT}{dx} = -\dfrac{2}{T}\dfrac{dT}{dx}$

In steady state $\int_0^l Q dx = -\int_{2T}^{T} 2\dfrac{dT}{T}$

$$Q = \frac{2\log_e\left(\frac{T_1}{T_2}\right)}{l} = 2\text{ J/s} \qquad \ldots\text{(i)}$$

At a distance x from the end whose temperature is T,

$$Q\,x = \left(2\log_e\frac{T_1}{T}\right) \qquad \ldots\text{(ii)}$$

From equations (i) and (ii)

$$\log_e T = \frac{x}{l}\log_e\left(\frac{T_2}{T_1}\right) + \log_e T_1$$

$$\log_e T = \log_e\left[T_1\left(\frac{T_2}{T_1}\right)^{x/l}\right]$$

$$T(x) = T_1\left(\frac{T_2}{T_1}\right)^{x/l} = 400\sqrt{2}\left[\frac{200\sqrt{2}}{400\sqrt{2}}\right]^{\frac{1}{2}} = \mathbf{400\ k}$$

***Example* 10:**

A given amount of gas is heated until its volume is doubled at constant pressure. If the initial temperature was 27°C, what is the final temperature?

***Solution*:**

$V_1 = V$

$T_1 = (27 + 273)\ K = 300\ K$

$V_2 = 2V$

$T_2 = ?\qquad \frac{V_1}{T_1} = \frac{V_2}{T_2}$

$T_2 = \frac{V_2 T_1}{V_1} = \frac{2V \times 300}{V} = 600\text{ K} = (600 - 273) = \mathbf{327°C}$

***Example* 11:**

An air bubble starts rising from the bottom of a lake. Its radius is $(5.168)^{1/3}$mm at the bottom and 2 mm at the surface. The depth of the lake is 4.664 m and the temperature in Kelvin at the surface is 47°C. What is the temperature at the bottom of the lake? Atmospheric pressure = 76 cm of mercury, g = 9.8 m/s², density of mercury = 13600 mg/m³, density of water = 1000 mg/m³

***Solution*:**

Let us first evaluate the atmospheric pressure in terms of water barometer. If h_w, d_w be the height of water barometer and density of water respectively h_m and d_m the corresponding quantities in terms of mercury, then

$$h_w d_w g = h_m d_m g$$

or $$h_w = \frac{h_m d_m}{d_w} = \frac{0.76 \times 13600}{1000}$$

$= 10.336$ m of water

∴ the atmospheric pressure at the surface of the lake = 10.336 m of water.

Assuming the density of water uniform over its depth, the pressure at the bottom of the lake

= (Atmospheric pressure + depth of water) m of water

= (10.336 + 4.664) *m* of water

= 15 m of water

Applying the gas equation to the conditions of the bubble at the bottom and top of the lake

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{15 \times \frac{4\pi}{3}\left\{(5.168)^{1/3} \times 10^{-3}\right\}^3}{T_1} = \frac{10.336 \times \frac{4\pi}{3}(2 \times 10^{-3})^3}{T_2}$$

$$= \frac{15 \times 5.168}{T_1} = \frac{10.336 \times 8}{320}$$

T_1 = **300 K**

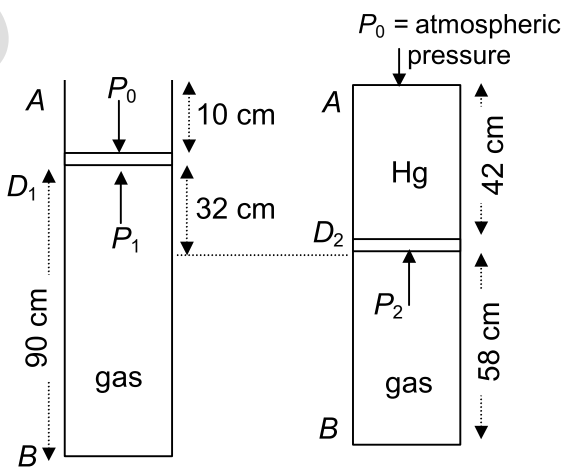
***Example* 12:**

A vertical cylinder of total length 100 cm is closed at the lower end and is fitted with a movable frictionless and gas tight disc at the other end. An ideal gas is trapped under the disc. Initially, the height of the gas column is 90cm when the disc is in equilibrium between the gas and atmosphere. Mercury is then slowly poured on the top of the disc and it just starts overflowing when the disc has descended through 32 cm. The atmospheric pressure is x × 10^{-3} cm. Find *x*. Assume the temperature of gas to remain constant and neglect the thickness and weight of the disc.

***Solution*:**

In the first case, the disc alone is in equilibrium with the compressed gas inside the cylinder .

In the second case, mercury standing over the disc is in equilibrium with the further compressed gas in the cylinder.



Let P_0 be the atmospheric pressure and *A* the cross-section of the tube.

In the first case,

Volume of the gas, $V_1 = 90$ A

Pressure of the gas $P_1 = P_0$

Since the weight of the disc is to be neglected.

In the second case,

Volume of the compressed gas = 58 A

Pressure of the gas = $P_0 + (42)$ cm of mercury

By applying Boyle's law,

$(P_0 + 42)\,58A = P_0 \times 90A$

$90\,P_0 - 58\,P_0 = 2436$

$32\,P_0 = 2436$

$P_0 = 76.125$ cm of mercury

Atmospheric pressure = 76.125 cm of mercury = 76125×10^{-3} cm

$\therefore$ x = **76125**

***Example* 13:**

A certain mass of the helium gas is at $0^\circ C$. It is suddenly expanded to twice its volume. Find the temperature after expansion if the ratio of the specific heats of the gas $\gamma = \frac{5}{3}$.

***Solution*:**

The temperature-volume relation of an adiabatic change can be given as $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$

In this case, $T_1 = 0^\circ C = 273\,K$ $\frac{V_2}{V_1} = 2$

$$\therefore \quad \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = \left(\frac{1}{2}\right)^{\frac{5}{3}-1} = \left(\frac{1}{2}\right)^{2/3}$$

$$T_2 = T_1\left(\frac{1}{2}\right)^{2/3} = 273 \times 0.63 = 172\,K = (172-273)^\circ C = \mathbf{-101^\circ C}$$

***Example* 14:**

A mass of 8 g of oxygen at the pressure of one atmosphere and at temperature 27° is enclosed in a cylinder fitted with a frictionless piston. The following operations are performed in the order given:

(A) The gas is heated at constant pressure to 127°C,

(B) then it is compressed isothermally to its initial volume and

(C) finally it is cooled to its initial temperature at constant volume.

(a) What is the heat absorbed by the gas during process (A) ?

(b) How much work is done by the gas in process (A) ?

(c) What is the work done on the gas in process (B) ?

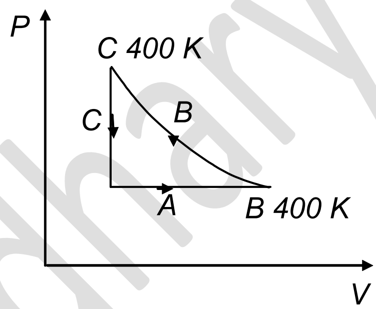
(d) How much heat is extracted from the gas in process (C) ?

[Specific heat capacity of oxygen C_v = 670 J/kgK;

Molecular weight of oxygen = 32; 1 atm = 1.04 x 10^5 N/m^2; R = 8.30 J/k-mole

***Solution*:**

$$V_A = \frac{8}{32} \times 22.4 \times \frac{300}{273} \text{ litre } = \frac{560}{91} \times 10^{-3} m^3$$



$$V_B = V_A \times \frac{400}{300} = \frac{4}{3} V_A$$

$$V_B - V_A = \frac{1}{3} V_A$$

$$= \frac{8}{1000} x\, 670\, x\, 100 + 1.04\, x\, 10^5\, x \left[\frac{560\, x\, 10^{-3}}{3\, x\, 91}\right] = 536 + 2080 = \textbf{744 J}$$

(b) $dW = p(V_B - V_A) = \textbf{208 J}$

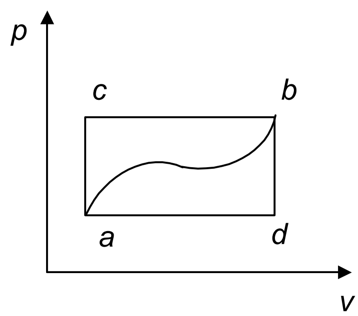
(c) Work done in compressing the gas isothermally = $\frac{m}{M} RT \log_e \frac{V_B}{V_A}$

$$= \frac{8}{32} x\, 8.30\, x\, 400 \log_e \frac{4}{3} = 830x0.2879 = \textbf{239 J}$$

(d) Heat given out by the gas in stage (c) = $mC_v \Delta T = \frac{8}{1000} x\, 670\, x\, 100 = \textbf{536 J}$

***Example* 15:**

When a system is taken from state a to state *b* along the path *acb* it is found that a quantity of heat *Q* = 200 J is absorbed by the system and a work W = 80 J is done by it. Along the path *adb*, *Q* = 144 J.



(i) What is the work done along the path *adb*?

(ii) If the work done on the system along the curved path *ba* is 52 J, does the system absorb or liberate heat and how much?

(iii) If U_a = 40 J, what is U_b ?

(iv) If U_d = 88 J, what is *Q* for the path *db* and *ad*?

Solution:

From the first law of thermodynamics, we have

$Q = \Delta U + \Delta W$

$Q = (U_b - U_a) + W$

Where U_b is the internal energy in the state *b* and U_a is the internal energy in the state *a*.

For the path *acb*, it is given that

Q = 200 J (absorption) and

W = 80 J (work done by the system)

$\therefore \quad U_b - U_a = Q - W = 200 - 80 = 120$ J

which is the increase in the internal energy of the system for the path *acb*. Whatever be the path between *a* and *b* the change in the internal energy will be 120 J only.

Q = 144 J

$\Delta U = U_b - U_a = 120$ J

$Q = (U_b - U_a) + W$

or 144 = 120 + W (or) W = **24 J**

Since W is positive, work is done by the system.

(ii) For the curved return path *ba*, it is given that

$W = -52$ J (work done on the system)

$\Delta U = -120$ J (negative since $\Delta U = (U_b - U_a)$

$\therefore \quad Q = -(U_b - U_a) + W = (-120\text{-}52)$ J $=$ **–172 J**

Negative sign indicates heat is extracted out of the system.

(iii) Since $U_b - U_a = 120$ J and $U_a = 40$ J

$U_b = U_a + 120 = 40 + 120 =$ **160 J**

(iv) For the path *db*, the process is isochoric since it is at constant volume.

Work done is zero.

$Q = \Delta U + W = \Delta U = U_b - U_d = 160 - 88 =$ **72 J**

For the path *ad*.

$Q = Q_{adb} - Q_{db} = 144 \text{ J} - 72 \text{ J} =$ **72 J**

MIND MAP

1. Thermal Expansion
$l = l_0 (1 + \alpha\Delta T)$
$S = S_0 (1 + \beta \Delta T)$
$V = V_0 (1 + \gamma\Delta T)$
$\alpha : \beta : \gamma :: 1 : 2 : 3$

2. $C = C' + 3\alpha$
where C is coefficient of real expansion & C' is coefficient of apparent expansion of liquid and α is coefficient of linear expansion of solid

3. Thermometry
$$\frac{C}{100} = \frac{K-273}{100} = \frac{F-32}{180} = \frac{R}{4}$$

4. Calorimetry
Heat given = Heat taken
$Q = ms\,\Delta\theta$ is used for heat given to raise temperature.
$Q = mL$ is used for phase change.

THERMAL PHYSICS

5. Rate of Heat flow through conduction in steady state
$$\frac{\Delta Q}{\Delta t} = \frac{KA(T_1 - T_2)}{l}$$
Net rate of loss of energy by radiation per unit area per second = $e\sigma (T_1^4 - T_2^4)$
Newton's law of cooling
$$\frac{dT}{dt} = -bA(T - T_0)$$
Weins displacement law:
$\lambda_m T = b$ (constant)

6. Ideal gas Laws
Boyle's law : PV = constant
Charls law: VT^{-1} = constant
Equation of state of an ideal gas
$PV = nRT$

7. First law of thermodynamics
$\Delta Q = \Delta U + \Delta W$
U is state function depends only on temperature.

Work done by a gas = $\int_{V_1}^{V_2} p\,dV$

8. Specific heat capacity of gas is process dependent
$C_P - C_V = R$
$C_P/C_V = \gamma$

9. Energy of a mole of an ideal gas per degree of freedom = $\frac{1}{2}RT$
For
monoatomic gas $\gamma = 1.67$
diatomic gas $\gamma = 1.40$
polyatomic gas $\gamma = 1.33$ or 1.4

10. Equation of isothermal process:
PV = constant
Equation of adiabatic process
PV^{γ} = constant
Slope of adiabatic curve = γ. Slope of isothermal curve.

11. Work done in isothermal process
$$= 2.303\, nRT \log_{10} \frac{V_2}{V_1}$$
Work done in adiabatic process
$$= \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

EXERCISE – I

IIT JEE & NEET-SINGLE CHOICE CORRECT

1. 200 gram of water at 48°C is mixed with 100 gram of water at 30°C. The resulting temperature of water is
(a) 39°C (b) 42°C (c) 36°C (d) 45°C

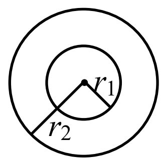
2. A block of metal foil is warmed by radiation from a small sphere at temperature T and at a distance d. The power received by the foil is P. If both the temperature and the distance are doubled, the power received by the foil will be
(a) 2 P (b) P (c) 16 P (d) 4 P

3. A body cools from 90°C to 80°C in 10 minutes when the room temperature is 25°C. The same body will cool from 80°C to 70°C in
(a) 22.5 minutes (b) 12 minutes (c) $8\frac{1}{3}$ minutes (d) 15 minutes

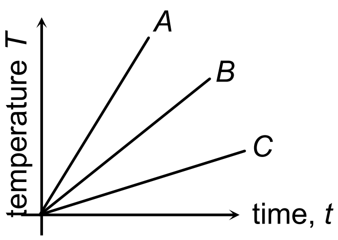
4. Two bodies A and B of same emissivity are placed in an evacuated vessel maintained at a temperature of 27°C. The temperature of A is 327°C and that of B is 127°C. The rates of heat loss from A and B will be nearly in the ratio
(a) 5 : 1 (b) 4 : 1 (c) 7 : 1 (d) 3 : 2

5. A gas occupies 1.5 m^3 at 0°C. If the temperature is raised to 273° C without altering the pressure, the new volume of the gas will be
(a) 1.5 m^3 (b) 2 m^3 (c) 3 m^3 (d) 0.75 m^3

6. If an annular disc of radii r_1 and r_2 is heated, then
(a) r_1 increases, r_2 decreases
(b) r_2 increases, r_1 decreases
(c) both r_1 and r_2 increase
(d) r_2 increases, r_1 remains unchanged



7. Which of the substances A, B or C has the highest specific heat? The temperature vs time graph is shown in the figure.
(a) A
(b) B
(c) C
(d) all have equal specific heat



8. The pressure of a gas kept in an isothermal container is 200 KPa. If half of the gas is removed from it, the pressure will be
(a) 800 K Pa (b) 400 K Pa (c) 200 K Pa (d) 100 K Pa

9. The correct relation connecting the universal gas constant (R), Avogadro number N and Boltzmann constant (K) is

(a) $R = NK^2$ (b) $K = NR$ (c) $N = RK$ (d) $R = NK$

10. A heated body emits radiation which has maximum intensity near the wavelength λ. The emissivity of the material is 0.5. If the absolute temperature of the body is doubled, the maximum intensity of radiation will be near the wavelength

(a) 2λ (b) $\frac{\lambda}{2}$ (c) 16 λ (d) 8 λ

11. If the maximum emission wavelength of radiations emitted by the moon and the sun are 10^{-4} m and 0.5×10^{-6} m respectively, then the ratio of temperature of the sun and the moon will be

(a) 1/100 (b) 200/1 (c) 1/200 (d) 100/1

12. If the length of a cylinder on heating increases by 2%, the area of its base will increase by

(a) 0.5 % (b) 2% (c) 1% (d) 4%

13. A wooden box is made of a 2 cm thick plank and has inner dimensions of 100 cm ×60 cm×60cm. The external temperature is 25^0C. If the box is used as an ice box, the rate at which ice will melt is (K_{wood} = 0.0004 cal/cm/^{0}C and L_{ice} =80 cal/g)

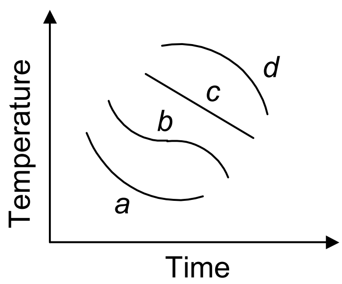
(a) 2.95 g/s (b) 3.95 g/s (c) 2.02 g/s (d) 1.95 g/s

14. At 27°C a gas is compressed suddenly such that its pressure becomes (1/8) of its original pressure. Final temperature will be ($\gamma = 5/3$)

(a) 420 K (b) 300 K (c) –142°C (d) 327° C

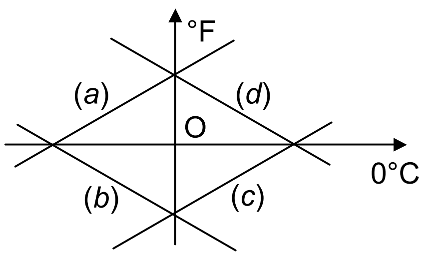
15. A block of steel heated at 100°C is left in a room to cool. Which of the curves represents the correct cooling behaviour?

(a) a (b) b
(c) c (d) d

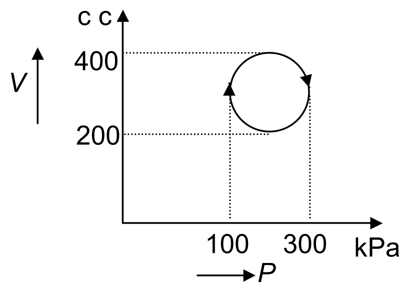


16. From the set of lines in the Figure, choose the correct graph that gives the Fahrenheit temperature against the corresponding Celsius temperature.

(a) a (b) b
(c) c (d) d



17. The heat absorbed by a system in going through the cyclic process as shown in the figure is



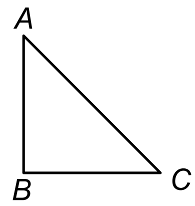
(a) 3.14 J (b) 31.4 J
(c) 3.14×10^{4} J (d) 3.14×10^{-3} J

18. The C_p/C_V ratio of a gas mixture consisting of 8 g of helium and 16 g of oxygen is
(a) 1.33 (b) 1.47 (c) 1.59 (d) 2

19. In an adiabatic expansion of air the volume increases by 5%. The percentage change in pressure is
(a) 2% (b) 3% (c) 5% (d) 7%

20. A gas consisting of diatomic molecules is expanded adiabatically. How many times has the gas to be expanded to reduce the root mean square velocity of molecules to $\frac{2}{3}$ of the initial value?
(a) 7.6 (b) 2.8 (c) 5.2 (d) 1.5

21. Three rods of identical cross-sectional area are made from the same metal, form the sides of an isosceles triangle *ABC* right angled at *B*. The points *A* and *B* are maintained at temperature *T* and $\sqrt{2}T$ respectively in the steady state. Assuming that only heat conduction takes place, temperature of the point *C* will be



(a) $\frac{3T}{\sqrt{2}+1}$ (b) $\frac{T}{\sqrt{2}+1}$ (c) $\frac{T}{\sqrt{3}(\sqrt{2}-1)}$ (d) $\frac{T}{\sqrt{2}-1}$

22. One mole of an ideal monoatomic gas at temperature T_0 expands slowly according to the law $\frac{P}{V}$ = constant. If the final temperature is $2T_0$, heat supplied to the gas is
(a) $2RT_0$ (b) $\frac{3}{2}RT_0$ (c) RT_0 (d) $\frac{1}{2}RT_0$

23. The molar heat capacity in a process of a diatomic gas if it does a work of $\frac{Q}{4}$ when a heat of Q is supplied to it is
(a) $\frac{2}{5}R$ (b) $\frac{5}{2}R$ (c) $\frac{10}{3}R$ (d) $\frac{6}{7}R$

24. The spectral emission power of a black body at 6000 K is maximum at 5000 Å. If the temperature is increased by 10% then decrease in the value of λ_m will be
(a) 10% (b) 7.5% (c) 5.0% (d) 2.5%

25. The average kinetic energy of a gas molecule at 27°C is 6.21×10^{-21} J. Its average kinetic energy at 227°C will be
(a) 52.2×10^{-21} J (b) 5.22×10^{-21} J (c) 10.35×10^{-21} J (d) 11.35×10^{-21} J

EXERCISE – II

IIT-JEE- SINGLE CHOICE CORRECT

1. A and B are two gases. $\frac{T_A}{M_A} = 4\frac{T_B}{M_B}$ where T is the temperature and M is the molecular mass. If C_A and C_B are speeds, then $\frac{C_A}{C_B}$ will be

(a) 2 (b) 4 (c) 0.5 (d) 0.25

2. Find the amount of work done to increase the temperature of one mole of an ideal gas by 30^0 if it is expanding under the condition $V \propto T^{2/3}$

(a) 166.2 J (b) 136.2 J (c) 1262 J (d) none of these

3. An electrically heating coil is placed in a calorimeter containing 360g of H_2O at 10^0C. The coil consumes energy at the rate of 90W. The water equivalent of calorimeter and the coil is 40g. The temperature of water after 10 minutes will be

(a) 42.14^0C (b) 32.14^0C (c) 22.14^0C (d) 52.14^0C

4. One mole of an ideal gas undergoes a process $P = \frac{P_0}{1+\left(\frac{V}{V_0}\right)^2}$, where P_0 and V_0 are constants. Find the temperature of the gas when $V = V_0$

(a) $\frac{P_0V_0}{R}$ (b) $\frac{2P_0V_0}{3R}$ (c) $\frac{2P_0V_0}{R}$ (d) $\frac{P_0V_0}{2R}$

5. To raise the temperature of 100 g of ice at 0^0C to 10^0C by a heater of 420 W the time required is

(a) 90 min (b) 90 seconds (c) 21.2 min (d) 21.2 seconds

6. An ideal gas ($C_V = 3/2\ R$) is maintained in a vessel of volume 83×10^{-4} m^3 at pressure 1.6×10^6 Nm^{-2} and temperature 300 K. If 2.49×10^4 Joule heat is given to this vessel, then its final temperature will be

(a) 600 K (b) 625 K (c) 650 K (d) 675 K

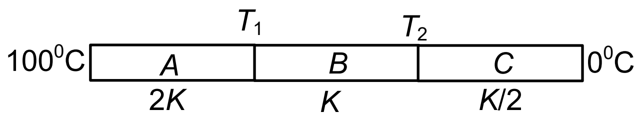
7. A gas having pressure 6×10^5 Nm^{-2} and volume 1 m^3 expands to 3 m^3 and its pressure falls to 4×10^5 Nm^{-2}. Given that the indicator diagram is a straight line, the work done on the system is

(a) 12×10^5 J (b) 6×10^5 J (c) 4×10^5 J (d) 10×10^5 J

8. Air ($\gamma = 1.4$) is filled in a motor car tube at 27^0C temperature and 2 atmosphere pressure. If the tube suddenly bursts then the final temperature will be (given $(1/2)^{2/7} = 0.82$)

(a) 642 K (b) 563 K (c) 300 K (d) 246 K

9. Three identical rods A, B and C of equal lengths and equal diameters are joined in series as shown in figure. Their thermal conductivities are $2K$, K and $K/2$ respectively. Calculate the temperature at two junction points



(a) 85.7, 57.1^0C (b) 80.85, 50.3 ^0C (c) 77.3, 48.3 ^0C (d) 75.8, 49.3^0C

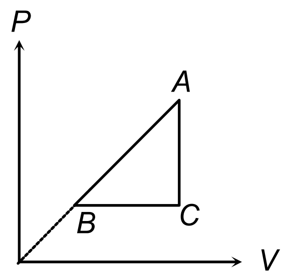
10. One mole of an ideal monatomic gas requires 210 J heat to raise the temperature by 10 K, when heated at constant pressure. If the same gas is heated at constant volume to raise the temperature by 10 K then heat required is

