SOLVED EXAMPLES

Ex.1 The figure shows two thin rods, one made of aluminum $[\alpha = 23 \times 10^{-6} (C^{\circ})^{-1}]$ and the other of steel $[\alpha = 12 \times 10^{-6} (C^{\circ})^{-1}]$. Each rod has the same length and the same initial temperature. They are attached at one end to two separate immovable walls. Temperature of both the rods is increased by the same amount, until the gap between the rods vanishes. Where do the rods meet when the gap vanishes?



- (A) The rods meet exactly at the midpoint.
- (B) The rods meet to the right of the midpoint.
- (C) The rods meet to the left of the midpoint.
- (D) Information insufficient
- **Sol.** As $\alpha_{Al} > \alpha_{steel}$ so expansion in aluminum rod is greater.
- **Ex.2** In a 20m deep lake, the bottom is at a constant temperature of 4° C. The air temperature is constant at -10° C. The thermal conductivity of ice is 4 times that water. Neglecting the expansion of water on freezing, the maximum thickness of ice will be

(A)
$$\frac{20}{11}$$
 m (B) $\frac{200}{11}$ m (C) 20 m (D) 10 m

Sol. The rate of heat flow is the same through water and ice in the steady state so

$$\frac{10^{\circ}C}{20^{\circ}x} \xrightarrow{X} 4K \text{ ice}}{20^{\circ}x} \xrightarrow{K} \text{ water}} \frac{KA(4-0)}{20-x} = \frac{4KA[0-(-10)]}{x} \Rightarrow x = \frac{200}{11} \text{ m}$$

Ex.3 Certain perfect gas is found to obey $PV^n = constant$ during adiabatic process. The volume expansion coefficient at temperature T is

(A)
$$\frac{1-n}{T}$$
 (B) $\frac{1}{(1-n)T}$ (C) $\frac{n}{T}$ (D) $\frac{1}{nT}$
Sol. $PV^n = \text{constant & } PV = \mu RT \quad V \propto T^{\left(\frac{1}{1-n}\right)} \Rightarrow \frac{\Delta V}{V} = \left(\frac{1}{1-n}\right)\frac{\Delta T}{T}$
 $\Rightarrow \text{ volume expansion coefficient } = \frac{\Delta V}{V\Delta T} = \frac{1}{(1-n)T}$

- **Ex.4** The temperature of a body rises by 44°C when a certain amount of heat is given to it. The same heat when supplied to 22 g of ice at -8° C, raises its temperature by 16°C. The water eqivalent of the body is [Given : $s_{water} = 1 \text{ cal/g}^{\circ}$ C & $L_f = 80 \text{ cal/g}, s_{ice} = 0.5 \text{ cal/g}^{\circ}$ C] (A) 25g (B) 50 g (C) 80 g (D) 100 g
- Sol. Supplied heat = (22)(0.5)(8) + (22)(80) + (22)(1)(16) = 88 + 1760 + 352 = 2200 calHeat capacity of the body = $\frac{2200 cal}{44^{\circ}C} = 50 cal/^{\circ}C$

Water equavalent of the body = $\frac{\text{Heat capacity of the body}}{\text{spcific heat capacity of water}} = \frac{50 \text{ cal/ }^{\circ}\text{C}}{1 \text{ cal/ }^{\circ}\text{C}} = 50 \text{ g}$



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Ex.5 Figures shows the expansion of a 2m long metal rod with temperature. The volume expansion coefficient of the metal is :-



(A)
$$\frac{25}{7}$$
 (B) $\frac{48}{11}$ (C) $\frac{52}{11}$ (D) $\frac{50}{11}$
Sol. $f_{eq} = \frac{f_1 n_1 + f_2 n_2 + f_3 n_3}{n_1 + n_2 + n_3} = \frac{(5n)(3) + (n)(5) + (5n)(6)}{5n + n + 5n} = \frac{50}{11}$



THERMAL PROPERTIES OF MATTER

Ex.10 A vessel contains 14 g (7 moles) of hydrogen and 96 g (3 moles) of oxygen at STP. Chemical reaction is induced by passing electric spark in the vessel till one of the gases is consumed. The temperature is brought back to it's starting value 273 K. The pressure in the vessel is-



(A) 0.1 atm

(B) 0.2 atm

(C) 0.3 atm

Sol. When electric spark is passed, hydrogen reacts with oxygen to form water (H_2O) . Each gram of hydrogen reacts with eight grams of oxygen. Thus 96 g of oxygen will be totally consumed together with 12 g of hydrogen.

The gas left in the vessel will be 2g of hydrogen i.e. number of moles $\mu = \frac{2}{2} = 1$.

Using
$$PV = \mu RT \implies P \propto \mu \frac{P_2}{P_1} = \frac{\mu_2}{\mu_1} \implies \frac{P_2}{1} = \frac{1}{10} \implies P_2 = 0.1 atm$$

Ex.11 Figure shows the adiabatic curve on log-log scale performed on a ideal gas. The gas must be :-



(A) Monoatomic

(B) Diatomic

(C) A mixture of monoatomic and diatomic

(D) A mixture of diatomic and polyatomic

Sol. For adiabatic process $TV^{\gamma-1} = constant$

 $\Rightarrow \log T + (\gamma - 1) \log V = \text{constant} \Rightarrow \text{slope} = -(\gamma - 1) = -\left(\frac{5}{10}\right) \Rightarrow \gamma = \frac{3}{2}$ For monoatomic gas $\gamma = \frac{5}{3}$; For diatomic gas $\gamma = \frac{7}{5}$ As $\frac{7}{5} < \gamma = \frac{3}{2} < \frac{5}{3}$

Hence, the gas must be a mixture of monoatomic & diatomic gas.

Ex.12 Figure demonstrates a polytropic process (i.e. $PV^n = constant$) for an ideal gas. The work done by the gas will be in process AB is





Ex.13	The respective speeds of five molecules are 2,1.5,1.6,1.6 and 1.2 km/s. The most probable speed i km/s will be			
	(A) 2	(B) 1.58	(C) 1.6	(D) 1.31
Sol.	Since maximum number	of molecules travel with s	peed 1.6 km/s so $v_{mn} = 1.6$ k	m/s
Ex.14	Suppose 0.5 mole of an is shows the final volume	ideal gas undergoes an iso V_{f} versus Q. The tempera	othermal expansion as energy at the gas is (use \bullet n 9	y is added to it as heat Q. Graph $D = 2$ and $R = 25/3$ J/mol-K)
	(A) 293 K	(B) 360 K	(C) 386 K	(D) 412 K
Sol.	$Q = W = nRT \bullet n \frac{V_f}{V_i}; T =$	$= \frac{Q}{nRl nV_f / V_i} = \frac{1}{0.5 \times 2}$	$\frac{500}{5 / 3 \times 1n3} = \frac{1500}{0.5 \times 25 / 3}$	$\frac{1}{1} = 360 \text{ K}$
Ex.15	Given T–P curve for thr in process 1, 2 and 3 i	ee processes. If initial an s W ₁ , W ₂ & W ₃ respecti	d final pressure are same fo vely. Correct order is	r all processes then work done



(A)
$$W_1 < W_2 > W_3$$
 (B) $W_1 > W_2 > W_3$

Sol. Here $T \propto P^n$ where for : graph-1, $n > 1 \Rightarrow W > 0$; graph-2, $n = 1 \Rightarrow W = 0$; graph-3, $n < 1 \Rightarrow W < 0$

Ex.16 When water is boiled at 2 atm pressure, the latent heat of vaporization is 2.2×10^6 J/kg and the boiling point is 120°C. At 2 atm pressure, 1 kg of water has volume of 10^{-3} m³ and 1 kg of steam has a volume of 0.824 m³. The increase in internal energy of 1 kg of water when it is converted into steam at 2 atm pressure and 120°C is [1 atm pressure = 1.013×10^5 N/m²]

(A) 2.033 J (B) 2.033×10^6 J (C) 0.167×10^6 J (D) 2.267×10^6 J Sol. Total heat given to correct convert water into steam at 120 °C is Q = mL = $1 \times 2.2 \times 10^6$ = 2.2×10^6 J The work done by the system against the surrounding is $P\Delta V = 2 \times 1.013 \times 10^5 (0.824 \times 0.001) = 0.167 \times 10^6$ J $\therefore \Delta U = O - W = 2.033 \times 10^6$ J

- **Ex.17** The acceleration of a particle moving rectilinearly varies with displacement as a = -4x. At x = 4 m and t = 0, particle is at rest. Select the **incorrect** alternative
 - (A) The maximum speed of the particle is 8 m/s.
 - (B) The distance travelled by the particle in first second is 20 m.
 - (C) The velocity acceleration graph of the particle is an ellipse.
 - (D) The kinetic energy-displacement graph of the particle is a parabola.

Sol. The equation shows a SHM : $a = -\omega^2 x \Rightarrow \omega = \sqrt{4} = 2 \Rightarrow$ Time period $= \frac{2\pi}{\omega} = \pi \sec \therefore x = A\sin(\omega t + \phi)$

From the given condition, A = 4 & $\phi = \frac{\pi}{2}$; V_{Pmax} = A ω = 8 m / s

Distance travelled in first second < 2A or < 8 m

 $KE = \frac{1}{2}m\omega^2 (A^2 - x^2)$ which represent a parabola.



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Ex.18 One mole of an ideal gas undergoes a process whose molar heat capacity is 4R and in which work done by gas for small change in temperature is given by the relation dW = 2RdT, then the ratio $\frac{C_P}{C}$ is

(A) 7/5 (B) 5/3 (C) 3/2 (D) 2

Sol. For small change dQ = dU + dW

 $\mathbf{nCdT} = \mathbf{nC}_{\mathbf{v}}\mathbf{dT} + 2\mathbf{nR}\mathbf{dT} :: \mathbf{C} = \mathbf{C}_{\mathbf{v}} + 2\mathbf{R}; 4\mathbf{R} = \mathbf{C}_{\mathbf{v}} + 2\mathbf{R} :: \mathbf{C}_{\mathbf{v}} = 2\mathbf{R}$

Also
$$C_v = \frac{R}{\gamma - 1}$$
 \therefore $\frac{R}{\gamma - 1} = 2R \Rightarrow 2\gamma - 2 = 1 \Rightarrow \gamma = \frac{3}{2}$

Ex.19 Figure shows the variation of the internal energy U with density ρ of one mole of an ideal monatomic gas for thermodynamic cycle ABCA. Here process AB is a part of rectangular hyperbola :-



(A) process AB is isothermal & net work in cycle is done by gas.

(B) process AB is isobaric & net work in cycle is done by gas.

(C) process AB is isobaric & net work in cycle is done on the gas.

(D) process AB is adiabatic & net work in cycle is done by gas.

Sol. For the process AB : $U\rho = constant$ (hyperbola)

U = $\frac{3}{2}$ RT (monoatomic ideal gas); $\frac{3}{2}\rho$ RT = constant

Comparing it with ideal gas equation $P = \left(\frac{1}{M}\right)\rho RT \Rightarrow P$ is constant.

P-V graph for the cycle is $P \xrightarrow{P} C$. Thus work done in cycle is positive X.

Ex.20 A gas undergoes an adiabatic process in which pressure becomes $\left(\frac{8}{3\sqrt{3}}\right)$ times and volume become $\frac{3}{4}$ of initial volume. If initial absolute temperature was T, the final temperature is

(A)
$$\frac{32 \text{ T}}{9\sqrt{3}}$$
 (B) $\frac{2 \text{ T}}{\sqrt{3}}$ (C) $\text{T}^{3/2}$ (D) $\frac{\sqrt{3} \text{ T}}{2}$
For adiabatic process, $P_1 V_1^{\gamma} = P_2 V_2^{\gamma} \Rightarrow P_0 V_0^{\gamma} = \left(\frac{8}{3\sqrt{3}}P_0\right) \left(\frac{3}{4}V_0\right)^{\gamma}$ (i)
Also, $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1} \Rightarrow TV_0^{\gamma-1} = T_2 \left(\frac{3}{4}V_0\right)^{\gamma-1}$...(ii) Solving (i) & (ii), $T_2 = \frac{2 \text{ T}}{\sqrt{3}}$

Sol.

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Ex.21 An irregular rod of same uniform material as shown in figure is conducting heat at a steady rate. The temperature gradient at various sections versus area of cross section graph will be



Now, we can see that θ can be decreased by increasing thermal conductivity of outer layer (K_0) and thickness of inner layer (\bullet_i).

Ex.23 Which of the following graph(S) shows the correct variation in intensity of heat radiations by black body and frequency at a fixed temperature–





Sol. According to Wien's law $\lambda_m \propto \frac{1}{T} \Rightarrow v_m \propto T$. As the temperature of body increases, frequency corresponding to maximum energy in radiation (v_m) increases.

Also area under the curve $\int E_{\lambda} d\lambda \propto \int E_{\nu} d\nu \propto T^4$

Ex.24 Water contained in a jar at room temperature (20°C) is intended to be cooled by method-I or method-II given below: Method -I : By placing ice cubes and allowing it to float.

Method-II: By wrapping ice cubes in a wire mesh and allowing it to sink.

Choose best method(S) to cool the water.

(A) Method-I from 20°C to 4°C

(B) Method-I from 4°C to 0°C(D) Method-II from 4°C to 0°C

- (C) Method-II from 20°C to 4°C
- **Sol.** Initially (above 4°C), a decrease in temperature, increases the density of water and consequently it descends, replacing the relatively warm water. Convention currents set up in this way demands the location of ice to be on the water surface.

Below 4°C, a decrease in temperature decreases the water density and as a result it ascends up displacing the relatively warm water. To setup convention currents in this way, the position of ice cubes should be at the bottom.

Ex.25 5 kg of steam at 100°C is mixed with 10 kg of ice at 0°C. Choose correct alternative/s

(Given $s_{water} = 1 \text{ cal/g}^{\circ}\text{C}$, $L_F = 80 \text{ cal/g}$, $L_V = 540 \text{ cal/g}$)

- (A) Equilibrium temperature of mixture is 160°C
- (B) Equilibrium temperature of mixture is 100°C
- (C) At equilibrium, mixture contains $13\frac{1}{3}$ kg of water
- **(D)** At equilibrium, mixture contains $1\frac{2}{3}$ kg of steam
- Sol. Required heat Available heat
 - 10 kg ice (0°C) 5 kg steam (100°C)

800 kcal 2700 cal

10 g water (0°C) 5 g water (100°C)

1000 kcal

10 g water (100°C)

So available heat is more than required heat therefore final temperature will be 100°C.

Mass of heat condensed $=\frac{800+1000}{540} = \frac{10}{3}$ kg. Total mass of water $= 10 + \frac{10}{3} = \frac{40}{3} = 13\frac{1}{3}$ kg

Total mass of steam = $5 - \frac{10}{3} = \frac{5}{3} = 1\frac{2}{3}$ kg



- n moles of an ideal triatomic linear gas undergoes a process in which the temperature changes with volume as **Ex.26** $T = k_1 V^2$ where k_1 is a constant. Choose correct alternative(S). (A) At normal temperature $C_v = \frac{5}{2}R$ (B) At any temperature $C_p - C_v = R$ (C) At normal temperature molar heat capacity C = 3R(D) At any temperature molar heat capacity C=3RAt normal temperature $C_v = \frac{f}{2}R = \frac{5}{2}R$; At any temperature $C_v = C_v = \left(\frac{f}{2}+1\right) - \frac{f}{2}R = R$ Sol. from process T = $k_1 V^2$ & ideal gas equation PV = nRT we have $PV^{-1} = constant \Rightarrow x = -1$ \Rightarrow C = C_v + $\frac{R}{1-x}$ = C_v + $\frac{R}{1+1}$ = C_v + $\frac{R}{2}$ At normal temperature C = $\frac{5}{2}R + \frac{R}{2} = 3R$ **Ex.27** Which of the following processes must violate the first law of thermodynamics (Q = W + ΔE_{int})? (A) W > 0, Q < 0 and $\Delta E_{...} > 0$ **(B)** W > 0, Q < 0 and $\Delta E_{int} < 0$ (C) W < 0, Q > 0 and $\Delta E_{int} < 0$ (D) W > 0, Q > 0 and $\Delta E_{int} < 0$ For (A): $W > 0 \& \Delta E_{int} > 0 \Rightarrow Q > 0$ For (B): $W > 0 \& \Delta E_{int} < 0 \Rightarrow Q > 0$ or Q < 0Sol. For (C): $W < 0 \& \Delta E_{uv} < 0 \Rightarrow Q < 0$ For (D): $W > 0 \& \Delta E_{uv} < 0 \Rightarrow Q > 0$ or Q < 0An ideal gas expands in such a way that PV^2 = constant throughout the process. Select correct alternative **Ex.28** (A) This expansion is not possible without heating (B) This expansion is not possible without cooling (C) Internal energy remains constant in this expansion (D) Internal energy increases in this expansion $PV = nRT \& PV^2 = constant \Rightarrow V \propto \frac{1}{T} \Rightarrow gas can expand only if it cools$ Sol. As tempeature decreases during expansion so internal energy will decrease. In Newton's law of cooling, $\frac{d\theta}{dt} = -k(\theta - \theta_0)$, the constant k is proportional to **Ex.29** (A) A, surface area of the body (B) S, specific heat of the body (C) $\frac{1}{m}$, m being mass of the body (D) e, emissivity of the body $\frac{\mathrm{d}Q}{\mathrm{d}t} = \mathrm{e}\sigma A \left(\theta^4 - \theta_0^4\right) \approx \left(3\,\mathrm{e}\sigma A \theta_0^3\right) \Delta \theta$ Sol. $\frac{\mathrm{dQ}}{\mathrm{ls}} = \mathrm{e}\sigma \mathrm{A}\left(\theta^4 - \theta_0^4\right) \approx \left(3\,\mathrm{e}\sigma\mathrm{A}\theta_0^3\right)\Delta\theta$ In a process on a closed system of ideal gas, the initial pressure and volume is equal to the final pressure **Ex.30** and volume (A) initial internal energy must be equal to the final internal energy (B) the work done on the system is zero (C) the work done by the system is zero
 - (D) the initial temperature must be equal to final temperature Here n = constant so if $P_2 = P_1$ and $V_2 = V_1$ then $T_2 = T_1$

Also work done by the system may be zero or may not be zero.



Sol.

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(**D**) $\frac{9}{8}V_0$

Ex.31 The graph below shows V-P curve for three processes. Choose the correct statement(s) (A) Work done is maximum in process 1. (B) Temperature must increase in process 2 & 3. (C) Heat must be supplied in process 1. (D) If final volume of gas in process 1, 2 and 3 are same then temperature must be same. Sol. Area under P-V curve and volume axis represent work. Internal energy in 1 increases (expansion at constant pressure) In process 2 and 3 internal energy may decrease depending on the process. Since final pressure of 1, 2 & 3 are different, final temperature must also be different. During an experiment, an ideal gas is found to obey a condition $\frac{P^2}{\rho} = \text{constant} [\rho = \text{density of the gas}]$. The Ex.32 gas is initially at temperature T, pressure P and density ρ . The gas expands such that density changes to $\frac{\rho}{2}$ (A) The pressure of the gas changes to $\sqrt{2P}$ (B) The temperature of the gas changes to $\sqrt{2T}$. (C) The graph of the above process on the P-T diagram is parabola. (D) The graph of the above process on the P-T diagram is hyperbola. PV = nRTSol. $P \propto \rho T \dots (i)$ $T \propto \frac{1}{\sqrt{\rho}} \dots (ii)$ $T \propto \frac{1}{\sqrt{\rho}} \dots (iii)$ Ex.33 to 35 One mole of a monoatomic ideal gas occupies two chambers of a cylinder partitioned by means of a movable piston.

One mole of a monoatomic ideal gas occupies two chambers of a cylinder partitioned by means of a movable piston. The walls of the cylinder as well as the piston are thermal insulators. Initially equal amounts of gas fill both the chambers at (P_0, V_0, T_0) . A coil is burnt in the left chamber which absorbs heat and expands, pushing the piston to the right. The gas on the right chamber is compressed until to pressure becomes 32 P₀.

P ₀ ,V ₀ ,T ₀	P_0, V_0, T_0
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33. The final volume of left chamber is

(A)
$$\frac{V_0}{8}$$
 (B) $\frac{15}{8}V_0$ (C) $\frac{7}{8}V_0$

34. The work done on the gas in the right chamber is

(A)
$$\frac{9}{2}P_0V_0$$
 (B) $-\frac{9}{2}P_0V_0$ (C) $\frac{13}{2}P_0V_0$ (D) $\frac{17}{2}P_0V_0$

- 35. The change in internal energy of the gas in the left chamber is
 - (A) $\frac{186}{4}$ RT₀ (B) $\frac{177}{4}$ RT₀ (C) $\frac{59}{2}$ RT₀ (D) $\frac{131}{4}$ RT₀



Sol.

33. Since the compression on the right is adiabatic so $P_0 V_0^{\gamma} = P_R V_R^{\gamma}$

$$\Rightarrow P_0 V_0^{5/3} = 32 P_0 V_R^{5/3} \Rightarrow V_R = \frac{V_0}{8} \Rightarrow V_L = V_0 + \frac{7}{8} V_0 = \frac{15}{8} V_0$$

34. Work done on the gas =
$$\frac{P_R V_R - P_0 V_0}{\gamma - 1} = \frac{4P_0 V_0 - P_0 V_0}{5 / 3 - 1} = \frac{9}{2} P_0 V_0$$

35. For mechanical equilibrium $P_L = P_R = 32 P_0$

So
$$P_L V_L = (32P_0) \left(\frac{15V_0}{8}\right) = 60P_0 V_0 = 60nRT_0 = nRT_L \implies T_L = 60T_0$$

The change in the internal energy of the gas in the left chamber

$$\Delta U = nC_{V}\Delta T = \frac{1}{2} \times \frac{3}{2}R \times 59T_{0} = \frac{177}{4}RT_{0}$$

Ex.36 to 38

At 20°C a liquid is filled upto 10 cm height in a container of glass of length 20 cm and cross-sectional area 100 cm² Scale is marked on the surface of container. This scale gives correct reading at 20°C. Given $\gamma_L = 5 \times 10^{-5} \text{ k}^{-1}$, $\alpha_{\sigma} = 1 \times 10^{-5} \text{ °C}^{-1}$



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Ex.39 to 41

One mole of an ideal monoatomic gas undergoes a cyclic process as shown in figure. Temperature at point 1 = 300 K and process 2-3 is isothermal.

 $(B)\frac{3R}{2}$

(D)2R



39. Net work done by gas in complete cycle is

(A)
$$(91n3+12)P_0V_0$$

(B) $(91n3+4)P_0V_0$
(C) $(91n3-4)P_0V_0$
(D) $(91n3-8)P_0V_0$

40. Heat capacity of process $1 \rightarrow 2$ is

(A)
$$\frac{R}{2}$$

(C) $\frac{5R}{2}$

41. The efficiency of cycle is

(A)
$$\left(\frac{91n3+4}{91n3+12}\right)$$
 (B) $\left(\frac{91n3-4}{91n3+12}\right)$ (C) $\left(\frac{91n3-4}{91n3+16}\right)$ (D) $\left(\frac{91n3+12}{91n3+16}\right)$

Sol.

39.
$$W = W_{12} + W_{23} + W_{31} = \frac{1}{2} (4P_0) (2V_0) + nRT \ln (3) - P_0 (8V_0) = -4P_0 V_0 + 9P_0 V_0 \ln 3 = (9\ln 3 - 4)P_0 V_0$$

40.
$$C = \frac{\Delta Q}{n\Delta T} = \frac{n\left(\frac{3R}{2}.\Delta T\right) + \Delta W}{n\Delta T} = \frac{3R}{2} + \frac{4P_0V_0}{n\Delta T} = \frac{3R}{2} + \frac{P_0V_0}{n\left(2T_0\right)} = \frac{3R}{2} + \frac{R}{2} = 2R$$

$$\Delta Q_{123} = n(2R)(\Delta T_{12}) + (W_{23}) = n(2R)(8T_0) + nR(9T_0)ln(3) = nRT_0(16 + 9ln3)$$

41.
$$\eta = \frac{W}{\Delta Q_{123}} = \left(\frac{91n3 - 4}{91n3 + 16}\right)$$

Ex.42 to 44

A body cools in a surrounding of constant temperature 30°C. Its heat capacity is 2J/°C. Initial temperature of the body is 40°C. Assume Newton's law of cooling is valid. The body cools to 36°C in 10 minutes.

42. In further 10 minutes it will cool from 36°C to :

(A) 34.8° C (B) 32.1° C (C) 32.8° C (D) 33.4°	(A) 34.8°C	°C (B) 32.1°C	(C) 32.8°C	(D) 33.6 ⁴
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43. The temperature of the body in °C denoted by θ the variation of θ versus time t is best denoted as



44. When the body temperature has reached 36°C, it is heated again so that it reaches to 40°C in 10 minutes. Assume that the rate of loss of heat at 38°C is the average rate of loss for the given time. The total heat required from a heater by the body is :

42.
$$\frac{40-36}{10} = k(38-30) \text{ and } \frac{36-x}{10} = k\left(\frac{36+x}{2}-30\right)x = 33.6$$

- 43. $\frac{d\theta}{dt} = -\frac{kA}{ms} (T T_0)$ Magnitude of slope will decrease with time.
- 44. $\Rightarrow \frac{40-36}{10} = k (38-30) \Rightarrow k = \frac{4}{10 \times 8} = \frac{1}{20}$

when the block is at 38°C and room temperature is at 30°C the rate of heat loss ms $\times \frac{d\theta}{dt} = ms k (38-30)$ Total heat loss in 10 minute $\Rightarrow \Delta Q = ms k (38-30) \times 10 = 2 \times \frac{1}{20} \times 8 \times 10 = 8 J$ Now heat agained by the object in the said 10 minutes. $Q = ms \Delta \theta = 2 \times 4 = 8 J$ Total heat required = 8 + 8 = 16 J

Ex.45 An ideal gas whose adiabatic exponent equals to $\gamma = \frac{7}{5}$ is expanded according to the law P=2V. The initial volume

of the gas is equal to $V_0 = 1$ unit. As a result of expansion the volume increases 4 times. (Take $R = \frac{25}{3}$ units)

	Column - I		Column - II
(A)	Work done by the gas	(P)	25 units
(B)	Increment in internal energy of the gas	(Q)	45 units
(C)	Heat supplied to the gas	(R)	75 units
(D)	Molar heat capacity of the gas in the process	(S)	15 units
		(T)	55 units

Sol. Ans. $(A) \rightarrow (S); (B) \rightarrow (R); (C) \rightarrow (Q); (D) \rightarrow (P)$



W =
$$\int P dV = \int_{V_0}^{4V_0} 2V dV = (V^2)_{V_0}^{4V_0} = 15V_0^2 = 15$$
 units

From PV = nRT, $2V^2 = nRT \implies 2(V_2^2 - V_1^2) = nR(\Delta T) \implies nR\Delta T = 30V_0^2$

$$\Delta U = nC_{v}\Delta T = \frac{nR}{\gamma - 1}\Delta T = \frac{30V_{0}^{2}}{\gamma - 1} = \frac{30(1)^{2}}{\frac{7}{5} - 1} = \frac{30}{2}(5) = 75 \text{ units}$$

 $Q = W + \Delta U = 15 + 30 = 45$ units

Molar heat capacity : C = C_v +
$$\frac{R}{1-x} = \frac{5}{2}R + \frac{R}{1-(-1)} = \frac{5}{2}R + \frac{R}{2} = 3R = 3 \times \frac{25}{3} = 25$$
 units

Ex.46		Column I (Questions)		Column II (Answers)
	(A)	The temperature of an iron piece is increased from 20° to 70°.	(P)	20
		What is change in its temperature on the Fahrenheit scale (in °F)?		
	(B)	At what temperature (in °C) do the Celsius and Fahrenheit reading	gs (Q)	40
		have the same numerical value?		
	(C)	100 g ice at 0°C is converted into steam at 100 °C.	(R)	-40
		Find total heat required (in kcal)		
		$(L_{f} = 80 \text{ cal/g}, s_{w} = 1 \text{ cal/g}^{\circ}C, L_{v} = 540 \text{ cal/g})$		
	(D)	A ball is dropped on a floor from a height of 5 m.	(S)	72
		After the collision it rises upto a height of 3m. Assume that		
		50% of the mechanical energy lost goes as thermal energy	(T)	90
		of the ball in the collision. $(s_{ball} = 500 \text{ J/K}, g = 10 \text{ m/s}^2)$		
Sol.	Ans.(A)	(S); (B) (R); (C) (T); (D) (P)		

(A)
$$\frac{C-0}{100} = \frac{F-32}{180} \Rightarrow \Delta F = \frac{9}{5}\Delta C = \frac{9}{5} \times 50 = 90^{\circ}F$$

(B)
$$\frac{x-0}{100} = \frac{x-32}{180} x = -40$$

(C) Total heat required = $mL_f + ms\Delta\theta + mL_v = 72000$ cal = 72 kcal

(D)
$$\operatorname{ms}\Delta\theta = \frac{50}{100} \times \operatorname{mg}(h_1 - h_2) \Longrightarrow \Delta\theta = \frac{1}{50} \,^{\circ}\mathrm{C} = 20 \times 10^{-3} \,^{\circ}\mathrm{C}$$

Ex.47 In an industrial process 10 kg of water per hour is to be heated from 20°C to 80°C. To do this steam at 150°C is passed from a boiler into a copper coil immersed in water. The steam condenses in the coil and is returned to the boiler as water at 90°C. How many kg of steam is required per hour.

(Specific heat of steam = specific heat of water = 1 cal/g°C, Latent heat of vaporisation = 540 cal/g)



Sol.	Suppose m kg steam is required per hour		
	Heat is released by steam in following three steps		
	(i) When 150°C steam $\xrightarrow{Q_1}$ 100°C steam	$Q_1 = mc_{steam} \Delta \theta = m \times 1 (150-100) = 50 m cal$	
	(ii) When 100°C steam $\xrightarrow{Q_2}$ 100°C water	$Q_2 = mL_v = m \times 540 = 540 m cal$	
	(iii) When 100 °C water $\xrightarrow{Q_2}$ 90°C water	$Q_3 = mc_w \Delta \theta = m \times 1 \times (100 - 90) = 10 m cal$	
	Hence total heat given by the steam	$Q = Q_1 + Q_2 + Q_3 = 600 \text{ m cal}$ (i)	
	Heat taken by 10 kg water	$Q' = mc_w \Delta \theta = 10 \times 10^3 \times 1 \times (80 - 20) = 600 \times 10^3 \text{ cal}$	
	Hence $Q = Q' \Rightarrow 600 \text{ m} = 600 \times 10^3 \Rightarrow \text{m} = 10^3 \text{ gm}$	= 1 kg	

Ex.48 The figure given below show different process for a given amount for an ideal gas. W is work done by the system and ΔQ is heat absorbed by the system.



Ex.50 The specific heat of a metal at low temperatures varies according to $S = (4/5)T^3$ where T is the absolute temperature. Find the heat energy needed to raise unit mass of the metal from T = 1 K to T = 2 K.

Sol.
$$Q = \int mSdT = \frac{mT^4}{5} \implies \frac{Q}{m} = \frac{15}{5} = 3$$



Sol.

Sol.

Ex.51 Two different rods A and B are kept as shown in figure.



The variation of temperature of different cross sections is plotted in a graph shown in figure. Find the ratio of thermal conductivities of B to A.

Sol.
$$\Rightarrow \left(\frac{\Delta Q}{\Delta t}\right)_{A} = \left(\frac{\Delta Q}{\Delta t}\right)_{B} \therefore \frac{K_{A}A(100-70)}{30} = \frac{K_{B}A(70-35)}{70} \Rightarrow K_{A} = \frac{K_{B}}{2} \Rightarrow \frac{K_{B}}{K_{A}} = 2$$

Ex.52 A clock pendulum made of invar has a period of 2 s at 20°C. If the clock is used in a climate where average temperature is 40°C, what correction (in seconds) may be necessary at the end of 10 days to the time given by clock ? $(\alpha_{invar} = 7 \times 10^{-7} \,^{\circ}\text{C}^{-1}, 1 \,^{\circ}\text{day} = 8.64 \times 10^4 \,^{\circ}\text{s})$

Sol.
$$T = 2\pi \sqrt{\frac{1}{g}} \implies \frac{\Delta T}{T} = \frac{1}{2} \frac{\Delta I}{1} = \frac{1}{2} \alpha \Delta \theta \implies \Delta T = \frac{T}{2} (\alpha \Delta \theta) = \left(\frac{10 \times 8.64 \times 10^4}{2}\right) (7 \times 10^{-7}) (20) = 6 \text{ s}$$

Ex.53 A cylinder of cross-section area A has two pistons of negligible mass separated by distances \bullet loaded with spring of negligible mass. An ideal gas at temperature T_1 is in the cylinder where the springs are relaxed. When the gas is heated by some means its temperature becomes T_2 and the springs get compressed by



 $\frac{1}{2}$ each. If P₀ is atmospheric pressure and spring constant $k = \frac{2P_0A}{l}$, then find the ratio of T₂ and T₁.

Sol.
$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$
 where $V_1 = \Phi A$ and $V_2 = 2\Phi A$ and $P_1 = P_0$ and $P_2 = \frac{kx}{A} + P_0 = 2P_0 \implies \frac{T_2}{T_1} = \frac{P_2V_2}{P_1V_1} = 4$

Ex.54 A body cools from 50°C to 49.9°C in 5 sec. It cools from 40°C to 39.9°C in t sec. Assuming Newtons law of cooling to be valid and temperature of surrounds at 30°C, value of t/5 will be?

Sol. From
$$\frac{\theta_1 - \theta_2}{t} = k \left(\frac{\theta_1 + \theta_2}{2} - \theta_0 \right)$$

We have
$$\frac{0.1}{5} = k \left(\frac{39.5}{2}\right)$$
 and $\frac{0.1}{t} = k \left(\frac{19.5}{2}\right) \implies \frac{t}{5} = \frac{39.5}{19.5} = 2 \implies t = 10 \implies \frac{t}{5} = 2$

Ex.55 One mole of a gas is taken from state A to state B as shown in figure.

Work done by the gas is $\alpha \times 10^{\beta}$ J. Find the value of $\alpha + \beta$.

(Given:
$$T_1 = 320 \text{ K}, \text{ R} = \frac{25}{3}$$
)





Sol. Work done = $\frac{1}{2} [P_0 + 2P_0] [2V_0 - V_0] = \frac{3}{2} P_0 V_0$

and
$$P_0 V_0 = R \times 320$$

So work done
$$\frac{3}{2} \times R \times 320 = \frac{3}{2} \times \frac{25}{3} \times 320 = 4000 \text{ J} = 4 \times 10^3 \text{ J} \implies \alpha + \beta = 4 + 3 = 7$$

- Ex.56 A vessel contains 1 mole of O₂ gas (molar mass 32) at a temperature T. The pressure of the gas is P. An identical vessel containing one mole of He gas (molar mass 4) at a temperature 2T has a pressure of xP. Find the value of x.
 Sol. PV = nRT, V is constant
- **Ex.57** The relation between internal energy U, pressure P and volume V of a gas in an adiabatic process is: U=a+bPV where a = b = 3. Calculate the greatest integer of the ratio of specific heats [γ].
- **Sol.** For an adiabatic process, dQ=dU+PdV=0

$$\Rightarrow d[a+bPV] + PdV=0 \Rightarrow bPdV + bV dP + PdV = 0 \Rightarrow (b+1)PdV + bV dP=0 \Rightarrow (b+1)\frac{dV}{V} + b\frac{dP}{P} = 0$$

$$\Rightarrow$$
 (b+1)logV + b logP= constant; V^{b+1}P^b=constant \Rightarrow $PV^{\frac{b+1}{b}} = constant$ $\therefore \gamma = \frac{b+1}{b} = \frac{4}{2} = 1.33$

Ex.58 A container having base area A_0 . Contains mercury upto a height \bullet_0 . At its bottom a thin tube of length $4\bullet_0$ and cross-section area $A(A \le A_0)$ having lower end closed is attached. Initially the length of mercury in tube is $3\bullet_0$. In remaining part 2 mole of a gas at temperature T is closed as shown in figure. Determine the work done (in joule) by gas if all mercury is displaced from tube by heating slowly the gas in the rear end of the tube by means of a heater. (Given : density of mercury = ρ , atmospheric pressure $P_0 = 2\bullet_0\rho g$, C_v of gas = 3/2 R, $A = (3/\rho)m^2$, $\bullet_0 =$ (1/9) m, all units in S.I.)



$$P' = P_0 + \rho g \bullet_0 + \rho g x = 3\rho g \bullet_0 + \rho g x \Longrightarrow W = -\int_{3I_0}^0 (3\rho g I_0 + \rho g x) A dx = 13.5 \rho g A I_0^2 = 5$$

Ex.59 One mole of a monoatomic gas is enclosed in a cylinder and occupies a volume of 4 liter at a pressure 100 N/m^2 . It is subjected to a process $T = \alpha V^2$, where α is a positive constant, V is volume of the gas and T is Kelvin temperature. Find the work-done by gas (in joule) in increasing the volume of gas to six times initial volume.

Sol.
$$W = \int P dV$$
 where $P = \frac{nRT}{V} = \alpha nRV \Rightarrow W = n\alpha R \int_{V_0}^{6V_0} V dV = \frac{n\alpha R}{2} \left[\left(6V_0 \right)^2 - \left(V_0 \right)^2 \right]$

$$\Rightarrow W = \frac{h\alpha R}{2}(35) V_0^2 = \frac{P_0 V_0 \times 35}{2} \left(Q \alpha = \frac{P_0}{nRV_0} \right)$$





- **Ex.60** One mole of an ideal monatomic gas undergoes the process $P = \alpha T^{1/2}$, where α is constant. If molar heat capacity of the gas is βR when R = gas constant then find the value of β .
- Sol. $P \propto T^{1/2}$ and $PV = nRT \Rightarrow PV^{-1} = constant$ $\therefore C = C_v + \frac{R}{1 (-1)} = \frac{3R}{2} + \frac{R}{2} = 2R$
- Ex. 61 Two identical metal plates are welded end to end as shown in figure-(i). 20 cal of heat flows through it in 4 minutes. if the plates are welded as shown in figure-(ii), find the time (in minutes) taken by the same amount of heat to flow through the plates.



- **Sol.** Rate of heat flow $\frac{\Delta Q}{\Delta t} = \frac{kA(T_1 T_2)}{l} \Rightarrow \Delta t \propto \frac{1}{A}$
- **Ex. 62** Two taps A and B supply water at temperatures 10° and 50° C respectively. Tap A alone fills the tank in 1 hour and tap B alone fills the tank in 3 hour. If we open both the taps together in the empty tank, if the final temperature of the water in the completely filled tank is found to be 5α (in °C). Find the value of α . Neglect loss of heat to surrounding and heat capacity of the tank.

Sol.
$$m(T-10) = \frac{m}{3}S(50 - T) \Rightarrow T = 20^{\circ}$$



Ex	xercise # 1		[Single Correct Choice	Type Questions]
1.	A centigrade and a Fahre Fahrenheit thermometer	nheit thermometer are registers 140°F What	dipped in boiling water. The wa is the temperature as registered	ter temperature is lowered until the by the centigrade thermometer :-
	(A) 30°	(B) 40°	(C) 60°	(D) 80°
2.	On an X temperature sc freezes at -70.0° Y and 50.0°Y on Y-scale is :-	ale, water freezes at – boils at –30.0° Y. T	125.0° X and boils at 375.0° X he value of temperature on X-	X. On a Y temperature scale, water -scale equal to the temperature of
	(A) 455.0°X	(B) -125.0°X	(C) 1375.0°X	(D) 1500.0°X
3.	The graph AB shown in	figure is a plot of temp	erature of a body in degree	t
	Celsius and degree Fahr	enheit. Then :		100°C
	(A) Slope of line AB is 9/	5		lade
	(B) Slope of line AB is 5/	'9		Eabrenheit
	(C) Slope of line AB is 1/	'9		32°F 212°F
	(D) slope of line AB is 3/	9		Aľ
4.	A faulty thermometer rea	nds freezing point and b	oiling point of water as –5°C a	nd 95°C respectively.
	What is the correct value	e of temperature as it re	ads 60°C on faulty thermomete	r?
	(A) 60°C	(B) 65°C	(C) 64°C	(D) 62°C
5.	Two absolute scales X and between T_x and T_y ?	nd Y assigned numerical	l values 200 and 450 to the triple	e point of water. What is the relation
	(A) $9T_{X} = 4T_{Y}$	$(\mathbf{B}) \mathbf{4T}_{\mathrm{X}} = \mathbf{9T}_{\mathrm{Y}}$	(C) $T_x = 3T_y$	(D) None of these
6.	At 4°C, 0.98 of the volum	ne of a body is immerse	d in water. The temperature at v	which the entire body gets immersed
	in water is (neglect the e	xpansion of the body)	$(\gamma_w = 3.3 \times 10^{-4} K^{-1}) :-$	
	(A) 40.8°C	(B) 64.6°C	(C) 60.6°C	(D) 58.8°C
7.	A meter washer has a hol Then d ₁ will :–	le of diameter d ₁ and ex	ternal diameter d_2 , where $d_2=3d$	l_1 . On heating, d_2 increases by 0.3%.
	(A) decrease by 0.1%	(B) decrease by 0.3%	% (C) increase by 0.1%	(D) increase by 0.3%.
8.	A steel scale is to be prep temperature variation due	ared such that the millir ring the ruling of the mil	neter intervals are to be accurate limeter marks is (α =12×10 ⁻⁶ C ⁻¹	e within 6×10^{-5} mm. The maximum):
	(A) 4.0°C	(B) 4.5°C	(C) 5.0°C	(D) 5.5°C.
9.	Two metal rods of the st materials of the rods has are cooled the junction	ame length and area of ve Young moduli Y_1 ar between the rods doe	C cross-section are fixed ends t and Y_2 , and coefficients of linear s not shift if:-	to end between rigid supports. The ar expansion α_1 and α_2 . When rods
	$(\mathbf{A}) \mathbf{Y}_1 \boldsymbol{\alpha}_1 = \mathbf{Y}_2 \boldsymbol{\alpha}_2$	$\textbf{(B)} \mathbf{Y}_1 \boldsymbol{\alpha}_2 = \mathbf{Y}_2 \boldsymbol{\alpha}_1$	(C) $Y_1 \alpha_1^2 = Y_2 \alpha_2^2$	(D) $Y_1^2 \alpha_1 = Y_2^2 \alpha_2$



10.A brass disc fits simply in a hole of a steel plate. The disc from the hole can be loosened if the system $(\alpha_{brass} > \alpha_{steel})$ (A) First heated then cooled(B) First cooled then heated(C) Is heated(D) Is cooled

11. In a vertical U-tube containing a liquid, the two arms are maintained at different temperatures, t_1 and t_2 . The liquid columns in the two arms have heights \bullet_1 and \bullet_2 respectively. The coefficient of volume expansion of the liquid is equal to:-

(A) $\frac{l_1 - l_2}{l_2 t_1 - l_1 t_2}$ (B) $\frac{l_1 - l_2}{l_1 t_1 - l_2 t_2}$ (C) $\frac{l_1 + l_2}{l_2 t_1 + l_1 t_2}$

12. A steel rod of length 1 m is heated from 25°C to 75°C keeping its length constant. The longitudinal strain developed in the rod is:- (Given : Coefficient of linear expansion of steel = $12 \times 10^{-6/\circ}$ C) (A) 6×10^{-6} (B) -6×10^{-5} (C) -6×10^{-4} (D) zero

13. A steel tape is placed around the earth at the equator when the temperature is 10°C. What will be the clearance between the tape and the ground (assumed to be uniform) if the temperature of the tape rises to 40°C? Neglect expansion of the earth. Radius of earth at equator is 6400 km & $\alpha_{steel} = 1.2 \times 10^{-5} \text{ K}^{-1}$ (A) 2.3 m (B) 2.1 m (C) 2.3 km (D) 230 m

14. The variation of lengths of two metal rods A and B with change in temperature is shown in figure. The ratio of $\frac{\alpha_A}{\alpha_B}$ is:-



15. A metal rod A of length \bullet_0 expands by $\Delta \bullet$ when its temperature is raised by 100°C. Another rod B of different metal of length $2\bullet_0$ expands by $\Delta \bullet/2$ for same rise in temperature. A third rod C of length $3\bullet_0$ is made up of pieces of rods A and B placed end to end expands by $2\Delta \bullet$ on heating through 100 K. The length of each portion of the composite rod is:-

(A)
$$\frac{5}{3} \bullet_0, \frac{4}{3} \bullet_0$$
 (B) $\bullet_0, 2 \bullet_0$ (C) $\frac{31_0}{2}, \frac{31_0}{2}$ (D) $\frac{2}{3} 1_0, \frac{7}{3} 1_0$

16. Bars of two different metals are bolted together, as shown in figure. The distance x does not change with temperature if:-





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- 17. The coefficient of linear expansion ' α ' of a rod of length 2m varies with the distance x from the end of the rod as $\alpha = \alpha_0 + \alpha_1 x$ where $\alpha_0 = 1.76 \times 10^{-5} \,^{\circ}\text{C}^{-1}$ and $\alpha_1 = 1.2 \times 10^{-6}\text{m}^{-1} \,^{\circ}\text{C}^{-1}$. The increase in the length of the rod, when heated through 100°C is:-
 - (A) 2cm (B) 3.76mm (C) 1.2 mm (D) None of these
- 18. A clock with a metallic pendulum gains 6 seconds each day when the temperature is 20°C and loses 6 second when the temperature is 40°C. Find the coefficient of linear expansion of the metal.

(A) $1.4 \times 10^{-5} \,^{\circ}C^{-1}$ (B) $1.4 \times 10^{-6} \,^{\circ}C^{-1}$ (C) $1.4 \times 10^{-4} \,^{\circ}C^{-1}$ (D) $0.4 \times 10^{-6} \,^{\circ}C^{-1}$

19. The coefficient of linear expansion α of the material of a rod of length \bullet_0 varies with absolute temperature as $\alpha = aT - bT^2$ where a & b are constants. The linear expansion of the rod when heated from T_1 to $T_2 = 2T_1$ is:-

(A)
$$\left(\frac{3}{2}aT_1^2 - \frac{7b}{3}T_1^3\right)L_0$$
 (B) $\left(4a - \frac{7b}{3}\right)T_1L_0$ (C) $\left(2aT_1^2 - \frac{7b}{3}T_1^3\right)L_0$ (D) None of these

20. The coefficient of apparent expansion of a liquid when determined using two different vessels A and B are γ_1 and γ_2 respectively. If the coefficient of linear expansion of the vessel A is α_1 , the coefficient of linear expansion of the vessel B is:-

(A)
$$\frac{\alpha_1\gamma_1\gamma_2}{\gamma_1+\gamma_2}$$
 (B) $\frac{\gamma_1-\gamma_2}{2\alpha_1}$ (C) $\frac{\gamma_1+\gamma_2+\alpha}{3}$ (D) $\frac{\gamma_1-\gamma_2+3\alpha_1}{3}$

21. A steel scale measures the length of a copper rod as \bullet_0 when both are at 20°C, which is the calibration temperature for the scale. The scale reading when both are at 40°C, is:-

(A)
$$(1+20\alpha_c)l_0$$
 (B) $(1+20\alpha_s)l_0$ (C) $(\frac{1+20\alpha_s}{1+20\alpha_c})l_0$ (D) $(\frac{1+20\alpha_c}{1+20\alpha_s})l_0$

22. A cup of tea cools from 80°C to 60°C in one minute. The ambient temperature is 30°C. In cooling from 60°C to 50°C. It will take :-

```
(A) 50 s (B) 90 s
```

(B) $\frac{200}{3}$ °C

```
(C) 60 s
```

(D) 48 s

100°C

(D) $\frac{100}{3}$ °C

50°C

Three rods of the same dimensions have thermal conductivities 3k, 2k and k. They are arranged as shown, with their ends at 100°C, 50°C and 0°C. The temperature of their junction is:-

(A) 75°C

23.

24. There is a small hole in a container. At what temperature should it be maintained in order that it emits one calorie of energy per second per meter²:-

(C) 40°C

```
(A) 10K (B) 500K (C) 200K (D) 100K
```

25. Ice starts forming in lake with water at 0° C when the atmospheric temperature is -10° C. If the time taken for 1 cm of ice be 7 hours, then the time taken for the thickness of ice to change from 1 cm to 2 cm is :-

(A) 7 hours (B) 14 hours (C) less than 7 hours (D) more than 7 hours

26. A blackened metallic foil is kept at a distance d from a spherical heater. The power absorbed by the foil is P. If the temperature of heater and distance both are doubled, then the power absorbed by the foil will be : –

(A) 8P (B) 4P (C) 2P (D) P



(D) 0.985

27. The area of cross-section of rod is given by $A = A_0 (1 + \alpha x)$ where $A_0 & \alpha$ are constant and x is the distance from one end. If the thermal conductivity of the material is K, what is the thermal resistance of the rod if its length is \bullet_0 ?

(A)
$$\operatorname{KA}_{0} \alpha \bullet n(1 + \alpha \bullet_{0})$$
 (B) $\frac{1}{\operatorname{KA}_{0} \alpha} \ln(1 + \alpha h_{0})$ (C) $\frac{\alpha}{\operatorname{KA}_{0}} \ln(1 + \alpha h_{0})$ (D) $\frac{\operatorname{KA}_{0}}{\alpha} \ln(1 + \alpha h_{0})$

28. Two different rods A and B are kept as shown in figure. The variation of temperature of different cross sections with distance is plotted in a graph shown in figure. The ratio of thermal conductivities of A and B is-



- 29.A red star and a green star radiate energy at the same rate which star is bigger.(A) Red(B) Green(C) Both have same size(D) Can't be say anything
- **30.** Which of the following graph shows the correct variation in intensity of heat radiations by black body and frequency at a fixed temperature:-



- 31. Two identical masses of 5 kg each fall on a wheel from a height of 10m. The wheel disturbs a mass of 2 kg water, the rise in temperature of water will be :-(A) 2.6° C (B) 1.2° C (C) 0.32° C (D) 0.12° C
- 32. 250 g of water and an equal volume of alcohol of mass 200 g are placed successively in the same calorimeter and cools from 60°C to 55°C in 130 sec and 67 sec respectively. If the water equivalent of the calorimeter is 10 g then the specific heat of alcohol in cal/g°C is :-

(A) 1.30 (B) 0.67 (C) 0.62

33. The weight of a person is 60 kg. If he gets 10 calories of heat through food and the efficiency of his body is 28%, then upto what height he can climb ? Take $g = 10 \text{ m s}^{-2}$ (A) 100 cm (B) 1.96 cm (C) 400 cm (D) 1000 cm

34. If H_c , H_k and H_F are heat required to raise the temperature of one gram of water by one degree in Celsius, Kelvin and Fahrenheit temperature scales respectively then :-

(A) $H_{K} > H_{C} > H_{F}$ (B) $H_{F} > H_{C} > H_{K}$ (C) $H_{K} = H_{C} > H_{F}$ (D) $H_{K} = H_{C} = H_{F}$



(A) 2

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35.	Hailstone at 0°C falls from a height of 1 km on an insulating surface converting whole of its kinetic energy into here what part of it will melt:- $[g = 10 \text{ m/s}^2, L_{ice} = 330 \times 10^3 \text{ J kg}^{-1}]$			ng whole of its kinetic energy into heat.
	(A) $\frac{1}{33}$	(B) $\frac{1}{8}$	(C) $\frac{1}{33} \times 10^{-4}$	(D) All of it will melt
36.	Water is used to cool the	radiators of engines in cars	s because :	
	(A) of its low boiling point	nt	(B) of its high specifi	ic heat
	(C) of its low density		(D) of its easy availab	pility
37.	Steam at 100°C is pa 0.02 kg at 15°C till the condensed in kg is :-	ssed through 1.1 kg of temperature of the calorin	water contained in a neter and its contents r	a calorimeter of water equivalent ises to 80°C. The mass of the steam
	(A) 0.130	(B) 0.065	(C) 0.260	(D) 0.135
38.	If the intermolecular for standard temperature and (A) 5.6 m ³	ces vanish away, the volun l pressure will be given by : (B) 4.5 m ³	ne occupied by the mol (C) 11.2 litre	lecules contained in 4.5 kg. water at (D) 11.2 m ³
39.	If mass-energy equivale (Note : The mass ener m = mass of object & c (A) increase (C) decrease	nce is taken into account, v gy of an object is the end = speed of light)	when water is cooled to ergy equivalent of its (B) remain unchange (D) first increase the	form ice, the mass of water should:- mass, as given by $E = mc^2$, where ed en decrease
40.	Pressure versus temperat	ure graphs of an ideal gas a	are as shown in figure.	Choose the wrong statement:-
		(ii) (ii)	(iii)	
	(A) Density of gas is incr(C) Density of gas is con	easing in graph (i) stant in graph (iii)	(B) Density of gas de(D) None of the above	ecreasing in graph (ii) re
41.	A refrigerator converts of heat removed per mi	100 g of water at 25°C int nute is:– (Specific heat of	to ice at -10° C in one ice = 0.5 cal/g°C, late	e hour and 50 minutes. The quantity ent heat of fusion = 80 cal/g)
10	(A) 50 cal	(B) 100 cal	(C) 200 cal	(D) 75 cal
42.	The expansion of unit m	ass of a perfect gas at cons	/b	in the diagram. Here:-
	(A) $a = volume, b = °C te$	mperature	(B) $a = volume, b = K$	temperature
43	(C) $a = C$ temperature, b	= volume	(D) $a = K$ temperature f the temperature is dou	be, b = volume while d then the change in the pressure
43.	(A) 100 % increase	(B) 200 % increase	(C) 50 % decrease	(D) 25 % decrease
44.	One mole of an ideal gas u	undergoes a process $P = \frac{1}{1+1}$	$\frac{P_0}{(V_0 / V)^2} \text{ Here } P_0 \text{ and } V$	V_0 are constants. Change in temperature
	of the gas when volume is	s changed from $V = V_0$ to $V =$	$= 2V_0$ is :-	
	$(\mathbf{A}) - \frac{2 \mathbf{P}_0 \mathbf{V}_0}{5 \mathbf{R}}$	(B) $\frac{11P_0V_0}{10R}$	$(\mathbf{C}) - \frac{5 \mathrm{P}_0 \mathrm{V}_0}{4 \mathrm{R}}$	(D) $P_0 V_0$
		A Ashal Daul Main	Now Robtal Dood	Now Dolbi 110035



(D) 171° C

Air is filled at 60° C in a vessel of open mouth. The vessel is heated to a temperature T so that $\frac{1}{4}$ th part of air 45. escapes. The value of T is :-

(C) 333° C

(B) 444° C (A) 80° C

- A gas has volume V and pressure P. The total translational kinetic energy of all the molecules of the gas is:-**46**.
 - (A) $\frac{3}{2}$ PV only if the gas is monoatomic.
 - (C) $> \frac{3}{2}$ PV if the gas is diatomic.