(a) 238 J (b) 126 J (c) 210 J (d) 350 J

11. A circular disc of iron is rotating about its axis at a constant velocity ω. Find percentage change in the linear speed of the rim of the disc if it is slowly heated from 20^0C to 50^0C keeping angular velocity constant (coefficient of linear expansion of iron is 1.2×10^{-5} $/^0C$)

(a) 3.6 % (b) $3.6 \times 10^{-1}\%$ (c) $3.6 \times 10^{-2}\%$ (d) $3.6 \times 10^{-3}\%$

12. P-V diagram of cyclic process $ABCA$ is as shown in figure. Choose the correct statement



(a) $\Delta Q_{A\rightarrow B}$ = negative

(b) $\Delta U_{B\rightarrow C}$ = positive

(c) ΔW_{CAB} = negative

(d) all of these

13. A liquid of mass m specific heat c heated to a temperature $2T$. Another liquid of mass $m/2$ and specific heat $2c$ is heated to a temperature T. If these two liquids are mixed, the resulting temperature of the mixture is

(a) $(2/3)T$ (b) $(8/5)T$ (c) $(3/5)T$ (d) $(3/2)T$

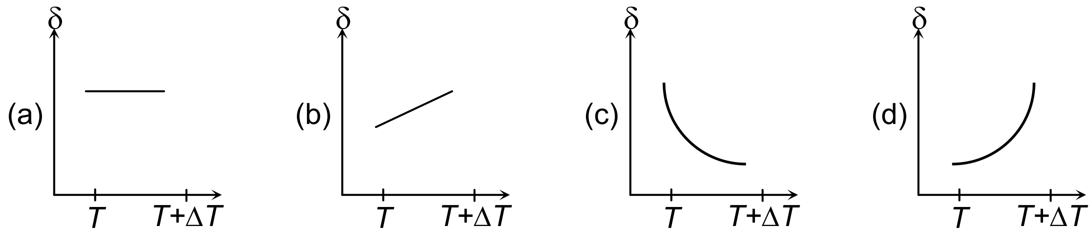
14. A lead bullet of 10g travelling at 300 m/s strikes against a block of wood and comes to rest. Assuming 50% of heat is absorbed by the bullet, the increase in its temperature is (specific heat of lead = 150 J/kg. K)

(a) 100^0C (b) 125^0C (c) 150^0C (d) 200^0C

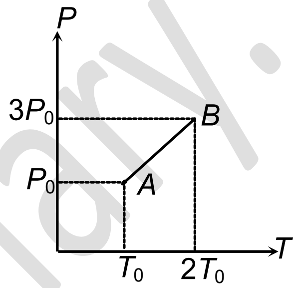
15. The gas in vessel is subjected to a pressure of 20 atmosphere at a temperature 27^0C. The pressure of the gas in a vessel after one half of the gas is released from the vessel and the temperature of the remainder is raised by 50^0C is

(a) 8.5 atm (b) 10.8 atm (c) 11.7 atm (d) 23.3 atm

16. An ideal gas initially at temperature T and volume V. Its volume is increased by ΔV due to an increase in temperature, pressure remaining constant. The quantity $\delta = \Delta V/(V\,\Delta T)$ varies with temperature as



17. Pressure versus temperature graph of an ideal gas is as shown in figure. Density of the gas at point A is ρ_0. Density at B will be



(a) $\frac{3}{4}\rho_0$ (b) $\frac{3}{2}\rho_0$

(c) $\frac{4}{2}\rho_0$ (d) $2\rho_0$

18. One mole of helium is adiabatically expanded from its initial state (P_i, V_i, T_i) to its final state (P_f, V_f, T_f). The decrease in the internal energy associated with this expansion is equal to

(a) $C_V(T_i - T_f)$ (b) $C_P(T_i - T_f)$

(c) $\frac{1}{2}(C_P + C_V)(T_i - T_f)$ (d) $(C_P - C_V)(T_i - T_f)$

19. An ideal gas expands isothermally from a volume V_1 to V_2 and then compressed to original volume V_1 adiabatically. Initially pressure is P_1 and final pressure is P_3. The total work done is W. Then

(a) $P_3 > P_1, W > 0$ (b) $P_3 < P_1, W < 0$ (c) $P_3 > P_1, W < 0$ (d) $P_3 = P_1, W = 0$

20. During an experiment, an ideal gas is found to obey an additional law – Vp^2 = constant. The gas is initially at temperature T and has volume V. When it expands to a volume 2V, the temperature becomes

(a) $\sqrt{2}T$ (b) $\frac{1}{2}T$ (c) $\sqrt{3}T$ (d) $2T$

ONE OR MORE THAN ONE CHOICE CORRECT

1. One mole of ideal monatomic gas is heated at constant pressure. Its initial volume and temperature are 8.2 litres and 27^0C respectively and final volume is 41 litres. If R = 8.3 J/mole K, then

(a) the increase in its internal energy is 14940 J.

(b) the work done by the gas is 9960 J.

(c) the heat absorbed is 4980 J.

(d) there is no increase in internal energy.

2. Two tanks of equal volumes contain equal masses of hydrogen and helium at the same temperature. Then

(a) the pressure of hydrogen is half that of helium

(b) the pressure of hydrogen is double that of helium

(c) the translational kinetic energy of all the molecules of hydrogen is double of that of all the molecules of helium

(d) the total kinetic energy of all the molecules of hydrogen is more than double of that of all the molecule of helium.

3. An ideal gas is taken from the state A (pressure P, volume V) to the state B (pressure P/2, volume 2V) along a straight line path on the P-V diagram select the statement (s) from the following

(a) the work done by the gas is the in the process A to B exceeds the work the taken from A to B along an isotherm.

(b) in the T-V diagram the path AB becomes part of a parabola.

(c) in the P-T diagram, the path AB becomes a part of a hyperbola

(d) in going from A to B, the temperature T of the gas first increases to a maximum value and then decreases.

4. A solid sphere and a solid cube, both made of the same metal, have same surface area and negligible thickness. They are filled with warm water of same temperature and placed in an enclosure of constant temperature, a few degrees below that of water. Then in the beginning the rate of

(a) energy lost by the sphere is less than that by the cube.

(b) energy lost by the sphere is more than that by the cube

(c) energy lost by the two are equal

(d) fall of temperature for sphere is more than that for the cube.

5. A closed vessel contains a maximum of two diatomic gases A and B. Molar mass of A is 16 times that of B and mass of gas A, contained in the vessel is 2 times that of B. Which of the following statements is /are correct.

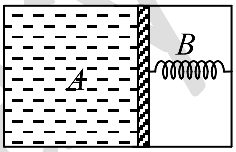
(a) average kinetic energy per molecule of A is equal to that of B.

(b) root mean square value of translational velocity of B is four times that of A.

(c) pressure exerted by B is eight times of that exerted by A.

(d) number of molecules of B in the cylinder is eight times that of A.

6. A thermally insulated chamber of volume $2V_0$ is divided by a frictionless piston of area S into two equal parts A and B. Part A has an ideal gas at pressure P_0 and temperature T_0 and in part B is vacuum. A massless spring of force constant k is connected with piston and the wall of the container as shown. Initially spring is unstretched. Gas in chamber A is allowed to expand. Let in equilibrium spring is compressed by x_0. Then



(a) final pressure of the gas is $\frac{kx_0}{S}$

(b) work done by the gas is $\frac{1}{2}kx_0^2$

(c) change in internal energy of the gas is $\frac{1}{2}kx_0^2$

(d) temperature of the gas is decreased

7. The bodies A and B have thermal emissivities of 0.01 and 0.81 respectively. The outer surface areas of the two bodies are equal. The two bodies emit total radiant power at the same rate. The wavelength λ_B corresponding to maximum spectral radiancy in the radiation from B is shifted from the wavelength corresponding to maximum spectral radiancy in the radiation from A, by 1.00 μm. If the temperature of A is 5802 K:

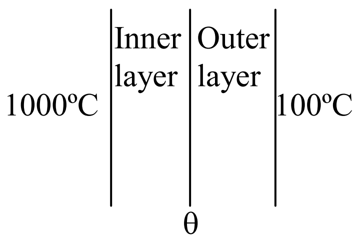
(a) the temperature of B is 1934 K

(b) λ_B = 1.5 μm

(c) the temperature of B is 1160 K

(d) the temperature of B is 2901 K

8. The temperature drop through a two layers furnace wall is 900ºC. Each layer is of equal area of cross-section. Which of the following actions will result in lowering the temperature θ of the interface?



(a) by increasing the thermal conductivity of outer layer

(b) by increasing the thermal conductivity of inner layer

(c) by increasing thickness of outer layer

(d) by increasing thickness of inner layer

9. Two spheres *A* and *B* have same radius but the heat capacity of *A* is greater than that of *B*. The surfaces of both are painted black. They are heated to the same temperature and allowed to cool. Then

(a) *A* cools faster than *B*

(b) both *A* and *B* cool at the same rate

(c) at any temperature the ratio of their rates of cooling is a constant

(d) *B* cools faster than *A*

10. Internal energy of an ideal diatomic gas at 300 K is 100 J. In this 100 J

(a) potential energy = 0

(b) rotational kinetic energy = 40 J

(c) translational kinetic energy = 60 J

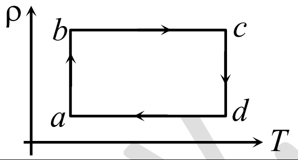
(d) translational kinetic energy is 100 J

EXERCISE – III

MATCH THE FOLLOWING

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

1. In the ρ- T graph shown in figure, match the following



Column I	Column II
I. Process a-*b*	**A.** Isochoric process
II. Process *b*-*c*	**B.** $\Delta U = 0$
III. Process c-*d*	**C.** P increasing
IV. Process *d*-*a*	**D.** P decreasing
	E. $W \neq 0$

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**: At a given temperature radiations emitted by pin hole cavities in different materials are different.

Statement-2: Pin hole cavities in all materials behave like perfect black body.

(a) (A) (b) (B) (c) (C) (d) (D)

2. **Statement-1**: Equal masses of helium and oxygen gases are given equal quantities of heat. There will be greater rise in the temperature of helium as compared to that of oxygen.

Statement-2: The molecular weight of oxygen in more than the molecular weight of helium.

(a) (A) (b) (B) (c) (C) (d) (D)

3. **Statement-1**: When temperature difference across the two sides of a wall is increased, its thermal conductivity increases.

Statement-2: Thermal conductivity depends on the nature of material of the wall.

(a) (A) (b) (B) (c) (C) (d) (D)

4. **Statement-1**: Work done by a gas in isothermal expansion is more than the work done by the gas in the same expansion adiabatically.

Statement-2: Temperature remains constant in isothermal expansion not in adiabatic expansion.

(a) (A) (b) (B) (c) (C) (d) (D)

5. **Statement-1**: Water can be boiled inside satellite by convection.

Statement-2: Convection is the process in which heat is transmitted from a place of higher temperature to a place of lower temperature by means of particles with their migrations from one place to another.

(a) (A) (b) (B) (c) (C) (d) (D)

LINKED COMPREHENSION TYPE

A metal block of heat capacity 80 J/^{0}C placed in a room at 20^{0}C is heated electrically. The heater is switched off when the temperature reaches 30^{0}C. The temperature of the block rises at the rate of 2 ^{0}C/s just after the heater is switched on and falls at the rate of 0.2^{0}C/s just after the heater is switched off. Assume Newton's law of cooling to hold.

1. Find the power of the heater

(a) zero (b) 60 watt
(c) 160 watt (d) 180 watt

2. Find the power radiated by the block just after the heater is switched off

(a) 16 watt (b) 8 watt
(c) 2 watt (d) 1 watt

3. Find the power radiated by the block when the temperature of the block is 25^{0}C

(a) zero (b) 1 watt
(c) 4 watt (d) 8 watt

EXERCISE –IV

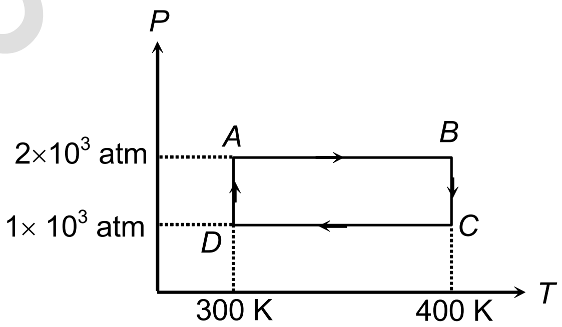
1. What should be the length of brass rod so that the change in its length may be the same at all temperatures as that of an iron rod of length 90 cm? $\alpha_{brass} = 18 \times 10^{-6}\ k^{-1}$ $\alpha_{iron} = 12 \times 10^{-6}\ k^{-1}$.

2. A steel rod of length 5 m is fixed rigidly between two supports. The coefficient of linear expansion of steel is 12×10^{-6} /°C. Calculate the stress (in MN/m^2) in the rod for an increase in temperature of 40°C. Young's modulus for steel is 2×10^{11} N/m^2.

3. A slab of stone of area 3600 cm^2 and thickness 10 cm is exposed on the lower surface to steam at 100°C. A block of ice at 0°C rests on the upper surface of the slab. In one hour, 4.8 kg of ice is melted. Calculate the thermal conductivity (in mW/m^{0}C) of stone.

4. An ideal gas is taken through a cyclic thermodynamic process through four steps. The amounts of heat involved in these steps are $Q_1 = 5960$ J; $Q_2 = -5585$ J; $Q_3 = -2980$ J; $Q_4 = 3645$ J respectively. The corresponding works involved are $W_1 = 2200$ J, $W_2 = -825$ J, $W_3 = -1100 J$ and W_4 respectively. Find the value of W_4.

5. $2/R$ moles of on ideal gas ($\gamma = 1.5$) undergo a cyclic process ($ABCDA$) as shown in figure. Assuming the gas to be ideal, calculate the following quantities in this process [ln 2 = 0.7]



(a) the net change in the heat energy

(b) the net work done by the gas

(c) the net change in internal energy

6. A lump of 0.1 kg of ice at -10°C is put in 0.15 kg of water at 20°C. How much water will be found in the mixture when it has reached thermal equilibrium?

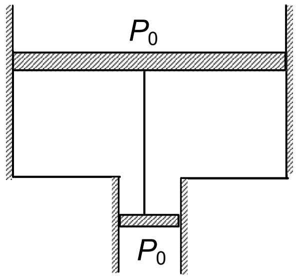
(Specific heat of ice = 2.1 kJ/kg; Latent heat of ice = 336 kJ/kg)

7. Three moles of an ideal gas $\left(C_p = \frac{7}{2}R\right)$ at pressure P_A and temperature T_A = 700k is isothermally expanded to twice its initial volume. It is then compressed at constant pressure to its original volume. Finally the gas is treated at constant volume to its original pressure P_A.

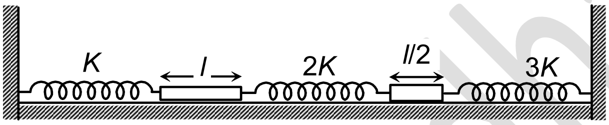
(a) Sketch P-V and P-T diagrams for the complete process.

(b) Calculate the work done by the gas and net heat supplied to the gas during the complete process.

8. A smooth vertical tube having two different sections is open to the atmosphere at both ends and is equipped with two pistons of corresponding areas; each piston sliding within a respective tube section. One mole of ideal gas is enclosed between the pistons tied with an inextensible thread. The cross-sectional area of the upper piston is 10 cm^2 greater than that of the lower one. The combined mass of two pistons is equal to 5 kg. The outside air pressure p_0 = 10 atm. Through what temperature range must the gas between the pistons be heated to shift the pistons through 5.0 cm?



9. The system shown consists of three springs and two rods. If the temperature of the rods in increased by ΔT, calculate the energy stored in each of the springs. The springs are initially relaxed, there is no friction. Take the coefficient of linear expansion of the material of the rods to be equal to α. [take $Kl^2 \alpha^2 \Delta T^2 = 968$]



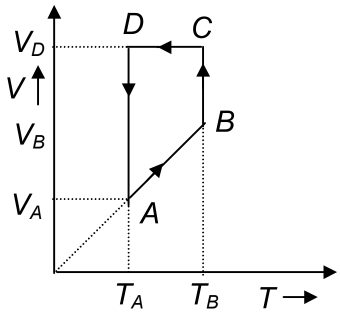
10. An ideal monatomic gas of two moles is taken through a cyclic process starting from A as shown in the figure. The volume ratios are $\frac{V_B}{V_A} = 2$ and $\frac{V_D}{V_A} = 4$. If the temperature T_A at A is 27° C, calculate:

(a) the temperature of the gas at point B,

(b) heat absorbed or released by the gas in AB and CD in multiple of R.

(c) the total work done by the gas during the complete cycle.

Where R is gas constant.



ANSWERS

EXERCISE – I

IIT JEE & NEET-SINGLE CHOICE CORRECT

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

EXERCISE – II

IIT-JEE-SINGLE CHOICE CORRECT

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

ONE OR MORE THAN ONE CHOICE CORRECT

1. (a,b)	2. (b,c)	3.(a,b,d)	4. (c,d)	5.(a,b,c,d)
6.(a,b,c,d)	7. (a,b)	8. (a,d)	9. (c,d)	10.(a,b,c)

EXERCISE – III

MATCH THE FOLLOWING

1. I – B,C; II – A,C, E ; III – B,D,E; IV – A,D

REASONING TYPE

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

LINKED COMPREHENSION TYPE

1. (c)	2. (a)	3. (d)

EXERCISE – IV

SUBJECTIVE PROBLEMS

1. 60 cm

2. 96 MN/m^2

3. 1240 mW/m°C

4. $W_4 = 765$ J

5. (a) 140 J (b) 140 J (c) zero

6. 181 gm

7. Net work done = 3486 J. Net heat supplied = 3486 J

8. 6.4 K (approximately)

9. 324 J, 162 J, 108 J

10. (a) 327°C

(b) $Q_{AB} = 1500\,R$, $Q_{CD} = -900\,R$

(c) 600 R

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 1

Q.1 An iron ball is heated. The percentage increase will be the largest in -
(1) diameter (2) surface area
(3) volume (4) density

Q.2 Two holes of unequal diameters d_1 and d_2 ($d_1>d_2$) are cut in a metal sheet. If the sheet is heated -
(1) Both d_1 and d_2 will decrease
(2) Both d_1 and d_2 will increase
(3) d_1 will increase, d_2 will decrease
(4) d_1 will decrease, d_2 will increase

Q.3 Two rods of lengths ℓ_1 and ℓ_2 are made of materials whose coefficient of linear expansions are α_1 and α_2. If the difference between two lengths is independent of temperature -
(1) $\frac{\ell_1}{\ell_2}=\frac{\alpha_1}{\alpha_2}$ (2) $\frac{\ell_1}{\ell_2}=\frac{\alpha_2}{\alpha_1}$
(3) $\ell_2^2\alpha_1=\ell_1^2\alpha_2$ (4) $\frac{\alpha_1^2}{\ell_1}=\frac{\alpha_2^2}{\ell_2}$

Q.4 The coefficient of linear expansion of steel and brass are 11×10^{-6}/ºC and 19×10^{-6}/ºC respectively. If their difference in lengths at all temperatures has to be kept constant at 30 cm, their lengths at 0ºC should be -
(1) 71.25 cm and 41.25 cm
(2) 82 cm and 52 cm
(3) 92 cm and 62 cm
(4) 62.25 cm and 32.25 cm

Q.5 A metallic bar is heated from 0ºC to 100ºC. The coefficient of linear expansion is 10^{-5} K^{-1}. What will be the percentage increase in length -
(1) 0.01% (2) 0.1% (3) 1% (4) 10%

Q. 6 A metal wire of length ℓ and area of cross-section A is fixed between rigid supports at negligible tension. If this is cooled, the tension in the wire will be -
(1) Proportional to ℓ
(2) Inversely proportional to ℓ
(3) Independent of ℓ
(4) Independent of A

Q.7 What will be the stress at –20ºC, if a steel rod with a cross-sectional area of 150 mm^2 is stretched between two fixed point ? The tensile load at 20ºC is 5000 N.
(Assume $\alpha = 11.7\times10^{-6}$/ºC, $Y = 200\times10^{11} N/m^2$)
(1) $12.7 \times 10^6 N/m^2$ (2) $1.27 \times 10^6 N/m^2$
(3) $127 \times 10^6 N/m^2$ (4) $0.127 \times 10^6 N/m^2$

Q. 8 If a bimetallic strip is heated, it will -
(1) bend towards the metal with lower thermal expansion coefficient
(2) bend towards the metal with higher thermal expansion coefficient
(3) not bend at all

(4) twist itself into a helix

Q.9 The temperature of a pendulum, the time period of which is t, is raised by ΔT. The change in its time period is -

(1) $\frac{1}{2}\alpha t\ \Delta T$ (2) $2\alpha t\ \Delta T$

(3) $\frac{1}{2}\alpha\ \Delta T$ (4) $2\alpha\Delta T$

Q.10 A pendulum clock is 5 sec fast at temperature of 15ºC and 10 sec slow at a temperature of 30ºC. At what temperature does it give the correct time -

(1) 18ºC (2) 20ºC (3) 22ºC (4) 25ºC

Q.11 A pendulum clock has an iron pendulum 1m long ($\alpha_{iron} = 10^{-5}$/ºC). If the temperature rises by 10ºC, the clock -

(1) Will lose 8 seconds per day
(2) Will lose 4.32 seconds per day
(3) Will gain 8 seconds per day
(4) Will gain 4.32 seconds per day

Q.12 A second's pendulum clock having steel wire is calibrated at 20ºC. When temperature is increased to 30ºC, then how much time does the clock lose or gain in one week ?
[$\alpha_{steel} = 1.2 \times 10^{-5}$(ºC)$^{-1}$] :

(1) 0.3628 s (2) 3.626 s
(3) 362.8 s (4) 36.28 s

Q.13 If the length of a cylinder on heating increases by 2%, the area of its base will increase by -

(1) 0.5% (2) 2%
(3) 1% (4) 4%

Q.14 A solid ball of metal has a spherical cavity inside it. If the ball is heated, the volume of the cavity will -

(1) Increase
(2) Decrease
(3) Remains unchanged
(4) Have its shape changed

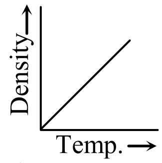
Q.15 If α, β, γ are linear, superficial and cubical expansivity of a solid, then -

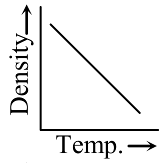
(1) $\alpha : \beta : \gamma = 1 : 2 : 3$
(2) $\alpha : \beta : \gamma = 3 : 2 : 1$
(3) $\alpha : \beta : \gamma = 2 : 3 : 1$
(4) $\alpha : \beta : \gamma = 3 : 1 : 2$

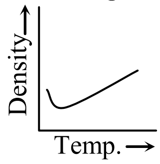
Q.16 The volume of a solid decreases by 0.6% when it is cooled through 50ºC. Its coefficient of linear expansion is -

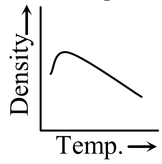
(1) 4×10^{-6} K (2) 5×10^{-5} K
(3) 6×10^{-4} K (4) 4×10^{-5} K

Q.17 Which of the following curve represent variation of density of water with temperature best -

(1) 

(2) 

(3) 

(4) 

Q.18 Density of substance at 0ºC is 10 gm/cc and at 100ºC, its density is 9.7 gm/cc. The coefficient of linear expansion of the substance will be -

(1) 10^{2} (2) 10^{-2}
(3)10^{-3} (4) 10^{-4}

Q. 19 A rectangular block is heated from 0°C to 100°C. The percentage increase in its length is 0.10%. What will e the percentage increase in it volume ?