The temperature of hot bath will be :-

options correctly represents the order ?

47.

48.

- (B) $\frac{3}{2}$ PV only if the gas is diatomic.
- (D) $\frac{3}{2}$ PV in all cases.



	_			
	Α	В	С	D
Numberofmoles	n	3 n	2n	n
Mass	4m	m	3 m	2m
Rmsspeed	V _{rms}	$2v_{rms}$	V _{rms}	$2v_{rms}$
Temperature	Т	Т	Т	Т

(D) $2n_1 = 3n_2$

(A)
$$T_B = T_C > T_A > T_D$$
 (B) $T_D > T_A > T_C > T_B$ (C) $T_D > T_A = T_B > T_C$ (D) $T_B > T_C > T_A > T_D$

Two identical glass bulbs are interconnected by a thin glass tube at 0°C.

Four containers are filled with monoatomic ideal gases. For each container, the number of moles, the mass of an individual atom and the rms speed of the atoms are expressed in terms of n, m and v_{ms} respectively. If T_A , $T_{\rm B}$, $T_{\rm C}$ and $T_{\rm D}$ are their temperatures respectively then which one of the

A gas is filled at N.T.P. in these bulb is placed in ice and another bulb is placed in hot bath, then the pressure of the gas becomes 1.5 times.

(B) 182°C

A mixture of n₁ moles of monoatomic gas and n₂ moles of diatomic gas has $\frac{C_P}{C_V} = \gamma = 1.5$:--**49**.

A)
$$n_1 = n_2$$
 (B) $2n_1 = n_2$

(C) $n_1 = 2n_2$

(C) 256°C

- **50**. From the following V-T diagram we can conclude:-
 - (A) $P_1 = P_2$ $(C) P_1 < P_2$

(A) 100°C

- 10^{23} molecules of a gas strike a target of area 1 m² at angle 45° to normal and rebound elastically with speed 51. 1 kms⁻¹. The impulse normal to wall per molecule is:- [Given : mass of molecule = 3.32×10^{-27} kg] (A) $4.7 \times 10^{-24} \text{ kg ms}^{-1}$ **(B)** $7.4 \times 10^{-24} \text{ kg ms}^{-1}$ (D) 2.33 kg ms⁻¹ (C) $3.32 \times 10^{-24} \text{ kg ms}^{-1}$
- **52.** A gas is expanded from volume V_0 to $2V_0$ under three different processes. Process 1 is isobaric process, process 2 is isothermal and process 3 is adiabatic. Let ΔU_1 , ΔU_2 and ΔU_3 , be the change in internal energy of the gas is these processes. Then :-

(A) $\Delta U_1 > \Delta U_2 > \Delta U_3$ (C) $\Delta U_2 < \Delta U_1 < \Delta U_3$



53. The density in grams per litre of ethylene (C_2H_4) at STP is :-(A) 1.25 **(B)** 2.50 (C) 3.75 **(D)** 5.25



(B) $P_1 > P_2$ (D) Can't say anything

51

54.	i of an ideal gas i i constant then volume expansion element is equal to		
	(A) $\frac{11}{T}$	(B) $\frac{1}{T}$	(C) $\frac{12}{T}$ (D) $\frac{2}{T}$
55.	Some of the thermodynamic parameters are given. Ch	mic param	neters are state variables while some are process variables. Some grouping of the correct one.
	(A) State variables	:	Temperature, No of moles
	Process variables	:	Internal energy, work done by the gas.
	(B) State variables	:	Volume, Temperature
	Process variables	:	Internal energy, work done by the gas.
	(C) State variables	:	Work done by the gas, heat rejected by the gas
	Process variables	:	Temperature, volume.
	(D) State variables	:	Internal energy, volume
	Process variables	:	Work done by the gas, heat absorbed by the gas.

For an ideal gas \mathbf{PT}^{11} = constant then volume expansion coefficient is equal to :

56. When water is heated from 0°C to 4°C and C_p and C_v are its specific heats at constant pressure and constant volume respectively, then :-

(A)
$$C_p > C_v$$
 (B) $C_p < C_v$ (C) $C_p = C_v$ (D) $C_p - C_v = R$

The internal energy of a gas is given by U = 5 + 2PV. It expands from V_0 to $2V_0$ against a constant pressure P_0 . The 57. heat absorbed by the gas in the process is :-**(B)** $3P_0V_0$ (C) 2

$$(\mathbf{A}) - 3P_0V_0$$

$$2P_0V_0$$
 (D) P_0V_0

58. 5n, n and 5n moles of a monoatomic, diatomic and non-linear polyatomic gases (which do not react chemically with each other) are mixed at room temperature. The equivalent degree of freedom for the mixture is :-

(A)
$$\frac{25}{7}$$
 (B) $\frac{48}{11}$ (C) $\frac{52}{11}$ (D) $\frac{50}{11}$

- **59**. The molar specific heat of the process $V \propto T^4$ for CH₄ gas at room temperature is:-**(B)** 7R (C) 3R (A) 4R **(D)** 8R
- The internal energy of a gas in an adiabatic process is given by U = a + bPV, find $\gamma :=$ **60**.

(A)
$$\frac{a+1}{a}$$
 (B) $\frac{b+1}{b}$ (C) $\frac{b+1}{a}$ (D) $\frac{a}{b+1}$



D α_1

 Δ

Exercise # 2 Part # I [Multiple Correct Choice Type Questions]

1. Three rods of equal length are joined to form an equilateral triangle ABC.D is the midpoint of AB. The coefficient of linear expansion is α_1 for AB, and α_2 for AC and BC. If the distance DC remains constant for small changes in temperature:-

(A)
$$\alpha_1 = \alpha_2$$
 (B) $\alpha_1 = 2\alpha_2$ **(C)** $\alpha_1 = 4\alpha_2$ **(D)** $\alpha_1 = \frac{1}{2}\alpha_2$

- 2. A triangular plate has two cavities, one square and one rectangular as shown in figure. The plate is heated.
 - (B) a and b both increase (A) a increase, b decrease (C) a and b increase, x and \bullet decrease (D) a, b, x and \bullet all increase
- 3. If water at 0°C, kept in a container with an open top, is placed in a large evacuated chamber:-
 - (A) All the water will vaporize.
 - (B) All the water will freeze.
 - (C) Part of the water will vaporize and the rest will freeze.
 - (D) Ice, water and water vapour will be formed and reach equilibrium at the triple point.
- 4. Which of the following statements is/are correct?
 - (A) A gas has two specific heats only
 - (B) A material will have only one specific heat, if and only if its coefficient of thermal expansion is equal to zero.
 - (C) A gas has infinite number of specific heats.
 - (D) None of these
- In the previous question, if the specific latent heat of vaporization of water at 0°C is n times the specific latent 5. heat of freezing of water at 0°C, the fraction of water that will ultimately freeze is:-

(A)
$$\frac{1}{\eta}$$
 (B) $\frac{\eta}{\eta+1}$ (C) $\frac{\eta-1}{\eta}$ (D) $\frac{\eta-1}{\eta+1}$

The figure shows two paths for the change of state of a gas from A to B. The ratio of molar heat 6. capacities in path 1 and path 2 is:-



(D) Data insufficient

- 7. Two identical beakers are filled with water to the same level at 4°C. If one say A is heated while the other B is cooled, then:-
 - (A) water level in A will rise
 - (C) water level in A will fall
- (B) water level in B will rise
- (D) water level in B will fall
- When two samples at different temperatures are mixed, the temperature of the mixture can be :--8.
 - (A) lesser than lower or greater than higher temperature
 - (B) equal to lower or higher temperature
 - (C) greater than lower but lesser than higher temperature
 - (D) average of lower and higher temperatures.





- 13. An ideal gas can be expanded from an initial state to a certain volume through two different processes (i) $PV^2 = constant$ and (ii) $P = KV^2$ where K is a positive constant. Then:-(A) Final temperature in (i) will be greater than in (ii)
 - (B) Final temperature in (i) will be greater than in (i)
 - (C) Total heat given to the gas in (i) case is greater than in (ii)
 - (D) Total heat given to the gas in (ii) case is greater than in (i)
- 14. During experiment, an ideal gas is found to obey a condition $P^2/\rho = \text{constant} [\rho = \text{density of the gas}]$. The gas is initially at temperature T, pressure P and density ρ . The gas expands such that density changes to $\rho/2$
 - (A) The pressure of the gas changes to $\sqrt{2}$ P
 - (B) The temperature of the gas changes to $\sqrt{2}$ T
 - (C) The graph of the above process on the P–T diagram is parabola
 - (D) The graph of the above process on the P-T diagram is hyperbola
- 15. When unit mass of water boils to become steam at 100°C, it absorbs Q amount of heat. The densities of water and steam at 100°C are ρ_1 and ρ_2 respectively and the atmospheric pressure is P_0 . The increase in internal energy of the water is:-

(A) Q
(B)
$$Q + P_0 \left(\frac{1}{\rho_1} - \frac{1}{\rho_2}\right)$$

(C) $Q + P_0 \left(\frac{1}{\rho_2} - \frac{1}{\rho_1}\right)$
(D) $Q - P_0 \left(\frac{1}{\rho_1} + \frac{1}{\rho_2}\right)$



(**D**) $2\rho_0$

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



- 17. At temperature T,N molecules of gas A each having mass m and at the same temperature 2 N molecules of gas B each having mass 2 m are filled in a container. The mean square velocity of molecules of gas B is v^2 and x component of mean square velocity of molecules of gas A is w^2 . The ratio of w^2 / v^2 is :-(A) 1 (B) 2 (C) 1/3 (D) 2/3
- 18. A closed vessel contains a mixture 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 are true?
 - (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

19. A vessel is partitioned in two equal halves by a fixed diathermic separator. Two different ideal gases are filled in left (L) and right (R) halves. The rms speed of the molecules in L part is equal to the mean speed of molecules in the R part. Then the ratio of the mass of a molecule in L part to that of a molecule in R part is:-



- (A) $\sqrt{\frac{3}{2}}$ (B) $\sqrt{\pi/4}$ (C) $\sqrt{2/3}$ (D) $3\pi/8$
- 20. Let \overline{v} , v_{ms} and v_p respectively denote the mean speed, the root-mean-square speed, and the most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T. The mass of a molecule is m:-
 - (A) No molecule can have speed greater than v_{rms} (B) No molecule can have speed less than $\frac{v_p}{\sqrt{2}}$
 - (C) $v_p < \overline{v} < v_{rms}$

(A) $\frac{3}{4}\rho_0$

(D) The average kinetic energy of a molecule is $\frac{3}{4}mv_p^2$

N(<100) molecules of a gas have velocities 1,2,3.... N, km/s respectively. Then:-
 (A) rms speed and average speed of molecules are same

(B) Ratio of rms speed to average speed is $\frac{\sqrt{(2N+1)(N+1)}}{6N}$ (C) Ratio of rms speed to average speed is $\frac{\sqrt{(2N+1)(N+1)}}{6}$

(**D**) Ratio of rms speed to average speed of a molecule $\frac{2}{\sqrt{6}} \sqrt{\frac{(2N+1)}{(N+1)}}$



- 22. The internal energy of a system remains constant when it undergoes :-
 - (A) a cyclic process (B) an isothermal process (C) an adiabatic process

(D) any process in which the heat given out by the system is equal to the work done on the system

23. The following are the P–V diagrams for cyclic processes for a gas. In which of these processes is heat absorbed by the gas ?



24. An ideal gas is heated from temperature T_1 to T_2 under various conditions. The correct statement(s) is/are:-(A) $\Delta U = nC_v (T_2 - T_1)$ for isobaric, isochoric and adiabatic process

(B) Work is done at expense of internal energy in an adiabatic process and both have equal values

- (C) $\Delta U = 0$ for an isothermal process
- **(D)** C = 0 for an adiabatic process
- 25. C_p is always greater than C_v due to the fact that :-
 - (A) No work is being done on heating the gas at constant volume.
 - (B) When a gas absorbs heat at constant pressure its volume must change so as to do some external work.
 - (C) The internal energy is a function of temperature only for an ideal gas.

(C) m_<m_

- (D) For the same rise of temperature, the internal energy of a gas changes by a smaller amount at constant volume than at constant pressure.
- 26. The indicator diagram for two process 1 and 2 carried on an ideal gas is shown in figure. If m_1 and m_2 be the slopes
 - $\left(\frac{dP}{dV}\right)$ for process 1 and process 2 respectively, then:-

 $(\mathbf{B}) \mathbf{m}_1 > \mathbf{m}_2$

 $(\mathbf{A})\mathbf{m}_1 = \mathbf{m}_2$

27. Logarithms of readings of pressure and volume for an ideal gas were plotted on a graph as shown in Figure. By measuring the gradient, It can be shown that the gas may be :-

(D) $m_{n}C_{n}=m_{n}C_{n}$

- (A) Monoatomic and undergoing an adiabatic change.
- (B) Monoatomic and undergoing an isothermal change.
- (C) Diatomic and undergoing an adiabatic change.
- (D) Triatomic and undergoing an isothermal change.
- 28. An ideal monoatomic gas undergoes a cycle process ABCA as shown in the fig. The ratio of heat absorbed during AB to the work done on the gas during BC is:-







THERMAL PROPERTIES OF MATTER

29. 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
$$\frac{kx_0 6}{S}$$



2P P

Α

В

00000

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

(D) Temperature of the gas is decreased.

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

30. A thermodynamic system undergoes cyclic process ABCDA as shown in figure. P. The work done by the system is :- 3P₀

(A)
$$P_0 V_0$$
 (B) $2P_0 V_0$ (C) $\frac{P_0 V_0}{2}$ (D) zero

- 31. Two cylinders A and B fitted with piston contain the equal amount of an ideal diatomic gas at 300K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30K, then the rise in the temperature of the gas in B is:(A) 30 K
 (B) 10 K
 (C) 50 K
 (D) 42 K
- 32. One mole of an ideal monatomic gas is taken from A to C along the path ABC. The temperature of the gas at A is T_0 . For the process ABC :-
 - (A) Work done by the gas is RT_0
 - (B) Change in internal energy of the gas is $\frac{11}{2}$ RT₀
 - (C) Heat absorbed by the gas is $\frac{11}{2}$ RT₀
 - (D) Heat absorbed by the gas is $\frac{13}{2}$ RT₀
- 33. The specific heats of a gas are C_p=0.2 cal/g °C & C_v = 0.15 cal/g °C. [Take R=2 cal/mole⁰C]
 (A) The molar mass of the gas is 40 g
 - (B) The molar mass of the gas cannot be determined from the data given
 - (C) The number of degrees of freedom of the gas molecules is 6
 - (D) The number of degrees of freedom of the gas molecules is 8
- 34. One mole of ideal gas undergoes a cyclic process ACBA as shown in figure. Process AC is adiabatic. The temperatures at A, B and C are 300, 600 and 450K respectively:-
 - (A) In process CA change in internal energy is 225R.
 - **(B)** In process AB change in internal energy is -150R.
 - (C) In process BC change in internal energy is -225R.
 - (D) Change in internal energy during the whole cyclic process is +150R.





35. One mole of an ideal gas at an initial temperature of T K does 6 R joules of work adiabatically. If the ratio of specific heats of this gas at constant pressure and at constant volume is 5/3, the final temperature of gas will be:-



- 37. A gas expands such that its initial and final temperatures are equal. Also, the process followed by the gas traces a straight line on the P–V diagram :-
 - (A) The temperature of the gas remains constant throughout.
 - (B) The temperature of the gas first increases and then decreases.
 - (C) The temperature of the gas first decreases and then increases.
 - (D) The straight line has a negative slope.
- 38. A point source of heat of power P is placed at the center of a spherical shell of mean radius R. The material of the shell has thermal conductivity k. If the temperature difference between the outer and the inner surface of the shell is not to exceed T, then the thickness of the shell should not be less than :-

(A)
$$\frac{2\pi R^2 kT}{P}$$
 (B) $\frac{4\pi R^2 kT}{P}$ (C) $\frac{\pi R^2 kT}{P}$ (D) $\frac{\pi R^2 kT}{4P}$

39. Radiation from a black body at the thermodynamic temperature T_1 is measured by a small detector at distance d_1 from it. When the temperature is increased to T_2 and the distance to d_2 , the power received by the detector is unchanged. What is the ratio d_2/d_1 ?

(A)
$$\frac{T_2}{T_1}$$
 (B) $\left(\frac{T_2}{T_1}\right)^2$ (C) $\left(\frac{T_1}{T_2}\right)^2_2$ (D) $\left(\frac{T_2}{T_1}\right)^4$

- 40. The emissive power of a black body at T=300 K is 100 Watt/m². Consider a body B of area A = 10 m², coefficient of reflectivity r = 0.3 and coefficient of transmission t=0.5. Its temperature is 300 K. Then which of the following is incorrect:-
 - (A) The emissive power of B is 20 W/m^2
- (B) The emissive power of B is 200 W/m²
- (C) The power emitted by B is 200 Watt
- (D) The emissivity of B is = 0.2
- 41. A black body emits radiation at the rate P when its temperature is T. At this temperature the wavelength at which the radiation has maximum intensity is λ_0 . If at another temperature T' the power radiated is 'P' and

wavelength at maximum intensity is
$$\frac{\lambda_0}{2}$$
 then:-
(A) P' T' = 32 PT (B) P' T' = 16 PT (C) P' T' = 8 PT (D) P' T' = 4 PT

- 42. A hollow copper sphere & a hollow copper cube of same surface area & negligible thickness, are filled with warm water of same temperature and placed in an enclosure of constant temperature, a few degrees below that of the bodies. Then in the beginning :-
 - (A) The rate of energy lost by the sphere is greater than that by the cube
 - (B) The rate of energy lost by the two are equal
 - (C) The rate of energy lost by the sphere is less than that by the cube
 - (D) The rate of fall of temperature for sphere is less than that for the cube .

- 43. A metallic sphere having radius 0.08 m and mass m = 10 kg is heated to a temperature of 227°C and suspended inside a box whose walls are at a temperature of 27°C. The maximum rate at which its temperature will fall is:-(Take e = 1, Stefan's constant σ = 5.8 x 10⁻⁸ Wm⁻² K⁻⁴ and specific heat of the metal s = 90 cal/kg/deg, J = 4.2 J/Calorie) **(B)** 0.066 °C/s (C) 0.044 °C/s (D) 0.03 °C/s (A) 0.055 °C/s
- **44**. A body cools in a surrounding which is at a constant temperature of θ_0 . Assume that it obeys Newton's law of cooling. Its temperature θ is plotted against time t. Tangent are drawn to the curve at the points $P(\theta = \theta_2)$ and $Q(\theta = \theta_1)$. These tangents meet the time axis at angles of ϕ_2 and ϕ_1 as shown, then:-





45. Two long, thin, solid cylinders are identical in size, but they are made of different substances with two different thermal conductivities. The two cylinders are connected in series between a reservoir at temperature T_{bet} and a reservoir at temperature T_{cold} . The temperature at the boundary between the two cylinders is T_{b} . One can conclude that:-

- (A) T_{b} is closer to T_{hot} than it is to T_{cold} . (B) T_{b} is closer to T_{cold} than it is to T_{hot} .
- (C) T_{b} is closer to the temp. of the reservoir that is in contact with the cylinder with the lower thermal conductivity.
- (D) T_{b} is closer to the temp. of the reservoir that is in contact with the cylinder with the higher thermal conductivity.
- A rod of length L with sides fully insulated is of a material whose thermal conductivity varies with temperature as **46.** $K = \frac{\alpha}{T}$, where α is a constant. The ends of the rod are kept at temperature T_1 and T_2 . The temperature T at x, where

x is the distance from the end whose temperature is T_1 is:-

(A)
$$T_1\left(\frac{T_2}{T_1}\right)^{\frac{x}{L}}$$
 (B) $\frac{x}{L}\ln\frac{T_2}{T_1}$ (C) $T_1e^{\frac{T_2x}{T_1L}}$ (D) $T_1 + \frac{T_2 - T_1}{L}x$

47. A spherical body with an initial temperature T_1 is allowed to cool in surroundings at temperature T_0 ($< T_1$). The mass of the body is m, its gram specific heat is c, density ρ , area A. If σ be the Stefan's constant then the temperature T of the body at time t can be best represented by:-

(A)
$$T = (T_1 - T_0) e^{-kt}$$
 where $k = \frac{12\sigma A T_0^3}{r\rho c}$
(B) $T = (T_1 - T_0) \lambda n (kt)$ where $k = \frac{\sigma A T_0}{mc^3}$
(C) $T = T_0 + (T_1 - T_0) e^{-kt}$ where $k = \frac{12\sigma T_0^3}{r\rho c}$
(D) $T = T_1 e^{-kt} - T_0$ where $k = \frac{\sigma A T_0^3}{r\rho c}$

Twelve conducting rods form the sides of a uniform cube of side ●. If in **48**. state, B and H ends of the cube are at 100°C and 0°C steady respectively. Find the temperature of the junction 'A' :-

(A)
$$80^{\circ}$$
C (B) 60° C (C) 40° C (D) 70° C

49. A ring consisting of two parts ADB and ACB of same conductivity k carries an amount of heat H. The ADB part is now replaced with another metal keeping the temperatures T₁ and T₂ constant. The heat carried increases to 2H. What

should be the conductivity of the new ADB part? Given $\frac{ACB}{ADB} = 3$

(B) 2k



(D) 3k

(A) $\frac{7}{3}$ k

(C) $\frac{5}{2}$ k

51.

50. A sphere of ice at 0° C having initial radius R is placed in an environment having ambient temperature > 0° C. The ice melts uniformly, such that shape remains spherical. After a time 't' the radius of the sphere has reduced to r. Which graph best depicts r(T)



52. Three bodies A, B and C have equal surface area and thermal emissivities in the ratio $e_A : e_B : e_C = 1 : \frac{1}{2} : \frac{1}{4}$. All the

three bodies are radiating at same rate. Their wavelengths corresponding to maximum intensity are λ_A , λ_B and λ_C respectively and their temperatures are T_A , T_B and T_C on kelvin scale, then select the incorrect statement

(A)
$$\sqrt{T_A T_C} = T_B$$

(B) $\sqrt{\lambda_A \lambda_C} = \lambda_B$
(C) $\sqrt{e_A T_A} \sqrt{e_C T_C} = e_B T_B$
(D) $\sqrt{e_A \lambda_A T_A \cdot e_B \lambda_B T_B} = e_C \lambda_C T_C$

53. Three identical rods AB, CD and PQ are joined as shown. P and Q are mid points of AB and CD respectively. Ends A, B, C and D are maintained at 0°C, 100°C, 30°C and 60°C respectively. The direction of heat flow in PQ is:-



In a 10-metre-deep lake, the bottom is at a constant temperature of 4°C. The air temperature is constant at – 4°C. The thermal conductivity of ice is 3 times that of water. Neglecting the expansion of water on freezing, the maximum thickness of ice will be:-

(A) 7.5 m (B) 6 m

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(C) 5 m
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(D) 2.5 m
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54.