(1) 0.03% (2) 0.10%
(3) 0.30% (4) None of these

Q. 20 A thin copper wire of length ℓ increases in length by 1% when heated from 0°C to 100°C. If a then cooper plate of area 2l × l is heated from 0°C to 100°C, the percentage increase in its area will be -

(1) 1% (2) 2%
(3) 3% (4) 4%

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 2

Q.1 A beaker is completely filled with water at 4°C. It will overflow -
(1) when heated but not when cooled
(2) when cooled but not when heated
(3) both when heated or cooled
(4) neither when heated nor when cooled

Q. 2 Two spheres are made of same metal and have same mass. One is solid and the other is hollow. When heated to the same temperature, which of the following statements is correct about the percentage increase in their diameters ?
(1) it will be more for hollow sphere
(2) it will more for solid sphere
(3) it will be same for both spheres
(4) It may be more or less depending on the ratio of the diameters of the two spheres

Q. 3 If a bimetallic strip is heated, it will -
(1) bend towards the metal with lower thermal expansion coefficient
(2) bend towards the metal with higher thermal expansion coefficient
(3) not bend at all
(4) twist itself into a helix

Q.4 When a bimetallic strip is heated, it -
(1) does not bend at all
(2) gets twisted in the form of an helix
(3) bends in the form of an arc with the more expandable material outside
(4) bends in the form of an arc with the more expandable material inside

Q.5 A breaker is filled with water at 4°C at one time the temperature is increased by few degrees above 4°C and at another time it is decreased by a few degrees below 4°C. One shall observe that -
(1) The level remains constant in each case
(2) In first case water flows while in second case its level comes down
(3) In second case water overflows while in first case it comes down
(4) Water overflows in both the cases

Q.6 The variation of density of a solid with temperature is given by the formula -
(1) $d_2 = \frac{d_1}{1+\gamma(t_2-t_1)}$ (2) $d_2 = \frac{d_1}{1-\gamma(t_2-t_1)}$
(3) $d_2 = \frac{d_1}{1-2\gamma(t_2-t_1)}$ (4) $d_2 = \frac{d_1}{2+2\gamma(t_2-t_1)}$

Q.7 Two spheres of the same radius are made from the same material. One is hollow and the other is solid. If they are heated together from 20°C to 100°C.
(1) both will expand equally
(2) hollow sphere will expand more
(3) solid sphere will expand more
(4) the relative expansion of solid and hollow sphere depends on the material of sphere

Q.8 Two rods of lengths ℓ_1 and ℓ_2 are made of materials whose coefficient of linear expansions are α_1 and α_2. If the difference between two lengths is independent of temperature -

(1) $\frac{\ell_1}{\ell_2} = \frac{\alpha_1}{\alpha_2}$ (2) $\frac{\ell_1}{\ell_2} = \frac{\alpha_2}{\alpha_1}$

(3) $\ell_2^2\alpha_1 = \ell_1^2\alpha_2$ (4) $\frac{\alpha_1^2}{\ell_1} = \frac{\alpha_2^2}{\ell_2}$

Q.9 The brass disc fits singly in a hole in a steel plate. To loose the disk from hole-
(1) we should heat the system
(2) we should cool the system
(3) we should apply a strong external force
(4) it can not be separated

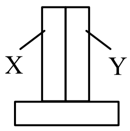
Q.10 An iron tyre is to be fitted onto a wooden wheel 1.0 metre in diameter. The diameter of the tyre is 6 mm, smaller than that of the wheel. The tyre should be heated so that its temperature increases by a minimum of (given coefficient of volume expansion of iron is- 3.6×10^{-5}/°C)
(1) 167°C (2) 334°C
(3) 500°C (4) 1000°C

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 3

Q.1 The real coefficient of volume expansion of glycerine is 0.000597 per ºC and linear coefficient of expansion of glass is 0.000009 per ºC. Then the apparent volume coefficient of expansion of glycerine is –
(1) 0.000558 per ºC (2) 0.00057 per ºC
(3) 0.00027 per ºC (4) 0.00066 per ºC

Q.2 The density of a substance at 0ºC is 10 g/cc and at 100ºC its density is 9.7 g/cc. Then the coefficient of linear expansion is-
(1) 10^2 (2) 10^{-5}
(3) 10^{-2} (4) 10^{-4}

Q.3 A bimetallic strip consists of metals X and Y. It is mounted rigidly at the base as shown. the metal X has a higher coefficient of expansion compared to that for metal Y. When bimetallic strip is placed in a cold bath-



(1) it will bend towards the right
(2) it will bend towards the left
(3) it will not bend but shrink
(4) it will neither bend nor shrink

Q.4 If the coefficient of cubical expansion is x times of the coefficient of superficial expansion, then value of x is-
(1) 3 (2) 2.5
(3) 1.5 (4) 2

Q.5 An ice block contains a glass ball. When the ice melts within the water containing vessel the level of water-
(1) rises
(2) falls
(3) unchanged
(4) first rises and then falls

Q.6 A beaker is completely filled with water at 4ºC. It will overflow if-
(1) heated above 4ºC
(2) cooled below 4ºC
(3) both heated and cooled above and below 4ºC respectively
(4) none of the above

Q.7 A pendulum clock is 5 s fast at a temperature of 15ºC and 10 s slow at a temperature of 30ºC. At what temperature does it give the correct time ?
(1) 10ºC (2) 20ºC
(3) 15ºC (4) 25ºC

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 4

Q.1 Two metal strips that constitute a thermostats necessarily differ in their
(1) Mass
(2) Length
(3) Resistivity
(4) Coefficient of linear expansion

Q.2 A bimetallic strip is formed out of two identical strips, one of copper and the other of brass. The coefficient of linear expansion of the two metals are α_C and α_B. On heating, the temperature of the strip goes up by ΔT and the strip bends to form an arc of radius of curvature R. Then R is
(1) Directly proportional to ΔT
(2) Inversely proportional to ΔT
(3) Directly proportional to $|\alpha_B - \alpha_C|$
(4) none of these

Q.3 Two rods one of aluminium of length ℓ_1, having coefficient of linear expansion α_a, and other of steel of length ℓ_2, having coefficient of linear expansion α_s are joined end to end. The expansion in both the rods is same for the same variation of temperature. Then the value of $\frac{\ell_1}{\ell_1+\ell_2}$ is -
(1) $\frac{\alpha_s}{\alpha_a+\alpha_s}$ (2) $\frac{\alpha_a}{\alpha_a+\alpha_s}$
(3) $\frac{\alpha_a}{\alpha_s}$ (4) $\frac{\alpha_s}{\alpha_a}$

Q.4 An ideal gas expanding such that PT^2 = constant. the coefficient of volume expansion of the gas is–
(1) $\frac{1}{T}$ (2) $\frac{2}{T}$
(3) $\frac{3}{T}$ (4) $\frac{4}{T}$

Q.5 If the coefficient of Linear expansion of a solid is 0.00009. Its coefficient of volume expansion is-
(1) 0.009 (2) 0.02
(3) 0.03 (4) 0.00027

Q.6 The volume of a metal sphere increases by 0.15% when its temperature is raised by 24ºC. The coefficient of linear expansion of metal is-
(1) 2.5×10^{-5}/ºC (2) 2.0×10^{-5}/ºC
(3) -1.5×10^{-5}/ºC (4) 1.2×10^{-5}/ºC

Q.7 An aluminimum sphere of 20 cm diameter is heated from 0ºC to 100ºC. Its volume changes by (given that coefficient of linear expansion for aluminium $\alpha_{Al} = 23 \times 10^{-6}$/ºC) -
(1) 2.89 cc (2) 9.28 cc
(3) 49.8 cc (4) 28.9 cc

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 5

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.
(1) If both Assertion & Reason are true & the Reason is a correct explanation of the Assertion.
(2) If both Assertion and Reason are true but Reason is not a correct explanation of the Assertion.
(3) If Assertion is true and Reason is false.
(4) If Assertion & Reason both are false.

Q.1 **Assertion :** A brass is just fitted in a hole in a steel plate. The system must be cooled to loosen the disc from the hole.
Reason : The coefficient of linear expansion for brass is greater than the coefficient of linear expansion for steel.
(1) A (2) B (3) C (4) D

Q.2 **Assertion :** The coefficient of volume expansion has dimension K^{-1}.
Reason : The coefficient of volume expansion is defined as the change in volume per unit change in temperature.
(1) A (2) B (3) C (4) D

Q.3 **Assertion :** When a solid iron ball is heated, percentage increase in its volume is largest.
Reason : Coefficient of superficial expansion is twice that of linear expansion where as coefficient of volume expansion is three times of linear expansion.
(1) A (2) B (3) C (4) D

Q.4 **Assertion :** A beaker is completely filled with water at 4ºC. It will overflow, both when heated or cooled.
Reason : There is expansion of water below and above 4ºC.
(1) A (2) B (3) C (4) D

Q.5 **Assertion :** For the same rise in temperature percentage change in area is two times the percentage change in length.
Reason : Coefficient of superficial (areal) expansion is always two time the coefficient of linear expansion.
(1) A (2) B (3) C (4) D

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 6

Q.1 A water fall is 84 m high. Assuming that half the kinetic energy of the falling water gets converted to heat, the rise in temperature of water is -
(1) 0.098ºC (2) 0.98ºC
(3) 9.8ºC (4) 0.0098ºC

Q.2 A lead bullet at 27ºC just melts when stopped by an obstacle . Assuming that 25% of heat is absorbed by the obstacle, then the velocity of the bullet at the time of striking- (M.P. of lead = 327ºC specific heat of lead = 0.03 cal/gm/ºC, latent heat of fusion of lead = 6cal/gm and J = 4.2 Joule/cal)
(1) 410 m/sec (2) 1230 m/sec
(3) 307.5 m/sec (4) none of these

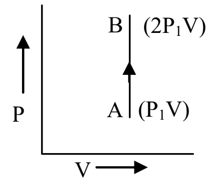
Q.3 Two bullets of same metal and mass 10gm and 5gm respectively collide against a target with the same velocity. If the whole energy of the bullets is used up in increasing their temperatures then greater increase of temperature will be in -
(1) first bullet (2) second bullet
(3) equal in both bullets (4) none of these

Q.4 An object of 5kg mass falls from a height of 30m. If the whole amount of mechanical energy is converted into heat, the number of calories generated is -
(1) 150 (2) 60 (3) 350 (4) 6

Q.5 A lead sphere of mass one kg falls from a height of 126m. If the whole kinetic energy is converted into heat, then increase in its temperature will be- (specific heat of lead is 30 calorie/kgºC and g = 9.8 m/sec^2)
(1) 9.8ºC (2) 4.2ºC (3) 4.7 ºC (4) 37ºC

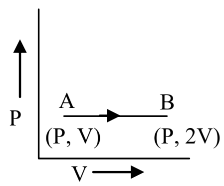
Q.6 A body of 10 kg mass falls form a height of 25m and gets rebound to 0.50m. If the loss in energy is converted to heat the body, then rise in temperature will be -
(sp. heat of material is 25.2 J/kgºK)
(1) 9.8 K (2) 0.095 K
(3) 0.0095 K (4) none of these

Q.7 A thermodynamical system goes from one state to another state (as shown in fig) the external work done is given by-



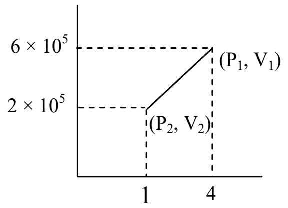
(1) PV (2) 2PV (3) zero (4) 2P^{2}V^2

Q.8 A thermodynamical system goes from state A to state B (as shown figure), the work done is given by-



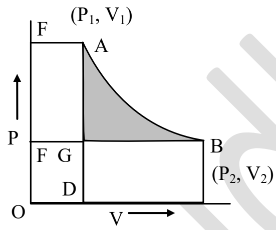
(1) PV (2) 2PV (3) zero (4) $2P^2V^2$

Q.9 A system changes from the state (P_1, V_1) to (P_2 , V_2) as shown in the figure below. What is the work done by the system ?



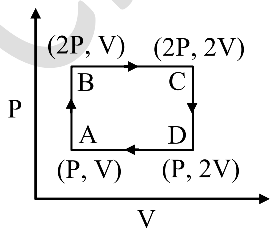
(1) 7.5×10^5 joule (2) 7.5×10^4 erg
(3) 12×10^5 joule (4) 6×10^5 joule

Q.10 An ideal gas is transformed from state A(P_1, V_1) to the state B(P_2, V_2) through path AB. In this process the work done by the gas is-



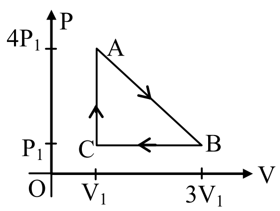
(1) W = area ABCDA
(2) W = area ABEFA
(3) W = area ABGA
(4) W = area ABCOFA

Q.11 An ideal monoatomic gas is taken round the cycle ABCDA as shown P-V diagram. The work-done during the cycle is -



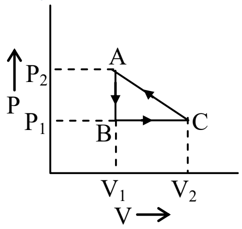
(1) PV (2) 2PV (3) PV/2 (4) zero

Q.12 An ideal gas is taken through series of changes ABCA. The amount of work involved in the cycle is -



(1) $12P_1V_1$ (2) $6P_1V_1$ (3) $3P_1V_1$ (4) P_1V_1

Q.13 As shown in the diagram, for a closed path ABCA -



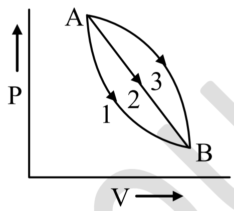
(1) the amount of work done by the system is zero

(2) the amount of work done by the system is $= -\frac{1}{2}$ $(P_2 - P_1)(V_2 - V_1)$

(3) the amount of work done on the system is $= (P_2 - P_1)(V_1 - V_2)$

(4) the amount of work done by the system is $= \frac{1}{2}$ $(P_2 - P_1)(V_2 - V_1)$

Q.14 A gas of given mass, is brought from stage A to B along three paths 1, 2 and 3, as shown in the figure. If the amount of work done in these three processes is respectively equal to W_1, W_2 and W_3, then -



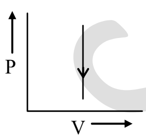
(1) $W_1 > W_2 > W_3$

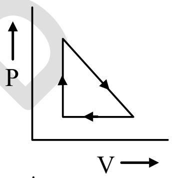
(2) $W_1 < W_2 < W_3$

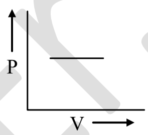
(3) $W_1 = W_2 = W_3$

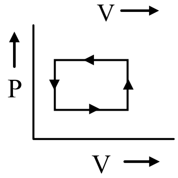
(4) $W_1 < W_2$, $W_3 < W_2$

Q.15 The indicator diagrams representing minimum and maximum amounts of work done are respectively.

(a) 

(b) 

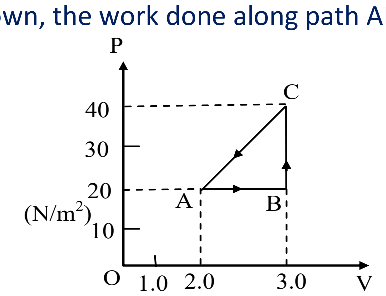
(c) 

(d) 

(1) c and a (2) a and c

(3) b and a (4) d and b

Q.16 In the indicator diagram shown, the work done along path AB is -

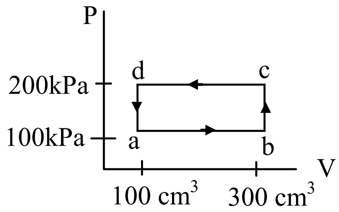


(1) Zero (2) 20 Joule
(3) – 20 Joule (4) 60 Joule

Q.17 In the above problem**(Q.No.16)** work done along path BC is-
(1) Zero (2) (40 – 20) = 20 J
(3) 40 J (4) 60 J

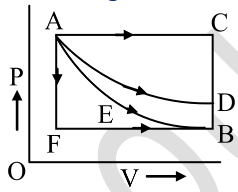
Q.18 In the above question**(Q.No.16)** the work done along path CA is –
(1) 20 Joule (2) 30 Joule
(3) – 30 Joule (4) Zero

Q.19 A thermodynamic system is taken through the cycle abcda, find the total heat rejected by the gas during the process –



(1) – 10J (2) – 20J (3) – 30J (4) – 40J

Q.20 An ideal system can be brought from stage A to B through four paths as shown in the figure. The energy given to the system is minimum in -



(1) path ACB (2) path ADB
(3) path AEB (4) path AFB

Q.21 A system is given 400 calories of heat and 1000 Joule of work is done by the system, then the change in internal energy of the system will be -
(1) 680 Joule (2) 680 erg
(3) 860 Joule (4) – 860 Joule

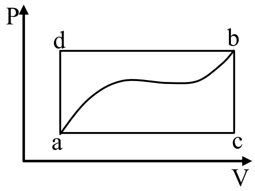
Q.22 For a thermodynamic process δQ = – 50 calorie and W = – 20 calorie. If the initial internal energy is – 30 calorie then final internal energy will be -
(1) 191.20 Calorie (2) – 60 Calorie
(3) 100 Calorie (4) – 100 Calorie

Q.23 The differential form of first law of thermodynamics is -
(1) δQ = δW + δU
(2) δQ = δW – δU
(3) δQ = δU – δW
(4) δQ + δU + δW = 0

Q.24 When an ideal diatomic gas is heated at constant pressure then what fraction of heat given is used to increase internal energy of gas ?
(1) $\frac{5}{7}$ (2) $\frac{3}{7}$
(3) $\frac{3}{5}$ (4) $\frac{2}{5}$

Q.25 A system absorbs 10^3 calories of heat and the system does 1675 Joule work. The internal energy of the system increases by 2515 Joule. The value of J is -
(1) 4.18 Cal/Joule (2) 420 Joule/cal
(3) 42 Joule/cal (4) 4.19 Joule/cal

Q.26 In the adjoined figure the indicator diagram of an ideal thermodynamic gas system is represented. If the change in internal energy along the path **acb** is 10 calorie then change in internal energy along the path **bda** will be -



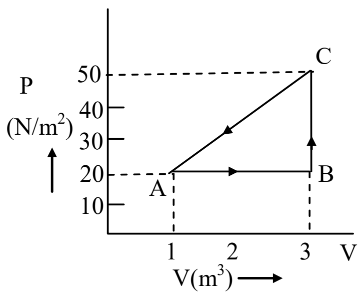
(1) 10 Calorie
(2) – 10 Calorie
(3) more than 10 Calorie
(4) less than 10 Calorie

Q.27 In the above problem, if the work done along path ac is 20 calorie then the heat given to the system along path acb will be-
(1) 20 Cal. (2) 10 Cal.
(3) 30 Cal. (4) – 10 Cal.

Q.28 A gas is compressed from 10 m^3 volume to 4m^3 volume at constant pressure of 50 N/m^2. Then the gas is heated by giving it 100 Joules of energy. The internal energy of the gas will-
(1) Increase by 100 Joule
(2) increase by 200 Joule
(3) increases by 400 Joule
(4) decrease by 200 Joule.

Q.29 The pressure of given mass of a gas in a thermodynamic system is changed in such a way that 20 joule of heat is released from the gas and 8 joule of work is done on the gas. If the initial internal energy of the gas was 30 joule then final internal energy will be-
(1) 2 Joule
(2) 42 Joule
(3) 18 Joule
(4) 58 Joule

Q.30 In the diagram, the graph between volume and pressure for a thermodynamical process in shown. If U_A = 0, U_B = 20J and the energy given from B to C is 30J, then at the stage of C, the internal energy of the system is -



(1) 50J (2) 60J
(3) 30J (4) 10J

Q.31 In the foregoing question**(Q.No.30)**, the amount of energy given to the system from A to B is -
(1) 50J (2) 60J
(3) 30J (4) 10J

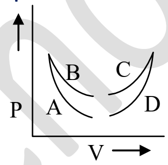
Q.32 In the foregoing question**(Q.No.30)**, work done in the process A $\rightarrow$ B $\rightarrow$ C $\rightarrow$ A is -
(1) 50J (2) 60J
(3) 30J (4) zero

Q.33 A system does 30 joule work after absorbing 32 cal heat. The change in the internal energy of the system will be -
(1) 92J (2) 104.4J
(3) 2J (4) 164.4J

Q.34 Among of work done in changing the state of a system is –15J. If the internal energy and change in internal energy 60J and + 15J, then -
(1) $\Delta Q = 30$ J, $U_f = 45$ J
(2) $\Delta Q = 0$, $U_f = 75$ J
(3) $\Delta Q = 30$ J, $U_f = 75$ J
(4) $\Delta Q = 0$, $U_f = 45$ J

Q.35 The change in internal energy during the adiabatic expansion of 2 mole gas is found to be (–) 100 J. The work done during the process will be -
(1) zero (2) – 100J
(3) 200J (4) 100J

Q.36 Four curves A, B, C and D are drawn in the figure for a given amount of a gas. The curves representing adiabatic and isothermal process are -



(1) C and D respectively
(2) D and C respectively
(3) A and B respectively
(4) B and A respectively

Q.37 In reference of above figure, no heat exchange between the gas and the surrounding will take place if the gas is taken along -
(1) curve A (2) curve B
(3) curve C (4) curve D

Q.38 During the adiabatic change of ideal gas, the relation between the pressure and the density will be -
(1) $\frac{P_1}{P_2} = \left(\frac{d_2}{d_1}\right)^{1/\gamma}$ (2) $P_1 d^{\gamma}_1 = P_2 d_2^{\gamma}$
(3) $P_1 d_1^{-\gamma} = P_2 d_2^{-\gamma}$ (4) $\frac{P_1}{P_2} = \left(\frac{d_1}{d_2}\right)^{1/\gamma}$

Q.39 The pressure of the gas filled in thermally insulated container is P and temperature is T. If the ratio of specific heats of the gas is γ, which of the following will be constant -
(1) $PT^{\gamma-1}$ (2) $P^{\gamma} T^{1-\gamma}$
(3) $P^{1-\gamma} T^{\gamma}$ (4) $P^{-\gamma} T^{\gamma-1}$

Q.40 The slope of indicator curve in adiabatic change relative to volume axis is -

(1) P/V^{γ} (2) $P^{\gamma}/V^{\gamma-1}$

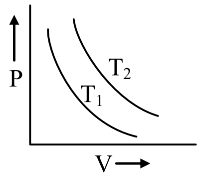
(3) $\frac{P}{\gamma(V)}$ (4) $-\gamma\left(\frac{P}{V}\right)$

Q.41 The ratio of slopes of adiabatic and isotherm is-

(1) $1 : \gamma$ (2) $1 : 1$

(3) $\gamma : 1$ (4) $1 : 4$

Q.42 Two curves are given at temperatures T_1 and T_2 in an isothermal process, then -



(1) $T_1 > T_2$ (2) $T_1 = T_2$

(3) $T_1 < T_2$ (4) no knowledge

Q.43 The initial volume and pressure of a gas are V and P respectively. It is expand by two different processes such that in each process the final volume becomes 2V. If the work done in isothermal change is W_1 and the amount of work done in adiabatic change is W_2, then -

(1) $W_1 > W_2$

(2) $W_1 < W_2$

(3) $W_1 = W_2$

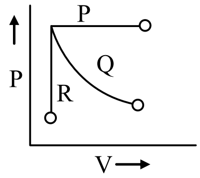
(4) nothing can be said

Q.44 Dry air at one atmospheric pressure is suddenly compressed so that its volume becomes one-fourth. Its pressure will become - (γ = 1.5)

(1) 4 atm (2) 8 atm

(3) 16 atm (4) 32 atm

Q.45 Three curves are shown in the P-V diagram. P, Q and R represent the processes respectively-



(1) isothermal, adiabatic, isometric

(2) isobaric, isothermal, isometric

(3) isometric, isobaric, adiabatic

(4) isometric, isobaric, isothermal

Q.46 If 1 kg air (g = 1.4) is heated adiabatically from 0ºC to 10ºC then increase in its internal energy will be- (C_v = 0.172 Cal/gmºC)