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A and B are two points on a uniform metal ring whose centre is C. The angle $ACB = \theta$. A and B maintained at 55. two different constant temperatures. When $\theta = 180^\circ$, the rate of total heat flow from A to B is 1.2 W. When $\theta = 90^{\circ}$, this rate will be:-(C) 1.6 W (A) 0.6 W **(B)** 0.9 W (D) 1.8 W **56**. A system S receives heat continuously from an electrical heater of power 10W. The temperature of S becomes constant at 50°C when the surrounding temperature is 20°C. After the heater is switched off, S cools from 35.1°C to 34.9°C in 1 minute. The heat capacity of S is:-(A) 100 J/°C **(B)** 300 J/°C (C) 750 J/°C (D) 1500 J/°C The solar constant for the earth is Σ . The surface temperature of the sun is T K. The sun subtends an angle θ 57. at the earth:-**(B)** $\Sigma \propto T^2$ (C) $\Sigma \propto \theta^2$ (D) $\Sigma \propto \theta$ (A) $\Sigma \propto T^4$ **58.** Temperature of black body is 3000K when black body cools, then change in wevelength $\Delta \lambda = 9$ micron corresponding to maximum energy density. Now temperature of black body is :-(A) 300 K **(B)** 2700 K (D) 1800 K (C) 270 K **59**. If the absorption coefficient and reflection coefficient of a surface of a body are 0.4 and 0.6 respectively then:-(A) Emissive power will be 0.2 (B) Transmission power will be 0.2 (C) Body will be totally transparent (D) Body will be totally opaque. **60**. Two Plates of equal areas are placed in contact with each other. Their thickness are 2cm and 3cm respectively. Temperature of external surface of first plate is -25° C and that of external surface of second plate is 25° C What will be temperature of contact surface if the plates :-(i) Are of same material (ii) Have thermal Conductivity in ratio 2 : 3. (A) (i) -5° C (ii) 0° C **(B)**(i) 5° C (ii) 0° C (C) (i) $0^{\circ}C$ (ii) $-5^{\circ}C$ (D) None of these 61. Three rods of same dimensions are arranged as shown in the figure. They have thermal conductivities k₁, k₂ & k₃. The points A and B are maintained at different temperatures. For the heat to flow at the same rate along ACB and AB :--**(B)** $k_3 = \frac{k_1 k_2}{k_1 + k_2}$ **(C)** $k_3 = k_1 + k_2$ **(D)** $k_3 = \frac{1}{2} (k_1 + k_2)$ (A) $k_3 = 2(k_1 + k_2)$ **62**. Two identical square rods of metal are welded end to end as shown in figure (A) 20 calories of heat flows through it in 4 minutes. If the rods are welded as shown (a) (b) in figure (B), the same amount of heat will flow through the rods in :-(A) 1 minute (B) 2 minutes (C) 4 minutes (D) 16 minutes 63. The figure shows a system of two concentric spheres of radii r, and r, and kept at temperatures T_1 and T_2 , respectively. The radial rate of flow of heat in a substance between the two concentric spheres, is proportional to:-(C) $\frac{r_1 r_2}{(r_2 - r_1)}$ **(B)** \bullet n $\left(\frac{\mathbf{r}_2}{\mathbf{r}_1}\right)$ (A) $\frac{(r_2 - r_1)}{(r_1 r_2)}$ **(D)** $(r_2 - r_1)$ **64**. The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity K and 2K and thickness x and 4x, respectively are T_2 and $T_1(T_2 > T_1)$. The rate of heat transfer T₂ Κ 2K T₁ through the slab, in a steady state is $\left(\frac{A(T_2 - T_1)K}{x}\right)f$, with f equals to:-(A) 1 **(B)** 1/2 (C) 2/3 **(D)** 1/3 Add. 41-42A, Ashok Park Main, New Rohtak Road, New Delhi-110035

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- A thermally insulated vessel contains some water at 0°C. The vessel is connected to a vacuum pump to pump out **65**. water vapour. This results in some water getting frozen. It is given latent heat of vaporization of water at $0^{\circ}C = 21 \times 10^5$ J/kg and latent heat of freezing of water = 3.36×10^5 J/kg. The maximum percentage amount of water that will be solidified in this manner will be:-**(B)** 33.6% (C) 21% **(D)** 24.36% (A) 86.2%
- **66**. The pressure of one mole of an ideal gas varies according to the law $P = P_0 - aV^2$, where P_0 and a are positive constants. The highest temperature that the gas may attain is:-

(A)
$$\frac{2P_0}{3R} \left(\frac{P_0}{3a}\right)^{1/2}$$
 (B) $\frac{3P_0}{2R} \left(\frac{P_0}{3a}\right)^{1/2}$ (C) $\frac{P_0}{R} \left(\frac{P_0}{3a}\right)^{1/2}$ (D) $\frac{P_0}{R} \left(\frac{P_0}{3a}\right)^{1/2}$

- **67.** Three identical adiabatic containers have helium, neon and oxygen gases at the same pressure. The gases are compressed to half their original volume. Then:-
 - (A) The final temperature of the gas in each container is same
 - (B) The final pressure of the gas in each container is same
 - (C) The final temperature of both helium and neon is same
 - (D) The final pressure of both helium and neon is same
- **68**. A closed cubical box made of perfectly insulating material has walls of thickness 8 cm and the only way for heat to enter or leave the box is through two solid metal plugs A and B, each of cross-sectional area 12 cm^2 and length 8 cm fixed in the opposite walls of the box as shown in the figure. Outer surface A is kept at 100°C while the outer surface B is kept at 4°C. The thermal conductivity of the material of the plugs is 0.5 cals⁻¹cm⁻¹ (°C⁻¹). A source of energy generating 36 cals⁻¹ is enclosed inside the box. The equilibrium temperature of the inner surface of the box (assuming that it is same at all points on the inner surface) is:-(C) 76°C (D) 85°C (A) 38°C **(B)** 57°C



V₀ speed V

0.3

0.1

500 1000 1500 Q(J)

1/2

Graph shows a hypothetical speed distribution for a sample of N gas particle :- (for V > V₀; $\frac{dN}{dV} = 0$) **69**.

- (A) The value of V_0 is 2N.
- **(B)** The ratio V_{avg}/V_0 is equal to 2/3.
- (C) The ratio V_{ms}/V_0 is equal to $1/\sqrt{2}$
- (D) Three fourth of the total particle has a speed between 0.5 V_0 and V_0 .
- 70. Suppose 0.5 mole of an ideal gas undergoes an isothermal expansion as energy is added to it as heat Q. Graph shows the final volume V, versus Q. The temperature of the gas is :-

(use
$$\bullet$$
n 9 = 2 and R = $\frac{25}{3}$ J/mol-K)
(A) 293 K (B) 360 K (C) 386 K (D) 412 K

71. A glass rod when measured with a zinc scale, both being at 30°C, appears to be of length 100 cm. If the scale shows correct reading at 0°C, then the true length of glass rod at 30°C and 0°C are:-

 $(\alpha_{glass} = 8 \times 10^{-6} \,^{\circ}\text{C}^{-1}, \alpha_{zinc} = 26 \times 10^{-6} \,^{\text{K}^{-1}})$ (A) 100.054 cm, 100.054 cm **(B)** 100.078 cm, 100.078 cm (C) 100.078 cm, 100.054 cm (D) 100.054 cm, 100.078 cm

- The temperature of an isotropic cubical solid of length \bullet_{α} , density ρ_{α} and coefficient of linear expansion α is 72. increased by 20°C. Then at higher temperature, to a good approximation:-
 - **(B)** Total surface area is $\bigoplus_{0}^{2} (1+40\alpha)$ (A) Length is $\bullet_{\alpha}(1+20\alpha)$ (D) Density is $\frac{\rho_0}{1+60\alpha}$ (C) Total volume is Φ_0^3 (1+60 α)



73. In a mercury–glass thermometer the cross–section of the capillary portion is A_0 and the volume of the bulb is V_0 at 273 K. If α and γ are the coefficients of linear and cubical expansion coefficients of glass and mercury respectively then length of mercury in the capillary at temperature to C is (Ignore the increase in cross-sectional area of capillary)

(A)
$$\frac{V_0}{A_0}(\gamma - 3\alpha)t$$

(B) $\frac{V_0}{A_0}(2\gamma - 3\alpha)t$
(C) $\frac{V_0}{A_0}(\gamma - 3\alpha)(t + 273)$
(D) $\frac{V_0\gamma t}{A_0}$
Bulb

74. Two fine steel wires, fastened between the projections of a heavy brass bar, are just taut when the whole system is at 0°C. What is the tensile stress in the steel wires when the temperature of the system is raised by 200°C? $(\alpha_{brass} = 2 \times 10^{-5} \text{ °C}^{-1}, \alpha_{steel} = 1.2 \times 10^{-5} \text{ °C}^{-1}, Y_{steel} = 200 \text{ GNm}^{-2})$



- 75. n moles of an ideal triatomic linear gas undergoes a process in which the temperature changes with volume as $T = k_1 V^2$ where k_1 is a constant. Choose incorrect alternative:-
 - (A) At normal temperature $C_v = \frac{5}{2}R$ **(B)** At any temperature $C_p - C_v = R$
 - (C) At normal temperature molar heat capacity C=3R (D) At any temperature molar heat capacity C=3R
- 5g of steam at 100°C is mixed with 10 g of ice at 0°C. Choose correct alternative/s) :-(Given s_{water} = 1 cal/g°C, 76. $L_{F} = 80 \text{ cal/g}, L_{V} = 540 \text{ cal/g})$

(A) Equilibrium temperature of mixture is 160°C (B) Equilibrium temperature of mixture is 100°C

- (C) At equilibrium, mixture contain $13\frac{1}{3}$ g of water (D) At equilibrium, mixture contain $1\frac{2}{3}$ g of steam
- 77. Four moles of hydrogen, two moles of helium and one mole of water vapour form an ideal gas mixture. What is the molar specific heat at constant pressure of mixture ?

(B) $\frac{23}{7}$ R

(A)
$$\frac{16}{7}$$
 R

(C)
$$\frac{19}{7}$$
 R

(D) $\frac{26}{7}$ R

78. A sample of gas follows process represented by PV^2 = constant. Bulk modulus for this process is B, then which of the following graph is correct?



79. A inert gas obeys the law PV^x = constant. For what value of x, it has negative molar specific heat-(A) x > 1.67**(B)** x < 1.67 (C) 1 < x < 1.4**(D)** 1 < x < 1.67





Statement-II : The adiabatic at any point has a steeper slope than the isothermal through the same point.

Statement-I: Air quickly leaking out of a balloon becomes cooler.
 Statement-II: The leaking air undergoes adiabatic expansion.

- Statement-I: Change in internal energy in the melting process is due to change in internal potential energy.
 Statement-II: This is because in melting, distance between molecules increase but temperature remains constant.
- Statement-I: Water kept in an open vessel will quickly evaporate on the surface of the Moon.
 Statement-II: The temperature at the surface of the moon is much higher than boiling point of water at Earth.
- Statement-I: Absolute zero temperature is not the temperature of zero energy.
 Statement-II: Only the internal kinetic energy of the molecules is represented by temperature.


- Statement-I: The steam at 100°C causes more severe burn to human body than the water at 100°C.
 Statement-II: The steam has greater internal energy due to latent heat of vaporization.
- Statement-I: An ideal gas has infinitely many molar specific heats.
 Statement-II: Specific heat is amount of heat needed to raise the temperature of 1 mole of gas by 1 K.
- Statement-I: The bulb of one thermometer is spherical while that of the other is cylindrical. Both have equal amount of mercury. The response of the cylindrical bulb thermometer will be quicker.
 Statement-II: Heat conduction in a body is directly proportional to cross-sectional area.
- Statement-I : On sudden expansion a gas cools.
 Statement-II : On sudden expansion, no heat is supplied to system and hence gas does work at the expense of its internal energy.
- Statement-I: A gas is taken from state A to state B through two different paths. Molar specific heat capacity in path (A) is more as compared to (B).

(1) A (2) B

Statement–II: Specific heat $C = \frac{Q}{n\Delta T}$ & $Q = \Delta U + W$ and W is equal to area under P–V diagram.

- Statement-I : In a process if initial volume is equal to the final volume, work done by the gas is zero.
 Statement-II : In an isochoric process work done by the gas is zero.
- Statement-I : The isothermal curves intersect each other at a certain point.
 Statement-II : The isothermal change are done slowly, so the isothermal curves have very little slope.
- 17. Statement-I: Two solid cylindrical rods of identical size and different thermal $\begin{pmatrix} K_1 & K_2 \end{pmatrix}$ conductivity K_1 and K_2 are connected in series. Then the equivalent thermal conductivity of two rod system is less than the value of thermal conductivity of either rod.

Statement-II: For two cylindrical rods of identical size and different thermal conductivity K₁ and K₂ connected

in series, the equivalent thermal conductivity K is given by $\frac{2}{K} = \frac{1}{K_1} + \frac{1}{K_2}$

- Statement-I: Equal amount of heat is supplied to two identical spheres A &
 B (see figure). The increment in temperature for sphere A is more than sphere B.
 Statement-II: Work done due to gravity on sphere A is positive while on sphere B is negative.
- Statement-I: When a bottle of cold carbonated drink is opened, a slight fog forms around the opening.
 Statement-II: Adiabatic expansion of the gas causes lowering of temperature and condensation of water vapours.
- Statement-I: A cloudy night is hotter than a clear sky night.
 Statement-II : Clouds are bad absorbers of heat.
- 21. Statement-I: Temperatures near the sea-coast are moderate. Statement-II: Water has a high thermal conductivity compared to ice.
- Statement-I: Potential energy of water at 0°C is more than ice at 0°C.
 Statement-II: Heat given to melt ice at 0°C is used up in increasing the potential energy of water molecules formed at 0°C.



- Statement-I: When hot water is poured in a beaker of thick glass, the beaker cracks.
 Statement-II: Glass is a bad conductor of heat and outer surface of the beaker does not expand.
- 24. Statement-I : Snow is better insulator than ice. Statement-II : Snow contain air packet and air is a bad conductor of heat.
- 25. Statement-I: When an electric fan is switched on in a closed room, the air of the room is cooled. Statement-II: When fan is switched on, the speed of the air molecules will increase.
- Statement-I: Animals curl into a ball, when they feel very cold.
 Statement-II: Animals by curling their body reduces the surface area.
- Statement-I: High thermal conductivity of metals is due to presence of free electrons.
 Statement-II: Electrons at same temperature have very high average velocity than atoms.
- 28. Statement-I: A sphere, a cube and a thin circular plate made of same material and of same mass are initially heated to 200°C, the plate will cool at fastest rate.

Statement-II: Rate of cooling = $\frac{\rho A \sigma}{ms} (T^4 - T_0^4) \propto$ surface area. Surface area is maximum for circular plate.

- 29. Statement–I: Water is considered unsuitable for use in thermometers. Statement–II: Thermal Expansion of water is non uniform.
- Statement-I: Liquids usually expand more than solids.
 Statement-II: The intermolecular forces in liquids are weaker than in solids.
- 31. Statement-I : Coolant coils are fitted at the top of a refrigerator, for formation of convection current. Statement-II : Air becomes denser on cooling.
- 32. Statement-I : Temperature of a rod is increased and again cooled to same initial temperature then its final length is equal to original length provided there is no deformation take place.

Statement-II: For a small temperature change, length of a rod varies as $\bullet = \bullet_0 (1 + \alpha \Delta T)$ provided $\alpha \Delta T << 1$. Here symbol have their usual meaning.



THERMAL PROPERTIES OF MATTER

E	xerc	ise # 3 Part # I		[Matrix Match Type Questions]
		Column-I		Column–II
	(A)	Isobaric process	(P)	No heat exchange
	(B)	Isothermal process	(Q)	Constant pressure
	(C)	Isoentropy process	(R)	Constant internal energy
	(D)	Isochoric process	(S)	Work done is zero
	Three 60°C 1	liquids A, B and C having same spe respectively. Temperature of the mix	cific hea xture wh	at and mass m, 2m and 3m have temperature 20°C, 40°C and then :
		Column I		Column II
	(A)	A and B are mixed	(P)	35°C
	(B)	A and C are mixed	(Q)	52°C
	(C)	B and C are mixed	(R)	50°C
	(D)	A, B and C all three are mixed	(S)	45°C
			(T)	None
	(A) (B)	Column I Temperature of junction B Heat current in AB	(P) (Q)	Column II Greater than 50°C Less than 50°C
	(C)	Heat current in BC	(R) (S) (T)	Is $\frac{2}{3}$ times heat current in AC None
	In the	V–T graph shown in figure:		
		Column I		Column II
	(A)	Gas A is and gas B is	(P)	monoatomic, diatomic
	(A) (B)	Gas A is and gas B is P_A / P_B is	(P) (Q)	monoatomic, diatomic diatomic, monoatomic
	(A) (B) (C)	Gas A is and gas B is P_A / P_B is n_A / n_p is	(P) (Q) (R)	monoatomic, diatomic diatomic, monoatomic > 1
	(A) (B) (C)	Gas A is and gas B is P_A / P_B is n_A / n_B is	(P) (Q) (R) (S)	monoatomic, diatomic diatomic, monoatomic > 1 < 1
	(A) (B) (C)	Gas A is and gas B is P_A / P_B is n_A / n_B is	(P) (Q) (R) (S) (T)	monoatomic, diatomic diatomic, monoatomic > 1 < 1 cannot say any thing
	(A) (B) (C)	Gas A is and gas B is P_A / P_B is n_A / n_B is Column I	(P) (Q) (R) (S) (T)	monoatomic, diatomic diatomic, monoatomic > 1 < 1 cannot say any thing Column II
	(A) (B) (C) (A)	Gas A is and gas B is P_A / P_B is n_A / n_B is Column I $In P = \frac{2}{3}E$, E is	(P) (Q) (R) (S) (T)	monoatomic, diatomic diatomic, monoatomic > 1 < 1 cannot say any thing Column II (P) Change in internal energy is only in isochoric proce
	(A) (B) (C) (A) (B)	Gas A is and gas B is P_A / P_B is n_A / n_B is Column I In $P = \frac{2}{3}E$, E is In U=3RT for an monoatomic gas U	(P) (Q) (R) (S) (T)	monoatomic, diatomic diatomic, monoatomic > 1 < 1 cannot say any thing Column II (P) Change in internal energy is only in isochoric proce (Q) Translational kinetic energy of unit volume
	(A) (B) (C) (A) (B) (C)	Gas A is and gas B is P_A / P_B is n_A / n_B is Column I In $P = \frac{2}{3}E$, E is In U=3RT for an monoatomic gas U In W = P(V_c - V_c), W is	(P) (Q) (R) (S) (T)	monoatomic, diatomic i diatomic, monoatomic > 1 < 1 cannot say any thing Column II (P) Change in internal energy is only in isochoric procession (Q) Translational kinetic energy of unit volume (R) Internal energy of one mole
	(A) (B) (C) (A) (B) (C) (D)	Gas A is and gas B is P_A / P_B is n_A / n_B is Column I In $P = \frac{2}{3}E$, E is In U=3RT for an monoatomic gas U In W = P(V_f - V_i), W is In $\Delta U = nC_i \Delta T, \Delta U$ is	(P) (Q) (R) (S) (T)	monoatomic, diatomic i diatomic, monoatomic 1





-2

THERMAL PROPERTIES OF MATTER

10. Four rods of material X and three rods of material Y are connected as shown in figure. All the rods are of identical lengths and cross-sectional area. Given thermal resistance of rod of material X, $R_x = R$ and thermal conductivities of materials are related by relation $K_Y = 2K_X$.



	Column I		Column II
(A)	Thermal resistance between B and E	(P)	$\frac{500}{13}$ °C
(B)	Thermal resistance between A and F	(Q)	$\frac{700}{13}$ °C
(C)	Temperature of junction B	(R)	$\frac{2R}{3}$
(D)	Temperature of junction D	(S)	$\frac{13R}{6}$

11. For a ideal monoatomic gas match the following graphs for constant mass in different processes (ρ = Density of gas)





If the liquid and gaseous phases of a pure substances are heated together in a closed container, both the temperature and the vapor pressure will increase until a point is reached at which the two phases can no longer be distinguished from one another. The temperature and pressure at which this occurs are called the critical temperature and pressure. Exceeding either of these parameters, by itself, will cause the gas/liquid phase transition to disappear. If the other variable is then changed as well, while the first variable is maintained above its critical point, a gradual transition will occur between the gaseous and liquid phases, with no clear boundary. (The liquid and solid phases, on the other hand, maintain a distinct boundary at all pressures above the triple point.) Shown in figure is a combined P–T phase diagram for materials A and B.

If heat is added to solids A and B, each in a container that is open to the atmosphere :-

(A) A will boil and B will melt

1.

(B) A will sublime and B will melt, then boil(D) Both A and B will first melt, then boil

►T(K)

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- (C) A will melt and B will sublime
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- 2. Which is true about the substances in figure ?
 - (A) At 2 atm pressure and 220 K temperature, A is a gas and B is solid
 - (B) At 6 atm pressure and 280 K temperature, A is a gas and B is a solid
 - (C) At 5 atm pressure and 100 K temperature, A is a gas and B is a solid
 - (D) At 4 atm pressure and 300 K temperature, both A and B are liquids

Comprehension #4

Consider a hypothetical situation where we are comparing the properties of two crystals made of atom A and atom B. Potential energy (U) v/s interatomic separation (R) graph for atom A and atom B is shown in figure (i) and (ii) and respectively.



- 1. Choose correct statement
 - (A) Volume of A and B expand on heating
 - (B) Volume of A and B contract on heating
 - (C) A expands on heating and B contracts on heating
 - (D) A contracts on heating and B expands on heating
- 2. When we heat the crystal of either atoms, the atom undergo oscillation. Choose correct statement for atoms of crystal A
 - (A) Their equilibrium position remains unchanged but average separation decreases
 - (B) Their equilibrium position remains unchanged but average separation increases
 - (C) Their separation at equilibrium position as well as average separation increases
 - (D) Their separation at equilibrium position decreases but average separation increases
- 3. It is seen that the potential energy can reach a maximum value of U_T at temperature T=10K. If r_1 and r_2 are 0.9999 r_0 and 1.0003 r_0 for atoms of crystal A, its approximate coefficient of linear expansion can be :-

(A) 4×10^{-5} /K (B) 1×10^{-5} /K (C) 2×10^{-5} /K (D) 3×10^{-5} /K

Comprehension #5

Solids and liquids both expand on heating. The density of substance decreases on expanding according to the relation

$$\rho_2 = \frac{\rho_1}{1 + \gamma (T_2 - T_1)}$$
, where, $\rho_1 \rightarrow$ density at T_1 , $\rho_2 \rightarrow$ density at T_2 , $\gamma \rightarrow$ coefficient of volume expansion of

substances.

When a solid is submerged in a liquid, liquid exerts an upward force on solid which is equal to the weight of liquid displaced by submerged part of solid.



Solid will float or sink depends on relative densities of solid and liquid.

A cubical block of solid floats in a liquid with half of its volume submerged in liquid as shown in figure (at temperature T)

- $\alpha_s \rightarrow \text{Coefficient of linear expansion of solid}$
- $\gamma_L \rightarrow \, \text{Coefficient}$ of volume expansion of liquid
- $\rho_s \rightarrow$ Density of solid at temperature T
- $\rho_L \rightarrow \text{Density of liquid at temperature T}$
- 1. The relation between densities of solid and liquid at temperature T is

(A)
$$\rho_s = 2\rho_L$$
 (B) $\rho_s = (1/2)\rho_L$ (C) $\rho_s = \rho_L$ (D) $\rho_s = (1/4)\rho_L$

- If temperature of system increases, then fraction of solid submerged in liquid

 (A) increases
 (B) decreases
 (C) remains the same
 (D) inadequate information
- 3. Imagine friction submerged does not change on increasing temperature the relation between γ_L and α_s is

(A) $\gamma_L = 3\alpha_s$ (B) $\gamma_L = 2\alpha_s$ (C) $\gamma_L = 4\alpha_s$ (D) $\gamma_L = (3/2)\alpha_s$

4. Imagine the depth of the block submerged in the liquid does not change on increasing temperature then

(A)
$$\gamma_L = 2\alpha$$
 (B) $\gamma_L = 3\alpha$ (C) $\gamma_L = (3/2)\alpha$ (D) $\gamma_L = (4/3)\alpha$

5. Assume block does not expand on heating. The temperature at which the block just begins to sink in liquid is

(A)
$$T + \frac{1}{\gamma_L}$$
 (B) $T + \frac{1}{(2\gamma_L)}$ (C) $T + \frac{2}{(\gamma_L)}$ (D) $T + \frac{\gamma_L}{2}$

Comprehension #6

Most substances contract on freezing. However, water does not belong to this category. We know that water expands on freezing. Further, coefficient of volume expansion of water in the temperature range from 0°C to 4°C is negative and above 4°C it is positive. This behaviour of water shapes the freezing of lakes as the atmospheric temperature goes down and it is still above 4°C.

1. As the atmospheric temperature goes down, but it is still above 4°C

(A) Cooled water at the surface flows downward because of its greater density

(B) Cooled water at the surface does not flow downward and remains at the surface because its smaller density

(C) Cooled water at the surface, through it remains on the surface because of its smaller density, will conduct heat from the interior to the atmosphere

(D) Cooled water at the surface flows to the bottom because of its smaller density

- 2. As the atmospheric temperature goes below 4°C
 - (A) Cooled water at the surface flows downward because of its greater density
 - (B) Cooled water at the surface does not flow downward and remains at the surface because of its smaller density
 - (C) Cooled water at the surface downward because of its smaller density
 - (D) Temperature of water in the lake reduces with depth
- 3. If the atmospheric temperature is below 0° C and ice begins to form at t = 0, thickness of ice sheet formed up to a time 't' will be directly proportional to a time 't' will be directly proportional to

(A) t^4 (B) t^2 (C) t (D) $t^{1/2}$





Gas A

Gas B

- 4. If the atmospheric temperature is below 0°C
 - (A) Ice will form from the bottom upward and the plants and animals in the lake will be displaced to the upper part of the lake.
 - (B) Ice will form in a random manner throughout the volume of the lake and with the passage of time, different segments of ice will join together to result in a collective ice mass
 - (C) Ice will form from the surface downward and plant and animal life will survive in the water beneath
 - (D) Water in the lake does not freeze. In fact, water in the atmosphere freezes and fall into the lake and floats on the surface of lake as ice.

Comprehension #7

Two closed identical conducting containers are found in the laboratory of an old scientist. For the verification of the gas some experiments are performed on the two boxes and the results are noted.

Experiment 1. When the two containers are weighed $W_A = 225$ g, $W_B = 160$ g and mass of evacuated container $W_c = 100$ g.

Experiment 2. When the two containers are given same amount of heat same temperature rise is recorded. The pressure change found are $\Delta P_A = 2.5$ atm. $\Delta P_B = 1.5$ atm

Required data for unknown gas :

Mono	He	Ne	Ar	Kr	Xe	Rd
(molar mass)	4g	20g	40g	84g	131g	222g
Dia	H_2	F_2	N ₂	0 ₂		
(molar mass)	2g	19g	28g	32g	71g	

1.	Identify the type of gas	filled in container A and	B respectively	
	(A) Mono, Mono	(B) Dia, Dia	(C) Mono, Dia	(D) Dia, Mono
2.	Identify the gas filled in	the container A and B		
	(A) N ₂ , Ne	(B) He, H ₂	(C) O_2 , Ar	(D) Ar, O ₂
3.	Total number of molecul	es in 'A' (Here N _A = avag	gadro number)	
	(A) $\frac{125}{64}$ N _A	(B) 3.125 N _A	(C) $\frac{125}{28}$ N _A	(D) 31.25 N _A
4	The initial internal energy	of the gas in container 'A' I	f the containers were at room	temperature 300K initially
	(A) 1406.25 cal	(B) 1000 cal	(C) 2812.5 cal	(D) None of these
5.	If the gases have initial te as the previous containe	emperature 300 K and they rs. Now the temperature	are mixed in an adiabatic c of the mixture is T and pr	ontainer having the same volume ressure is P. Then
	(A) $P > P_A$, $T > 300 K$		(B) $P > P_B$, $T = 300$ K	



(C) $P < P_A$, T = 300 K

(D) $P > P_A$. T < 300 K

Comprehension #8

In a home experiment, Ram brings a new electric kettle with unknown power rating. He puts 1 litre water in the kettle and switches on. But to his dismay, the temperature becomes constants at 60° C after some time. The room temperature is 20° C. Ram gets bored and switches off the kettle. He sees that during first 20 s water cools down by 2° C.

1. Which is the best graph for temperature v/s time?



Comprehension #9

Five moles of helium are mixed with two moles of hydrogen to form a mixture. Take molar mass of helium $M_1=4g$ and that of hydrogen $M_2=2g$

- The equivalent molar mass of the mixture is 1. **(B)** $\frac{13 \text{ g}}{7}$ 189 (A) 6g (D) None 2. The equivalent degree of freedom f of the mixture is (D) None (A) 3.57 **(B)** 1.14 (C) 4.4 3. The equivalent value of γ is **(B)** 1.53 (C) 1.56 (A) 1.59 (D) None
- 4. If the internal energy of He sample is 100J and that of the hydrogen sample is 200J, then the internal energy of the mixture is
 (A) 900 J
 (B) 128.5 J
 (C) 171.4J
 (D) 300J

Comprehension #10

Two rods of equal cross sections area are joined end the end as shown in figure. These are supported between two rigid vertical walls. Initially the rods are unstrained.