(1) 1720 Joule (2) 7224 Joule

(3) 172 Calorie (4) 7224 Calorie

Q.47 In an adiabatic process -
(1) the internal energy of the system remains constant
(2) the pressure of the system remains constant
(3) the volume of the system remains constant
(4) heat energy stored in it remains constant

Q.48 In an adiabatic expansion of a gas, its temperature -
(1) always increases
(2) always diminishes
(3) remains constant
(4) diminishes initially and then increases

Q.49 In an adiabatic process, temperature of a gas is doubled by compression, the final pressure will be -
(1) doubled
(2) more than double
(3) less than double
(4) much greater than double

Q.50 In an adiabatic process, n moles of a perfect gas expand from temperature T_1 to T_2. The amount of work done by the gas will be -
(1) $C_p(T_1 - T_2)/n$ (2) $C_v(T_1 - T_2)/n$
(3) $nC_p(T_1 - T_2)$ (4) $nC_v(T_1 - T_2)$

Q.51 A perfect gas is compressed adiabatically. In that state the value of $\Delta P/P$ will be -
(1) $\frac{1}{\gamma}\cdot\frac{\Delta V}{V}$ (2) $-\frac{\Delta V}{V}$
(3) $-\gamma\frac{\Delta V}{V}$ (4) $+\gamma\frac{\Delta V}{V}$

Q.52 In an adiabatic expansion of 2 moles of a gas, the change in its internal energy was found to be –100J. The work done in this process is -
(1) zero (2) –1000 J (3) 200 J (4) 100 J

Q.53 The pressure and volume of a gas are P and V. If its pressure is reduced to P/2, by (A) isothermal process (B) by adiabatic process then the final volume will be -
(1) more in A
(2) more in B
(3) equal in A and B
(4) depends on the nature of gas

Q.54 An ideal heat engine exhausting heat at 77ºC is to have a 30% efficiency. It must take heat at -
(1) 127ºC (2) 227ºC
(3) 327ºC (4) 673ºC

Q.55 A Carnot engine, whose sink is at 300 K, has an efficiency of 40%. By how much the source temperature should be changed so as to increase the efficiency to 60% ?
(1) 250K increase (2) 250 K decrease
(3) 325K increase (4) 325 K decrease

Q.56 During isothermal expansion at 800 K, the working substance of a Carnot's engine releases 480 calories of heat. If the sink be at 300 K, then the work done by the working substance during isothermal expansion will be -

(1) 190 cal. (2) 480 cal

(3) 270 cal (4) 360 cal

Q.57 Two steam engine A and B, have their sources respectively at 700 K and 650 K and their sinks at 350 K and 300 K. Then -

(1) A is more efficient than B

(2) B is more efficient than A

(3) both are equally efficient

(4) depends on the fuels used in A & B

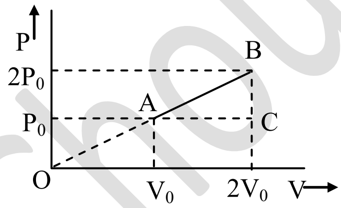
IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 7

Q.1 If 41.8 k cal heat is produced by applying the brakes to stop a car of mass 800 kg. The speed of the car before the brakes were applied, was -
(1) 15 m/s (2) 20.9 m/s
(3) 25 m/s (4) 30 m/s

Q.2 An ideal gas expands from state (P_1, V_1) to state (P_2, V_2), where $P_2 = 2P_1$ and $V_2 = 2V_1$. The path of the gas is expressed by the following relation,
$P = P_1\left[1+\left(\frac{V - V_1}{V_1}\right)^2\right]$. Work done is -
(1) $P_1 V_1$ (2) 4/3 P_1V_1
(3) $2P_1 V_1$ (4) $4P_1 V_1$

Q.3 A piece of ice (at 0ºC) of initial mass 50 kg starts slipping on a horizontal surface with a initial speed of 5.38 m/s and stops after travelling distance 28.3m. The mass of ice melted due to friction between ice and surface is -
(1) 1.1 gm (2) 2.2. gm
(3) 4.4 gm (4) 22 gm

Q.4 One mole of monatomic gas is brought from state A to state B. The initial temperature at A is T_0. The temperature at B will be -

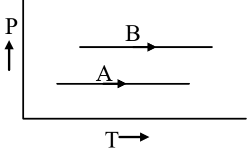


(1) T_0 (2) $2T_0$ (3) $3T_0$ (4) $4T_0$

Q.5 In the above question**(Q.No.4)**, heat absorbed along the path ACB is -
(1) $\frac{11}{2}RT_0$ (2) $\frac{9}{2}RT_0$
(3) $\frac{7}{2}RT_0$ (4) $\frac{5}{2}RT_0$

Q.6 In question**(Q.No.4)**,, the heat absorbed in going from A to B is -
(1) $2RT_0$ (2) $6RT_0$
(3) $4RT_0$ (4) $8RT_0$

Q.7 Consider the two process on a system as shown in figure. The volumes in the initial state and in the final state are the same in the two process A and B. If W_1 and W_2 be the work done by the system in the processes A and B respectively then-



(1) $W_1 > W_2$
(2) $W_1 = W_2$
(3) $W_1 < W_2$
(4) Nothing can be said about the relation between W_1 and W_2

Q.8 A sample of an ideal gas expanded to twice its original volume of 1 m^3 in a process for which $P = KV^2$ where K is a constant whose value is 5 atm / m^6. The work done by the expanding gas is-

(1) 11.78 J (2) 1178 J
(3) 11.78×10^5 J (4) 11.78×10^3 J

Q.9 A gas expands in a piston - cylinder device from V_1 to V_2, the process being described by $P = \frac{a}{V} + b$. Where P : Pressure and V : Volume The work done in process is -

(1) $a \ln \frac{V_1}{V_2} + b (V_2 - V_1)$

(2) $- a \ln \frac{V_2}{V_1} - b (V_2 - V_1)$

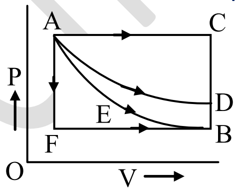
(3) $- a \ln \frac{V_1}{V_2} - b (V_2 - V_1)$

(4) $a \ln \frac{V_2}{V_1} + b (V_2 - V_1)$

Q.10 Two samples (A) and (B) of gas initially of the same temperature and pressure are compressed from a volume V to a volume V/2. One isothermally and the other adiabatically respectively. The final pressure of -

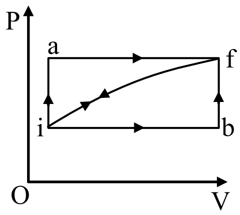
(1) A is greater than that of B
(2) A is equal to that of B
(3) A is less than that of B
(4) A is twice the pressure of B

Q.11 A system can be taken from state A to the state B by any of the four path shown in the diagram. The heat given to the system will be minimum for the path -



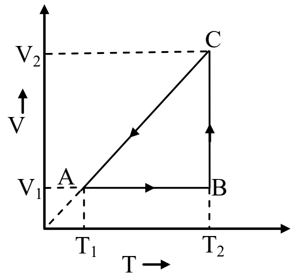
(1) ACB (2) ADB
(3) AEB (4) AFB

Q.12 When a system is taken from state to state f along the path iaf, it is found that Q = 50 cal and W = 20cal. Along the path ibf. Q = 36 cal. W along path ibf is -



(1) 30 cal (2) 16 cal
(3) 6 cal (4) 14 cal

Q.13 A cyclic process for 1 mole of an ideal gas is shown in figure in the V-T. diagram. The work done in AB, BC and CA respectively -



(1) 0, $RT_2 \,\ell n\left(\frac{V_1}{V_2}\right)$, R (T_1 - T_2)

(2) R (T_1 - T_2), 0, $RT_1 \,\ell n \frac{V_1}{V_2}$

(3) 0 , $RT_2 \,\ell n\left(\frac{V_2}{V_1}\right)$, R (T_1 - T_2)

(4) 0, $RT_2 \,\ell n\left(\frac{V_2}{V_1}\right)$, R (T_2 - T_1)

Q.14 An ideal gas is taken through cyclic thermodynamic process through four steps. The amount of heat involved is these steps are Q_1 = 5960J, Q_2 = –5585J, Q_3 = –2980J and Q_4 = 3645J respectively. The corresponding quantities of work involved are W_1 = 2200J, W_2 = –825J, W_3 = –1100J, and W_4 respectively. Then, the value of W_4 is -

(1) Zero (2) 275J (3) 765J (4) 1040J

Q.15 A bullet travelling with velocity 100 m/sec hits a concrete wall. All its kinetic energy is converted into heat energy in the bullet with the result that there is an increase of 50ºC in the temperature of the bullet. What will be the increase in temperature if the bullet were travelling with a velocity 200 meters/sec ?

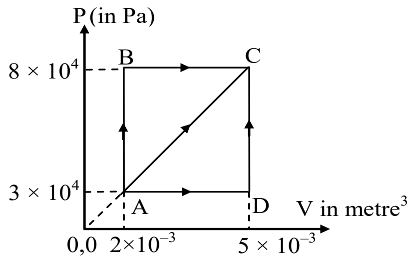
(1) 100ºC (2) 50ºC (3) 200ºC (4) 400ºC

Q.16 The amount of heat required to raise the temperature of a diatomic gas by 1ºC at constant pressure is Q_p and at constant volume is Q_v. The amount of heat which goes as internal energy of the gas in the two cases is nearly -

(1) Q_p & Q_v (2) 0.71 Q_p & 0.71 Q_v

(3) 0.71 Q_p & Q_v (4) 0.7 Q_p & 0.9 Q_v

Q.17 A thermodynamic process is shown in this figure. The pressure and volumes corresponding to some points in the figure are -



$P_A = 3 \times 10^4$ Pa, $V_A = 2 \times 10^{-3}$ m^3

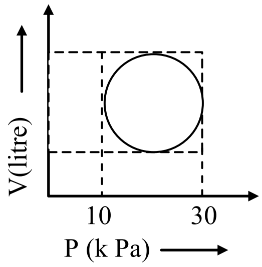
$P_B = 8 \times 10^4$ Pa, $V_D = 5 \times 10^{-3}$ m^3.

In process AB, 600 J of heat is added to the system and in process BC 200 J of heat is added to the system. The change in internal energy of the system in process AC would be -

(1) 560 J (2) 800 J

(3) 600 J (4) 640 J

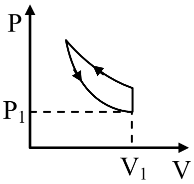
Q.18 Heat energy absorbed by a system in going through a cyclic process shown is figure is -

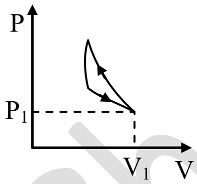


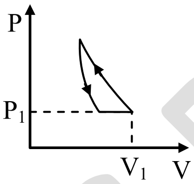
(1) $10^7 \pi$ J (2) $10^4 \pi$ J
(3) $10^2 \pi$ J (4) $10^{-3} \pi$ J

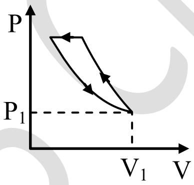
Q.19 A body of mass 10 kg falls from a height of 2.5 m and rebounds to a height of 0.5 m. If whole of potential energy lost is utilised in heating the body, then rise in its temperature will be - (The specific heat of material of the body = 25.2 J/kg - K)
(1) 9.5 K (2) 0.95 K
(3) 0.095 K (4) 0.0095 K

Q.20 The pressure of given mass of an ideal gas is P_1 and its volume is V_1. It is compressed isothermally and then expanded adiabatically till its pressure restores to initial value P_1 and then the gas remains its initial volume V_1. The above process can be correctly represented in the following indicator diagram -

(1) 

(2) 

(3) 

(4) 

Q.21 A gas at 10^5 Pascal pressure and 27ºC temperature is compressed adiabatically to $\frac{1}{8}$th of its initial volume. The final temperature of gas becomes 927ºC. The value of γ for the gas will be -
(1) $\frac{3}{2}$ (2) $\frac{4}{3}$ (3) $\frac{5}{4}$ (4) $\frac{5}{3}$

Q.22 There are two parts of a vessel. The pressure in one part is P and its volume is V. The volume of another part is 4V and there is vacuum in it. if the intervening wall is ruptured, then work done by the gas and change in its internal energy will be -

P	Vacuum
V	4V

(1) $\delta W = 2PV$, dU = – ve
(2) $\delta W = 3PV$, dU = 0
(3) $\delta W = 0$, dU = + ve
(4) $\delta W = 0$, dU = 0

Q.23 From what height a block of ice must fall into a well so that $\frac{1}{100}$ th of its mass may melt ? The temperature of water in the well is 0ºC -

(1) 3360 m (2) 33.6 m
(3) 336 m (4) 3.36 m

Q.24 A 0.1 kg steel ball falls from a height of 10m and bounces to a height of 7m. If the dissipated energy goes to the ball, the rise in its temperature will be -
(Specific heat of steel = 0.11 k Cal/kg K)

(1) 1.0ºC (2) 0.064ºC
(3) 0.72ºC (4) 0

Q.25 Two steam engine A and B, have their sources respectively at 700K and 650K and their sinks at 350K and 300K. Then -

(1) A is more efficient than B
(2) B is more efficient than A
(3) both are equally efficient
(4) depends on the fuels used in A and B

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 8

Q.1 A monoatomic gas (γ = 5/3) is suddenly compressed to $\frac{1}{8}$ of its original volume adiabatically, then the pressure of the gas will change to -

(1) $\frac{24}{5}$

(2) 8

(3) $\frac{40}{3}$

(4) 32 times its initial pressure

Q.2 The internal energy U is a unique function of any state, because change in U -

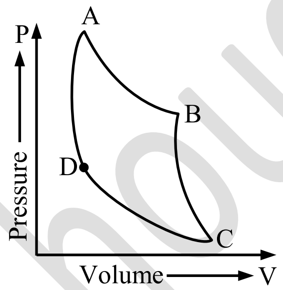
(1) Does not depend upon path

(2) Depend upon the path

(3) Corresponds to an adiabatic process

(4) Corresponds to an isothermal process

Q.3 In the P- V diagram, the point B and C correspond to temperatures T_1 and T_2 respectively. It can be concluded that -



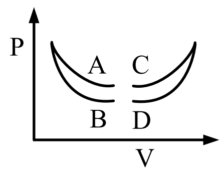
(1) $T_1 = T_2$

(2) $T_1 > T_2$

(3) $T_1 < T_2$

(4) Nothing can be said about T_1/T_2

Q.4 With respect to the figures, no heat exchange between the gas and the surroundings will take place, if the gas is taken along curve -

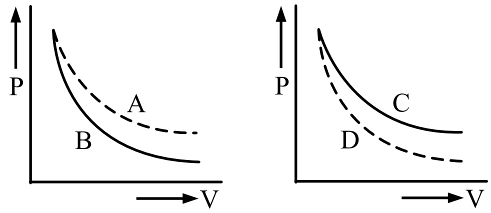


(1) A (2) B (3) C (4) D

Q.5 In a thermodynamic process pressure of a fixed mass of a gas is changed in such a manner that the gas releases 202 joules of heat and 8 joules of work was done on the gas. If the initial internal energy of the gas was 30 joules, then the final internal energy will be -

(1) 2 J (2) 42 J (3) 18 J (4) 58 J

Q.6 In the following figure, four curves A, B, C, D are shown the curves are -



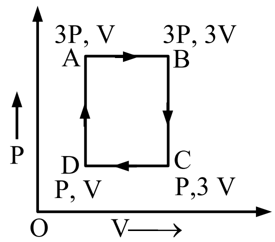
(1) Isothermal for A and B while adiabatic for C and D
(2) Isothermal for A and C while adiabatic for B and D
(3) Isothermal for A and D
(4) Adiabatic for A and C while isothermal for B and D

Q.7 During the adiabatic expansion of 2 moles of a gas, the internal energy of the gas is found to decrease by 2 joules, the work done during the process on the gas will be equal to -
(1) 1 J (2) – 1 J (3) 2 J (4) – 2 J

Q.8 When a gas expands adiabatically -
(1) No energy is required for expansion
(2) Energy is required and it comes from the wall of the container of the gas
(3) Internal energy of the gas is used in doing work
(4) Law of conservation of energy does not hold

Q.9 Equal volumes of a perfect gas are compressed to half of their initial volumes. The first of brought about by isothermal process and the second by adiabatic process then -
(1) Both temperature and pressure will increase in the isothermal process
(2) In the isothermal process, the temperature will decrease and pressure will increase
(3) Both temperature and pressure will increase in adiabatic process
(4) In the adiabatic process, the temperature will diminish and pressure will increase

Q.10 An ideal monoatomic gas is taken round the cycle ABCDA as shown in following P-V diagram. The work done during the cycle is -



(1) PV (2) 2 PV (3) 4 PV (4) Zero

Q.11 The first law of thermodynamics is -
(1) Law of conservation of energy
(2) Law of conservation of mechanical energy
(3) Law of conservation of gravitational P.E.
(4) None of the above

Q.12 A gas expands 0.25 m^3 at constant pressure 10^3 N/m^2, the work done is -
(1) 2.5 ergs (2) 250 J (3) 250 W (4) 250 N

Q.13 We consider a thermodynamic system. If ΔU represents the increase in its internal energy and W the work done by the system, which of the following statements is true –
(1) ΔU = –W in an adiabatic process
(2) ΔU = W in an isothermal process
(3) ΔU = – W in an isothermal process
(4) ΔU = W in an adiabatic process

Q.14 An inventor claims that when temperature of source and sink are 127°C and 27°C respectively then efficiency of engine is 26%, then -
(1) It is impossible
(2) It's possible but possibility is less
(3) It's possibility is high
(4) Data is insufficient

Q.15 The efficiency of carnot engine is 50% and temperature of sink is 500 K. If temperature of source is kept constant and its efficiency raised to 60%, then the required temperature of the sink will be
(1) 100 K (2) 600 K (3) 400 K (4) 500 K

Q.16 An ideal gas heat engine operator in carnot cycle between 227°C and 127°. It absorbs 6×10^4 cals of heat at higher temperature. Amount of heat converted to work is -
(1) 2.4×10^4 cals (2) 6×10^4 cals
(3) 1.2×10^4 cals (4) 4.8×10^4 cals

Q.17 The translational kinetic energy of molecules of one mole of a monoatomic gas is U = 3NKT/2. The value of atomic specific heat of gas under constant pressure will be -
(1) $\frac{3}{2}$ R (2) $\frac{5}{2}$ R (3) $\frac{7}{2}$ R (4) $\frac{9}{2}$ R

Q.18 The $\left(\frac{W}{Q}\right)$ of a carnot-engine is $\frac{1}{6}$, now the temp. of sink is reduced by 62°C, then this ratio becomes twice, therefore the initial temp. of the sink and source are respectively -
(1) 33°C, 67°C (2) 37°C, 99°C
(3) 67°C, 33°C (4) 97 K, 37 K

Q.19 If the system takes 100 cal heat, and releases 80 cal to sink, if source temperature is 127°C find the sink temperature -
(1) 47°C (2) 127°C
(3) 67°C (4) 107°C

Q.20 In thermodynamic processes which of the following statement is not true -
(1) In an adiabatic process PV^{γ} = constant
(2) In an adiabatic process the system is insulated from the surroundings
(3) In an isochoric process pressure remains constant
(4) In an isothermal process the temperature remains constant

Q.21 The internal energy change in a system that has absorbed 2 Kcals of heat and done 500 J of work is -
(1) 7900 J (2) 8900 J
(3) 6400 J (4) 5400 J

Q.22 In an adiabatic process, the quantity which remains constant is-
(1) total heat of system
(2) temperature
(3) volume
(4) pressure

Q.23 An ideal gas at 27ºC is compressed adiabatically to $\frac{8}{27}$ its original volume, then the rise in temperature will be-
(1) 480ºC (2) 450ºC
(3) 375ºC (4) 225ºC

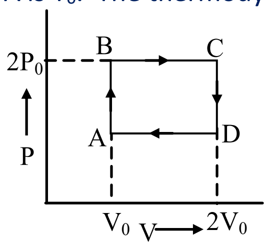
Q.24 During the adiabatic expansion of two moles of a gas the internal energy of a gas is found to decrease by 2 joule. The work done during the process on gas will be equal to-
(1) – 2 J (2) 3 J
(3) 1 J (4) 2 J

Q.25 In an adiabatic change, the pressure and temperature of a monoatomic gas are related by relation as $P \propto T^C$, where C is equal to-
(1) $\frac{5}{4}$ (2) $\frac{5}{3}$
(2) $\frac{5}{2}$ (4) $\frac{3}{5}$

Q.26 The latent heat of vaporization of water is 2240 J. If the work done in the process of vaporization of 1 g is 168 J, then increase in internal energy will be-
(1) 1904 J (2) 2072 J
(3) 2240 J (4) 2408 J

Q.27 The volume of a gas is reduced adiabatically to (1/4) of its volume at 27ºC. If γ = 1.4, the new temperature will be-
(1) $300 \times (4)^{0.4}$ K (2) $150 \times (4)^{0.4}$ K
(3) $250 \times (4)^{0.4}$ K (4) none of these

Q.28 N moles of a monoatomic gas is carried round the reversible rectangular cycle ABCDA as shown in the diagram. The temperature at A is T_0. The thermodynamic efficiency of the cycle is-



(1) 50% (2) 15%
(3) 20% (4) 25%

Q.29 A monoatomic gas is suddenly compressed to 1/8th of its initial volume adiabatically. The ratio of final pressure to initial pressure is - (γ = 5/3)
(1) 32 (2) 40/3 (3) 24/5 (4) 8

Q.30 First law of thermodynamics is a special case of-
(1) Boyle's law
(2) Charles law
(3) law of conservation of mass
(4) law of conservation of energy

Q.31 If the heat of 110 J is added to a gaseous system, whose internal energy increases by 40 J, then the amount of external work done is-
(1) 80 J (2) 70 J (3) 115 J (4) 140 J

Q.32 Work done by 0.1 mole of a gas at 27ºC. To double its volume at constant pressure, is- (R = 2 cal/mol-K)
(1) 546 cal (2) 60 cal
(3) 600 cal (4) 54 cal

Q.33 An ideal carnot engine, whose efficiency is 40% receives heat at 500 K. If its efficiency is 50%, then the intake temperature for the same exhaust temperature is-
(1) 600 K (2) 700 K
(3) 800 K (4) 900 K

Q.34 We consider a thermodynamic system. If ΔU represents the increase in its internal energy and W the work done by the system, which of the following statements is true ?
(1) $\Delta U = -W$ in an adiabatic process
(2) $\Delta U = W$ in an isothermal process
(3) $\Delta U = -W$ in an isothermal process
(4) $\Delta U = W$ in an adiabatic process

Q.35 When you make ice cubes, the entropy of water-
(1) does not change
(2) increases
(3) decreases
(4) may either increase or decrease depending on the process used

Q.36 The internal energy of an ideal gas increases during an isothermal process when the gas is-
(1) expanded by adding more molecules to it
(2) expanded by adding more heat to it
(3) expanded against zero pressure
(4) compressed by doing work on it

Q.37 A sample of gas expands from volume V_1 to V_2. The amount of work done by the gas is greater when the expansion is-
(1) adiabatic
(2) isobaric
(3) isothermal
(4) equal in all above cases

Q.38 A carnot engine takes heat from a reservoir at 627ºC and rejects heat to a sink at 27ºC.. Its efficiency will be-
(1) 3/5 (2) 1/3
(3) 2/3 (4) 200/209

Q.39 If R is universal gas constant, the amount of heat needed to raise the temperature of 2 moles of an ideal monoatomic gas from 273 K to 373 K when no work is done is-
(1) 100 R (2) 150 R
(3) 300 R (4) 500 R

Q.40 If ΔU and ΔW represent the increase in internal energy and work done by the system respectively in a thermodynamical process, which of the following is true ?
(1) $\Delta U = -\Delta W$, in a adiabatic process
(2) $\Delta U = \Delta W$, in a isothermal process
(3) $\Delta U = \Delta W$, in a adiabatic process
(4) $\Delta U = -\Delta W$, in a isothermal process

Q.41 A monoatomic gas at pressure P_1 and volume V_1 is compressed adiabatically to $1/8^{th}$ its original volume. What is the final pressure of gas –
(1) P_1 (2) 16 P_1
(3) 32 P_1 (4) 64 P_1

Q.42 During an isothermal expansion, a confined ideal gas does – 150 J of work against its surroundings. This implies that :
(1) 150 J of heat has been added to the gas
(2) 150 J of heat has been removed from the gas
(3) 300 J of heat has been added to the gas
(4) no heat is transferred because the process is isothermal.

Q.43 When 1 kg of ice at 0ºC melts to water at 0ºC, the resulting change in its entropy, taking latent heat of ice to be 80 Cal/ºC, is :
(1) 293 Cal /K (2) 273 Cal/K
(3) 8×10^4 Cal/K (4) 80 Cal/K

Q.44 A mass of diatomic gas ($\gamma = 1.4$) at a pressure of 2 atmospheres is compressed adiabatically so that its temperature rises from 27ºC to 927ºC. The pressure of the gas in the final state is
(1) 8 atm (2) 28 atm
(3) 68.7 atm (4) 256 atm

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM - 9

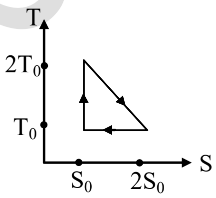
Q.1 Even Carnot engine cannot give 100% efficiency because we cannot -
(1) prevent radiation
(2) find ideal sources
(3) reach absolute zero temperature
(4) eliminate friction

Q.2 "Heat cannot be itself flow from a body at lower temperature to a body at higher temperature" is a statement or consequence of -
(1) Conservation of momentum
(2) Conservation of mass
(3) First law of thermodynamics
(4) Second law of thermodynamics

Q.3 A Carnot engine takes 3×10^6 cal. of heat from a reservoir at 627ºC, and gives it to a sink at 27º C. The work done by the engine is -
(1) 8.4×10^6 J
(2) 16.8×10^6 J
(3) Zero
(4) 4.2×10^6 J

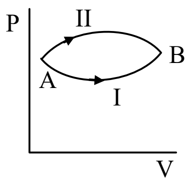
Q.4 Which of the following statements is correct for any thermodynamic system ?
(1) The internal energy changes in all processes
(2) Internal energy and entropy are state functions
(3) The change in entropy can never be zero
(4) The work done in an adiabatic process is always zero

Q.5 The temperature-entropy diagram of a reversible engine cycle is given in the figure. Its efficiency is -



(1) 1/2 (2) 1/4
(3) 1/3 (4) 2/3

Q.6 A system goes from A to B via two processes I and II as shown in figure. If ΔU_1 and ΔU_2 are the changes in internal energies in the processes I and II respectively, then-

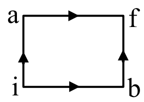


(1) $\Delta U_1 = \Delta U_2$
(2) relation between ΔU_1 and ΔU_2 can not be determined
(3) $\Delta U_2 > \Delta U_1$
(4) $\Delta U_2 < \Delta U_1$

Q.7 The work of 146 kJ is performed in order to compress one kilo mole of a gas adiabatically and in this process the temperature of the gas increases by 7º C. The gas is -
($R = 8.3$ J mol^{-1} K^{-1}) -
(1) a mixture of monoatomic and diatomic
(2) monoatomic
(3) diatomic
(4) triatomic

Q.8 A Carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is-
(1) 99 J (2) 90 J
(3) 1 J (4) 100 J

Q.9 When a system is taken from state i to state f along the path iaf, it is found that Q = 50 cal and W = 20 cal. Along the path ibf Q= 36 cal. W along the path ibf is-



(1) 6 cal (2) 16 cal
(3) 66 cal (4) 14 cal

Q.10 An ideal gas with pressure P, volume V, and temperature T is expanded isothermally to a volume 2V and a final pressure P_i. If the same gas is expanded adiabatically to a volume 2V, the final pressure is P_a. The ratio of the specific heat capacities for the gas is 1.67. The ratio P_a/P_i is -
(1) $1/2^{0.67}$ (2) $1/3^{0.67}$
(3) $2^{0.67}$ (4) $4^{0.67}$

Q.11 A given quantity of an ideal gas is at pressure P and absolute temperature T. The isothermal bulk modulus of the gas is -
(1) (2/3)P (2) P (3) (3/2)P (4) 2P

Q.12 A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is -
(1) 4 RT (2) 15 RT (3) 9 RT (4) 11 RT

Q.13 A monoatomic ideal gas initially at temperature T_1, is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature T_2 releasing the piston suddenly. If L_1 and L_2 are the lengths of the gas column before and after expansion respectively, then T_1/T_2 is given by -

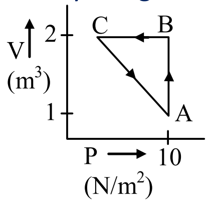
(1) $\left(\frac{L_1}{L_2}\right)^{2/3}$ (2) $\frac{L_1}{L_2}$

(3) $\frac{L_2}{L_1}$ (4) $\left(\frac{L_2}{L_1}\right)^{2/3}$

Q.14 Starting with the same initial conditions, an ideal gas expands from volume V_1 to V_2 in three different ways. The work done by the gas is W_1 if the process is purely isothermal, W_2 if purely isobaric and W_3 if purely adiabatic. Then -

(1) $W_2 > W_1 > W_3$ (2) $W_2 > W_3 > W_1$
(3) $W_1 > W_2 > W_3$ (4) $W_1 > W_3 > W_2$

Q.15 An ideal gas is taken the cycle $A \to B \to C \to A$, as shown in the figure. If the net heat supplied to the gas in the cycle is 5 J, the work done by the gas in the process $C \to A$ is -

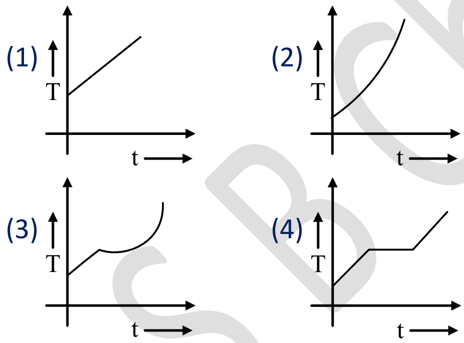


(1) – 5 J (2) – 10 J
(3) – 15 J (4) – 20 J

Q.16 An ideal gas in state (P_1, V_1) is isothermally expanded to state (P_2, V_2). Then it is adiabatically compressed to initial volume V_1. Pressure being P_3 in final state. If W is work done by the gas in the whole process then-

(1) $P_3 > P_1$ & $W < 0$ (2) $P_3 < P_1$ & $W > 0$
(3) $P_3 < P_2$ & $W < 0$ (4) $P_3 > P_2$ & $W > 0$

Q.17 A liquified oxygen at 50 K is heated to 300 K at constant pressure. Heat is supplied constant rate then graph between temperature & time is-



Q.18 An ideal gas is taken in a process at constant temperature 20ºC from initial pressure = 1.015×10^5 Pa to final pressure = 1.165×10^5 Pa in which volume decreases by 10% then Bulk modulus is -

(1) 1.5×10^{-5} Pa (2) 1.5×10^6 Pa
(3) 1.5×10^5 Pa (4) 1.6×10^{-6} Pa

Q.19 In an isothermal thermodynamical process, the value of work done by a system is -

(1) Dependent on the path
(2) Equal to the amount of energy absorbed or ejected
(3) Equal to the area between PV curves and V-axis
(4) All of the above

Q.20 A mass of a gas at 0°C is expanded adiabatically so that its volume becomes 4 times the original, the temperature of gas will fall - (γ = 1.5)

(1) 136.5 K (2) 9.8 K (3) 65 K (4) 32 K

Q.21 If energy given to a system is 35 joules and the work done by the system is 15 joules, the change in the internal energy of the system is -
(1) – 50J (2) 20 J (3) 30 J (4) 50 J

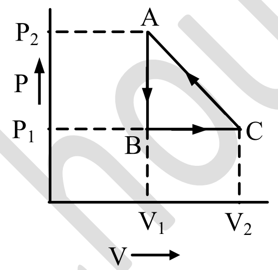
Q.22 20 litres of hydrogen gas at one atmospheric pressure is compressed at 5 atmospheric pressure without involving any change in temperature, what will be its volume -
(1) 10 litres (2) 1 litre (3) 2 litres (4) 4 litres

Q.23 The adiabatic elasticity (E Φ) of H_2 gas ($\gamma = 1.4$) under normal temperature and pressure will be -
(1) 1×10^5 N/m^2 (2) 1×10^{-8} N/m^2
(3) 1.4 N/m^2 (4) 1.4×10^5 N/m^2

Q.24 The pressure in a car tyre is four times the atmospheric pressure and its temperature is 300 K. If it bursts all of a sudden, its temperature will be ($\gamma = 1.4$) -
(1) $300\,(4)^{1.4/0.4}$ (2) $300\,(4)^{0.4/1.4}$
(3) $300\,(2)^{0.4/1.4}$ (4) $300\,(4)^{-0.4/1.4}$

Q.25 A gas at 50 N/m^2 pressure is compressed from 10m^3 to 4m^3 under constant pressure. Subsequently it is given 100 J of heat. The internal energy of the gas will be -
(1) Increased by 100 J (2) Increased by 200 J
(3) Increased by 400 J (4) Decreased by 200 J

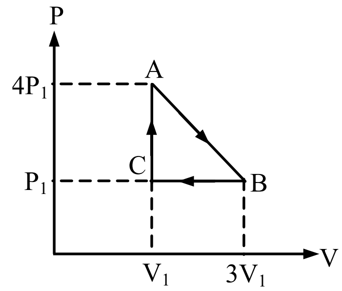
Q.26 As shown in the diagram for a closed path ABCA -



(1) The amount of work done by the system is zero
(2) The amount of work done by the system is = $-\frac{1}{2}(P_2 - P_1)(V_2 - V_1)$
(3) The amount of work done on the system is = $(P_2 - P_1)(V_1 - V_2)$
(4) The amount of work done by the system is = $\frac{1}{2}(P_2 - P_1)(V_2 - V_1)$

Q.27 A diatomic ideal gas is heated under constant pressure, the part of heat that increase internal energy of gas is -
(1) 2/5 (2) 3/5 (3) 3/7 (4) 5/7

Q.28 An ideal gas is taken round the cycle ABCA. In the cycle the amount of work done involved is -



(1) $12\,P_1V_1$ (2) $6\,P_1V_1$
(3) $3\,P_1V_1$ (4) P_1V_1

Q.29 Graphs between PV diagram for isothermal and adiabatic processes are drawn the relation between their slopes will be -
(1) Slope of isothermal curve = γ (slope of isothermal curve)
(2) Slope of isothermal curve = γ (slope of adiabatic curve)
(3) Slope of isothermal curve = slope of adiabatic curve
(4) Slope of adiabatic curve = γ^2(slope of isothermal curve)

Q.30 One mole ideal gas is compressed adiabatically at 27°C. Its temperature becomes 102°C. The work done in this process will be - (γ = 1.5)
(1) – 625 J (2) 625 J (3) 1245 J (4) –1245 J

Q.31 Arrange the following in increasing order of work - (in equal expansion process)
(1) Adiabatic > isothermal > isobaric
(2) Isobaric > adiabatic > isothermal
(3) Adiabatic > isobaric > isothermal
(4) None of the above

Q.32 A system does 50 J of work under adiabatic condition. In this process -
(1) Temperature of system will increase
(2) Temperature of system will remain constant
(3) Internal energy of system will increase
(4) Internal energy of system will decrease

Q.33 For a gas C_v = 4.96 cal/mole K, the increase in internal energy of 2 mole gas in heating from 340 K to 342 K will be -
(1) 27.80 Cal (2) 19.84 Cal
(3) 13.90 Cal (4) 9.92 Cal

Q.34 The volume of a poly-atomic gas $\left(\gamma = \frac{4}{3}\right)$ compressed adiabatically to $\frac{1}{8^{th}}$ of the original volume. If the original pressure of the gas is P_0 the new pressure will be-
(1) 8 P_0 (2) 16 P_0 (3) 6 P_0 (4) 2 P_0

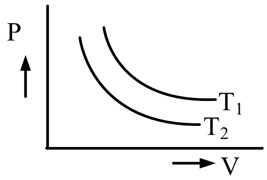
Q.35 If an ideal flask containing hot coffee is shaken, the temperature of the coffee will -
(1) decrease
(2) increase
(3) remain same
(4) decrease if temperature is below 4°C and increase if temperature is equal to or more than 4°C

Q.36 Water is used to cool the radiators of engines in cars because -
(1) of its low boiling point
(2) of its high specific heat
(3) of its low density
(4) of its easy density

Q.37 Work done depends in gaseous process -
(1) Initial state
(2) Final state
(3) Initial & Final state
(4) Initial, Final state & Path

Q.38 The volume of a gas expands by 0.25 m^3 at a constant pressure of 10^3 N/m^2. The work done is equal to -
(1) 2.5 (2) 250 J (3) 250 W (4) 250 N

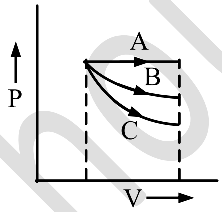
Q.39 The following graphs between P and V are plotted at two temperature T_1 and T_2. Then which of the following is correct -



(1) $T_1 > T_2$
(2) $T_1 = T_2$
(3) $T_1 < T_2$
(4) Incomplete data, no conclusion can be drawn

Q.40 The correct equation of state for an adiabatic process is -
(1) $T^{\gamma}V^{\gamma-1}$ = constant (2) $T^{\gamma}V^{\gamma}$ = constant
(3) $TV^{\gamma-1}$ = constant (4) $T^{\gamma}P^{\gamma}$ = constant

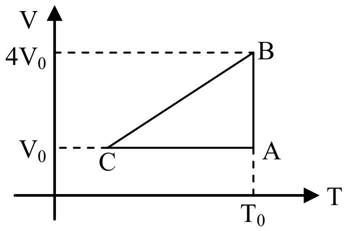
Q.41 During isothermal, isobaric and adiabatic processes, work done for same change in volume will be maximum for -



(1) Isothermal (2) Isobaric
(3) Adiabatic (4) None of the above

Q.42 A diatomic ideal gas is used in a Carnot engine as the working substance. If during the adiabatic expansion part of the cycle the volume of the gas increases from V to 32 V, the efficiency of the engine is-
(1) 0.25 (2) 0.5 (3) 0.75 (4) 0.99

Q.43 One mole of an ideal gas in initial state A undergoes a cyclic process ABCA, As shown in figure. Its pressure at A is P_0. Choose the correct option(s) from the following

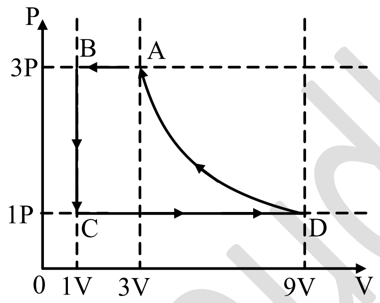


(1) Internal energies at A and B are the same
(2) Work done by the gas in process AB is $P_0V_0 \ell n\ 4$
(3) Pressure at C is $P_0/4$
(4) Temperature at C is $\frac{T_0}{4}$

Q.44. A diatomic ideal gas is compressed adiabatically to $\frac{1}{32}$ of its initial volume. In the initial temperature of the gas is T_i (in Kelvin) and the final temperature is aT_i, the value of a is
(1) 3 (2) 1 (3) 4 (4) 6

Q.45 5.6 liter of helium gas at STP is adiabatically compressed to 0.7 liter. Taking the initial temperature to be T_1, the work done in the process is-
(1) $\frac{9}{8}RT_1$ (2) $\frac{3}{2}RT_1$
(3) $\frac{15}{8}RT_1$ (4) $\frac{9}{2}RT_1$

Q.46 One mole of a monoatomic ideal gas is taken through a cycle ABCDA as shown in the P-V diagram. **Column-II** gives the characteristics involved in the cycle. Match them with each of the processes given in **Column-I**



Column-I	Column-II
(A) Process $A \to B$	(p) Internal energy decreases
(B) Process $B \to C$	(q) Internal energy increases
(C) Process $C \to D$	(r) Heat is lost
(D) Process $D \to A$	(s) Heat is gained
	(t) Work is done on the gas

(1) $A \to$ p, r, t; $B \to$ p, r; $C \to$ q, s; $D \to$ r, t
(2) $A \to$ p; $B \to$ p, r; $C \to$ q, s; $D \to$ r, t
(3) $A \to$ p, r, t; $B \to$ p, s; $C \to$ s; $D \to$ r, t
(4) $A \to$ r, t; $B \to$ p, q; $C \to$ q, t; $D \to$ r, t

Q.47 100 g of water is heated from 30° C to 50°C. Ignoring the slight expansion of the water, the change in its internal energy is (specific heat of water is 4184 J/kg/K) :
(1) 4.2 kJ (2) 8.4 kJ
(3) 84 kJ (4) 2.1 kJ

Q.48 A Carnot engine operating between temperatures T_1 and T_2 has efficiency $\frac{1}{6}$. When T_2 is lowered by 62 K; its efficiency increases to $\frac{1}{3}$. Then T_1 and T_2 are respectively:
(1) 372 K and 310 K (2) 372 K and 330 K
(3) 330 K and 268 K (4) 310 K and 248 K

Q.49 The thermally insulated vessel contains an ideal gas of molecular mass M and ratio of specific heat γ. It is moving with speed v and is suddenly brought to rest. Assuming no heat is lost to the surroundings, its temperature increases by :

(1) $\frac{(\gamma-1)}{2(\gamma+1)R}Mv^2$ K (2) $\frac{(\gamma-1)}{2\gamma R}Mv^2$ K

(3) $\frac{\gamma Mv^2}{2R}$ K (4) $\frac{(\gamma-1)}{2R}Mv^2$ K

Q.50 The specific heat capacity of a metal at low temperature (T) is given as :

$C_p(kJK^{-1}kg^{-1}) = 32\left(\frac{T}{400}\right)^3$

A 100 gram vessel of this metal is to be cooled from 20ºK to 4ºK by a special refrigerator operating at room temperature (27ºC). The amount of work required to cool the vessel is -

(1) greater than 0.148 kJ
(2) between 0.148 kJ and 0.028 kJ
(3) less than 0.028 kJ
(4) equal to 0.002 kJ

Q.51 A container with insulating walls is divided into two equal parts by a partition fitted with a valve. One part is filled with an ideal gas at a pressure P and temperature T, whereas the other part is completely evacuated. If the valve is suddenly opened, the pressure and temperature of the gas will be -

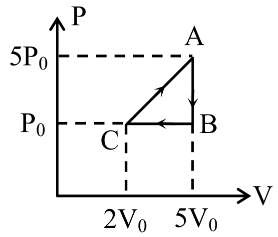
(1) $\frac{P}{2}, \frac{T}{2}$ (2) P, T

(3) $P, \frac{T}{2}$ (4) $\frac{P}{2}, T$

Q.52 300 calories of heat is supplied to raise the temperature of 50 gm of air from 20°C to 30°C without any change in its volume. Change in internal energy per gram of air is

(1) zero (2) 0.6 calories
(3) 1.2 calories (4) 6.0 calories

Q.53 The work done by a gas taken through the closed process ABCA, see figure, is



(1) $6P_0V_0$ (2) $4P_0V_0$
(3) P_0V_0 (4) zero

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.
(1) If both Assertion & Reason are true & the Reason is a correct explanation of the Assertion.
(2) If both Assertion and Reason are true but Reason is not a correct explanation of the Assertion.
(3) If Assertion is true but the Reason is false.
(4) If Assertion & Reason both are false.

Q.1 **Assertion :** Adiabatic process is isoentropic.
Reason : For adiabatic process $\delta Q = 0$.
(1) A (2) B (3) C (4) D

Q.2 **Assertion :** In adiabatic expansion of monoatomic ideal gas, if volume increases by 24% then pressure decreases by 40%.
Reason : For adiabatic process $\frac{\Delta P}{P} - \frac{\gamma \Delta V}{V} = 0$.
(1) A (2) B (3) C (4) D

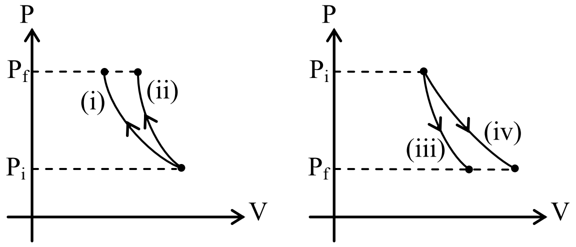
Q.3 **Assertion :** The specific heat of an ideal gas in adiabatic process is infinite.
Reason : Internal energy of ideal gas depends only on temperature.
(1) A (2) B (3) C (4) D

Q.4 **Assertion :** A system undergoes a cyclic process in which it absorbs Q_1 heat and gives out Q_2 heat. The efficiency of the process is
$\eta = 1 - \frac{Q_2}{Q_1}$.
Reason : Work done in cyclic process is path independent.
(1) A (2) B (3) C (4) D

Q. 5 **Assertion :** When an ideal diatomic is heated at constant pressure the fraction of the heat energy supplied which increases the internal energy of the gas is $\frac{5}{7}$.
Reason : Fraction is given by $\frac{\Delta U}{\delta Q} = \frac{C_V}{C_P}$.
(1) A (2) B (3) C (4) D

Q.6 **Assertion :** The average degree of freedom per molecule for a gas is 6. If gas performs 25 J of work when it expands at a constant pressure then the heat absorbed by the gas is 100 J.
Reason : First law of thermodynamics is $\delta Q = \delta W + \Delta U$ where $\Delta U = nC_V\Delta T$
(1) A (2) B (3) C (4) D

Q.7 **Assertion :** In following figure curve (i) and (iv) represent isothermal process while (ii) & (iii) represent adiabatic process.



Reason : The adiabatic at any point has a steeper slope than the isothermal through the same point.
(1) A (2) B (3) C (4) D

Q.8 **Assertion :** When a hot liquid is mixed with a cold liquid, the temperature of the mixer is undefined for some time and then becomes nearly constant.
Reason : If two bodies at different temperature are mixed in a calorimeter, the total internal energy of the two bodies remain conserved.
(1) A (2) B (3) C (4) D

Q.9 **Assertion :** If work is done by a system, its volume must increase.
Reason : The first law of thermodynamics is a statement of conservation of heat.
(1) A (2) B (3) C (4) D

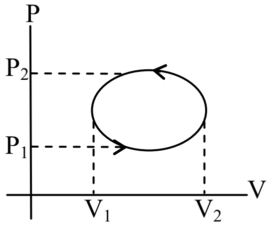
Q.10 **Assertion :** According to first law of thermodynamics energy is conserved.
Reason : First law of thermodynamics is $\delta W = \delta Q - dU$.
(1) A (2) B (3) C (4) D

Q.11 **Assertion :** It is not possible for a system, unaided by an external agency to transfer heat from a body at lower temperature to another at a higher temperature.
Reason : It is not possible to violate the second law of thermodynamics.
(1) A (2) B (3) C (4) D

Q.12 **Assertion :** Two system, which are in thermal equilibrium with a third system, are in thermal equilibrium with each other.
Reason : The heat flows spontaneously from a system at a higher temperature to a system at a lower temperature.
(1) A (2) B (3) C (4) D

Q.13 **Assertion :** Change in internal energy in the melting process is due to change in internal potential energy.
Reason : This is because in melting, distance between molecules increase but temperature remains constant.
(1) A (2) B (3) C (4) D

Q.14 **Assertion :** Work done in a cyclic process as shown in figure.



$W = \frac{\pi}{4}(P_2 - P_1)(V_2 - V_1)$

Reason : The change in internal energy for a cyclic process is equal to the area enclosed by the P-V diagram.

(1) A (2) B (3) C (4) D

Q.15 **Assertion :** The specific heat for an adiabatic process is zero.

Reason : At a point on a PV diagram, the slope of an adiabatic is γ times the slope of an isothermal.

(1) A (2) B (3) C (4) D

Q.16 **Assertion :** Change in internal energy is independent of the path.