1. If temperature of system is increased by ΔT then junction will not shift if-

(A)
$$Y_1 \alpha_1 = Y_2 \alpha_2$$
 (B) $Y_1 \alpha_1 \bullet_1 = Y_2 \alpha_2 \bullet_2$ **(C)** $\alpha_1 = \alpha_2$ **(D)** $Y_2 \alpha_1 \bullet_1 = Y_1 \alpha_2 \bullet_2$

- If temperature of system is increased by ΔT then thermal stress developed in first rod–
 - (A) is equal to thermal stress developed in second rod
 - (B) is greater than thermal stress developed in second rod
 - (C) is less than thermal stress developed in second rod
 - (D) None of these



2.

2.

3.

3. If temperature of system is increased by ΔT then shifting in junction if $Y_1 \alpha_1 > Y_2 \alpha_2$ is given by-

(A)
$$\frac{l_1 l_2 (Y_1 \alpha_2 - Y_2 \alpha_1)}{Y_1 l_1 + Y_2 l_2}$$
 (B) $\frac{l_1 l_2 (Y_1 \alpha_1 - Y_2 \alpha_2)}{Y_1 l_2 + Y_2 l_1}$ (C) $\frac{l_1 l_2 (Y_1 \alpha_1 - Y_2 \alpha_2)}{Y_1 l_1 + Y_2 l_2}$ (D) None of these

Comprehension #11

Refrigerator is an apparatus which takes heat from a cold body, work is done on it and the work done together with the heat absorbed is rejected to the source. An ideal refrigerator can be regarded as Carnot's ideal heat engine working in the reverse direction. The coefficient of performance of refrigerator is defined as

$$\beta = \frac{\text{Heat extracted from cold reservoir}}{\text{work done on working subs tan ce}} = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2} = \frac{T_2}{T_1 - T_2}$$

$$\sum_{\substack{\text{source}\\T_1}} \frac{Q_1}{\text{working}} \frac{Q_2}{U_1 - U_2} = \frac{S_2}{U_1 - U_2}$$
A Carnot's refrigerator takes heat from water at 0°C and discards it to a r

A Carnot's refrigerator takes heat from water at 0° C and discards it to a room temperature at 27° C. 1kg of water at 0° C is to be changed into ice at 0° C. (L_{ice} = 80 kcal/kg)

- 1.How many calories of heat are discarded to the room ?(A) 72.8 kcal(B) 87.9 kcal(C) 80 kcal(D) 7.9 kcal
- 2. What is the work done by the refrigerator in this process (1 cal = 4.2 joule)(A) 7.9 kJ (B) 33.18 kJ (C) 43.18 kJ (D) 23.18 kJ
- 3. What is the coefficient of performance of the machine ? (A) 11.1 (B) 10.1 (C) 9.1 (D) 8.1

Comprehension #12

Entropy (S) is a thermodynamic variable like pressure P, volume V and temperature T. Entropy of a thermodynamic system is a measure of disorder of molecular motion. Greater is disorder, greater is entropy. Change in entropy of a thermodynamic system is the ratio of heat supplied to absolute temperature. In an adiabatic reversible process, entropy remains constant while in any irreversible process entropy increases. In nature the processes are irreversible; therefore entropy of universe is continuously increasing.

1.	The unit of entropy	in S–I system is–		
	(A) cal/K	(B) joule/kg	(C) joule/K	(D) kilocal/°C
2.	When milk is heated	d, its entropy :		
	(A) increases	(B) decreases	(C) remains unchanged	(D) may decrease or increase

- After a long-long time, the energy available for work will be :
 (A) as much as present value
 (B) much less than preser
 - (C) much more than present value
- (B) much less than present value(D) can not say
- iore than present value

Comprehension #13

A substance is in the solid form at 0°C. The amount of heat added to this substance and its temperature is plotted in the graph. The specific heat capacity of the solid substance is $0.5 \text{ cal/g}^{\circ}C$.

1.	The mass of the subst	ance is-		
	(A) 6g	(B) 12g	(C) 3g	(D) Can't be calculated
2.	Latest heat capacity in	n melting process is-		
	(A) cal/g	(B) 175/3 cal/g	(C) 400/3 cal/g	(D) Can't say
3.	Specific heat capacity	in the liquid state is-		
	(A) 5/27 cal/g°C	(B) 5/27 cal/gK	(C) 10/27 cal/g°C	(D) Can't say



Comprehension #14

A cyclic process for an ideal gas is shown in figure. Given $W_{AB} = +700 \text{ J}$, $W_{BC} = +400 \text{ J}$, $Q_{CA} = -100 \text{ J}$.



Comprehension #15

The efficiency of a heat engine is defined as the ratio of the mechanical work done by the engine in one cycle to the heat absorbed from the high temperature

source.
$$\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$$
 Cornot devised an ideal engine which is based on

a reversible cycle of four operations in succession : isothermal expansion, adiabatic expansion, isothermal compression and adiabatic compression.

For carnot cycle $\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$. Thus $\eta = \frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1}$ According to carnot theorem "No irreversible engine

working

can have efficiency greater than carnot reversible engine working between same hot and cold reservoirs".



1. A carnot engine whose low temperature reservoir is at 7°C has an efficiency of 50%. It is desired to increase the efficiency to 70%. By how many degrees should the temperature of the high temperature reservoir be increased?

(A) 273 K (B)
$$\frac{1120}{3}$$
 K (C) 140 K (D) None of these

2. An inventor claims to have developed an engine working between 600K and 300K capable of having an efficiency of 52%, then-

(A) It is impossible (B) It is possible (C) It is nearly possible (D) Data is insufficient

- 3. Efficiency of a carnot's cycle change from $\frac{1}{6}$ to $\frac{1}{3}$ when source temperature is raised by 100 K. The temperature of the sink is-
 - (A) $\frac{1000}{3}$ K (B) $\frac{500}{3}$ K (C) 250 K (D) 100 K



Exercise # 4

[Subjective Type Questions]

- 1. A bimetallic strip of thickness d and length L is clamped at one end at temperature t_1 . Find the radius of curvature of the strip if it consists of two different metals of expansivity α_1 and α_2 ($\alpha_1 > \alpha_2$) when its temperature rises to t_2° C.
- 2. Two rods each of length L_2 and coefficient of linear expansion α_2 each are connected freely to a third rod of length L_1 and coefficient of expansion α_1 to form an isosceles triangle. The arrangement is supported on a knife-edge at the midpoint of L_1 which is horizontal. What relation must exist between L_1 and L_2 so that the apex of the isosceles triangle is to remain at a constant height from the knife edge as the temperature changes?
- 3. Two metal cubes with 3 cm–edges of copper and aluminium are arranged as shown in figure. Find



(i) The total thermal current from one reservoir to the other.

(ii) The ratio of the thermal current carried by the copper cube to that carried by the aluminium cube.

Thermal conductivity of copper is 60 W/m–K and that of aluminium is 40 W/m–K.

- 4. A 'thermacole' icebox is a cheap and efficient method for storing small quantities of cooked food in summer in particular. A cubical icebox of side 30 cm has a thickness of 5.0 cm. If 4.0 kg of ice is put in the box, estimate the amount of ice remaining after 6 h. The outside temperature is 45 °C, and co–efficient of thermal conductivity of thermacole is 0.01 J s⁻¹ m¹ °C⁻¹. [Heat of fusion of water = 335×10^3 J kg⁻¹]
- 5. Calculate θ_1 and θ_2 in shown situation.



6. A lagged stick of cross section area 1 cm² and length 1m is initially at a temperature of 0°C. It is then kept between 2 reservoirs of temperature 100° C and 0° C. Specific heat capacity is 10 J/kg° C and linear mass density is 2 kg/m. Find

(i) Temperature gradient along the rod in steady state

- (ii) Total heat absorbed by the rod to reach steady state
- 7. The figure shows the face and interface temperature of a composite slab containing of four layers of two materials having identical thickness. Under steady state condition, find the value of temperature θ .



8.





9. Calculate the temperature of the black body from given graph.



- 10. In an industrial process 10 kg of water per hour is to be heated from 20°C to 80°C. To do this, steam at 150°C is passed from a boiler into a copper coil immersed in water. The steam condenses in the coil and is returned to the boiler as water at 90°C. How many kg of steam are required per hour? Specific heat of steam = 1 kilocal kg⁻¹ °C⁻¹. Latent heat of steam = 540 kilocal kg¹.
- 11. Two bodies A and B have thermal emissivities of 0.01 and 0.81 respectively. The outer surface areas of the two bodies are same, the two bodies emit total radiant power at the same rate. The wavelength $\lambda_{\rm B}$ corresponding to maximum spectral radiance from B is shifted from the wavelength corresponding to maximum spectral radiancy in the radiation from A by 1.0 μ m. If the temperature of A is 5802K, Calculate :-
 - (i) The temperature of (ii) Wavelength $\lambda_{\rm B}$

12. Answer the following questions in brief :

- (i) A poor emitter has a large reflectivity. Explain why.
- (ii) A copper tumbler feels much colder than a wooden block on a cold day. Explain why.
- (iii) The earth would become so cold that life is not possible on it in the absence of the atmosphere. Explain why?
- (iv) Why clear nights are cooler than cloudy nights ?
- (v) Why does a piece of red glass when heated and taken out glow with green light?
- (vi) Why does the earth not become as hot as the sun although it has been receiving heat from the sun for ages ?
- (vii) Animals curl into a ball when they are very cool. Why?
- (viii) Heat is generated continuously in an electric heater but its temperature becomes constant after some time. Explain why?
- (ix) A piece of paper wrapped tightly on a wooden rod is observed to get charred quickly when held over a flame as compared to a similar piece of paper when wrapped on a brass rod. Explain why?
- (x) Liquid in a metallic pot boils quickly whose base is made black and rough than in a pot whose base is highly polished. Why ?
- 13. The temperature of equal masses of three different liquids A, B and C are 12°C, 19°C and 28°C respectively. The temperature when A and B are mixed is 16°C and when B and C are mixed it is 23°C. What will be the temperature when A and C are mixed?
- 14. Aluminium container of mass 10 g contains 200 g of ice at -20° C. Heat is added to the system at the rate of 100 calories per second. What is the temperature of the system after four minutes? Draw a rough sketch showing the variation of the temperature of the system as a function of time. Given :

Specific heat of ice = $0.5 \text{ cal } \text{g}^{-1} (^{0}\text{C})^{-1}$

Specific heat of aluminium = $0.2 \text{ cal } \text{g}^{-1} (^{0}\text{C})^{-1}$

Latent heat of fusion of ice = 80 cal g⁻¹

15. The temperature of 100 g of water is to be raised from 24°C to 90°C by adding steam to it. Calculate the mass of the steam required for this purpose.



- 16. A lead bullet just melts when stopped by an obstacle. Assuming that 25 percent of the heat is absorbed by the obstacle, find the velocity of the bullet if its initial temperature is 27°C. (Melting point of lead = 327°C, Specific heat of lead = 0.03 cal/g°C, Latent heat of fusion of lead = 6 cal/g, J = 4.2 J/cal.
- 17. Answer the following questions based on the P–T phase diagram of carbon dioxide



- (i) At what temperature and pressure can the solid, liquid and vapour phases of CO_2 co-exist in equilibrium
- (ii) What is the effect of decrease of pressure on the fusion and boiling point of CO_2 ?
- (iii) What are the critical temperature and pressure for CO_2 ? What is their significance?
- (iv) Is CO_2 solid, liquid or gas at (A) -70 °C under 1 atm, (B) 60 °C under 10 atm, (C) 15 °C under 56 atm?
- 18. A thin tube of uniform cross-section is sealed at both ends. It lies horizontally, the middle 5 cm containing mercury and the two equal ends containing air at the same pressure P. When the tube is held at an angle of 60° with the vertical direction, the length of the air column above and below the mercury column are 46 cm and 44.5 cm respectively. Calculate the pressure P in centimetres of mercury. (The temperature of the system is kept at 30°C).
- 19. Two glass bulbs of equal volume are connected by a narrow tube and are filled with a gas at 0°C and a pressure of 76 cm of mercury. One of the bulbs is then placed in melting ice and the other is placed in a water bath maintained at 62°C. What is the new value of the pressure inside the bulbs ? The volume of the connecting tube is negligible.
- 20. An oxygen cylinder of volume 30 litres has an initial gauge pressure of 15 atm and a temperature of 27° C. After some oxygen is with drawn from the cylinder, the gauge pressure drops to 11 atm and its temperature drops to 17°C. Estimate the mass of oxygen taken out of the cylinder. ($R = 8.31 \text{ J} \text{ mol}^{-1} \text{ K}^{-1}$, molecular mass of $O_2 = 32 \text{ u}$.)
- 21. A closed container of volume 0.2 m³ contains a mixture of neon and argon gases, at a temperature of 27°C and pressure of 1×10^5 Nm⁻². The total mass of the mixture is 28 g. If the molar masses of neon and argon are 20 and 40 g mol⁻¹ respectively, find the masses of the individual gases in the container assuming them to be ideal (Universal gas constant R = 8.314 J/mol-K).
- 22. For a gas $\frac{R}{C_P} = 0.4$. For this gas calculate the following (i) Atomicity and degree of freedom (ii) Value of C_v and γ

(iii) Mean gram - molecular kinetic energy at 300 K temperature

23. Figure shows plot of PV/T versus P for 1.00×10^{-3} kg of oxygen gas at two different temperatures.



- (i) What does the dotted plot signify ?
- (ii) Which is true. $T_1 > T_2$ or $T_1 < T_2$?
- (iii) What is the value of PV/T where the curves meet on the y-axis?



24. An ideal gas is enclosed in a tube and is held in the vertical position with the closed end upward. The length of the pellet of mercury entrapping the gas is h = 10 cm and the length of the tube occupied by gas is $\bullet = 40$ cm. Calculate the length occupied by the gas when it is turned



through $\theta = 60^{\circ}$ and 90°. Atmospheric pressure, H = 76 cm of mercury.

- One gram mole of oxygen at 27°C and one atmospheric pressure is enclosed in a vessel. (i) Assuming the 25. molecules to be moving with v_{ms} , find the number of collisions per second which the molecules make with one square metre area of the vessel wall. (ii) The vessel is next thermally insulated and moved with a constant speed v_o. It is then suddenly stopped. The process results in a rise of the temperature of the gas by 1°C. Calculate the speed v_0 .
- 26. Two moles of helium gas undergo a cyclic process as shown in figure. Assuming the gas to be ideal, calculate the following quantities in this process.
 - (i) The net change in the heat energy. (ii) The net work done (iii) The net change in internal energy
- 27. A sample of 2 kg monoatomic helium (assumed ideal) is taken from A to C through the process ABC and another sample of 2 kg of the same gas is taken through the process ADC (see fig). Given molecular mass of helium = 4.



10⁴ |

(i) What is the temperature of helium in each of the states A, B, C and D?

(ii) Is there any way of telling afterwards which sample of helium went through the process ABC and which went through the process ADC ? Write Yes and No.

(iii) How much is the heat involved in the process ABC and ADC ?

Examine the following plots and predict whether in (i) $P_1 < P_2$ and $T_1 > T_2$, in (ii) $T_1 = T_2 < T_3$, in(iii) $V_1 > V_2$, in(iv) $P_1 > T_2$ 28. $P_{2} \text{ or } P_{2} > P_{1}$



- 29. The pressure in monoatomic gas increases linearly from 4×10^5 N/m² to 8×10^5 N/m² when its volume increases from 0.2 m³ to 0.5 m³. Calculate the following -
 - (i) Work done by the gas (ii) Increase in internal energy
 - (iii) Amount of heat supplied (iv) Molar specific heat of the gas
- In the given figure an ideal gas changes its state from A to state C by two paths ABC and AC. 30.



Find the path along which work done is the least. **(i)** (ii) The internal energy of gas at A is 10J and amount of heat supplied to change its state to C through the path AC is 200J. Calculate the internal energy at C. (iii) The internal energy of gas at state B is 20J. Find the amount of heat supplied to the gas from A to B.



- 31. Three moles of an ideal gas ($C_p = \frac{7}{2}R$) at pressure, P_A and temperature T_A is isothermally expanded to twice its initial volume. It is then compressed at constant pressure to its original volume. Finally gas is compressed at constant volume to its original pressure P_A .
 - (i) Sketch P-V and P-T diagrams for the complete process.
 - (ii) Calculate the net work done by the gas, and net heat supplied to the gas during the complete process.
- 32. On mole of a monoatomic ideal gas is taken through the cycle shown in figure. $A \rightarrow B$: Adiabatic expansion $B \rightarrow C$: Cooling at constant volume $C \rightarrow D$: Adiabatic compression $D \rightarrow A$: Heating at constant volume The pressure and temperature at A, B, etc., are denoted by P_A , T_A , P_B , T_B etc.,

respectively. Given that $T_A = 1000$ K, $P_B = \left(\frac{2}{3}\right)P_A$ and $P_C = \left(\frac{1}{3}\right)P_A$.

Calculate the following quantities : (i) The work done by the gas in the process $A \rightarrow B$ (ii) The heat lost by

the gas in the process B \rightarrow C (iii) The temperature T_D. (Given : $\left(\frac{2}{3}\right)^{2/5} = 0.85$)

- 33. At 27°C two moles of an ideal monoatomic gas occupy a volume V. Then gas is adiabatically expanded until its volume becomes 2V. Calculate : (i) The final temperature of the gas (ii) Change in its internal energy (iii) The work done by the gas during this process
- 34. Two moles of helium gas ($\gamma = 5/3$) are initially at temperature 27°C and occupy a volume of 20 L. 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. (i) Sketch the process on a P–V diagram (ii) What are the final volume and pressure of the gas ? (iii) What is the work done by the gas ?
- 35. An ideal gas having initial pressure P, volume V and temperature T is allowed to expand adiabatically until its volume becomes 5.66 V while its temperature falls to $\frac{T}{2}$. (i) How many degrees of freedom do gas molecules have? (ii) Obtain the work done by the gas during the expansion as a function of the initial pressure P and volume V. [Take (5.66)^{0.4}=2]
- 36. Calculate the work done when one mole of a perfect gas is compressed adiabatically. The initial pressure and volume of the gas are 10^5 N/m^2 and 6L respectively. The final volume of the gas is 2L, molar specific heat of the gas at constant volume is $\frac{3R}{2}$.
- 37. An ideal gas has a specific heat at constant pressure $C_p = \frac{5R}{2}$. The gas is kept in a closed vessel of volume 0.0083 m³, at a temperature of 300 K and a pressure of 1.6×10^6 N/m². An amount of 2.49×10^4 J of heat energy is supplied to the gas. Calculate the final temperature and pressure of the gas.
- 38. An ideal gas is taken through a cyclic thermodynamic process through four steps. The amounts of heat involved in these steps are $Q_1 = 5960 \text{ J}$, $Q_2 = -5585 \text{ J}$, $Q_3 = -2980 \text{ J}$ and $Q_4 = 3645 \text{ J}$ respectively. The corresponding quantities of work involved are $W_1 = 2200 \text{ J}$, $W_2 = -825 \text{ J}$, $W_3 = -1100 \text{ J}$ and W_4 respectively. (i) Find the value of W_4 . (ii) What is the efficiency of the cycle ?
- 39. A gaseous mixture enclosed in a vessel of volume V consists of one gram mole of gas A with

$$=\frac{C_{P}}{C_{V}}=\frac{5}{3}$$
) an another gas B with $\gamma=\frac{7}{5}$ at a certain temperature T. The gram molecular weights of the

gases A and B are 4 and 32 respectively. The gases A and B do not react with each other and are assumed to be ideal. The gaseous mixture follows the equation $PV^{19/13} = constant$, in adiabatic process. Find the number of gram moles of the gas B in the gaseous mixture.



γ

40. One mole of monoatomic ideal gas undergoes a process ABC as shown in figure. The maximum temperature of the



- 41. A gas has molar heat capacity C = 37.35 J mole⁻¹K⁻¹ in the process PT = constant. Find the number of degree of freedom of molecules in the gas.
- 42. P-V graph for an ideal gas undergoing polytropic process PV^m = constant is shown here. Find the value of m.



- **43.** An ideal monoatomic gas occupies volume 10–3 m3 at temperature 3K and pressure 103 Pa. The internal energy of the gas is taken to be zero at this point. It undergoes the following cycle : The temperature is raised to 300 K at constant volume, the gas is then expanded adiabatically till the temperature is 3K, followed by isothermal compression to the original volume. Plot the process on a PV diagram. Calculate (i) The work done and the heat transferred in each process and the internal energy at the end of each process, (ii) The thermal efficiency of the cycle.
- 44. A vertical cylinder of cross-sectional area 0.1 m² closed at both ends is fitted with a frictionless piston of mass M dividing the cylinder into two parts. Each part contains one mole of an ideal gas in equilibrium at 300K. The volume of the upper part is 0.1 m³ and that of the lower part is 0.05 m³. What force must be applied to the piston so that the volumes of the two parts remain unchanged when the temperature is increased to 500K?
- 45. One mole of an ideal gas is heated isobarically from the freezing point to the boiling point of water each under normal pressure. Find out the work done by the gas and the change in its internal energy. The amount of heat involved is 1kJ.
- 46. An ideal gas at NTP is enclosed in a adiabatic vertical cylinder having area of cross section $A = 27 \text{ cm}^2$, between two light movable pistons as shown in the figure. Spring with force constant k = 3700 N/m is in a relaxed state initially. Now the lower piston is moved upwards a height $\frac{h}{2}$, being the initial length of gas column. It is observed that the upper piston moves up by a distance $\frac{h}{2}$. Find

the initial length of gas column. It is observed that the upper piston moves up by a distance $\frac{n}{16}$. Find h taking γ for the gas to be 1.5. Also find the final temperature of the gas.



47. There is a soap bubble of radius 2.4×10^{-4} m in air cylinder which is originally at the pressure of 10^5 Nm⁻². The air in the cylinder is now compressed isothermally until the radius of the bubble is halved. Calculate now the pressure of air in the cylinder. The surface tension of the soap film is 0.08 N/m.



THERMAL PROPERTIES OF MATTER

48. An ideal monoatomic gas is confined in a cylinder by a spring-located position of cross-section 8.0×10^{-3} m². Initially the gas is at 300 K and occupies a volume of 2.4×10^{-3} m³ and the spring is in its relaxed (unstretched, uncompressed) state. The gas is heated by a small electric heater until the piston moves out slowly by 0.1 m. Calculate the final temperature of the gas and the heat supplied (in joules) by the heater.



The force constant of the spring is 8000 N/m, and the atmospheric pressure 1.0×10^5 Nm⁻². The cylinder and the piston are thermally insulated. The piston is massless and there is no friction between the piston and the cylinder. Neglect heat loss through the lead wires of the heater. The heat capacity of the heater coil is negligible. Assume the spring to the massless.

49. The rectangular box shows in figure has a partition which can slide without friction along the length of the box. Initially each of the two chambers of the box has one mole of a monoatomic ideal gas ($\gamma = 5/3$) at a pressure P₀, volume V₀ and temperature T₀. The chamber on the left is slowly heated by an electric heater. The walls of the box and the partition are

thermally insulated. Heat loss through the lead wires of the heater is negligible. The gas in the left chamber expands

pushing the partition until the final pressure in both chambers becomes $\frac{243P_0}{32}$. Determine (i) the final temperature

of the gas in each chamber and (ii) the work done by the gas in the right chamber.

50. One mole of a diatomic ideal gas ($\gamma = 1.4$) is taken through a cyclic process starting from point A. The process A \rightarrow B is an adiabatic compression. B \rightarrow C is isobaric expansion, C \rightarrow D an adiabatic expansion and D \rightarrow A is isochoric. The

volume ratio are $\frac{V_A}{V_B} = 16$ and $\frac{V_C}{V_D} = 2$ and the temperature at A is $T_A = 300$ K. Calculate the temperature of the gas at

the points B and D and find the efficiency of the cycle.

- 51. A cylindrical block of length 0.4 m and area of cross-section 0.04 m² is placed coaxially on a thin metal disc of mass 0.4 kg and of the same cross-section. The upper face of the cylinder is maintained at a constant temperature of 400 K and the initial temperature of the disc is 300 K. If the thermal conductivity of the material of the cylinder is 10 V/mK and the specific heat capacity of the material of the disc is 600 J/kg-K, how long will it take for the temperature of the disc of increase to 350 K? Assume, for purposes of calculation, the thermal conductivity of the disc to be very high and the system to be thermally insulated except for the upper face of the cylinder.
- 52. A double-pane window used for insulating a room thermally from outside consists of two glass sheets each of area 1 m² and thickness 0.01 m separated by a 0.05 m thick stagnant air space. In the steady state, the room glass interface and the glass-outdoor interface are at constant temperatures of 27°C and 0°C respectively. Calculate the rate of heat flow through the window pane. Also find the temperatures of other interfaces. Given thermal conductivities of glass and air as 0.8 and 0.08 W m⁻¹K⁻¹ respectively.
- 53. The apparatus shown in figure consists of four glass columns connected by horizontal sections. The height of two central columns B and C are 49 cm each. The two outer columns A and D are open to the atmosphere. A and C are maintained at a temperature of 95°C while the columns B and D are maintained at 5°C. The height of the liquid in A and D measured from the base line are 52.8 cm and 51 cm respectively. Determine the coefficient of thermal expansion of the liquid.







droplets move if the flask 1 is heated by 2°C while flask 2 is cooled by 2°C. Ignore any expansion of flask wall.

- 56. A weightless piston divides a thermally insulated cylinder into two parts of volumes V and 3V.2 moles of an ideal gas at pressure P=2 atmosphere are confined to the part with volume V=1 litre. The remainder of the cylinder is evacuated. The piston is now released and the gas expands to fill the entire space of the cylinder. The piston is then pressed back to the initial position. Find the increase in internal energy in the process and final temperature of the gas. The ratio of the specific heat of the gas $\gamma = 1.5$.
- 57. Two moles of an ideal monoatomic gas are confined within a cylinder by a massless and frictionless spring loaded piston of cross-sectional area 4×10^{-3} m². The spring is, initially in its relaxed state. Now the gas is heated by an electric heater, placed inside the cylinder, for some time. During this time, the gas expands and does 50 J of work in moving the piston through a distance 0.10 m. The temperature of the gas increases by 50 K. Calculate the spring constant and the heat supplied by the heater.
- 58. A barometer is faulty. When the true barometer reading are 73 cm and 75 cm of Hg, the faulty barometer reads 69 cm and 70 cm respectively (i) What is the total length of the barometer tube? (ii) What is the true reading when the faulty barometer reads 69.5 cm? (iii) What is the faulty barometer reading when the true barometer reads 74 cm?
- 59. Two vertical cylinders are connected by a small tube at the bottom. It contains a gas at constant temperature. Initially the pistons are located at the same height. The diameters of the two cylinders are different. Outside the cylinder the space is vacuum. Gravitational acceleration is g. $h_0 = 20$ cm, $m_1 = 2$ kg and $m_2 = 1$ kg. The pistons are initially in equilibrium. If the masses of the piston are interchanged find the separation between the two pistons when they are again in equilibrium. Assume constant temperature.



conductivity as shown in figure. These parts contains H₂, He and CO₂ gas at initial temp. $\theta_1 = 372^{\circ}$ C, $\theta_2 = -15^{\circ}$ C

and $\theta_3 = 157^{\circ}$ C respectively. If initial length and pressure of each part are 1 and P₀ respectively, calculate final pressure and length of each part. Use : $\gamma_{CO_2} = 7/5$.