Reason : Internal energy is a property of the system.

(1) A (2) B (3) C (4) D

Q.17 **Assertion :** The specific heat for an adiabatic process is zero.

Reason : Heat exchange is zero in adiabatic process.

(1) A (2) B (3) C (4) D

Q.18 **Assertion :** The efficiency of a carnot cycle depends on the nature of the gas used.

Reason : Work done in adiabatic process depends on nature of gas, and adiabatic is a part of carnot cycle.

(1) A (2) B (3) C (4) D

Q.19 **Assertion :** In adiabatic compression, the internal energy and temperature of the system get decreased.

Reason : The adiabatic compression is a slow process.

(1) A (2) B (3) C (4) D

Q.20 **Assertion :** The isothermal curves intersect each other at a certain point.

Reason : The isothermal change takes place rapidly, so, the isothermal curves have very little slope.

(1) A (2) B (3) C (4) D

Q.21 **Assertion :** The Carnot cycle is useful in understanding the performance of heat engines.

Reason : The Carnot cycle provides a way of determining the maximum possible efficiency achievable with reservoirs of given temperature.

(1) A (2) B (3) C (4) D

Q.22 **Assertion :** Work and heat are two equivalent forms of energy.

Reason : Work is the transfer of mechanical energy irrespective of temperature difference, whereas heat is the transfer of thermal energy because of temperature difference only.

(1) A (2) B (3) C (4) D

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 11

Q.1 The amount of heat required to raise the temperature of 1 kg of water through 1°C is called -
(1) kilocalorie (2) calorie
(3) B.T.U. (4) calorie/°C

Q.2 How much heat energy is gained when 5 kg of water at 20ºC is brought to its boiling point ?
(1) 1680 kJ (2) 1700 kJ
(3) 1720 kJ (4) 1740 kJ

Q.3 Heat is -
(1) The amount of internal energy contained in a body
(2) Equal to $ms\theta$ (where m = mass, s = specific heat and θ = temperature of the body)
(3) The sum of kinetic and potential energy of molecules of the body
(4) The amount of internal energy flowing from a body at higher temperature

Q.4 The value of specific heat of an ideal gas, with rise in temperature -
(1) Increases (2) Decreases
(3) Is independent (4) None of these

Q.5 The specific heat of a gas -
(1) Has only two values C_p and C_v
(2) Has only one value at a specific temperature
(3) May have any value between 0 and ∞
(4) Depends on the mass of the gas.

Q.6 Experiments were carried out by the students for determination of values of C_p and C_v in cal/mole K, the following pair is correct -
(1) $C_v = 2, C_p = 1$ (2) $C_v = 4, C_p = 5$
(3) $C_v = 3, C_p = 4$ (4) $C_v = 3, C_p = 5$

Q.7 The ratio of C_p of a mono-atomic gas and C_v of a diatomic gas is -
(1) 3 : 5 (2) 5 : 3
(3) 1 : 1 (4) 7 : 5

Q.8 The approximate value of C_v of 1 gm helium gas is -
(1) 3/4 cal/gmºC (2) 3 cal/gmºC
(3) 3/2 cal/gmºC (4) 2/3 cal/gmºC

Q.9 With the rise in atomicity of a gas the ratio of specific heats of a gas -
(1) Increase
(2) Decrease
(3) Remains unchanged
(4) May increase or decrease

Q.10 The specific heat of gas under constant pressure is 7/2 R, the gas is -
(1) Mono- atomic (2) Diatomic
(3) Tri-atomic (4) Ideal

Q.11 On mixing 1 mole of He and 1 mole of oxygen, the value of molar specific heat at constant volume is-
(1) R (2) 2R (3) 3R (4) 4R

Q.12 In the above question, the value of molar specific heat at constant pressure will be -
(1) R (2) 2R (3) 3R (4) 4R

Q.13 A temperature different of 5ºC on Celsius scale corresponds to the following temperature difference in the Fahrenheit scale -
(1) 9º (2) 41º (3) 2.8º (4) 15º

Q.14 In a temperature scale called Z the boiling point of water is at 65º Z and the freezing point is at – 14º Z. Then the temperature T = – 98º Z corresponds on the Fahrenheit scale to -
(1) – 191 ºF
(2) – 159 ºF
(3) 79ºF
(4) none of the above

Q.15 Suppose that on a temperature scale X, water boils at – 53.5ºX and freezes at – 170ºX. What would be temperature of 340K be on the X scale ?
(1) 544º (2) –103º
(3) –91.9º (4) –120.5º

Q.16 0ºC is equivalent to the following -
(1) 273.15 K (2) 273 K
(3) 0 K (4) 32 K

Q.17 The temperature of a substance rises by 27ºC. The rise is temperature in Kelvin scale will be -
(1) 300 K (2) 2.46 K
(3) 27 K (4) 7 K

Q.18 Two spheres made of same substance have diameters in the ratio 1 : 2. Their thermal capacities are in the ratio of -
(1) 1 : 2 (2) 1: 8
(3) 1: 4 (4) 2 : 1

Q.19 The amount of heat required to change the state of 1 kg of substance at constant temperature is called -
(1) kilo cal (2) calorie
(3) specific heat (4) latent heat

Q.20 The water equivalent of a 400 g copper calorimeter (specific heat = 0.1 cal/g°C) -
(1) 40 g (2) 4000 g
(3) 200 g (4) 4 g

Q.21 The thermal capacity of 40 g of aluminium (specific heat = 0.2 cal/gm°C) -
(1) 40 cal/°C (2) 160 cal/°C
(3) 200 cal/°C (4) 8 cal/°C

Q.22 A ball of mass 20 g and specific heat capacity 0.1 cal/g –ºC. The water equivalent of ball is -
(1) 2g (2) 4g
(3) 6g (4) 5g

Q.23 The heat capacity of a metal is 4200 J/k. Its water equivalent is -
(1) 0.5 kg (2) 1 kg
(3) 1.5 kg (4) 2 kg

Q.24 The amount of heat required to raise the temperature of a body from 20ºC to 60º C is (water equivalent of body is 10 gm).
(1) 200 cal (2) 300 cal
(3) 400 cal (4) 500 cal

Q.25 If C_p and C_v are gram specific heats at constant pressure and constant volume respectively, then it is found that for hydrogen $C_p - C_v = a$ and for oxygen $C_p - C_v = b$. The relation between a and b is -
(1) a = b (2) a = 4b
(3) a = 16b (4) 16a = b

Q.26 11 grams of carbondioxide are heated at constant pressure from 27ºC to 227ºC. The amount of heat transferred to carbondioxide will be -
(1) 110 Calorie (2) 220 Calorie
(3) 450 Calorie (4) 2200 Calorie

Q.27 1 gram of ice at 0ºC is converted to steam at 100ºC. The amount of heat required will be-
(1) 756 Calorie (2) 12000 Calorie
(3) 716 Calorie (4) 450 Calorie

Q.28 When the temperature of an iron sphere of mass 1kg. falls from 30ºC to 25º C, then 550 calories of heat are released The heat capacity of iron sphere will be in Cal/ºC -
(1) 110 (2) 220
(3) 330 (4) 440

Q.29 In the above problem the specific heat of iron will be -
(1) 0.72 (2) 0.33
(3) 0.11 (4) 0.44

Q.30 The amount of heat required to increase the temperature of 1 mole of an ideal gas through 10K at constant pressure is 207 joule. Keeping the same gas at constant volume, the amount of heat required to increase its temperature through 10K will be -
(1) 124 Joule (2) 215.3 joule
(3) 29 Joule (4) 198.7 Joule

Q.31 Two liquids A and B are at 32ºC and 24ºC. When mixed in equal masses the temperature of the mixture is found to be 28ºC. Their specific heats are in the ratio of -
(1) 3 : 2 (2) 2 : 3
(3) 1 : 1 (4) 4 : 3

Q.32 A liquid of mass m and specific heat c is heated to a temperature 2T. Another liquid of mass m/2 and specific heat 2c is heated to a temperature T. If these two liquids are mixed, the resulting temperature of the mixture is-
(1) (2/3)T (2) (8/5)T
(3) (3/5)T (4) (3/2)T

Q.33 The temperature of equal masses of three different liquids A, B and C are 12ºC, 19ºC and 28ºC respectively. The temperature when A and B are mixed is 16ºC, when B and C are mixed is 23ºC; what is the temperature when A and C are mixed ?

(1) 31ºC (2) 20.26ºC
(3) 19.5ºC (4) 28ºC

Q.34 One kg of ice at 0°C is mixed with 1 kg of water at 10°C. The resulting temperature will be-

(1) between 0°C and 10°C
(2) 0°C
(3) less than 0°C
(4) greater than 0°C

Q.35 If 10 g of ice at 0°C is mixed with 10 g of water at 40°C, the final mass of water in the mixture is-

(1) 10 g (2) 15 g
(3) 18 g (4) 20 g

Q.36 540 g of ice at 0°C is mixed with 540 g of water at 80°C. The final temperature of the mixture is-

(1) 0°C (2) 40°C
(3) 80°C (4) less than 0°C

Q.37 Steam at 100°C is passed into 2.0 kg of water contained in a calorimeter of water equivalent 0.02 kg at 15°C till the temperature of the calorimeter and its contents rises to 95°C. The mass of steam condensed in kg is-

(1) 0.301 (2) 0.298
(3) 0.60 (4) 2.02

Q.38 10 gm of ice at – 20ºC is added to 10 gm of water at 50ºC. Specific heat of water = 1 cal/g-ºC, specific heat of ice = 0.5 cal/gm-ºC. Latent heat of ice = 80 cal/gm. Then resulting temperature is-

(1) –20ºC (2) 15ºC
(3) 0ºC (4) 50ºC

Q.39 5 gm of steam at 100ºC is passed into six gm of ice at 0ºC. If the latent heats of steam and ice in cal per gm are 540 and 80 respectively, then the final temperature is-

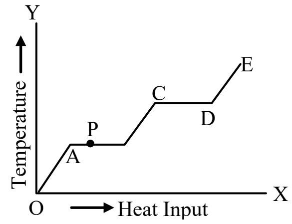
(1) 0ºC (2) 100ºC
(3) 50ºC (4) 30ºC

Q.40 A vessel contains 10^{-1} kg of ice at 0ºC. Now steam is passed into the vessel to melt ice. Neglecting the thermal capacity of the vessel, find the mass of water in the vessel when all ice melts into water-

(1) 12.5 gm (2) 100 gm
(3) 112.5 gm (4) 125 gm

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 12

Q.1 The variation of temperature of a material as heat is given to it at constant rate is shown in fig. The material is in solid state at the point O. The state of the material at point P is -



(1) solid
(2) liquid
(3) vapour
(4) partly solid partly liquid

Q.2 The specific heat of same substance is expressed in two unit i.e., C_1 cal/g°C and C_2 cal/g°F. Which of the following relation is true-
(1) $C_1 > C_2$
(2) $C_1 < C_2$
(3) $C_1 = C_2$
(4) C_1 and C_2 can not be compared

Q.3 One gram of ice is mixed with one gram of steam. After thermal equilibrium, the temperature of the mixture is -
(1) 0°C (2) 100°C
(3) 55°C (4) 80°C

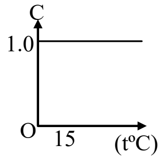
Q.4 The temperature of ice is – 10°C [specific heat = 0.5 kcal/(kg-°C)] and that of water 60°C. They are mixed in equal amounts. What part of the ice will be melted ?
(1) $5/6^{th}$
(2) $11/16^{th}$
(3) whole of ice will be melted
(4) $5/11^{th}$

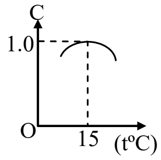
Q.5 Which of the following produces mode severe burns ?
(1) boiling water (2) steam
(3) hot air (4) sun rays

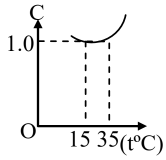
Q.6 Of the following, the one which has highest specific heat is-
(1) aluminium (2) copper
(3) silver (4) water

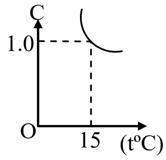
Q.7 If temperature scale is changed from °C to °F, the numerical value of specific heat will -
(1) increase
(2) decrease
(3) remain unchanged
(4) increase for some substances and decrease for other

Q.8 The specific heat of water in cal/g° C varies with temperature t°C according to curve-

(1) 

(2) 

(3) 

(4) 

Q.9 The specific heat capacity of a body depends on-
(1) the heat given
(2) the temperatures raised
(3) the mass of the body
(4) the material of the body

Q.10 Water equivalent of a body is measured in-
(1) kg (2) calorie
(3) Kelvin (4) m^3

Q.11 Which of the following pairs of physical quantities may be represented in the same unit ?
(1) heat and temperature
(2) temperature and mole
(3) heat and work
(4) specific heat and heat

Q.12 The mechanical equivalent of heat-
(1) has the same dimension as heat
(2) has the same dimension as work
(3) has the same dimension as energy
(4) is dimensionless

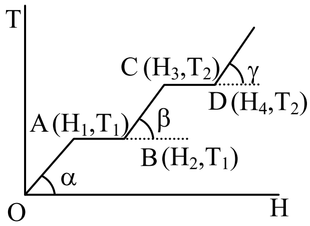
Q.13 An electric heater rated as 2 kW is used to heat 200 kg of water from 10ºC to 70ºC. Assuming no heat losses, the time taken is -
(1) 25.2 s (2) 6×10^3 s
(3) 25.2×10^3 s (4) 25.2×10^6 s

Q.14 5 g of water at 30ºC and 5 g of ice at –20C are mixed together in a calorimeter. Neglect the water equivalent of the calorimeter. The final temperature of the mixture is- (Specific heat of ice = 0.5 cal g^{-1} ºC^{-1})
(1) 0ºC (2) –20ºC
(3) –10ºC (4) + 1.2ºC

Q.15 In Q. 14 the amount of ice melted is -
(1) 0 g (2) 0.25 g
(3) 0.50 g (4) 1.25 g

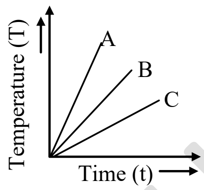
Q.16 One gram of ice at 0ºC is added to 5 gram of water at 10ºC. If the latent heat of ice be 80 cal/g, then the final temperature of the mixture is -
(1) 5ºC (2) 0ºC
(3) –5ºC (4) None of the above

Q.17 The graph shows the variation of temperature (T) of one kilogram of a material with the heat (H) supplied to it. At O, the substance is in the solid state. From the graph, we can conclude that -



(1) T_2 is the melting point of the solid
(2) BC represents the change of state from solid to liquid
(3) $(H_2 - H_1)$ represents the latent heat of fusion of the substance
(4) $(H_3 - H_1)$ represents the latent heat of vaporization of the liquid

Q.18 Which of the substances A, B or C has the highest specific heat ? The temperature vs time graph is shown -



(1) A
(2) B
(3) C
(4) All have equal specific heat

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 13

Q.1 The specific heat of a gas-
(1) Has only two value C_p and C_v
(2) Has a unique value at a given temperature
(3) Can have any value between 0 and ∞
(4) Depends upon the mass of the gas

Q.2 The thermal capacity of 40 gm of aluminium (specific heat = 0.2 cal/gm/ºC is-
(1) 40 cal/ºC (2) 160 cal/ºC
(3) 200 cal/ºC (4) 8 cal/ºC

Q.3 Molar specific heat at constant volume is C_v for a monoatomic gas is-
(1) 3R/2 (2) 5R/2 (3) 6R/2 (4) 2R

Q.4 For a certain gas, the ratio of specific heats is given to be γ = 1.5 for this gas-
(1) C_v = 3R/J (2) C_p = 3R/J (3) C_p = 5R/J (4) C_v = 5R/J

Q.5 For a gas $\frac{R}{C_v}$ = 0.67. This gas is made up of molecules which are-
(1) Diatomic
(2) Mixture of diatomic and polyatomic molecules
(3) Monoatomic
(4) Polyatomic

Q.6 Degrees of freedom of a diatomic gas due to its translational motion will be-
(1) 2 (2) 3 (3) 5 (4) Zero

Q.7 For hydrogen gas $C_p - C_v$ = a and for oxygen gas $C_p - C_v$ = b. So the relation between a and b is given by-(Where C_p, C_v are molar specific heat at constant pressure and constant volume)
(1) a = 16b (2) b = 16a
(3) a = 4b (4) a = b

Q.8 22 gm of CO_2 at 27ºC is mixed with 16gm of O_2 at 37ºC. The temperature of the mixture is-
(1) 31.16ºC (2) 27ºC
(3) 37ºC (4) 30ºC

Q.9 Relation between the ratio of specific heats (γ) of gas and degree of freedom 'f' will be-
(1) $\gamma = f + 2$ (2) $\frac{1}{\gamma} = \frac{1}{f} + \frac{1}{2}$
(3) $f = 2/(\gamma - 1)$ (4) $f = 2(\gamma - 1)$

Q.10 The molar specific heat at constant pressure of an ideal gas is (7/2)R. The ratio of specific heat at constant pressure to that at constant volume is-
(1) $\frac{7}{5}$ (2) $\frac{8}{7}$ (3) $\frac{5}{7}$ (4) $\frac{9}{7}$

Q.11 When a solid is converted into a gas, directly by heating, then this process is known as-
(1) sublimation (2) vaporization
(3) condensation (4) boiling

Q.12 For a gas, if the ratio of specific heats at constant pressure P and constant volume V is γ, then the value of degree of freedom is-

(1) $\frac{\gamma+1}{\gamma-1}$ (2) $\frac{\gamma-1}{\gamma+1}$

(3) $\frac{1}{2}(\gamma-1)$ (4) $\frac{2}{\gamma-1}$

Q.13 If a thermometer reads freezing point of water as 20ºC and boiling point as 150ºC, how much thermometer read when the actual temperature is 60ºC ?

(1) 98ºC (2) 110ºC

(3) 40ºC (4) 60ºC

Q.14 A centigrade and Fahrenheit thermometers are dipped in boiling water. The water temperature is lowered until the Fahrenheit thermometer registers a temperature of 140º. The fall of temperature as registered by the centigrade thermometer is-

(1) 80ºC (2) 40ºC

(3) 50ºC (4) 90ºC

Q.15 One gram of ice is added to 5 gram of water at 10ºC. If the latent heat of ice is 80 cal/g, the final temperature of the mixture is-

(1) –5ºC (2) 10ºC

(3) 0ºC (4) none of these

Q.16 The reading of centigrade thermometer coincides with that of Fahrenheit thermometer in a liquid. The temperature of the liquid is-

(1) –40ºC (2) 313ºC

(3) 0ºC (4) 100ºC

Q.17 If C_p and C_v denote the specific heats (per unit mass) of an ideal gas of molecular weight M.-

(1) $C_p - C_v = R$ (2) $C_p - C_v = R / M$

(3) $C_p - Cv = MR$ (4) $C_p - C_v = R / M^2$

Where R is the molar gas constant

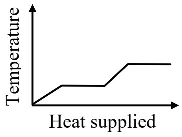
IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 14

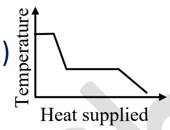
Q.1 Heat given to a body which raises its temperature by 1°C is -
(1) Water equivalent
(2) Thermal capacity
(3) Specific heat
(4) Temperature gradient

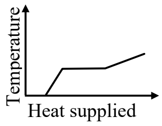
Q.2 If mass-energy equivalence is taken into account, when water is cooled to form ice, the mass of water should-
(1) Increase
(2) Remain unchanged
(3) Decrease
(4) First increase then decrease

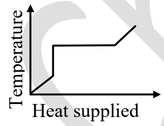
Q.3 If C_p and C_v denote the specific heats of nitrogen per unit mass at constant pressure and constant volume respectively, then-
(1) $C_p – C_v = R/28$ (2) $C_p – C_v = R/14$
(3) $C_p – C_v = R$ (4) $C_p – C_v = 28\ R$

Q.4 A block of ice at – 10ºC is slowly heated and converted to steam at 100ºC. Which of the following curves represents the phenomenon qualitative -

(1) 

(2) 

(3) 

(4) 

Q.5 2kg ice at – 20ºC is mixed with 5 kg water at 20ºC. Then final amount of water in the mixture would be Given , specific heat of ice = 0.5/gºC specific heat of water = 1 cal/gºC Latent heat of fusion of ice = 80 cal/g -
(1) 4kg (2) 6 kg (3) 3kg (4) 7kg

Q.6 Calorie may be defined as amount of heat energy required to raise the temp of 1 gram water by 1ºC from -
(1) 13.5ºC to 14.5ºC at 76 mm of Hg
(2) 3.5ºC to 4.5ºC at 76 mm
(3) 98.5ºC to 99.5ºC at 760 mm
(4) 14.5 ºC to 15.5ºC at 760 mm

Q.7 1 mole of a gas with $\gamma = 7/5$ is mixed with 1 mole of a gas with $\gamma = 5/3$, then the value of γ for the resulting mixture is -
(1) 7/5 (2) 2/5 (3) 24/16 (4) 12/7

Q.8 One mole of ideal monoatomic gas ($\gamma = 5/3$) is mixed with one mole of diatomic gas ($\gamma = 7/5$). What is γ for the mixture ? γ denotes the ratio of specific heat at constant pressure, to that at constant volume-
(1) 3/2 (2) 23/15 (3) 35/23 (4) 4/3

Q.9 A gaseous mixture consists of 16 g of helium and 16 g of oxygen. The ratio $\frac{C_P}{C_v}$ of the mixture is-

(1) 1.59 (2) 1.62 (3) 1.4 (4) 1.54

Q.10 Two rigid boxes containing different ideal gases are placed on a table. Box A contains one mole of nitrogen at temperature T_0, while Box B contains one mole of helium at temperature (7/3) T_0. The boxes are then put into thermal contact with each other, and heat flows between them until the gases reach a common final temperature. (Ignore the heat capacity of boxes). Then, the final temperature of the gases, T_f, in terms of T_0 is -

(1) $T_f = \frac{3}{2} T_0$ (2) $T_f = \frac{5}{2} T_0$

(3) $T_f = \frac{3}{7} T_0$ (4) $T_f = \frac{7}{3} T_0$

Q.11 Ratio of molecular specific heats of a di-atomic gas will be-

(1) 1.4 (2) 1.33

(3) 1.67 (4) None of these

Q.12 If f be the total degrees of freedom of the molecules of gas then the ratio of the specific heats of gas is-

(1) 1 + f / 2 (2) 1 + f / 3

(3) 1 + 2 / f (4) 1 + 3 / f

Q.13 Statement A : $C_p - C_v = R$; Statement B : $\frac{C_p}{C_v} = 1.67$

(1) A and B statement are true for all ideal gases

(2) A is true for all ideal gases and B is true for only monoatomic gases

(3) A and B are true for monoatomic gases

(4) A is true for all ideal gases and B is true for only diatomic gases

Q.14 If the ratio of specific heats is γ and R is the gas constant then what will be the value of specific heat for gas at constant volume-

(1) $R / (\gamma - 1)$ (2) $R / (\gamma + 1)$

(3) R / γ (4) $R (\gamma - 1)$

Q.15 For a gas if $\gamma = 1.4$, then atomicity, C_p and C_v of the gas are respectively-

(1) Monoatomic, 5R/2, 3R/2

(2) Monoatomic, 7R/2, 5R/2

(3) Diatomic, 7R/2, 5R/2

(4) Triatomic 7R/2, 5R/2

Q.16 Which of the following formula is wrong-

(1) $C_v = \frac{R}{\gamma - 1}$ (2) $C_p = \frac{\gamma R}{\gamma - 1}$

(3) $C_p/C_v = \gamma$ (4) $C_p - C_v = 2R$

Q.17 If one mole of a mono-atomic gas ($\gamma = 5/3$) is mixed with one mole of a diatomic gas ($\gamma = 7/5$), the value of γ for the mixture is-

(1) 1.4 (2) 1.5 (3) 1.53 (4) 3.07

Q.18 The specific heat of an ideal gas depends on temperature as-

(1) $\frac{1}{T}$ (2) T

(3) $\sqrt{T}$ (4) Does not depends on temperature

Q.19 The value of C_v for one mole of Neon gas is-

(1) $\frac{1}{2}R$ (2) $\frac{3}{2}R$ (3) $\frac{5}{2}R$ (4) $\frac{7}{2}R$

Q.20 A diatomic gas molecules has translational, rotational and vibrational degrees of freedom, then ratio $\frac{C_p}{C_v}$ is-

(1) 1.28 (2) 1.33 (3) 1.4 (4) 1.6

Q.21 Find the ratio of specific heat at constant pressure to the specific heat at constant volume for NH_3 -

(1) 1.33 (2) 1.44 (3) 1.28 (4) 1.67

Q.22 Correct relation between molar specific heat at constant pressure and constant volume-

(1) $C_p - C_v = r$ (2) $C_p - C_v = \frac{R}{J}$

(3) $C_p - C_v = R$ (4) $mC_pdt - mC_vdt = R$

Q.23 The $\frac{C_p}{C_v} = 1.33$ is for-

(1) mono atomic (2) diatomic
(3) triatomic (4) polyatomic

Q.24 Most accurate values are -

(1) $C_P = 3$, $C_V = 1$ (2) $C_P = 5$, $C_V = 3$
(1) $C_P = 4$, $C_V = 5$ (4) $C_P = 6$, $C_V = 2$

Q.25 A piece of ice (heat capacity = 2100 $Jkg^{-1}{}^{\circ}C^{-1}$ and latent heat = 3.36×10^8 J kg^{-1}) of mass m grams is at –5ºC at atmospheric pressure. It is given 420 J of heat so that the ice starts melting. Finally when the ice-water mixture is in equilibrium, it is found that 1 gm of ice has melted. Assuming there is no other heat exchange in the process, the value of m is ?

(1) 2 (2) 4 (3) 6 (4) 8

Q.26 The thermal capacity of any body is

(1) a measure of its capacity to absorb heat
(2) a measure of its capacity to provide heat
(3) the quantity of heat required to raise its temperature by a unit degree
(4) the quantity of heat required to raise the temperature of a unit mass of the body by a unit degree.

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 and Reason is false.
(D) If Assertion & Reason both are false.

Q.1 **Assertion :** The ratio $\frac{C_v}{C_p}$ for a monoatomic gas is more than for a diatomic gas.
Reason : The molecules of a monoatomic gas have more degrees of freedom than those of a diatomic gas.
(1) A (2) B (3) C (4) D

Q.2 **Assertion :** The ratio $\frac{C_p}{C_v}$ is more for helium gas than for hydrogen gas.
Reason : Atomic mass of helium is more than that of hydrogen.
(1) A (2) B (3) C (4) D

Q.3 **Assertion :** The adiabatic exponent of a mixture of a gases can be obtained as $\gamma_{mix} = \frac{n_1\gamma_1 + n_2\gamma_2}{n_1 + n_2}$
Reason : For a gas mixture $(C_v)_{mix} = \frac{n_1C_{v_1} + n_2C_{v_2}}{n_1 + n_2}$ and $(C_p)_{mix} = \frac{n_1C_{p_1} + n_2C_{p_2}}{n_1 + n_2}$ or $\gamma_{mix} = \left(\frac{C_p}{C_v}\right)_{mix}$
(1) A (2) B (3) C (4) D

Q.4 **Assertion :** All the poly-atomic gas molecules have six degrees of freedom.
Reason : The number of degree of freedom depends only name of atomicity of gas.
(1) A (2) B (3) C (4) D

Q.5 **Assertion :** $C_p > C_v$, for an ideal gas (always).
Reason : Work is done in expansion of the gas at constant pressure.
(1) A (2) B (3) C (4) D

Q.6 **Assertion :** Water equivalent of a body is depends upon the mass of body.
Reason : Heat capacity of body is directly proportional to mass.
(1) A (2) B (3) C (4) D

Q.7 **Assertion :** If heat is given to a body then its temperature always increases.
Reason : When heat is given to a solid body then its internal energy increases.
(1) A (2) B (3) C (4) D

Q.8 **Assertion :** If same amount of ice at 0ºC and water is taken, then total ice will only melt if the temperature of water is greater than 80ºC.
Reason : From principle of calorimetry, when two substance at different temperature are mixed then heat given by hot substance is equal to heat taken by cold substance.
(1) A (2) B (3) C (4) D

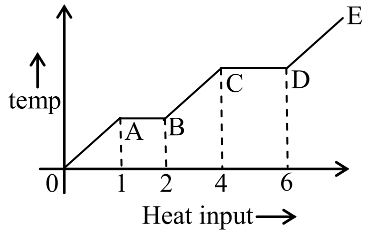
Q.9 **Assertion :** In pressure-temperature (P–T) phase diagram of water, the slope of the melting curve is found to be negative.
Reason : Ice contracts in melting to water.
(1) A (2) B (3) C (4) D

Q.10 **Assertion :** A person skin is more severely burnt when put contact with 2gm of steam at 100ºC then, when put in contact with 2 gm of water at 100ºC.

Reason : The mass of water having the same heat capacity, as a given body is called the water equivalent of the body.

(1) A (2) B (3) C (4) D

Q.11 **Assertion :** A solid material is supplied heat at a constant rate. The temperature of the material is changing with the heat input as shown in figure. Latent heat of vaporisation of substance is double that of fusion (given CD = 2AB).



Reason : $L_f \propto AB$ and $L_v \propto CD$

(1) A (2) B (3) C (4) D

Q.12 **Assertion :** Water kept in an open vessel will quickly evaporate on the surface of the moon.

Reason : The temperature at the surface of the moon is much higher than boiling point of water.

(1) A (2) B (3) C (4) D

Q.13 **Assertion :** For a gas atom the number of degrees of freedom is 3.

Reason : $\frac{C_p}{C_v} = \gamma$

(1) A (2) B (3) C (4) D

Q.14 **Assertion :** The melting point of ice decreases with increase of pressure.

Reason : Ice contracts on melting.

(1) A (2) B (3) C (4) D

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 16

Q.1 Under steady state the temperature of a body -
(1) increases with time
(2) decreases with time
(3) does not change with time and is same at all points of the body
(4) does not change with time and can be different at different points of the body

Q.2 In the steady state of temperature the flow of heat across the body depends -
(1) only upon its thermal conductivity
(2) upon its thermal capacity
(3) upon its thermal conductivity and upon its thermal capacity
(4) neither upon its thermal conductivity nor upon its thermal capacity

Q. 3 The rate of flow of heat through a metal bar of area of cross-section 1 m^2 when temperature gradient is 1°C/m under steady state is called -
(1) thermal resistance (2) thermal conductivity
(3) diffusibility (4) resistivity

Q. 4 Metals are good conductors of heat because-
(1) they contain a large number of free electrons
(2) their atoms collide frequently
(3) they have shining surfaces
(4) they are habitual of heat flow

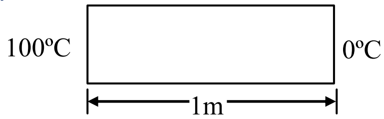
Q.5 The coefficients of thermal conductivity of a metal depends on -
(1) temperature difference between the two sides
(2) thickness of the metal plate
(3) area of the plate
(4) none of the above

Q.6 In which case does the thermal conductivity increase from left to right -
(1) Al, Cu, Ag (2) Ag, Cu, Al
(3) Cu, Ag, Al (4) Al, Ag, Cu

Q. 7 Four rods with different radii r and length ℓ are used to connect two reservoirs of heat at different temperatures. Which one will conduct most heat ?
(1) r = 1 cm, ℓ = 1m
(2) r = 2 cm, ℓ = 2 m
(3) r = 1 cm, ℓ = 1/2 m
(4) r = 2 cm, ℓ = 1/2 m

Q. 8 Heat is flowing through two cylindrical rods of same material. The diameters of the rods are in the ratio 1 : 2 and their lengths are in the ratio 2 : 1. If the temperature difference between their ends is same, then the ratio of amounts of heat conducted through them per unit time will be -
(1) 1 : 1 (2) 2 : 1
(3) 1 : 4 (4) 1 : 8

Q. 9 A rod of 1 m length and area of cross-section 1 cm^2 is connected across two heat reservoirs at temperatures 100°C and 0°C as shown. The heat flow per second through the rod in steady state will be- [Thermal conductivity of material of rod = 0.09 kilocal $m^{-1}s^{-1}$(°C)]



(1) 9×10^{-4} kilocal/sec
(2) 9 kilocal/sec
(3) 0.09 kilocal/sec
(4) 9×10^{-6} kilocal/sec

Q.10 The quantity of heat which crosses unit area of a metal plate during conduction depends upon -
(1) The density of the metal
(2) The temperature gradient perpendicular to the area
(3) The temperature to which the metal is heated
(4) The area of the metal plate

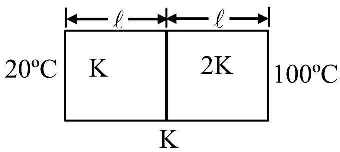
Q.11 When two ends of a rod wrapped with cotton are maintained at different temperatures and after some time every point of the rod attains a constant temperature, then -
(1) Conduction of heat at different points of the rod stops because the temperature is not increasing.
(2) Rod is bad conductor of heat
(3) Heat is being radiated from each point of the rod
(4) Each point of the rod is giving heat to its neighbour at the same rate at which it is receiving heat.

Q.12 The coefficient of thermal conductivity of copper, mercury and glass are respectively K_c, K_m and K_g such that $K_c > K_m > K_g$. If the same quantity of heat is to flow per second per unit area of each and the corresponding temperature gradients are X_c, X_m and X_g, then -
(1) $X_c = X_m = X_g$ (2) $X_c > X_m > X_g$
(3) $X_c < X_m < X_g$ (4) $X_m < X_c < X_g$

Q.13 The S.I. unit of thermal conductivity is -
(1) $Js^{-1}\ m^{-1}°C^{-1}$ (2) $Js\ m^{-1}°C^{-1}$
(3) $Js^{-1}\ m^{-1}°C$ (4) $Js^{-1}m°C^{-1}$

Q. 14 If ℓ is the length and A is the area of cross-section of a rod and K is thermal conductivity of material, then the thermal resistance is given by-
(1) $\frac{K\ell}{A}$ (2) $\frac{\ell}{KA}$
(3) $\frac{\ell K}{A}$ (4) $\frac{A}{K\ell}$

Q. 15 Two rods are connected as shown. The rods are of same length and same cross sectional area. In steady state, the temperature (θ) of the interface will be -



(1) 60°C (2) 73.3°C
(3) 46.7°C (4) 37.3°C

Q. 16 Two walls of thickness d_1 and d_2, thermal conductivities K_1 and K_2 are in contact. In the steady state if the temperatures at the outer surfaces are T_1 and T_2, the temperature are the common wall will be-

(1) $\frac{K_1T_1 + K_2T_2}{d_1d_2}$

(2) $\frac{K_1T_1d_2 + K_2T_2d_1}{K_1d_2 + K_2d_1}$

(3) $\frac{(K_1d_1 + K_2d_2)T_1T_2}{T_1 + T_2}$

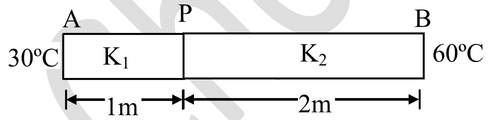
(4) $\frac{K_1d_1T_1 + K_2d_2T_2}{K_1d_1 + K_2d_2}$

Q. 17 A slab consists of two parallel layers of two different materials of same thickness and having thermal conductivities K_1 and K_2. The equivalent thermal conductivity K of the slab is-

(1) $K_1 + K_2$ (2) $\frac{2K_1K_2}{K_1 + K_2}$

(3) $\frac{K_1 + K_2}{K_1K_2}$ (4) $K_1 K_2$

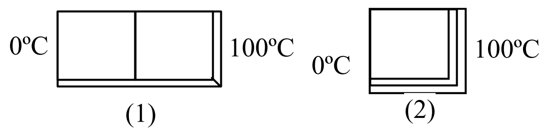
Q. 18 Two rods A and B are connected in series as shown in fig. the conductivity of A is K_1 = 100 W/m - °C and conductivity of B is K_2 = 50 W/m - °C. The free ends of the rods A and B has temp. 30° and 60° respectively the temp. of common meeting point will be -



(1) 35°C (2) 40°C (3) 45°C (4) 50°

Q. 19 In above **Q.18**, what is the equivalent conductivity of rods A and B -
(1) 50 W/m-°C (2) 60 W/m-°C
(3) 80 W/m-°C (4) 100 W/m-°C

Q. 20 Two identical square rods of metal are welded end to end as shown in fig (1). 20 cal of heat flows through it in 4 min. If the rods are welded as shown in fig. (2), the same amount of heat will flow through the rods in -



(1) 1 min (2) 2 min
(3) 4 min (4) 16 min.

Q. 21 Two rods of length d_1 and d_2 and coefficients of thermal conductivities K_1 and K_2 are kept touching each other. Both have the same area of cross-section. The equivalent thermal conductivity is-

(1) $K_1 + K_2$ (2) $K_1d_1 + K_2d_2$

(3) $\frac{K_2d_1 + K_1d_2}{d_1 + d_2}$ (4) $\frac{d_1 + d_2}{\frac{d_1}{K_1} + \frac{d_2}{K_2}}$

Q.22 Nature of thermal radiations is similar to the nature of -
(1) electro magnetic waves
(2) gravity waves
(3) β rays
(4) sound waves

Q.23 The amount of thermal radiations emitted per second by a surface depends upon-
(1) nature of the surface only
(2) area of the surface only.
(3) difference of temperature between surface and its surrounding only.
(4) all of the above.

Q.24 Heat radiations travel in vacuum with a velocity equal to -
(1) 3×10^8 m/sec (2) 3×10^{10} m/sec
(3) 1120 ft/sec (4) 3×10^6 m/sec

Q.25 The emissive power of a body, as used in Kirchoff's law, may have values such that-
(1) $0 < e_\lambda < 1$ (2) $-1 < e_\lambda < 0$
(3) $1 < e_\lambda < 2$ (4) $0 < e_\lambda < \infty$

Q.26 The absorptive power of a body has numerical values such that-
(1) $0 < a_\lambda < 1$ (2) $-1 < a_\lambda < 0$
(3) $1 < a_\lambda < 2$ (4) $0 < a_\lambda < \infty$

Q.27 Heat radiation exhibit the phenomenon of polarization which means that the radiation is in the form of -
(1) Electromagnetic waves which are longitudinal.
(2) Electromagnetic waves which are transverse.
(3) Of ray of longitudinal photons.
(4) Of ray of transverse photon.

Q.28 Following is not a property of radiation -
(1) It travels with velocity of light
(2) Medium is necessary for propagation
(3) Its nature is electromagnetic
(4) It has quantum nature

Q.29 Transfer of heat in friction is by -
(1) Convection (2) Conduction
(3) Radiation (4) None of the above

Q.30 Which of the following surface will emit least heat radiation –
(1) White (bright) (2) White and rough
(3) Polished black (4) Black and rough

Q.31 Coefficient reflection of black body is -
(1) Zero (2) Infinity
(3) 1 (4) 0.5

Q.32 If p calorie heat energy falls on a body and q calorie heat is absorbed then the absorption coefficient will be -
(1) p/q (2) p – q (3) q/p (4) q + p

Q.33 Emissive power of any surface (e), Absorptive power (a), Reflecting power (r) and transmission power (t) are related as -
(1) a + e + t = 1 (2) a + r + t = 1
(3) r + e + t = 1 (4) r + e + a = 1

Q.34 If transmission power of a surface is $\frac{1}{6}$ and reflective power is $\frac{1}{3}$, then its absorptive power will be-
(1) $\frac{1}{3}$ (2) $\frac{1}{2}$ (3) $\frac{1}{6}$ (4) $\frac{1}{12}$

Q.35 If same amount of ice in placed in black and white cloth then ice in black cloth will -
(1) Melt more (2) Melt less
(3) Melt equal (4) Not melt at all

Q.36 Out of the radiations falling on surface of a body, 30% radiations are absorbed and 30% are transmitted then its reflection coefficient will be -
(1) 0.3 (2) 0.6
(3) 0.4 (4) Zero

Q.37 Reflection and absorption coefficient's of a given surface at 0ºC for a fixed wavelength are 0.5 each. At same temperature and wavelength the transmission coefficient of surface will be -
(1) 0.5
(2) 1.0
(3) Zero
(4) In between zero and one

Q.38 The feature which is wrong for a black body is -
(1) $a_\lambda = 1$
(2) a = 1
(3) $e_\lambda = 0$
(4) absorbs radiations of all wavelengths incident upon it

Q.39 The coefficient of transmission for an ideal black body is -
(1) Zero (2) Infinity
(3) One (4) More than one

Q.40 In a room heat is transferred via -
(1) Conduction only
(2) Convection only
(3) Radiation only
(4) All the three modes

Q.41 That object which completely absorbs all the incident radiation, is called –
(1) Black body (2) Good absorber
(3) Black object (4) Good emitter

Q.42 If a black body is heated, then it emits -
(1) White radiation
(2) Only infrared radiation
(3) Only ultraviolet radiation
(4) Black radiation

Q.43 Black body is –
(1) Only a good absorber
(2) Only a good emitter
(3) Good absorber as well as a good emitter
(4) A good absorber but a poor emitter

Q.44 We get heat from the sun by -
(1) Conduction (2) Convection
(3) Radiation (4) Diffusion

Q.45 The velocity of heat radiation in vacum is-
(1) equal to that of light
(2) less than that of light
(3) greater than that of light
(4) equal to that of sound

Q.46 From Kirchoff's law the ratio of emissive power and absorption power of all bodies –
(1) Are different.
(2) Is equal to emissive power of black body at same temperature.
(3) Is equal to emissive power of white body.
(4) Is equal to emissive power of black body at any temperature.

Q.47 If at temperature T, the emissive power and absorption power of a body for wavelength are e_λ and a_λ respectively, then -
(1) $e_\lambda = a_\lambda$
(2) $e_\lambda > a_\lambda$
(3) $e_\lambda < a_\lambda$
(4) There will not be any definite relation between e_λ and a_λ

Q.48 A substance when at high temperature emits wave length λ_1, λ_2, λ_3 and λ_4 only, When this substance is at low temperature then it will absorb only following wavelengths -
(1) λ_1
(2) λ_2
(3) λ_1 and λ_2
(4) λ_1, λ_2, λ_3 and λ_4

Q.49 During total solar eclipse Fraunhoffer's lines appear bright because -
(1) Moon totally covers both parts of sun photosphere and chromosphere.
(2) Sun light is scattered by moon.
(3) Moon blocks the radiations emitted by chromosphere.
(4) Moon blocks the radiations emitted by photosphere and radiations emitted by chromosphere reach the earth.

Q.50 Fraunhoffer lines are found -
(1) In solar spectrum
(2) Spectrum produced by light of neon bulb
(3) Spectrum produced by light of discharge tube
(4) None of the above

Q.51 Fraunhoffer lines can be explained by -
(1) Stefan's law (2) Planck's law
(3) Kirchoff's law (4) Newton's law

Q.52 A polished metal plate with a rough black spot on it is heated to about 1400K and quickly taken into a dark room. Which one of the following statements will be true -
(1) The spot will appear brighter than the plate
(2) The spot will appear darker than the plate
(3) The spot and plate will appear equally bright.
(4) The spot and the plate will not be visible in the dark room.

Q.53 A blackened steel plate is put in a dark room after being heated up to a high temperature. A white spot on the plate appears-
(1) brighter than the plate
(2) as bright as the plate
(3) dull as compared to the plate
(4) appears to be yellow

Q.54 In the solar spectrum the Fraunhoffer lines are produced due to-
(1) emission (2) absorption
(3) reflection (4) transmission.

Q.55 The Fraunhoffer lines becomes bright during the solar eclipse because of -
(1) the diffraction of the sun rays by the moon.
(2) the sun rays are completely cut off by the moon and only the rays emitted by the moon reach the earth
(3) the rays from the chromosphere are stopped by the moon and only the rays from the photosphere are able to reach the earth.
(4) the rays from the photosphere are stopped by the moon and only the rays from the chromosphere are able to reach the earth.

Q.56 The MKS unit of Stefan's constant is-
(1) Watt / m^2-K^4. (2) Watt m^2-K^4.
(3) Watt / m^2-K (4) Watt/m^2

Q.57 The temperature of a black body becomes half of its original temperature, the amount of radiation emitted by the body will reduce to-
(1) 1/16 (2) 1/4
(3) 1/2 (4) remains unchanged.

Q.58 Choose the correct statement-
(1) Stefan's law and Newton's law of cooling both hold true at all the temperature.
(2) Stefan's law holds when the excess of temperature over the surroundings is small, whereas Newton's law is valid at all the temperature.
(3) Newton's law holds when the excess of temperature over the surroundings is small, whereas Stefan's law is valid at all temperatures.
(4) Excess of temperature over the surroundings should be small for both the laws to hold true.

Q.59 Four bodies of specific heats s_1, s_2, s_3 and s_4 are cooled in the same surroundings. If $s_1 > s_2 > s_3 > s_4$, and temperature of all the four bodies is the same, then the specific heat of body which cools fastest, will be -

(1) s_1 (2) s_2
(3) s_3 (4) s_4

Q.60 At any temperature the radiation energy emitted by a cube of length L is proportional to -

(1) L
(2) L^2
(3) L^3
(4) None of the above

Q.61 Temperature of a piece of metal is increased from 27ºC to 327ºC. The rate of emission of radiation by a metal will become -

(1) Double
(2) Four times
(3) Eight times
(4) Sixteen times

Q.62 Two bodies A and B are kept in an evacuated chamber at 27ºC. The temperatures of A and B are 327ºC and 427ºC respectively. The ratio of rates of loss of heat from A and B will be -

(1) 0.52 (2) 0.25 (3) 1.52 (4) 2.52

Q.63 If the temperature of a black body is increased by 50% then the amount of radiation emitted by it will -

(1) Increase by 400% (2) Decrease by 400%
(3) Decrease by 50% (4) Increase by 50%

Q.64 The effective area of a black body is 0.1 m^2 and its temperature is 1000 K . The amount of radiations emitted by it per min is -

(1) 1.34 k cal (2) 81 k cal
(3) 5.63 k cal (4) 1.34 k J

Q.65 The energy emitted per second by a black body at 1227ºC is E. If the temperature of the black body is increased to 2727ºC, the energy emitted per second in terms of E is -

(1) 16 E (2) E
(3) 4E (4) 2E

Q.66 A body at temperature T (K) is kept in the surroundings at T_0 (K) . If T >> T_0, then the rate of emission of heat by the body to the surroundings is proportional to -

(1) $(T - T_0)^4$ (2) $T^4 - T_0^4$
(3) $(T - T_0)^{1/4}$ (4) T / T_0

Q.67 A solid sphere of radius R and a hollow sphere of internal radius r and external radius R are made of copper. These are heated to same temperature and then allowed to cool in the same surroundings, then -

(1) Solid sphere will cool first
(2) Hollow sphere will cool first
(3) Both will cool at the same rate
(4) Only solid sphere will cool

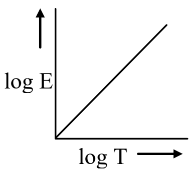
Q.68 Amount of heat radiations emitted by a solid sphere of radius r at any temperature is proportional to the following -
(1) r (2) r^2
(3) r^3 (4) r^4

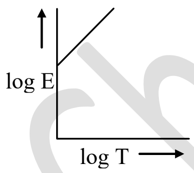
Q.69 Radius of a sphere is R, density is d and specific heat is s, It is heated and then allowed to cool. Its rate of decrease of temperature will be proportional to -
(1) Rds (2) 1/Rds
(3) $1/R^2ds$ (4) R^2ds

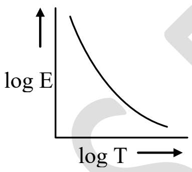
Q.70 If a body at 27ºC emits 0.3 watt of heat then at 627ºC, it will emit heat equal to -
(1) 24.3 watt (2) 0.42 watt
(3) 2.42 watt (4) 0.9 watt

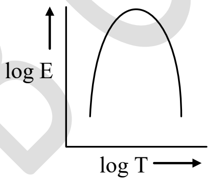
Q.71 If temperature of surface of sun becomes half then the energy emitted by it to earth per second will reduce to -
(1) $\frac{1}{2}$ (2) $\frac{1}{4}$
(3) $\frac{1}{16}$ (4) $\frac{1}{64}$

Q.72 If the rate of emission of radiation by a body at temperature TK is E then graph between log E and log T will be -

(1) 

(2) 

(3) 

(4) 

Q.73 The ratio of radii of two spheres of same metal is 1:2. The ratio of the amounts of radiation emitted by them per second at same temperature will be -
(1) 1 : 8 (2) 2 : 1
(3) 8 : 1 (4) 1 : 4

Q.74 The energy emitted by a black body at 727ºC is E. If the temperature of the body is increased to 2227ºC, then the emitted energy will become -
(1) 19 times (2) 13 times
(3) 39 times (4) 227 times

Q.75 The rate of cooling of a body depends on -
(1) The difference of temperature of the body and the surrounding.
(2) Area of surface of body.
(3) Nature of surface of body.
(4) All of the above.