- 61. An ideal diatomic gas undergoes a process in which its internal energy relates to the volume as $U=a\sqrt{V}$, where a is a constant. (i) find the work performed by the gas and the amount of heat to be transferred to this gas to increase its internal energy by 100J. (ii) find the molar specific heat of the gas for this process.
- 62. The figure shows an insulated cylinder divided into three parts, A, B & C. Pistons I and II are connected by a rigid rod and can move without friction inside the cylinder. Piston I is perfectly conducting while piston II is perfectly insulating. The initial state of the gas ($\gamma = 1.5$) present in each compartment A, B and C is as shown. Now, compartment A is slowly given heat through a heater H







в

 P_0, V_0, T_0

 P_0, V_0, T_0

С

 P_0, V_0, T_0

Ex	xercise # 5	Part # I Frevi	ous Year Questions] [A	MEEE/JEE-MAIN]
		KTG CAL	DRIMETRV	
1.	Cooking gas containers ar will-	e kept in a lorry moving wit	h uniform speed. The temp	erature of the gas molecules inside [AIEEE - 2002]
	(1) increase		(2) decrease	
	(3) remains same		(4) decrease for some, where the source of t	hile increase for others
2.	At what temperature is th	e rms velocity of a hydroge	en molecule equal to that of	f an oxygen molecules at 47° C? [AIEEE-2002]
	(1) 80 K	(2) –73 K	(3) 3 K	(4) 20 K
3.	1 mole of a gas with $\gamma = 7/$	5 is mixed with 1 mole of a	gas with $\gamma = 5/3$, then the va	lue of γ for the resulting mixture is [AIEEE-2002]
	(1) 7/5	(2) 2/5	(3) 24/16	(4) 12/7
4.	During an adiabatic proce The ratio C_p/C_V for the g	ss, the pressure of a gas is fo as is-	ound to be proportional to th	e cube of its absolute temperature. [AIEEE -2003]
	(1) 4/3	(2) 2	(3) 5/3	(4) 3/2
5.	One mole of ideal monoator ? γ denotes the ratio of sp (1) $3/2$	pomic gas ($\gamma = 5/3$) is mixed w pecific heat at constant pre (2) 23/15	vith one mole of diatomic gas ssure, to that at constant ve (3) 35/23	s ($\gamma = 7/5$). What is γ for the mixture olume - [AIEEE - 2004] (4) 4/3
6.	A gaseous mixture consis	tts of 16 g of helium and 16	g of oxygen. The ratio $\frac{C_p}{C_y}$	of the mixture is-
	(1) 1.59	(2) 1.62	(3) 1.4	(4) 1.54
7.	If C_p and C_V denote the respectively, then-	e specific heats of nitrogen	n per unit mass at constan	nt pressure and constant volume [AIEEE - 2007]
	(1) $C_P - C_V = R/28$	(2) $C_{\rm P} - C_{\rm V} = R/14$	(3) $C_P - C_V = R$	(4) $C_p - C_V = 28 R$
8.	An insulated container of volume V_1 and contains id ideal gas at pressure P_2 are equilibrium temperature of	f gas has two chambers sep leal gas at pressure P_1 and te d tempeature T_2 . If the part of the gas in the container w	parated by an insulating parated by an insulating paratement T_1 . The other charition is removed without do ill be-	artition. One of the chambers has amber has volume V_2 and contains bing any work on the gas, the final [AIEEE - 2008]
	(1) $\frac{T_1 T_2 (P_1 V_1 + P_2 V_2)}{P_1 V_1 T_2 + P_2 V_2 T_1}$	(2) $\frac{P_1V_1T_1 + P_2V_2T_2}{P_1V_1 + P_2V_2}$	(3) $\frac{P_1V_1T_2 + P_2V_2T_1}{P_1V_1 + P_2V_2}$	(4) $\frac{T_1 T_2 (P_1 V_1 + P_2 V_2)}{P_1 V_1 T_1 + P_2 V_2 T_2}$
9.	The speed of sound in oxy	gen (O_2) at a certain tempeat	ture is 460 ms ⁻¹ . The speed of	of sound in helium (He) at the same
	temperature will be (assur	me both gases to be ideal)		[AIEEE - 2008]

(1) 460
$$\sqrt{\frac{200}{21}}$$
 ms⁻¹ (2) 500 $\sqrt{\frac{200}{21}}$ ms⁻¹ (3) 650 $\sqrt{2}$ ms⁻¹ (4) 330 $\sqrt{2}$ ms⁻¹



- 10.One kg of a diatomic gas is at a pressure of 8×10^4 N/m². The density of the gas is 4 kg/m³. What is the energy
of the gas due to its thermal motion ?[AIEEE 2009](1) 6×10^4 J(2) 7×10^4 J(3) 3×10^4 J(4) 5×10^4 J
- 11.
 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) : [AIEEE 2011]

 (1) 84 kJ
 (2) 2.1 kJ
 (3) 4.2 kJ
 (4) 8.4 kJ
- 12. Three perfect gases at absolute temperatures T_1 , T_2 and T_3 are mixed. The masses of molecules are m_1 , m_2 , and m_3 and the number of molecules are n_1 , n_2 and n_3 respectively. Assuming no loss of energy, then final temperature of the mixture is :- [AIEEE 2011]

(1)
$$\frac{n_1 T_1^2 + n_2 T_2^2 + n_3 T_3^2}{n_1 T_1 + n_2 T_2 + n_3 T_3}$$
 (2) $\frac{n_1^2 T_1^2 + n_2^2 T_2^2 + n_3^2 T_3^2}{n_1 T_1 + n_2 T_2 + n_3 T_3}$ (3) $\frac{T_1 + T_2 + T_3}{3}$ (4) $\frac{n_1 T_1 + n_2 T_2 + n_3 T_3}{n_1 + n_2 + n_3}$

13. 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 20°K to 4°K by a special refrigerator operating at room temperature (27°C). The amount of work required to cool the vessel is:(1) equal to 0.002 kJ
(2) greater than 0.148 kJ

```
(3) between 0.148 kJ and 0.028 kJ
```

(2) greater than 0.148 k.(4) less than 0.028 kJ

 $\frac{T}{2}$

[AIEEE - 2002]

14. 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 :- [AIEEE - 2011]

(1)
$$\frac{P}{2}$$
, T (2) $\frac{P}{2}$, $\frac{T}{2}$ (3) P, T (4) P,

THERMODYNAMICS

15. Which statement is incorrect ?

- (1) All reversible cycles have same efficiency
- (2) Reversible cycle has more efficiency than an irreversible one
- (3) Carnot cycle is a reversible one
- (4) Carnot cycle has the maximum efficiency in all cycles

16.	If mass-energy equivalence is taken into account,	when water is cooled to for	m ice, the mass of water should- [AIEEE - 2002]
	(1) increase (2) remain unchanged	(3) decrease	(4) first increase then decrease
17.	Even carnot engine cannot give 100% efficiency	because we cannot-	[AIEEE - 2002]
	(1) prevent radiation	(2) find ideal sources	
	(3) reach absolute zero temperature	(4) eliminate friction	
18.	"Heat cannot be itself flow from a body at lower	temperature to a body at hi	gher temperature" is a statement
	or consequence of-		[AIEEE - 2003]
	(1) second law of thermodynamics	(2) conservation of mor	nentum

- (3) conservation of mass (4) first law of thermodynamics
- 19.Which of the following parameters does not characterise the thermodynamic state of matter ?[AIEEE 2003](1) Temperature(2) Pressure(3) Work(4) Volume



20. A carnot engine takes 3×10^6 cal of heat from a reservoir at 627 °C and gives it to a sink at 27 °C. The work done by the engine is-[AIEEE - 2003] (2) $8.4 \times 10^6 \text{ J}$ (4) zero

(1) 4.2×10^6 J

(3) 16.8×10^6 J

21. 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
- 22. Two thermally insulated vessels 1 and 2 are filled with air at temperatures (T_1, T_2) , volume (V_1, V_2) and pressure (P_1, P_2) respectively. If the valve joining the two vessels is opened, the temperature inside the vessel at equilibrium will be-[AIEEE-2004]

(1)
$$T_1 + T_2$$
 (2) $\frac{(T_1 + T_2)}{2}$ (3) $\frac{T_1 T_2 (P_1 V_1 + P_2 V_2)}{P_1 V_1 T_2 + P_2 V_2 T_1}$ (4) $\frac{T_1 T_2 (P_1 V_1 + P_2 V_2)}{P_1 V_1 T_1 + P_2 V_2 T_2}$

23. Which of the following is incorrect regarding the first law of thermodynamics ? [AIEEE - 2005] (1) It is applicable to any cyclic process

- (2) It is a restatement of the principle of conservation of energy
- (3) It introduces the concept of the internal energy
- (4) It introduced the concept of the entropy
- 24. The temperature-entropy diagram of a reversible engine cycle is given in thefigure. Its efficiency is-

2S₀

(2) 1/4

(4) 2/3**(3)** 1/3

25. 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-[AIEEE - 2005]

> (1) $\Delta U_1 = \Delta U_2$ (2) relation between ΔU_1 and ΔU_2 cannot be determined (3) $\Delta U_2 > \Delta U_1$ (4) $\Delta U_2 < \Delta U_1$

26. 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 gases, T_{f} in terms of T_0 is-[AIEEE - 2006]

(1)
$$T_f = \frac{3}{7}T_0$$
 (2) $T_f = \frac{7}{3}T_0$ (3) $T_f = \frac{3}{2}T_0$ (4) $T_f = \frac{5}{2}T_0$

The work of 146 kJ is performed in order to compress one kilo mole of a gas adiabatically and in this process 27. the temperature of the gas increases by 7°C. The gas is- ($R = 8.3 \text{ J mol}^{-1} \text{ K}^{-1}$) [AIEEE - 2006] (2) triatomic (1) diatomic

(3) a mixture of monoatomic and diatomic (4) monoatomic



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[AIEEE - 2005]

[AIEEE - 2004]

- 28. A carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigetator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is- [AIEEE - 2007] (1) 99 J (2) 90 J (3) 1 J (4) 100 J
- When a system is taken from state i to state f along the path iaf, it is found that Q = 50 cal and 29. W = 20 cal. Along the path ibf Q = 36 cal. W along the path ibf is-[AIEEE - 2007]



Directions : Question number 30, 31 and 32 are based on the following paragraph.

(2) 1904 R

Two moles of helium gas are taken over the cycle ABCDA, as shown in the P-T diagram.



Assuming the gas to be ideal the work done on the gas in taking it from A to B is :-30. [AIEEE - 2009] (1) 400 R(2) 500 R (3) 200 R (4) 300 R 31. The work done on the gas in taking it from D to A is :-[AIEEE - 2009] (1) -690 R (2) +690 R (3) –414 R (4) +414 R 32. The net work done on the gas in the cycle ABCDA is :-[AIEEE - 2009] (4) 276 R

33. 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 :- [AIEEE - 2010] (1) 0.25 (2) 0.5(3) 0.75 (4) 0.99

(3) Zero

A thermally insulated vessel contains an ideal gas of molecular mass M and ratio of specific heats γ . It is moving with 34. speed v and is suddenly broght to rest. Assuming no heat is lost to the surroundings, its temperature increases by:-[AIEEE - 2011]

(1)
$$\frac{\gamma M v^2}{2R} K$$
 (2) $\frac{(\gamma - 1)}{2R} M v^2 K$ (3) $\frac{(\gamma - 1)}{2(\gamma + 1)R} M v^2 K$ (4) $\frac{(\gamma - 1)}{2\gamma R} M v^2 K$
A Carnot engine operating between temperatures T_1 and T_2 has efficientcy $\frac{1}{6}$. When T_2 is lowered by 62 K, its efficiency increases to $\frac{1}{3}$. Then T_1 and T_2 are, respectively:- [AIEEE - 2011]
(1) 330 K and 268 K (2) 310 K and 248 K (3) 372 K and 310 K (4) 372 K and 330 K



35.

(1) 1076 R

- 36.An aluminium sphere of 20 cm diameter is heated from 0°C to 100°C. Its volume changes by (given that coefficient
of linear expansion for aluminium $\alpha_{AI} = 23 \times 10^{-6/\circ}$ C :-[AIEEE 2011](1) 28.9 cc(2) 2.89 cc(3) 9.28 cc(4) 49.8 cc
- 37. A metal rod of Young's modulus Y and coefficient of thermal expansion α is held at its two ends such that its length remains invariant. If its temperature is raised by t°C, the linear stress developed in it is:- [AIEEE 2011]
 - (1) $\frac{\alpha t}{Y}$ (2) $\frac{Y}{\alpha t}$ (3) Yat (4) $\frac{1}{(Yat)}$
- Helium gas goes through a cycle ABCDA (consisting of two isochoric and two isobaric lines) as shown in figure.
 Efficiency of this cycle is nearly (Assume the gas to be close to ideal gas) :- [AIEEE 2012]



- 39. A Carnot engine, whose efficiency is 40% takes in heat from a source maintained at a temperature of 500 K. It is desired to have an engine of efficiency 60%. Then, the intake temperature for the same exhaust (sink) temperature must be :-
 - (1) 600 K (2) efficiency of Carnot engine cannot be made larger than 50% (3) 1200 K (4) 750 K

40. The above p-v diagram represents the thermodynamic cycle of an engine, operating with an ideal monoatomic gas. The amount of heat, extracted from the source in a single cycle is : [AIEEE - 2013]

(1)
$$p_0 v_0$$
 (2) $\left(\frac{13}{2}\right) p_0 v_0$ (3) $\left(\frac{11}{2}\right) p_0 v_0$ (4) $4 p_0 v_0$



MODE OF HEAT TRANSFER

41.	Heat given to a body v	which raises its temperatu	re by 1°C is-		[AIEEE - 2002]
	(1) water equivalent	(2) thermal capacity	(3) specific heat	(4) temperat	ture gradient
42.	Which of the following	is more close to a black	body-		[AIEEE - 2002]
	(1) Black board paint	(2) Green leaves	(3) Black holes	(4) Red ros	es
43.	Infrared radiations are	detected by-			[AIEEE - 2002]
	(1) spectrometer	(2) pyrometer	(3) nanometer	(4) photome	eter
44.	Two spheres of the sam	e material have radii 1 m	and 4 m and temperatur	es 4000 K and 20	000 K respectively.
	The ratio of the energy	radiated per second by t	he first sphere to that b	y the second is-	[AIEEE - 2002]
	(1) 1 : 1	(2) 16 : 1	(3) 4 : 1	(4) 1 : 9	
45.	If the temperature of the	e sun were to increase fro	m T to 2T and its radius	s from R to 2R, th	nen the ratio of the
	radiant energy received	on earth to what it was	previously, will be-		[AIEEE - 2004]
	(1) 4	(2) 16	(3) 32	(4) 64	



46. The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity K and 2K and thickness x and 4x, respectively are T_2 and $T_1(T_2 > T_1)$. The rate of heat transfer through the slab, in a

steady state is
$$\left(\frac{A(T_2 - T_1)K}{x}\right)$$
 f, with f equals to- [AIEEE - 2004]
(1) 1 (2) 1/2 (3) 2/3

47. The figure shows a system of two concentric spheres of radii r_1 and r_2 and kept at temperatures T_1 and T_2 , respectively. The radial rate of flow of heat in a substance between the two concentric spheres, is proportional to-[AIEEE - 2005]

(1)
$$\frac{(r_2 - r_1)}{(r_1 r_2)}$$
 (2) $\bullet n\left(\frac{r_2}{r_1}\right)$ (3) $\frac{r_1 r_2}{(r_2 - r_1)}$

48. Assuming the sun to be a spherical body of radius R at a temperature of T K, evaluate the total radiant power, incident on earth, at a distance r from the sun- (when radius of earth is r_0) [AIEEE - 2006]

1)
$$4\pi r_0^2 R^2 \sigma T^4/r^2$$
 (2) $\pi r_0^2 R^2 \sigma T^4/r^2$ **(3)** $r_0^2 R^2 \sigma T^4 / 4\pi R^2$ **(4)** $R^2 \sigma T^4/r^2$

49. One end of a thermally insulated rod is kept at a temperature T_1 and the other at T_2 . The rod is composed of two sections of lengths \bullet_1 and \bullet_2 and thermal conductivities K_1 and K_2 respectively. The temperature at the interface of the two sections is-[AIEEE - 2007]

1)
$$(K_2 \bullet_2 T_1 + K_1 \bullet_1 T_2)/(K_1 \bullet_1 + K_2 \bullet_2)$$

2) $(K_2 \bullet_1 T_1 + K_1 \bullet_2 T_2)/(K_2 \bullet_1 + K_1 \bullet_2)$
3) $(K_1 \bullet_2 T_1 + K_2 \bullet_1 T_2)/(K_1 \bullet_2 + K_2 \bullet_1)$
4) $(K_1 \bullet_1 T_1 + K_2 \bullet_2 T_2)/(K_1 \bullet_1 + K_2 \bullet_2)$



4x

2K

 T_2

Κ

(4) 1/3

(4) $(r_2 - r_1)$

50. A long metallic bar is carrying heat from one of its ends to the other end under steady-state. The variation of temperature θ along the length x of the bar from its hot end is best described by which of the following figures? [AIEEE - 2009]



51. A liquid in a beaker has temperature $\theta(t)$ at time t and θ_0 is temperature of surroundings, then according to Newton's law of cooling the correct graph between $\log_e (\theta - \theta_0)$ and t is :- [AIEEE - 2012]





THERMAL PROPERTIES OF MATTER

52. A wooden wheel of radius R is made of two semicircular parts (see figure). The two parts are held together by a ring made of a metal strip of cross sectional area S and Length L. L is slightly less than $2\pi R$. To fit the ring on the wheel, it is heated so that its temperature rises by ΔT and it just steps over the wheel. As it cools down to surrounding temperature, it presses the semicircular parts together. If the coefficient of linear expansion of the metal is α , and its Young's modulus is Y, the force that one part of the wheel applies on the other part is : [AIEEE - 2012] (1) $2SY\alpha\Delta T$ (2) $2\pi SY\alpha\Delta T$ (3) SY $\alpha\Delta T$ (4) $\pi SY\alpha\Delta T$ 53. If a piece of metal is heated to temperature θ and then allowed to cool in a room which is at temperature θ_0 the graph between the temperature T of the metal and time t will be closed to : [AIEEE - 2013] (**3**) θ₀ **(2)** θ₀ **(4)** θ_ι (1) $f \rightarrow$ 54 The pressure that has to be applied to the ends of a steel wire of length 10 cm to keep its length constant when its temperature is raised by 100°C is : [JEE (Main) - 2014] (For steel Young's modulus is $2 \times 10_{11}$ N m-2 and coefficient of thermal expansion is $1.1 \times 10_{-5}$ K-1) (1) 2.2×10^7 Pa (2) $2.2 \times 10^6 P$ (3) 2.2×10^8 Pa (4) 2.2×10^9 Pa 55. One mole of diatomic ideal gas undergoes a cyclic process ABC as shown in figure. The process BC is adiabatic. The temperatures at A, B 800 K and C are 400 K, 800 K and 600 K respectively. Choose the correct statement: [JEE (Main) - 2014] 600 K (1) The change in internal energy in the process AB is -350 R. 400 K (2) The change in internal energy in the process BC is -500 R. (3) The change in internal energy in whole cyclic process is 250 R. (4) The change in internal energy in the process CA is 700 R. 56 Three rods of Copper, Brass and Steel are welded together to from a Y-shaped structure. Area of cross - section of each rod = 4 cm². End of copper rod is maintained at 100°C where as ends of brass and steel are kept at 0° C. Lengths of the copper, brass and steel rods are 46, 13 and 12 cms respectively. The rods are thermally insulated from surroundings except at ends. Thermal conductivities of copper, brass and steel are 0.92, 0.26 and [JEE (Main) - 2014] 0.12 CGS units respectively. Rate of heat flow through copper rod is : (4) 2.4 cal/s (1) 4.8 cal/s(2) 6.0 cal/s(3) 1.2 cal/s 57 On heating water, bubbles being formed at the bottom of the vessel detach and rise. Take the bubbles to be spheres of radius R and making a circular contact of radius r with the bottom of the vessel. If r < < R, and the surface tension of water is T, value of r just before bubbles detach is : (density of water is ρ) [**JEE** (Main) - 2014] (1) $R^2 \sqrt{\frac{\rho_w g}{T}}$ (2) $R^2 \sqrt{\frac{3\rho_w g}{T}}$ (3) $R^2 \sqrt{\frac{\rho_w g}{3T}}$ (4) $R^2 \sqrt{\frac{\rho_w g}{6T}}$



58. A solid body of constant heat capacity 1 J/°C is being heated by keeping it in contact with reservoirs in two ways:

(i) Sequentially keeping in contact with 2 reservoirs such that each reservoir supplies same amount of heat.

(ii) Sequentially keeping in contact with 8 reservoirs such that each reservoirs supplies same amount of heat.

In both the cases body is brought from initial temperature 100°C to final temperature 200°C. Entropy change of the body in the two cases respectively is : [JEE (Main) - 2015]

(1) $\ln 2, 2\ln 2$ (2) $2\ln 2, 8\ln 2$ (3) $\ln 2, 4\ln 2$ (4) $\ln 2, \ln 2$

59. Consider a spherical shell of radius R at temperature T. The black body radiation inside it can be considered as an ideal gas of photons with internal energy per unit volume $u = \frac{U}{V} \propto T^4$ and pressure $P = \frac{1}{3} \left(\frac{U}{V} \right)$. If the shell now undergoes an adiabatic expansion the relation between T and R is : [JEE (Main) - 2015]

(1)
$$T \propto \frac{1}{R}$$
 (2) $T \propto \frac{1}{R^3}$ (3) $T \propto e^{-R}$ (4) $T \propto e^{-3R}$

60. Consider an ideal gas confined in an isolated closed chamber. As the gas undergoes an adiabatic expansion, the average time of collision between molecules increases as V^q, when V is the volume of the gas. The value of q is :

$$\begin{pmatrix} \gamma = \frac{C_{P}}{C_{V}} \end{pmatrix}$$
[JEE (Main) - 2015]
(1) $\frac{\gamma + 1}{2}$
(2) $\frac{\gamma - 1}{2}$
(3) $\frac{3\gamma + 5}{6}$
(4) $\frac{3\gamma - 5}{6}$

61. 'n' moles of an ideal gas undergoes a process A → B as shown in the figure. The maximum temperature of the gas during the process will be :
 [JEE (Main) - 2016]



- 62.A pendulum clock loses 12 s a day if the temperature is 40°C and gains 4s a day if the
temperature is 20°C. The temperature at which the clock will show correct time, and the
co-efficient of linear expansion (α) of the metal of the pendulum shaft are respectively:[JEE (Main) 2016](1) 60°C; $\alpha = 1.85 \times 10^{-4/\circ}$ C
(3) 55°C; $\alpha = 1.85 \times 10^{-2/\circ}$ C(2) 30°C; $\alpha = 1.85 \times 10^{-3/\circ}$ C
(4) 25°C; $\alpha = 1.85 \times 10^{-5/\circ}$ C
- 63. An ideal gas undergoes a quasi static, reversible process in which its molar heat capacity C remains constant. If during this process the relation of pressure P and volume V is given by $PV^n = constant$, then n is given by (Here C_p and C_v are molar specific heat at constant pressure and constant volume, respectively): [JEE (Main) 2016]
 - (1) $n = \frac{C C_p}{C C_v}$ (2) $n = \frac{C_p C}{C C_v}$ (3) $n = \frac{C C_v}{C C_p}$ (4) $n = \frac{C_p}{C_v}$







A block of ice at -10°C is slowly heated and converted to steam at 100°C. Which of the following curves represents the phenomena qualitatively: [IIT-JEE 2000]



10. 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 W_1 if the process is purely isothermal, W_2 if purely isobaric and W_3 if purely adiabatic, then :-

(A) $W_2 > W_1 > W_3$ (B) $W_2 > W_3 > W_1$ (C) $W_1 > W_2 > W_3$ (D) $W_1 > W_3 > W_2$

11. An ideal gas is initially at temperature T and volume V. Its volume is increased by ΔV due to an increase in temperature ΔT , pressure remaining constant. The quantity $\delta = \frac{\Delta V}{V\Delta T}$ varies with temperature as:-



12. Two monoatomic ideal gases 1 and 2 of molecular masses m_1 and m_2 respectively are enclosed in separate containers kept at the same temperature. The ratio of the speed of sound in gas 1 to the gas 2 is given by :-

[IIT-JEE 2000]

A)
$$\sqrt{\frac{m_1}{m_2}}$$

13. Three rods made of the same material and having the same cross-section have been joined as shown in the figure. Each rod is of the same length. The left and right ends are kept at 0°C and 90°C respectively. The temperature of junction of the three rods will be :

(B) 60°C

In a given process of an ideal gas, dW = 0 and dQ < 0. Then for the gas :-

 $\underline{m_2}$

14.

[IIT-JEE 2001] (C) 30°C

(C) $\frac{m_1}{m_2}$



[IIT-JEE 2001]

(A) the temperature will decrease

(C) the pressure will remain constant

(D) the temperature will increase

(B) the volume will increase

15. P-V plots for two gases during adiabatic processes are shown in the figure. Plots 1 and 2 should correspond [IIT-JEE 2001]

(A) He and O_2

(B) O₂ and He

(C) He and Ar

(D) O_2 and N_2



THERMAL PROPERTIES OF MATTER

An ideal gas is taken through the cycle $A \rightarrow B \rightarrow C \rightarrow A$, as shown in the 16. figure. If the net heat supplied to the gas in the cycle is 5 J, the work done $V(m^3)$ by the gas in the process $C \rightarrow A$ is :-**[IIT-JEE 2002]** (A) -5J **(B)**-10J(C) -15J **(D)**-20J $P(N/m^2)$ Which of the following graphs correctly represent the variation of $\beta = -\frac{dV/dP}{V}$ with P for an ideal gas at 17. constant temperature ? **[IIT-JEE 2002] (B) (C) (D) (A)** D 18. An ideal black-body at room temperature is thrown into a furnance. It is observed that **[IIT-JEE 2003]** (A) initially it is the darkest body and at later times the brightest (B) it is the darkest body at all times (C) it cannot be distinguished at all times (D) initially it is the darkest body and at later times it cannot be distinguished The graph, shown in the diagram, represents the variation of temperature (T) 19. of the bodies, x and y having same surface area, with time (T) due to the emission of radiation. Find the correct relation between the emissivity and absorptivity power of the two bodies :-**[IIT-JEE 2003]** (A) $e_x > e_y$ and $a_x < a_y$ (B) $e_x < e_y$ and $a_x > a_y$ (C) $e_x > e_y$ and $a_x > a_y$ (D) $e_x < e_y$ and $a_x < a_y$ 20. Two rods, one of aluminium and the other made of steel, having initial length \bullet_1 and \bullet_2 are connected together to form a single rod of length $\mathbf{O}_1 + \mathbf{O}_2$. The coefficient of linear expansion for aluminium and steel area α_1 and α_{s} respectively. If the length of each rod increases by the same amount when their temperature are raised by t°C, then find the ratio $\frac{l_1}{l_1 + l_2}$:-**[IIT-JEE 2003]** (C) $\frac{\alpha_s}{(\alpha_a + \alpha_s)}$ (D) $\frac{\alpha_a}{(\alpha_a + \alpha_s)}$ (B) $\frac{\alpha_a}{\alpha_s}$ (A) $\frac{\alpha_s}{\alpha_s}$ 21. The P-T diagram for an ideal gas is shown in the figure, where AC is anadiabatic process, find the corresponding P-V diagram :-**[IIT-JEE 2003] (C) (D) (B)**



С

C

- 22. 2 kg of ice at -20°C is mixed with 5 kg of water at 20°C in an insulating vessel having a negligible heat capacity. Calculate the final mass of water remaining in the container. It is given that the specific heats of water and ice are 1 kcal/kg/°C while the latent heat of fusion of ice is 80 kcal/kg :-**[IIT-JEE 2003]** (A) 7 kg **(B)** 6 kg (C) 4 kg (D) 2 kg
- 23. Liquid oxygen at 50 K is heated to 300 K at constant pressure of 1 atm. The rate of heating is constant. Which of the following graphs represent the variation of temperature with time :-**[IIT-JEE 2004]**



- An ideal gas expands isothermally from a volume V, and V, and then compressed to original volume V, adiabatically. 24. Initial 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**[IIT-JEE 2004]** (A) $P_3 > P_1, W > 0$
- 25. Two identical conducting rods are first connected independently to two vessels, one containing water at 100°C and the other containing ice at 0°C. In the second case, the rods are joined end to end and connected to the same vessels.

Let q_1 and q_2 g/s be the rate of melting of ice in the two cases respectively. The ratio $\frac{q_1}{q_2}$ is :- [IIT-JEE 2004] (A) $\frac{1}{2}$ (B) $\frac{2}{1}$ (C) $\frac{4}{1}$ (D) $\frac{1}{4}$

A)
$$\frac{1}{2}$$

26. Three discs, A, B and C having radii 2m, 4m and 6m respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensity are 300 nm, 400 nm and 500 nm respectively. The power radiated by them are Q_A , Q_B and Q_C respectively :-[IIT-JEE 2004] **(B)** Q_{B} is maximum **(C)** Q_{C} is maximum **(D)** $Q_{A} = Q_{B} = Q_{C}$ (A) Q_A is maximum 27.

Water of volume 2L in a container is heated with a coil of 1 kW at 27°C. The lid of the container is open and energy dissipates at rate of 160 J/s. In how much time temperature will rise from 27°C to 77°C? (Give specific heat of water is 4.2 kJ/kg) :-**[IIT-JEE 2005]** (A) 8 min 20 s **(B)** 6 min 2 s (C) 7 min **(D)** 14 min

- In which of the following process, convection does not take place primarily :-28. **[IIT-JEE 2005]** (B) Boiling of water (A) Sea and land breeze
 - (C) Warming of glass of bulb due to filament (**D**) Heating air around a furnace

29. Variation of radiant energy emitted by sun, filament of tungsten lamp and welding arc as a function of its wavelength is shown in figure. Which of the following option is the correct match :-**IIIT-JEE 2005**

- (A) Sun- T_1 , tungsten filament- T_2 , welding arc- T_3
- **(B)** Sun– T_2 , tungsten filament– T_1 , welding arc– T_3
- (C) Sun– T_3 , tungsten filament– T_2 , welding arc– T_1
- (**D**) Sun $-T_3$, tungsten filament $-T_1$, welding arc $-T_2$



Calorie is defined as the amount of heat required to raise temperature of 1 g of water by 1°C and it is defined 30. under which of the following conditions :-**[IIT-JEE 2005]**

(A) From 14.5°C to 15.5°C at 760 mm of Hg

- (C) From 13.5°C to 14.5°C at 76 mm of Hg
- (B) From 98.5°C to 99.5°C at 760 mm of Hg (D) From 3.5°C to 4.5°C at 76 mm of Hg



31.A body with area A and temperature T and emissivity e = 0.6 is kept inside a spherical black body. What will
be the maximum energy radiated :-[IIT-JEE 2005](A) $0.60 eAT^4$ (B) $0.80 eAT^4$ (C) $1.00 eAT^4$ (D) $0.40 eAT^4$ 32.An ideal gas is expanding such that $PT^2 = constant$. The coefficient of volume expansion of the gas is:-(A) $\frac{1}{T}$ (B) $\frac{2}{T}$ (C) $\frac{3}{T}$ (D) $\frac{4}{T}$ [IIT-JEE 2008]

33. Two non-reactive monoatomic ideal gases have their atomic masses in the ratio 2 : 3. The ratio of their partial pressures, when enclosed in a vessel kept at a constant temperature, is 4 : 3. The ratio of their densities is :[IIT-JEE 2013]

34. Two rectangular blocks, having identical dimensions, can be arranged either in configuration I or in configuration II as shown in the figure. One of the blocks has thermal conductivity k and the other 2k. The temperature difference between the ends along the x-axis is the same in both the configurations. It takes 9s to transport a certain amount of heat from the hot end to the cold end in the configuration I. The time to transport the same amount of heat in the configuration II is :-



35. One mole of a monatomic ideal gas is taken along two cyclic processes $E \rightarrow F \rightarrow G \rightarrow E$ and $E \rightarrow F \rightarrow H \rightarrow E$ as shown in the PV diagram. The processes involved are purely isochoric, isobaric, isothermal or adiabatic.



Match the paths in List I with the magnitudes of the work done in the List II and select the correct answer using the codes given blow the lists. [IIT-JEE 2013]

	List I				List II
P.	$G \rightarrow H$	Ξ		1.	$160 P_0 V_0 \ln 2$
Q.	$G \rightarrow I$	H		2.	$36 P_0 V_0$
R.	$F \rightarrow H$	Ŧ		3.	$24 P_0 V_0$
S.	$F \rightarrow C$	Ĵ		4.	$31 P_0 V_0$
Codes	:				
	Р	Q	R	S	
(A)	4	3	2	1	
(B)	4	3	1	2	
(C)	3	1	2	4	
(D)	1	3	2	4	



- 36. Parallel rays of light of intensity I = 912 Wm⁻² are incident on a spherical black body kept in surroundings of temperature 300 K. Take Stefan-Boltzmann constant $\sigma = 5.7 \times 10^{-8}$ Wm⁻² K⁻⁴ and assume that the energy exchange with the surroundings is only through radiation. The final steady state temperature of the black body is close to
 [IIT-JEE 2014]
 (A) 330 K
 (B) 660 K
 (C) 990 K
 (D) 1550 K
- 37. A water cooler of storage capacity 120 litres can cool water at a constant rate of P watts. In a closed circulation system (as shown schematically in the figure), the water from the cooler is used to cool an external device that generates constantly 3 kW of heat (thermal load). The temperature of water fed into the device cannot exceed 30°C and the entire stored 120 litres of water is initially cooled to 10°C. The entire system is thermally insulated. The minimum value of P (in watts) for which the device can be operated for 3 hours is [IIT-JEE 2016]



MCQs with one or more than one correct answer

1. Let \overline{v} , v_{rms} and v_p respectively denote the mean speed, root mean square speed and most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T. The mass of a molecule is m. Then:-

[IIT-JEE 1998]

- (A) No molecule can have energy greater than $\sqrt{2} v_{\rm rms}$
- (B) No molecule can have speed less than $\frac{v_p}{\sqrt{2}}$

(C)
$$v_p < \overline{v} < v_{rm}$$

- (D) The average kinetic energy of a molecule is $\frac{3}{4}$ mv_p²
- 2. During the melting of a slab of ice at 273 K at atmospheric pressure :- [IIT-JEE 1998]
 - (A) Positive work is done by the ice-water system on the atmosphere
 - (B) Positive work is done on the ice-water system by the atmosphere
 - (C) the internal energy of the ice-water increases
 - (D) The internal energy of the ice-water system decreases
- 3. A bimetallic strip is formed out of two identical strips one of copper and the other of brass. The coefficients 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 :- [IIT-JEE 1999]
 - (A) Proportional to ΔT (B) Inversely proportional to ΔT
 - (C) Proportional to $|\alpha_{\rm B} \alpha_{\rm C}|$ (D) Inversely proportional to $|\alpha_{\rm B} \alpha_{\rm C}|$
- 4. C_v and C_p denote the molar specific heat capacities of a gas at constant volume and constant pressure, respectively. Then [IIT-JEE 2009]
 - (A) $C_p C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas
 - **(B)** $C_{p} + C_{v}$ is larger for a diatomic ideal gas than for a monoatomic ideal gas
 - (C) C_p/C_v is larger for a diatomic ideal gas than for a monatomic ideal gas
 - (D) C_p . C_v is larger for a diatomic ideal gas than for a monoatomic ideal gas



5. The figure shows the P-V plot of an ideal gas taken through a cycle ABCDA. The part ABC is a semi-circle and CDA is half of an ellipse. Then, **[IIT-JEE 2009]** (A) the process during the path $A \rightarrow B$ is isothermal (B) heat flows out of the gas during the path $B \rightarrow C \rightarrow D$ (C) work done during the path $A \rightarrow B \rightarrow C$ is zero (D) positive work is done by the gas in the cycle ABCDA 6. The figure below shows the variation of specific heat capacity (C) of a solid as a function of temperature (T). The temperature is increased continuously from 0 to 500 K at a constant rate. Ignoring С any volume change, the following statement(S) is (are) correct to a reasonable approximation :-**[IIT-JEE 2013]** 100 200 300 400 500 T(K) (A) The rate at which heat is absorbed in the range 0-100 K varies linearly with temperature T. (B) Heat absorbed in increasing the temperature from 0-100 K is less than the heat required for increasing the temperature from 400-500 K. (C) There is no change in the rate of heat absorption in the range 400–500 K (D) The rate of heat absorption increases in the range 200–300 K 7. Heater of an electric kettle is made of a wire of length L and diameter d. It takes 4 minutes to raise the temperature of 0.5 kg water by 40 K. This heater is replaced by a new heater having two wires of the same material, each of length L and diameter 2d. The way these wires are connected is given in the options. How much time in minutes will it take to raise the temperature of the same amount of water by 40K? **[IIT-JEE 2014]** (A) 4 if wires are in parallel (B) 2 if wires are in series (C) 1 if wires are in series (D) 0.5 if wires are in parallel. 8. A container of fixed volume has a mixture of one mole of hydrogen and one mole of helium in equilibrium at temperature T. Assuming the gases are ideal, the correct statement(s) is (are) **[IIT-JEE 2015]** (A) The average energy per mole of the gas mixture is 2RT. (B) The ratio of speed of sound in the gas mixture to that in helium gas is $\sqrt{6/5}$. (C) The ratio of the rms speed of helium atoms to that of hydrogen molecules is 1/2. (D) The ratio of the rms speed of helium atoms to that of hydrogen moleucles is $1/\sqrt{2}$. 9. An ideal monoatomic gas is confined in a horizontal cylider by a spring loaded piston (as shown in the figure). Initially the gas is at temperature T₁, pressure P₁ and volume V₁ and the spring is in its relaxed state. The gas is then heated very 00000000 slowly to temperature T_2 , pressure P_2 and volume V_2 . During this process the piston moves out by a distance x. Ignoring the friction between the piston and the cylider, the correct statement(s) is (are). **IIT-JEE 2015** (A) If $V_2 - 2V_1$ and $T_2 = 3T_1$, then the energy stored in the spring is $\frac{1}{4}P_1V_1$ (B) If $V_2 = 2V_1$ and $T_2 = 3T$, then the change in internal energy is $3P_1V_1$ (C) If $V_2 = 3V_1$ and $T_2 = 4T$, then the work done by the gas is $\frac{7}{3}P_1V_1$ (D) If $V_2 = 3V_1$ and $T_2 = 4T_1$, the heat supplied to the gas is $\frac{17}{6} P_1 V_1$ Add. 41-42A, Ashok Park Main, New Rohtak Road, New Delhi-110035

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- 10. A gas is enclosed ina cylinder with a movable frictionless piston. Its initial thermodynam state at pressure $P_i = 10^5$ Pa and volume $V_i = 10^{-3}$ m³ changes to a final state at $P_f = (1/32) \times 10^5$ Pa and $V_f = 8 \times 10^{-3}$ m³ in an adiabatic quasistatic process, such that $P^3V^5 =$ constant. Consider another thermodynamic process that brings the system from the same initial state to the same final state in two steps : an isobaric expansion at P_i folowed by an isochoric (isovolumetric) process at volume V_f . The amount of heat supplied to the system in the two-step process is approximately (A) 112 J (B) 294 J (C) 588 J (D) 813 J [IIT-JEE 2016]
- 11. The ends Q and R of two thin wires, PQ and Rs, are soldered (joined) together. Initially each of the wires has a length of 1 m at 10°C. Now the end P is maintained at 10 °C, while the end S is heated and maintained at 400 °C. The system is thermally insulated from its surroundings. If the thermal conductivity of wire PQ is twic that of the wire RS and the coefficient of linear thermal expansion of PQ is 1.2×10^{-5} K⁻¹, the change in length of the wire PQ is [IIT-JEE 2016]

(A) 0.78 mm (B) 0.90 mm (C) 1.56 mm (D) 2.34 mm Match the Column 1. For the given process :-**[IIT-JEE 2006]** Column I Column II 30 20 M Process $J \rightarrow K$ W > 0**(A) (P)** 10 K Process $K \rightarrow L$ W < 0**(B) (Q)** 10 20 Process $L \rightarrow M$ Q > 0**(C) (R) (D)** Process $M \rightarrow J$ Q < 0**(S)**

Column–I gives some devices and Column–II gives some processes on which the functioning of these devices depend. Match the devices in Column–I with the process in Column–II. [IIT-JEE 2007]

	Column I		Column II
(A)	Bimetallic strip	(P)	Radiation from a hot body
(B)	Stem engine	(Q)	Energy conversion
(C)	Incandescent lamp	(R)	Melting
(D)	Electric fuse	(S)	Thermal expansion of solids

Column I contains a list of processes involving expansion of an ideal gas. Match this with Column II describing the thermodynamic change during this process. Indicate your answer by darkening the appropriate bubbles of the 4 × 4 matrix given in the ORS. [IIT-JEE 2008]

Column I

 (A) An insulated container has two chambers separated by a valve. Chamber I contains an ideal gas and the Chamber II has vacuum. The valve is opened.

Ш - tideal gas vacuum

Column II

(P) The temperature of the gas decreases


(B)	An ideal monoatomic gas expands to twice its original	(Q)	The temperature of the gas
	volume such that its pressure P $\propto \frac{1}{ V ^2}$, where V is		increases or remains constant
	the volume of the gas.		
(C)	An ideal monoatomic gas expands to twice its	(R)	The gas loses heat
	original volume such that its pressure $p \propto \frac{1}{V^{4/3}}$,		
	where V is its volume		
(D)	An ideal monoatomic gas expands such that its pressure P and volume V follows the behaviour shown in the graph	(S)	The gas gains heat
	P P		
	V ₁ 2V ₁ V		

Assertion & Reason

 Statement-I : The total translation kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume.
 [IIT-JEE 2007]

Statement–II: The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.

- (A) statement-I is true, statement-II is true; statement-II is a correct explanation for statement-I
- (B) statement-I is true, statement-II is true, statement-II is NOT a correct explanation for statement-I
- (C) statement–I is true, statement–II is false
- (D) statement-I is false, statement-II is true

Comprehension Type Questions

Comprehension#1

A fixed thermally conducting cylinder has a radius R and height L_0 . The cylinder is open at its bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface, as shown in the figure. The atmospheric pressure is P_0 . [IIT-JEE 2007]



1. The piston is now pulled out slowly and held at a distance 2L from the top. The pressure in the cylinder between its top and the piston will then be :-

2.

(B)
$$\frac{P_0}{2}$$
 (C) $\frac{P_0}{2} + \frac{Mg}{\pi R^2}$ **(D)** $\frac{P_0}{2} - \frac{Mg}{\pi R^2}$

While the piston is at a distance 2L from the top, the hole at the top is sealed. The piston is then released, to a position where it can stay in equilibrium. In this condition, the distance of the piston from the top is :-

A)
$$\left(\frac{2P_0\pi R^2}{\pi R^2 P_0 + Mg}\right)(2L)$$
 (B) $\left(\frac{2P_0\pi R^2 - Mg}{\pi R^2 P_0}\right)(2L)$ (C) $\left(\frac{P_0\pi R^2 + Mg}{\pi R^2 P_0}\right)(2L)$ (D) $\left(\frac{P_0\pi R^2}{\pi R^2 P_0 - Mg}\right)(2L)$



3. The piston is taken completely out of the cylinder. The hole at the top is sealed. A water tank is brought below the cylinder and put in a position so that the water surface in the tank is at the same level as the top of the cylinder as shown in the figure. The density of the water is ρ . In equilibrium, the height H of the water column in the cylinder satisfies :-

(A)
$$\rho g(L_0 - H)^2 + P_0(L_0 - H) + L_0 P_0 = 0$$

(C) $\rho g(L_0 - H)^2 + P_0(L_0 - H) - L_0 P_0 = 0$

(B)
$$\rho g(L_0 - H)^2 - P_0(L_0 - H) - L_0 P_0 =$$

(D) $\rho g(L_0 - H)^2 - P_0(L_0 - H) + L_0 P_0 =$

Comprehension#2

A small spherical monoatomic ideal gas bubble $\left(\gamma = \frac{5}{3}\right)$ is trapped inside a liquid of density ρ_{\bullet} (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the **bottomisT**₀, the height of the liquid is H and the atmospheric pressure is P₀ (Neglect surface tension). [IIT-JEE 2008]



- (B) The force due to gravity and the force due to the pressure of the liquid
- (C) The force due to gravity, the force due to the pressure of the liquid and the force due to viscosity of the liquid
- (D) The force due to gravity and the force due to viscosity of the liquid.
- 2. When the gas bubble is at a height y from the bottom, its temperature is :-

(A)
$$T_0 \left(\frac{P_0 + \rho_1 gH}{P_0 + \rho_1 gy}\right)^{2/5}$$
 (B) $T_0 \left(\frac{P_0 + \rho_1 g(H - y)}{P_0 + \rho_1 gH}\right)^{2/5}$ (C) $T_0 \left(\frac{P_0 + \rho_1 gH}{P_0 + \rho_1 gy}\right)^{3/5}$ (D) $T_0 \left(\frac{P_0 + \rho_1 g(H - y)}{P_0 + \rho_1 gH}\right)^{3/5}$

3. The buoyancy force acting on the gas bubble is (Assume R is the universal gas constant)

(A)
$$p_{\bullet}nRgT_{0} \frac{(P_{0} + \rho_{1}gH)^{2/5}}{(P_{0} + \rho_{1}gy)^{7/5}}$$

(B) $\frac{\rho_{1}nRgT_{0}}{(P_{0} + \rho_{1}gH)^{2/5}[P_{0} + \rho_{1}g(H - y)]^{3/5}}$
(C) $p_{\bullet}nRgT_{0} \frac{(P_{0} + \rho_{1}gH)^{3/5}}{(P_{0} + \rho_{1}gy)^{8/5}}$
(D) $\frac{\rho_{1}nRgT_{0}}{(P_{0} + \rho_{1}gH)^{3/5}[P_{0} + \rho_{1}g(H - y)]^{2/5}}$

Comprehension#3

In the figure a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat. The lower compartment of the container is filled with 2 moles of an ideal monatomic gas at 700 K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400 K. The

heat capacities per mole of an ideal monatomic gas are $C_V = \frac{3}{2}R$, $C_P = \frac{5}{2}R$, and those for an ideal diatomic gas

are
$$C_V = \frac{5}{2}R$$
, $C_P = \frac{7}{2}R$.

IIT-JEE 2014]



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= 0 = 0

- 1. Consider the partition to be rigidly fixed so that it does not move. When equilibrium is achieved, the final temperature of the gases will be
 - (A) 550 K (B) 525 K (C) 513K (D) 490 K

2. Now consider the partition to be free to move without friction so that the pressure of gases in both compart ments is the same. Then total work done by the gases till the time they achieve equilibrium will be

(A) 250 R (B) 200 R (C) 100 R (D) -100 R

Subjective Questions

1. One mole of an ideal monoatomic gas is taken round the cyclic process ABCA as shown in figure. Calculate:

- (i) The work done by the gas.
- (ii) The heat rejected by the gas in the path CA and the heat absorbed by the gas in the path AB.
- (iii) The net heat absorbed by the gas in the path BC.
- (iv) The maximum temperature attained by the gas during the cycle.
- 2. A solid body X of heat capacity C is kept in an atmosphere whose temperature is $T_A = 300$ K. At time t = 0, the temperature of X is $T_0 = 400$ K. It cools according to Newton's law of cooling. At time t_1 its temperature is found to be 350 K. At this time (t_1) the body X is connected to a large body Y at atmospheric temperature T_A through a conducting rod of length L, cross-section area A and thermal conductivity K. The heat capacity of Y is so large that any variation in its temperature may be neglected. The cross-section area A of the connecting rod is small compared to the surface area of X. Find the temperature of X at time $t = 3t_1$. [IIT-JEE 1998]
- 3. Two moles of an ideal monoatomic gas initially at pressure P_1 and volume V_1 undergo an adiabatic compression until its volume is V_2 . Then the gas is given heat Q at constant volume V_2 . [IIT-JEE 1999]

(i) Sketch the complete process on a P-V diagram.

(ii) Find the total work done by the gas, the total change in internal energy and the final temperature of the gas. (Give your answer in terms of P_1 , V_1 , V_2 , Q and R)

- 4. Two moles of an ideal monoatomic gas is taken through a cycle ABCA as shown in the P–V diagram. During the process AB, pressure and temperature of the gas very such that PT = constant. If $T_1 = 300K$, calculate
 - (i) The work done on the gas in the process AB and
 - (ii) The heat absorbed or released by the gas in each of the processes.

Give answers in terms of the gas constant P.

5. An ice cube of mass 0.1 kg at 0°C is placed in an isolated container which is at 227°C. The specific heat S of the container varies with temperature T according to the empirical relation S = A + BT, where A = 100 cal/kg–K and $B = 2 \times 10^{-2}$ cal/kg–K². If the final temperature of the container is 27°C, determine the mass of the container (Latent heat of fusion for water = 8×10^4 cal/kg, specific heat of water = 10^3 cal/kg–K). [IIT-JEE 2001]





2P

Ρ

[IIT-JEE 2000]

T₁

2T1

6. A monoatomic ideal gas of two moles is taken through a cyclic process starting

from A as shown in the figure. The volume ratio 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 :

- (i) The temperature of the gas at point B.
- (ii) Heat absorbed or released by the gas in each process.

7. A 5m long cylindrical steel wire with radius 2×10^{-3} m is suspended vertically from a rigid support and carries a bob of mass 100 kg at the other end. If the bob gets snapped, calculate the change in temperature of the wire ignoring losses. (For the steel wire : Young's modulus = 2.1×10^{11} Pa; Density = 7860 Kg/m³; Specific heat = 420 J/kg–K).

[IIT-JEE 2001]

[IIT-JEE 2002]

8. A cubical box of side 1m contains helium gas (atomic weight 4) at a pressure of 100 N/m². During an observation time of 1s, an atom travelling with the root mean square speed parallel to one of the edges of the cube, was found to make 5000 hits with a particular wall, without any collision with other atoms.

Take : R = 25/3 J/mol-K and $k = 1.38 \times 10^{-23}$ J/K.

(i) Evaluate the temperature of the gas.

- (ii) Evaluate the average kinetic energy per atom.
- (iii) Evaluate the total mass of helium gas in the box.
- An insulated box containing a monoatomic gas of molar mass M moving with a speed v₀ is suddenly stopped.
 Find the increment in gas temperature as a result of stopping the box. [IIT-JEE 2003]
- 10. The top of an insulated cylindrical container is covered by a disc having emissivity 0.6 and conductivity 0.167 W/km and thickness 1 cm. The temperature is maintained by circulating oil as shown : [IIT-JEE 2003]
 (i) Find the radiation loss to the surroundings in J/m² s if temperature
 - of the upper surface of disc is 127°C and temperature of surroundings is 27°C. (ii)Also find the temperature of the circulating oil. Neglect the heat loss due



- 11. The piston cylinder arrangement shown contains a diatomic gas at temperature 300 K. The cross-sectional area of the cylinder is 1m². Initially the height of the piston above the base of the cylinder is 1m. The temperature is now raised to 400 K at constant pressure. Find the new height of the piston above the base of the cylinder. If the piston is now brought back to its original height without any heat loss, find the new equilibrium temperature of the gas. You can leave the answer in fraction. [IIT-JEE 2004]
- 12. A cube of coefficient of linear expansions α_s is floating in a bath containing a liquid of coefficient of volume expansion γ_1 . When the temperature is raised by ΔT , the depth upto which the cube is submerged in the liquid remains the same. Find the relation between α_s and γ_1 showing all the steps. [IIT-JEE 2004]







⁽iii) The total work done by the gas during the complete cycle. Express your answer in terms of the gas constant R.

13. One end of a rod of length L and cross-sectional area A is kept in a furnace of temperature T_1 . The other end of the rod is kept at a temperature T_2 . The thermal conductivity of the material of the rod is K and emissivity of the rod is e. it is given that $T_2 = T_s + \Delta T$, where $\Delta T < < T_s$, Ts being the temperature of the surroundings. If $\Delta T \propto (T_1 - T_s)$, find the proportionality



constant that heat is lost only by radiation at the end where the temp, of the rod is T₂. [IIT-JEE 2004]

14. A metal of mass 1 kg at constant atmospheric pressure and at initial temperature 20°C is given a heat of 200000 J. Find the following : (i) change in temperature (ii) work done and (iii) change in internal energy. (Given : Specific heat 400 J/kg/°C, coefficient of cubical expansion, $\gamma = 8 \times 10^{-5}$ /°C, density $\rho = 9000$ kg/m³,

atmospheric pressure = 10^5 N/m².