Q.76 Hot coffee is to be taken after 10 minutes it is put into a cup. To obtain much hotness at the time of drinking, when should the cream be put into coffee -
(1) Some time before drinking.
(2) Just after putting the coffee in cup.
(3) Five minutes before drinking.
(4) Any time between putting the coffee and drinking.

Q.77 When placed in air at 30ºC, the temperature of a body decreases from 60ºC to 50ºC in ten minutes. After next ten minutes its temperature will be -
(1) Less than 40ºC
(2) 40ºC
(3) More than 40ºC
(4) Not definite

Q.78 A body takes 4 minutes to cool from 100ºC to 70ºC. If the room temperature is 15ºC then how many minutes will it need to cool from 70ºC to 40ºC -
(1) 4 (2) 5
(3) 6 (4) 7

Q.79 A solid sphere, a cube and a plate, all are made of same material and all have same mass. These are heated to a temperature 100ºC and then allowed to cool at the temperature of room. Which of these will cool down first -
(1) Cube
(2) Plate
(3) Sphere
(4) All will cool down simultaneously

Q.80 Radius of a calorimeter is r and depth is ℓ. It is filled completely with water and then cooled from temperature θ in the surroundings at a temperature θ_0 .If the emissive power of the surface of calorimeter is 1 and that of open surface of water is 0.5, then the ratio of rates of heat radiated by the surface of calorimeter and open surface of water will be -
(1) $\frac{\ell}{r}$ (2) $1+\frac{\ell}{r}$
(3) $1+\frac{2\ell}{r}$ (4) $2\left(1+\frac{2\ell}{r}\right)$

Q.81 A metallic sphere cools from 50ºC to 40ºC in 300 seconds. If the room temperature is 20ºC then its temperature in next 5 minutes will be -
(1) 38ºC (2) 36ºC (3) 33.3ºC (4) 30ºC

Q.82 Negative sign in the equation
$dQ/dt = -K(T - T_0)$ shows that -
(1) Heat of the body increases with time.
(2) Heat of the body remains same.
(3) Heat of the body reduces with time.
(4) Constant is negative.

Q.83 Which qualities are needed for cooking utensils -
(1) More specific heat and less thermal conductivity.
(2) Less specific heat and more thermal conductivity.
(3) More specific heat and more thermal conductivity.

(4) Less specific heat and less thermal conductivity

Q.84 Heat capacities of two bodies are in the ratio 1 : 4. If in the same surroundings the rate of loss of heat from the bodies are equal then the ratio of their rates of fall of temperature will be -
(1) 1 : 4 (2) 4 : 1 (3) 1 : 8 (4) 8 : 1

Q.85 Temperatures of two hot bodies B_1 and B_2 are 100ºC and 80ºC respectively. The temperature of surrounding is 40ºC. At t = 0, the ratio of rates of cooling of the two bodies (liquid) $R_1 : R_2$ will be -
(1) 3 : 2 (2) 5 : 4
(3) 2 : 1 (4) 4 : 5

Q.86 According to Newton's law of cooling ms $\frac{d\theta}{dt} = -K(\theta - \theta_0)$. If σ is Stefan's constant, A is surface area of the body and T_o is temperature of surroundings in K, then the value of K on the basis of Stefan-Boltzmann law is -
(1) $\sigma A T_0^4$ (2) $\sigma A T_0^3$
(3) $4\sigma A T_0^4$ (4) $4\sigma A T_0^3$

Q.87 If by taking same volume of water and kerosene in two identical calorimeters, they are cooled for same temperature difference in identical circumstances, then for them -
(1) The changes in internal energies are same.
(2) The rates of cooling (rate of loss of heat) are same.
(3) The rates of loss of heat and fall of temperature are same.
(4) The rates of fall of temperature are same.

Q.88 According to Newton's law of cooling the rate of loss of heat is -
(1) Directly proportional to $(\theta - \theta_0)$
(2) Inversely proportional to $(\theta - \theta_0)$
(3) Directly proportional to $(\theta^4 - \theta_0^4)$
(4) Directly proportional to $(\theta^2 - \theta_0^4)$

Q.89 The vertex in the spectrum of radiations emitted by a black body, on increasing the temperature-
(1) Shifts towards the greater wavelength
(2) Shifts towards the lesser wavelength
(3) Does not shift
(4) None of the above

Q.90 Increasing the temperature of a black body -
(1) Frequency and wavelength both increase for maximum radiation.
(2) Frequency and wavelength both decrease for maximum radiation.
(3) Wavelength increases while frequency decreases for maximum radiation.
(4) Frequency increases while wavelength decreases for maximum radiation.

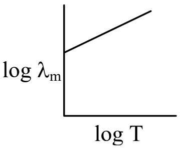
Q.91 Wein's law is -
(1) $\lambda_m \propto T$ (2) $\lambda_m \propto T^2$
(3) $\lambda_m \propto T^{-1}$ (4) $\lambda_m \propto T^{-2}$

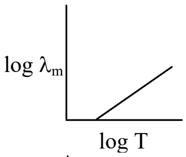
Q.92 Frequency for maximum energy radiation of ideal black body at temperature T is υ_m. If Wein's constant is b and velocity of heat radiation in vacuum is c then -
(1) $\upsilon_m = b/T$ (2) $\upsilon_m = b/cT$
(3) $\upsilon_m = cT/b$ (4) $\upsilon_m = bT/c$

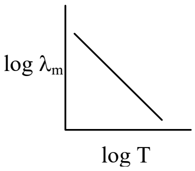
Q.93 At 700K temperature, the wavelength of maximum energy emitted by a body is 4.08 micron. If the temperature of body is increased to 1400K, then the wavelength of maximum energy will be -
(1) 10.2 micron (2) 16.32 micron
(3) 8.16 micron (4) 2.04 micron

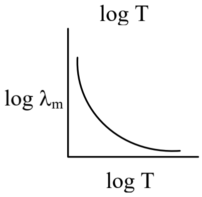
Q.94 Two stars A and B radiate maximum energy at wavelengths 4000Å and 5000Å respectively. The ratio of their temperature will be -
(1) 1 : 2 (2) 2 : 1
(3) 4 : 5 (4) 5 : 4

Q.95 Wein's displacement law is shown by the following relation $\lambda_m T = b$ then the curve drawn between log T and log λ_m will be -

(1) 

(2) 

(3) 

(4) 

Q.96 The value of Wein's constant b (in micron × K) is -
(1) 2.9 (2) 0.29×10^{-3}
(3) 2.9×10^{3} (4) 0.29

Q.97 Two spheres of the same material have radii 1m and 4m and temperature 4000K and 2000K respectively. The ratio of the amounts of energies radiated by the two per second will be -
(1) 1 : 1 (2) 1 : 2
(3) 1 : 4 (4) 1 : 16

Q.98 The spectral emissive power of a black body at a temperature of 6000K is maximum at λ_m = 5000Å. If the temperature is increased by 10%, then the decrease in λ_m will be -
(1) 2.5% (2) 5.0%
(3) 7.5% (4) 10%

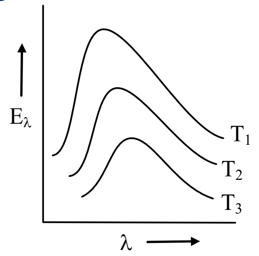
Q.99 From Wein's law, the star which appears blue must be -
(1) Very cold (2) Colder than sun
(3) A black hole (4) Hotter than Sun

Q.100 The variation of maximum intensity (E_m) of radiation with temperature is proportional to the following -
(1) T (2) T^2
(3) T^5 (4) T^4

Q.101 Temperature of the surface of Sun is 6000 K and maximum emission is obtained at 5000Å. If in the light obtained from moon, the maximum energy is obtained at 100 micron then temperature of the moon will be –
(1) 30 K (2) 300 K
(3) 3000 K (4) 120 K

Q.102 Temperature of an ordinary bulb is 3000K. At what wavelength will it emit maximum energy -
(1) 10Å (2) 100Å
(3) 10^3Å (4) 10^4Å

Q.103 If for a black body the graph of change is emissive power at different temperatures T_1, T_2 and T_3 with wavelength is according to the figure then -



(1) $T_1 = T_2 = T_3$ (2) $T_3 > T_2 > T_1$
(3) $T_1 > T_2 > T_3$ (4) $T_3 > T_1 > T_2$

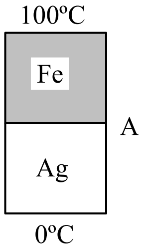
Q.104 At temperature of 1600K the wavelength of maximum emission of radiation is 2 μ, at temperature of 2000K the corresponding wavelength will be -
(1) 1μ (2) 1.6 μ
(3) 2 μ (4) 2.5 μ

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 17

Q. 1 A 2cm thick slab of commercial thermocouple, 100 cm^2 in cross–section and having thermal conductivity 2×10^{-4} cal sec^{-1} cm^{-1} $(C^o)^{-1}$ has insulating regions differing by 100ºC. The quantity of heat flowing through it in a day will be -

(1) 20.4 kcal (2) 43.2 kcal
(3) 86.4 kcal (4) 63.6 kcal

Q. 2 Two cylinders of the same diameter, one of iron and other of silver are placed in close contact as shown in figure. If the thermal conductivity of silver is 11 times that of iron the temperature of interface A is approximately



(1) 91.7 ºC (2) 80ºC
(3) 50ºC (4) 8.3ºC

Q. 3 A wall has two layer A and B, each made of a different material. Both layers have the same thickness. The thermal conductivity of the material of A is twice that of B. Under thermal equilibrium, the temperature difference across the wall is 36°C. The temperature difference across layer A is -

(1) 6°C (2) 12°C (3) 10°C (4) 24°C

Q. 4 The coefficient of thermal conductivity of copper is nine time that of steel. In the composite cylindrical bar shown in Fig. What will be the temp. at the junction of copper and steel ?

(1) 75°C (2) 67°C
(3) 33°C (4) 25°C

Q. 5 One end of a copper rod of length 1.0 m and area of cross-sector 10^{-3} m^2 is immersed in boiling water and the other end in ice. If the coefficient of thermal conductivity of copper is 92 cal/ms °C and the latent heat of ice is 8×10^4 cal/kg, then the amount of ice which will melt in one minute is -

(1) 9.2×10^{-3} kg (2) 8×10^{-3} kg
(3) 6.9×10^{-3} kg (4) 5.4×10^{-3} kg

Q. 6 Two identical vessels, made of different materials having conductivities K_1 and K_2 are completely filled with ice at 0°C. Due to temperature of surroundings, the ice in the two vessels melts in 25 min and 20 min respectively. The ratio of K_1 and K_2 is -

(1) 5/4 (2) 4/5
(3) 16/25 (4) $\frac{4/5}{\sqrt{(5/4)}}$

Q. 7 A metallic rod is heated at one end continuously. After some time steady stage is reached. The flow of heat in the steady state does not depend on -

(1) the area of cross-section of the rod
(2) the temperature gradient
(3) the mass of the rod

(4) the time of flow of heat

Q. 8 Two rods of length ℓ and 2ℓ, thermal conductivities 2K and K are connected end to end. If cross-sectional areas of to rods are equal, then equivalent thermal conductivity of the system is -

(1) (5/6/)K (2) 1.5K
(3) 1.2 K (4) (8/9)K

Q. 9 Two rods of same length and material transfer given amount of heat in 12 s, when they are joined end to end. When they are joined length-wise then they will transfer same amount of heat in same conditions in-

(1) 1.5 s (2) 3 s
(3) 24 s (4) 48 s

Q.10 When the temperature of a body is 80ºC its rate of cooling is 4ºC/min and when the temperature becomes 50ºC the rate of cooling becomes 2ºC/min. The temperature of surroundings is –

(1) 35ºC (2) 25ºC
(3) 30ºC (4) 20ºC

Q.11 A metal sphere cools from 62ºC to 50ºC in 10 minutes and then cools upto 42ºC in next 10 minutes. If the temperature of surrounding is 26ºC, then its temperature after next 10 minutes will be–

(1) 30ºC (2) 34ºC
(3) 36.67ºC (4) 38.52ºC

Q.12 The temperature of a black body is 3000K. When the black body cools then at any time the wavelength of maximum energy density has changed by $\Delta\lambda$ = 9μm. The temperature of black body at that time will be –

(1) 300K (2) 2700K
(3) 270K (4) 1800K

Q.13 Two liquids of same volume take 324s and 810s respectively in cooling from 60ºC to 50ºC in identical circumstances. If the ratio of specific heats of these liquids is 3 : 4, then the ratio of their densities will be – (Water equivalent of calorimeter is negligible)

(1) $\frac{3}{4}$ (2) $\frac{4}{9}$ (3) $\frac{8}{15}$ (4) $\frac{9}{20}$

Q.14 A sphere of density d, satisfied heat s and radius r is hung by a thermally insulating thread in an enclosure which is kept at a lower temperature than the sphere. The temperature of the sphere starts to drop at a rate which depends upon the temperature difference between the sphere and the enclosure. If the temperature difference is ΔT and surrounding temperature is T_0 then rate of fall in temperature will be –

[Given that $\Delta T << T_0$]

(1) $\frac{4\sigma T_0^3\,\Delta T}{rdc}$ (2) $\frac{12\sigma T_0^3\,\Delta T}{rdc}$
(3) $\frac{12\sigma T_0^4\,\Delta T}{rdc}$ (4) $\frac{12\sigma\,\Delta T}{rdc\,T_0^3}$

Q.15 A body cools from 50ºC to 40°C in 5min. If temperature of the surroundings is 20ºC, the temperature of the body after 5 min would be -

(1) 36ºC (2) 35ºC
(3) 33.33ºC (4) 30ºC

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 18

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 and Reason is false.
(D) If Assertion & Reason both are false.

Q.1 **Assertion :** The S.I. unit of thermal conductivity is watt $m^{-1} K^{-1}$.
Reason : Thermal conductivity is a measure of ability of the material to allow the passage of heat through it.
(1) A (2) B (3) C (4) D

Q.2 **Assertion :** It is hotter over the top of a fire than at the same distance from the sides.
Reason : Air surrounding the fire conducts more heat upwards.
(1) A (2) B (3) C (4) D

Q.3 **Assertion :** Woolen clothes keep the body warm in winter.
Reason : Air is a bad conductor of heat.
(1) A (2) B (3) C (4) D

Q.4 **Assertion :** The equivalent thermal conductivity of two plates of same thickness in contact (series) is less than the smaller value of thermal conductivity.
Reason : For two plates of equal thickness in contact(series) the equivalent thermal conductivity is given by :

$$\frac{1}{K} = \frac{1}{K_1} + \frac{1}{K_2}$$

(1) A (2) B (3) C (4) D

Q.5 **Assertion :** Greater the coefficient of thermal conductivity of a material, smaller is the thermal resistance of a rod of that material.
Reason : Thermal resistance is the ratio of temperature difference between the ends of the conductor and the rate of flow of heat.
(1) A (2) B (3) C (4) D

Q.6 **Assertion :** If temperature of any IBB (Ideal Black Body) is increased by 100% then there will be 400% increase in quantity of radiation emitted from its surface.
Reason : Equation $\frac{\Delta E}{E} = 4\frac{\Delta T}{T}$ also true for large percentage increase ($E = \sigma T^4$)
(1) A (2) B (3) C (4) D

Q.7 **Assertion :** Wein's displacement law fails at short wavelengths.
Reason : Intensity of radiations of very short wavelength is small.
(1) A (2) B (3) C (4) D

Q.8 **Assertion :** In the conduction made of transmission of heat, transfer of heat is due to interatomic collisions, without the atoms leaving their locations.

Reason : Steady state during conduction of heat through a rod means temperature gradient of all parts of the rod is same.
(1) A (2) B (3) C (4) D

Q.9 **Assertion :** In a room containing air, heat can go from one place to another by radiation only.
Reason : In conduction and convection, heat is transferred from one place to other by actual motion of heated material.
(1) A (2) B (3) C (4) D

Q.10 **Assertion :** A hollow metallic closed container maintained at a uniform temperature can act as a source of black body radiation.
Reason : All metals act as black bodies.
(1) A (2) B (3) C (4) D

Q.11 **Assertion :** As the temperature of a block body is raised, wavelength corresponding to which energy emitted is maximum, reduces.
Reason : Higher temperature would mean higher energy and hence higher wavelength.
(1) A (2) B (3) C (4) D

Q.12 **Assertion :** Radiation is the fastest mode of heat transfer.
Reason : The nature of emitted radiations from ideal black body depends only on its temperature.
(1) A (2) B (3) C (4) D

Q.13 **Assertion :** Heat radiation are always obtained in infrared region of electromagnetic wave spectrum.
Reason : Complementary colour are those two colour present in the spectrum which when mixed produce white light.
(1) A (2) B (3) C (4) D

Q.14 **Assertion :** Heat radiations and light have identical properties.
Reason : A cool body does not radiate heat to the hotter surroundings.
(1) A (2) B (3) C (4) D

Q.15 **Assertion :** Coolness is felt in summer when we enter in an air conditioned room.
Reason : At every possible temperature there is a continuous heat energy exchange between a body and its surrounding.
(1) A (2) B (3) C (4) D

Q.16 **Assertion :** IBB (Ideal Black Body) is a good emitter at high temperature.
Reason : Good emitters are good absorbers and vice versa.
(1) A (2) B (3) C (4) D

Q.17 **Assertion :** Absorptive power is a dimensionless quantity and a body having low emissive power should have low absorptive power.
Reason : The ratio of emissive power to absorptive power is same for all bodies at a given temperature and is equal to the emissive power of a blackbody at that temperature.
(1) A (2) B (3) C (4) D

Q.18 **Assertion :** A body with large reflectivity is a poor emitter.
Reason : A body with large reflectivity is a poor absorber of heat.
(1) A (2) B (3) C (4) D

Q.19 **Assertion :** A body that is a good radiator is also a good absorber of radiation at a given wavelength.

Reason : According to Kirchoff's law the absorptivity of a body is equal to its emissivity at a given wavelength.
(1) A (2) B (3) C (4) D

Q.20 **Assertion :** For higher temperature the peak emission wavelength of a black body shifts to lower wavelength.
Reason : Peak emission wavelength of black body is proportional to the fourth power of temperature.
(1) A (2) B (3) C (4) D

Q.21 **Assertion :** Perspiration from human body helps in cooling the body.
Reason : A thin layer of water on the skin enhances its emissivity.
(1) A (2) B (3) C (4) D

Q.22 **Assertion :** Bodies radiate heat at all temperature.
Reason : Rate of radiation of heat is inversely proportional to the fourth power of absolute temperature.
(1) A (2) B (3) C (4) D

Q.23 **Assertion :** Blue star is at high temperature than red star.
Reason : Wien's displacement law states that $T \propto \frac{1}{\lambda_m}$.
(1) A (2) B (3) C (4) D

Q.24 **Assertion :** If the temperature of a star is doubled, then the rate of loss of heat from it becomes 16 times.
Reason : Specific heat varies with temperature.
(1) A (2) B (3) C (4) D

Q.25 **Assertion :** The radiation from sun's surface varies as the fourth power of its absolute temperature.
Reason : The sun is not a black body.
(1) A (2) B (3) C (4) D

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 1 (ANSWERS)

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	3	2	2	1	1	3	3	1	1	2	2	4	4	1	1
Ques.	16	17	18	19	20										
Ans.	4	4	4	3	2										

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 2 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10
Ans.	3	3	1	3	4	1	1	2	2	3

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 3 (ANSWERS)

Q.No.	1	2	3	4	5	6	7
Ans.	2	4	2	3	2	3	2

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 4 (ANSWERS)

Q.No.	1	2	3	4	5	6	7
Ans.	4	2	1	3	4	4	4

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 5 (ANSWERS)

Q.No.	1	2	3	4	5
Ans.	1	1	1	1	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
Ans	1	1	3	3	1	1	3	1	3	1	1	3	2	2	2
Q.No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans	2	1	3	2	4	1	2	1	1	4	2	3	3	3	1
Q.No.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans	2	3	2	2	4	3	1	3	3	4	3	3	1	2	2
Q.No.	46	47	48	49	50	51	52	53	54	55	56	57			
Ans	2	4	2	2	4	3	4	1	2	1	2	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
Ans	2	2	2	4	1	2	3	3	4	3	4	3	3	3	3
Q.No.	16	17	18	19	20	21	22	23	24	25					
Ans	3	1	3	2	3	4	4	3	2	2					

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
Ans	4	1	2	2	3	2	4	3	3	3	1	2	1	1	3
Q.No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans	3	2	2	1	3	1	1	3	1	3	2	1	2	1	4
Q.No.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	
Ans	2	2	1	1	3	1	2	3	3	1	3	1	1	4	

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
Ans	3	4	1	2	3	1	3	2	1	1	2	4	4	1	1
Q.No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans	1	4	3	4	1	2	4	4	4	3	2	4	3	1	4
Q.No.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans	4	1	2	2	2	2	4	2	1	3	2	3	1,2	3	1
Q.No.	46	47	48	49	50	51	52	53							
Ans	1	2	1	4	2	4	4	1							

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 10 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans	1	4	4	3	1	1	1	2	3	1	1	1	1	4	2
Q.No.	16	17	18	19	20	21	22								
Ans	1	1	4	4	4	1	1								

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 11 (ANSWERS)

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	4	3	3	4	3	1	2	2	2	3	1	2	3	1	3	2	4	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	4	1	2	3	3	3	3	1	3	1	3	4	2	2	2	1	2	3	2	3

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.	4	1	2	2	2	4	2	3	4	1	3	4	3	1	4
Q.No.	16	17	18												
Ans.	2	3	3												

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	16	17
Ans.	3	4	1	2	3	2	4	1	3	1	1	4	1	2	3	1	1

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
Ans.	2	3	1	1	2	4	3	1	2	1	1	3	2
Q.No.	14	15	16	17	18	19	20	21	22	23	24	25	26
Ans.	1	3	4	2	4	2	1	1	2	3	2	4	3

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 15 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ans.	4	2	4	4	1	1	4	1	1	2	1	1	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	16	17	18	19	20
Ans.	4	1	2	1	4	1	4	4	1	2	4	3	1	2	2	2	2	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.	4	1	4	1	1	1	2	2	2	1	1	3	2	2	1	3	3	3	1	4
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	1	1	3	3	1	2	1	4	4	1	3	1	3	2	4	1	1	3	4	2
Q.No.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	4	1	1	2	1	2	2	2	2	1	3	2	4	3	4	2	3	4	2	4
Q.No.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	3	3	2	2	1	4	2	1	2	4	3	3	4	4	3	3	1	4	4	3
Q.No.	101	102	103	104																
Ans.	1	4	3	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.	3	4	2	4	3	2	3	3	2	4	3	1	3	2	3

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 18 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	2	3	1	4	2	4	4	2	4	3	3	2	2	3	1
Q.No.	16	17	18	19	20	21	22	23	24	25					
Ans.	1	1	1	3	3	3	4	1	2	3					