- 15.In an insulated vessel, 0.05 kg steam at 373 K and 0.45 kg of ice at 253 K are mixed find the final temperature
of the mixture (in kelvin). Given : $L_{fusion} = 80 \text{ cal/g} = 336 \text{ J/g}$; $L_{vaporization} = 540 \text{ cal/g} = 2268 \text{ J/g}$;
 $S_{ice} = 2100 \text{ J/kg}$, K = 0.5 cal/gK; and $S_{water} = 4200 \text{ J/kg}$, K = 1 cal/gKExample 100 \text{ gm} + 100 \text{ gm}
- 16. A metal rod AB of length 10x has its one end A in ice at 0°C and the other end B in water at 100 °C. It a point P on the rod is maintained at 400 °C, then it is found that equal amounts of water and ice evaporate and melt per unit time. The latent heat of evaporation of water 540 cal/g and latent heat of melting of ice is 80 cal/g. If the point P is at λx distance from the ice end then find out the value of λ . [Neglect any heat loss to the surrounding.]

[**IIT-JEE 2009**]

17. A thermodynamic system is taken from an initial state *i* with internal energy $U_i = 100$ J to the final state *f* along two different paths *iaf* and *ibf*, as schematically shown in the figure. The work done by the system along the paths *af*, *ib* and *bf* are $W_{af} = 200$ J, $W_{ib} = 50$ J and $W_{bf} = 100$ J respectively. The heat supplied to the system along the path iaf, ib and bf are Q_{iaf} , Q_{ib} and Q_{bf} respectively. If the internal energy of the system in the state b is $U_b = 200$ J and $Q_{iaf} = 500$ J, the ratio Q_{bf}/Q_{ib} is [IIT-JEE 2014]



- 18. Two spherical stars A and B emit blackbody radiation. The radius of A is 400 times that of B and A emits 10⁴ times the power emitted from B. The ratio $\left(\frac{\lambda_A}{\lambda_B}\right)$ of their wavelengths λ_A and λ_B at which the peaks occur in their respective radiation curves is.
- 19. A metal is heated in a furnace where a sensor is kept above the metal surface to read the power radiated (P) by the metal. The sensor has a scale that displays $\log_2 (P/P_0)$, where P_0 is a constant. When the metal surface is at a temperature of 487°C, the sensor shows a value 1. Assume that the emissivity of the metallic surface remains constant. What is the value displayed by the sensor when the temperature of the metal surface is raised to 2767 °C? [IIT-JEE 2016]
- 20. Consider two solid spheres P and Q each of density 8 gm cm⁻³ and diameters 1 cm and 0.5 cm, respectively. Sphere P is dropped into a liquid of density 0.8 gm cm⁻³ and viscosity $\eta = 3$ poiseulles. Sphere Q is dropped into a liquid of density 1.6 gm cm⁻³ and viscosity $\eta = 2$ poiseulles. The ratio of the terminal velocities of P and Q is

[IIT-JEE 2016]



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(A) $T_1 > T_2$

There are two thin spheres A and B of the same material and same thickness. They emit radiation like black bodies. Radius of A is double that of B. A and B have same temperature T. When A and B are kept in a room of temperature T_0 (< T), the ratio of their rates of cooling (rate of fall of temperature) is: [assume negligible heat exchange between A and B]

(D) $T_1 = T_2$

(A) 2:1 (B) 1:1 (C) 4:1 (D) 8:1



8. In the figure shown AB is a rod of length 30 cm and area of cross-40°C section 1.0 cm² and thermal conductivity 336 S. I. units. The ends 20°C 20cm A & B are maintained at temperatures 20° C and 40 °C respectively. A point C of this rod is connected to a box D, containing ice at 0° highly conducting wire ce D C, through a highly conducting wire of negligible heat capacity. The rate at which ice melts in the box is : [Assume latent heat of fusion for ice $L_f = 80 \text{ cal/gm}$] (\mathbf{A}) 84 mg/s **(B)** 84 g/s (C) 20 mg/s (\mathbf{D}) 40 mg/s 9. Two elastic rods are joined between fixed supports as shown in the figure. Condition for no change in the lengths of individual rods with the increase of temperature $(\alpha_1, \alpha_2 = \text{linear expansion co-efficient})$ $A_1, A_2 = Area of rods$ $y_1, y_2 = Young modulus)$ (A) $\frac{A_1}{A_2} = \frac{\alpha_1 \ y_1}{\alpha_2 \ y_2}$ (B) $\frac{A_1}{A_2} = \frac{L_1 \ \alpha_1 \ y_1}{L_2 \ \alpha_2 \ y_2}$ (C) $\frac{A_1}{A_2} = \frac{L_2 \ \alpha_2 \ y_2}{L_1 \ \alpha_1 \ y_1}$ (D) $\frac{A_1}{A_2} = \frac{\alpha_2 \ y_2}{\alpha_1 \ y_1}$ 10. Four particles have speeds 1, 0, 2, 3 m/s. The root mean square speed of the particles is: (in m/s) **(D)** $\sqrt{\frac{14}{2}}$ **(B)** $\sqrt{35}$ (C) 1.5 (A) 3.5 11. In a process the density of a gas remains constant. If the temperature is doubled, then the change in the pressure will be : (A) 100 % increase **(B)** 200 % increase (C) 50 % decrease (D) 25 % decrease 12. A steel rod of length 1m is heated from 25°C to 75°C keeping its length constant. The longitudinal strain developed in the rod is (Given : Coefficient of linear expansion of steel = $12 \times 10^{-6/\circ}$ C) (A) 6×10^{-6} **(B)** -6×10^{-5} $(C) - 6 \times 10^{-4}$ (D) zero A rod of length \bullet and cross section area A has a variable thermal conductivity given by $k = \alpha T$, where α is a positive 13. constant and T is temperature in kelvin. Two ends of the rod are maintained at temperatures T₁ and T₂ (T₁ > T₂). Heat current flowing through the rod will be (A) $\frac{A \alpha (T_1^2 - T_2^2)}{\lambda}$ (B) $\frac{A \alpha (T_1^2 + T_2^2)}{\lambda}$ (C) $\frac{A \alpha (T_1^2 + T_2^2)}{3\lambda}$ (D) $\frac{A \alpha (T_1^2 - T_2^2)}{2\lambda}$ 14. P-T diagram is shown below then choose the corresponding V-T diagram Ŕ **(C) (B) (D)** Ť



15. A diatomic ideal gas undergoes a thermodynamic change according to the P–V diagram shown in the figure. The total heat given to the gas is nearly :



- On an X temperature scale, water freezes at -125.0° X and boils at 375.0° X. On a Y temperature scale, water 16. freezes at -70.0° Y and boils at -30.0° Y. The value of temperature on X-scale equal to the temperature of 50.0°Y on Y-scale is : **(B)** -125.0° X **(C)** 1375.0° X (A) 455.0° X (D) 1500.0° X
- 17. A solid spherical black body of radius r and uniform mass distribution is in free space. It emits power 'P' and its rate of cooling is R then

```
(C) R P \propto 1/r^2 (D) R P \propto \frac{1}{r}
                            (B) R P ∝ r
(A) R P \propto r^2
```

18. A black body emits radiation at the rate P when its temperature is T. At this temperature the wavelength at which the radiation has maximum intensity is λ_0 . If at another temperature T' the power radiated is P' and

wavelength at maximum intensity is $\frac{\lambda_0}{2}$ then

(B) P' T' = 16PT (C) P' T' = 8PT (**D**) P' T' = 4PT (A) P' T' = 32PT

- 19. The emissive power of a black body at T = 300 K is 100 Watt/m². Consider a body B of area A = 10 m² coefficient of reflectivity r = 0.3 and coefficient of transmission t = 0.5. Its temperature is 300 K. Then which of the following is incorrect :
 - (A) The emissive power of B is 20 W/m^2
- **(B)** The emissive power of B is 200 W/m^2
- (C) The power emitted by B is 200 Watts

- (D) The emissivity of B is = 0.2
- 20. There are four objects A, B, C and D. It is observed that A and B are in thermal equilibrium and C and D are also in thermal equilibrium. However, A and C are not in thermal equilibrium. We can conclude that :

(A) B and D are in thermal equilibrium

- (B) B and D could be in thermal equilibrium
- (C) B and D cannot be in thermal equilibrium
- (D) The zeroth law of thermodynamics does not apply here because there are more than three objects
- If H_C, H_K and H_F are heat required to raise the temperature of one gram of water by one degree in Celsius, 21. Kelvin and Fahrenheit temperature scales respectively then :

A)
$$H_{K} > H_{C} > H_{F}$$
 (B) $H_{F} > H_{C} > H_{K}$ **(C)** $H_{K} = H_{C} > H_{F}$ **(D)** $H_{K} = H_{C} = H_{F}$

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

(A) 166.2 J (C) 126.2 J (D) none of these **(B)** 136.2



23. A gas is expanded from volume V_0 to $2V_0$ under three different processes. Process 1 is isobaric process, process 2 is isothermal and process 3 is adiabatic. Let $\Delta U_1, \Delta U_2$ and ΔU_3 be the change in internal energy of the gas in these three processes. Then :

> (A) $\Delta U_1 > \Delta U_2 > \Delta U_3$ (B) $\Delta U_1 < \Delta U_2 < \Delta U_3$ (C) $\Delta U_2 < \Delta U_1 < \Delta U_3$ (D) $\Delta U_2 < \Delta U_3 < \Delta U_1$

- 24. Logarithms of readings of pressure and volume for an ideal gas were plotted on a graph as shown in Figure. By measuring the gradient, it can be shown that the gas may be
 - (A) monoatomic and undergoing an adiabatic change
 - (B) monoatomic and undergoing an isothermal change
 - (C) diatomic and undergoing an adiabatic change
 - (D) triatomic and undergoing an isothermal change.



25. A metallic sphere having radius 0.08 m and mass m = 10kg is heated to a temperature of 227°C and suspended inside a box whose walls are at a temperature of 27°C. The maximum rate at which its temperature will fall is :- (Take e = 1, Stefan's constant σ = 5.8 x 10⁻⁸ Wm⁻² K⁻⁴ and specific heat of the metal s = 90 cal/kg/deg J = 4.2 Joules/Calorie)

(A) .055 °C/sec

(B) .066 °C/sec (C) .044 °C/sec

(D) 0.03 °C/sec

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

- 26. A partition divides a container having insulated walls into two compartments I and II. The same gas fills the two compartments whose initial parameters are given. The partition is a conducting wall which can move freely without friction. Which of the following statement is/are correct, with reference to the final equilibrium position?
 - (A) The Pressure in the two compartments are equal.
 - (B) Volume of compartment I is $\frac{3V}{5}$ (C) Volume of compartment II is $\frac{12V}{5}$
 - (**D**) Final pressure in compartment I is $\frac{5P}{3}$

P, V, T 2P, 2V, T

27. During an experiment, an ideal gas is found to obey a condition $\frac{P^2}{\rho} = \text{constant} [\rho = \text{density of the gas}]$. The gas is

initially at temperature T, pressure P and density ρ . The gas expands such that density changes to $\frac{\rho}{2}$

- (A) The pressure of the gas changes to $\sqrt{2}$ P.
- (B) The temperature of the gas changes to $\sqrt{2}$ T.
- (C) The graph of the above process on the P-T diagram is parabola.
- (D) The graph of the above process on the P-T diagram is hyperbola.







SECTION - III : ASSERTION AND REASON TYPE

34. Statement-1 : Two solid cylindrical rods of identical size and different thermal conductivity K₁ and K₂ are connected in series. Then the equivalent thermal conductivity of two rod system is less than the value of thermal conductivity of either rod.



Statement-2 : For two cylindrical rods of identical size and different thermal conductivity K_1 and K_2 connected in series, the equivalent thermal conductivity K is given by

$$\frac{2}{K} = \frac{1}{K_1} + \frac{1}{K_2}$$

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1

- (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
- (C) Statement-1 is True, Statement-2 is False
- (D) Statement-1 is False, Statement-2 is True.
- 35. Statement-1: As the temperature of the blackbody increases, the wavelength at which the spectral intensity (E_{λ}) is maximum decreases.

Statement-2: The wavelength at which the spectral intensity will be maximum for a black body is proportional to the fourth power of its absolute temperature.

- (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
- (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
- (C) Statement-1 is True, Statement-2 is False
- (D) Statement-1 is False, Statement-2 is True.

36. Statement-1: An ideal gas is enclosed within a container fitted with a piston. When volume of this enclosed gas is increased at constant temperature, the pressure exerted by the gas on the piston decreases.

Statement-2: In the above situation the rate of molecules striking the piston decreases. If the rate at which molecules of a gas having same average speed striking a given area of the wall decreases, the pressure exerted by gas on the wall decreases.

- (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
- (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
- (C) Statement-1 is True, Statement-2 is False
- (D) Statement-1 is False, Statement-2 is True

SECTION - IV : COMPREHENSION TYPE

Comprehension #1

Two closed identical conducting containers are found in the laboratory of an old scientist. For the verification of the gas some experiments are performed on the two boxes and the results are noted.



Experiment 1. When the two containers are weighed $W_A = 225 \text{ g}$, $W_B = 160 \text{ g}$ and mass of evacuated container $W_C = 100 \text{ g}$.

Experiment 2. When the two containers are given same amount of heat same temperature rise is recorded. The pressure change found are

$$\Delta P_A = 2.5$$
 atm. $\Delta P_B = 1.5$ atm.



PHYSICS FOR JEE MAIN & ADVANCED

	Required data for unknown gas :											
	Mono (molar mass)	He 4g	Ne 20g	Ar 40 g	Kr 84 g	Xe 131 g	Rd 222 g					
	Dia (molar mass)	H₂ 2g	F₂ 19 g	N₂ 28g	O₂ 32g	Cl₂ 71 g						
37.	Identify th (A) Mono,	e type of gas Mono	s filled in co (B) Dia, I	ntainer A an Dia	d B respecti (C) Mor	vely. no, Dia	(D) Dia,	(D) Dia, Mono.				
38.	Identify th (A) N ₂ , Ne	(D) Ar, C	02									
39.	If the gases have initial temperature 300 K and they are mixed in an adiabatic container having the same volume as the previous containers. Now the temperature of the mixture is T and pressure is P. Then (A) $P > P_A$, $T > 300 K$ (B) $P > P_B$, $T = 300 K$ (C) $P < P_A$, $T = 300 K$ (D) $P > P_A$, $T < 300 K$											
Compr	ehension #2 A body coo the body is	2 ols in a surro s 40°C . Assu	unding of co ume Newton [*]	nstant tempe s law of coo	erature 30 °C ling is valid	. Its heat capa . The body co	acity is 2J/°C. ools to 38°C in	Initial temperature of 10 minutes.				
40.	In further 1 (A) 36°C	10 minutes it	will cool fro (B) 36.4°C	om 38°C to _ C	: (C) 37°C	2	(D) 37.5°	С				
41.	The temperature 40° C \uparrow θ 30° C (A)	rature of the $t \rightarrow t$	e body in °C $40^{\circ}C$ $\overrightarrow{}$ θ $30^{\circ}C$ (B)	denoted by	θ the variati $\uparrow^{40}_{\theta_{30}}$	on of θ versu $0^{\circ}C$ $0^{\circ}C$ $t \rightarrow t$	this time t is be $\uparrow^{40^\circ C}$ θ (0,0) (0,0)	est denoted as $t \rightarrow t$				
42.	When the b total heat n (A) 3.6J	oody tempera equired from	ature has read n a heater by (B) 0.364.	ched 38 °C, i 7 the body is J	t is heated ag :: (C) 8 J	gain so that it	reaches to 40° (D) 4 J	C in 10 minutes .The				
			SECTIO	N-V:MA	TRIX - M	АТСН ТҮН	PE					
43.	An ideal n the corresp	nonoatomic ponding effe	gas undergo cts in colum	es different i n-II. The le	types of pro- tters have us	cesses which sual meaning.	are described	in column-I. Match				
	$(\mathbf{A}) \mathbf{P} = 2\mathbf{V}^2$	2			(P) If ve also in	olume increas	ses then tempe	rature will				
	(B) $PV^2 = 0$	constant			(Q) If v decre	olume increas	ses then tempe	erature will				
	$(\mathbf{C}) \mathbf{C} = \mathbf{C}_{\mathbf{v}}$	+ 2R			(R) For supp	expansion, h lied to the ga	eat will have t s.	o be				
	(D) $C = C_v$	– 2R			(S) If te done	mperature in e by gas is po	creases then w sitive.	vork				
	(T) If temperature decreases then work done by gas positive							work done by gas is				



44. A sample of gas goes from state A to state B in four different manners, as shown by the graphs. Let W be the work done by the gas and ΔU be change in internal energy along the path AB. Correctly match the graphs with the statements provided.



SECTION - VI : INTEGER TYPE

45. Consider a vertical tube open at both ends. The tube consists of two parts, each of different cross-sections and each part having a piston which can move smoothly in respective tubes. The two pistons are joined together by an inextensible wire. The combined mass of the two piston is 5 kg and area of cross-section of the upper piston is 10 cm² greater than that of the lower piston. Amount of gas enclosed by the pistons is one mole. When the gas is heated slowly, pistons move by 50 cm. Find rise in the temperature of the gas, in the form $\frac{X}{R}K$ where R is universal gas constant. Use g = 10 m/s² and outside pressure = 10⁵ N/m²). Fill value of X in the





answer sheet.

46. Figure shows the variation of internal energy (U) with the pressure (P) of 2.0 mole gas in cyclic process abcda. The temperature of gas at c and d are 300 and 500 K. Calculate the heat absorbed by the gas during the process 10xR ln2 then x is .



47. Current i = 2A flows through the resistance $R = 10\Omega$. With what constant speed v (in m/s), must the piston move in upward direction so that temperature of ideal gas may remain unchanged. (g = 10 m/s²)



48. One mole of an ideal monatomic gas undergoes a linear process from A to B, in which is pressure P and its volume V change as shown in figure, where $V_0 = 8$ litres. As the volume of the gas is increased, in some range of volume the gas expands with absorbing the heat (the endothermic process); in the other range the gas emits the heat (the exothermic process). Then find the volume (in litres) after which if the volume of gas is further increased the given process switches from endothermic to exothermic.





ANSWER KEY

EXERCISE - 1

1.	С	2.	С	3.	В	4.	В	5.	А	6. I	В	7.	D	8. C	9. A	10. D	11. A	12. C	13. C
14.	В	15.	А	16.	В	17.	В	18.	А	19. <i>A</i>	A	20.	D	21. D	22. D	23. B	24. D	25. D	26. B
27.	В	28.	В	29.	С	30.	С	31.	D	32. (С	33.	В	34. C	35. A	36. B	37. D	38. A	39. C
40.	D	41.	В	42.	С	43.	А	44.	В	45. I	D	46.	D	47. D	48. C	49. A	50. C	51. A	52. A
53.	А	54.	С	55.	D	56.	В	57.	В	58. I	D	59.	В	60. B					

EXERCISE - 2 : PART # I

1	C 2 B,D	3 C	4 B,C	5 B	6 B	7. A, B	8 B,C,D	9 B,C
10.	A,B,C,D	11. C	12. B	13. A,C	14. B,D	15. B	16. B	17. D
18 .	A,B,C,D	19. D	20. C, D	21 . D	22. A,B,D	23. A,B,C	24. A,B,C,D	25. A,B
26.	C,D	27. C	28. C	29. A, B, C, D	30. D	31. D	32. A,C	33. A,C
34.	А	35. D	36. B	37. B,D	38. B	39. B	40. B	41. A
42.	B,D	43. B	44. B	45. D	46. A	47. C	48. B	49. A
50.	В	51. B	52. D	53. A	54. A	55. C	56. D	57. A,C
58.	A	59. D	60. A	б . в	62. A	63. C	64. D	65. A
6 6.	A	67. C,D	68. C	69. A,B,C,E	70. В	71. C	72. A,C,D	73. A
74.	В	75. D	76. B,C,D	77. A	78. A,B,C	79. D		

PART # II

 1
 C
 2
 B
 3
 D
 4
 A
 5
 A
 6
 A
 7
 A
 8
 C
 9
 D
 10. A
 11. D
 12. A
 13. A

 14. A
 15. D
 16. D
 17. D
 18. A
 19. A
 20. A
 21. C
 22. A
 23. A
 24. A
 25. A
 26. A

 27. C
 28. A
 29. A
 30. A
 31. A
 32. B
 B
 31. A
 32. B

EXERCISE - 3 : PART # I

2. $A \rightarrow T$; $B \rightarrow R$; $C \rightarrow Q$; $D \rightarrow T$

6. $A \rightarrow Q$; $B \rightarrow R$; $C \rightarrow P$; $D \rightarrow Q$ **8**. $A \rightarrow T$; $B \rightarrow T$; $C \rightarrow P$; $D \rightarrow Q$

10. $A \rightarrow R$; $B \rightarrow S$; $C \rightarrow Q$; $D \rightarrow P$

4. A \rightarrow T; B \rightarrow T; C \rightarrow T

1. $A \rightarrow Q$; $B \rightarrow R$; $C \rightarrow P$; $D \rightarrow S$ 3. $A \rightarrow P$; $B \rightarrow R$; $C \rightarrow T$ 5. $A \rightarrow Q$; $B \rightarrow T$; $C \rightarrow S$; $D \rightarrow T$ 7. $A \rightarrow P$, R; $B \rightarrow S$; $C \rightarrow Q$; $D \rightarrow S$ 9. $A \rightarrow S$; $B \rightarrow R$; $C \rightarrow Q$; $D \rightarrow P$ 11. $A \rightarrow Q$; $B \rightarrow R$; $C \rightarrow S$; $D \rightarrow P$

Comp. #1 :	1. A	2 . C			
Comp. #3:	1. D	2 . A			
Comp. #5 :	1. B	2 . D	3 . A	4 . A	5 . A
Comp. #7:	1. C	2 . D	3 . B	4 . C	5 . B
Comp. #9:	1. D	2 . A	3 . C	4 . D	
Comp #11	1. B	2 . B	3 . B		
Comp. #13:	1. A	2 . B	3 . C		
Comp. #15:	1. B	2 . A	3 . A		

PART # II				
Comp. #2 :	1. D	2 . D		
Comp. #4 :	1. C	2 . B	3 . C	
Comp. #6 :	1. A	2 . B	3 . D	4 . C
Comp. #8 :	1. B	2 . B	3. B	
Comp. #10:	1. B	2 . A	3 . B	
Comp. #12:	1. C	2 . A	3 . B	
Comp. #14:	1. B	2 . A	3 . C	

PHYSICS FOR JEE MAIN & ADVANCED



57.	2000 N/m, 1295 J 58 . 74 cm, 73.94 cm, 69.52 cm 59 . 30 cm
60.	$\frac{13}{12}$ P, $1_1 = 0.6$ 1, $1_2 = 1.5$ 1, $1_3 = 0.9$ 1 61. (i) 80J, 180 J (ii) 4.5 R
62.	(i) $P_A = P_C = \frac{27}{8} P_0, P_B = \frac{21}{4} P_0$ (ii) $T_A = T_B = \frac{21}{4} T_0, T_C = \frac{3}{2} T_0$ (iii) 18 $P_0 V_0$
	(iv) $W_{A} = P_{0}V_{0}, W_{B} = 0$ (v) $\frac{17}{2}P_{0}V_{0}$
	EXERCISE - 5 : PART # I
1. 14. 27. 40. 53.	3 2. 4 3. 3 4. 4 5. 1 6. 2 7. 1 8. 1 9. 1 10. 3 11. 4 12. 4 13. 3 1 15. 1 16. 1 17. 3 18. 1 19. 3 20. 2 21. 2 22. 3 23. 4 24. 3 25. 1 26. 3 1 28. 2 29. 1 30. 1 31. 4 32. 4 33. 3 34. 2 35. 3 36. 1 37. 3 38. 2 39. 4 2 41. 2 42. 1 43. 2 46. 47. 3 48. 2 49. 3 50. 4 51. 2 52. 1 3 54. 3 55. 2 56 1 57. NONE 58. 4 59. 1 60. </td
	PART # II
M(1. 14. 27. M(CQ's (Single Correct answers) A 2. C 3. D 4. D 5. C 6. D 7. D 8. B 9. A 10. A 11. C 12. B 13. B A 15. B 16. A 17. A 18. D 19. D 20. C 21. A 22. B 23. C 24. C 25. D 26. B A 28. C 29. D 30. A 31. A 32. C 33. D 34. A 35. A 36. A 37. B
1 M a	C,D 2 B,C 3 B,D 4 B,D 5 B,D 6 ABCD 7. B,D 8. A,B,D 9. A,B/B 10. C 11. A tch the column
1 . A	$\rightarrow S; B \rightarrow P,R; C \rightarrow R; D \rightarrow Q,S \qquad 2.A \rightarrow Q,S; B \rightarrow Q; C \rightarrow P;Q; D \rightarrow Q,R \qquad 3.A \rightarrow Q; B \rightarrow P,R; C \rightarrow P,S D \rightarrow Q,S \qquad (A \rightarrow Q); C \rightarrow P,S \rightarrow Q,S \qquad (A \rightarrow Q); C \rightarrow P,S \rightarrow Q,S \qquad (A \rightarrow Q); C \rightarrow P,S \rightarrow Q,S \qquad (A \rightarrow Q); C \rightarrow P,S \rightarrow Q,S \qquad (A \rightarrow Q); C \rightarrow P,S \rightarrow Q,S \qquad (A \rightarrow Q); C \rightarrow P,S \rightarrow Q,S \qquad (A \rightarrow Q); C \rightarrow P,S \rightarrow Q,S \qquad (A \rightarrow Q); C \rightarrow P,S \rightarrow Q,S \qquad (A \rightarrow Q); C \rightarrow P,S \rightarrow Q,S \qquad (A \rightarrow Q); C \rightarrow P,S \rightarrow Q,S \qquad (A \rightarrow Q); C \rightarrow Q)$
Co	mprehension Based Questions
Col Col	nprehension#1 1. A 2. D 3. C Comprehension#2 1. D 2. B 3. B
As	sertion–Reason 1. B
Su	ojective Questions
1.	(i) P_0V_0 (ii) $\frac{5}{2}P_0V_0$, $3P_0V_0$ (iii) $\frac{1}{2}P_0V_0$ (iv) $\frac{25}{8}\frac{P_0V_0}{R}$ 2. $\begin{bmatrix} 300+12.5e^{-\frac{2KAt_1}{CL}} \end{bmatrix} K$
3.	(i) $P_2 = \frac{B}{V_1 + V_2 + V_2} $ (ii) $W = \frac{3}{2} P_1 V_1 \left[1 - \left(\frac{V_1}{V_2}\right)^{2/3} \right], \Delta U = \frac{3}{2} P_1 V_1 \left[\left(\frac{V_1}{V_2}\right)^{2/3} - 1 \right], T = \frac{Q}{3R} + \frac{Q}{3R} $
4.	(i) 1200 R (ii) $Q_{AB} = -2100 \text{ R}, Q_{BC} = 1500 \text{ R}, Q_{CA} = 1200 \text{ R}_{1n2}$ 5. 0.5 kg
6.	(i) 600 K (ii) 1500R, 831.6K, $-900R$, $-831.6R$ (iii) 600R 7. 4.568×10^{-3} °C
8.	(i) 160K (ii) 3.3×10^{-21} J (iii) 0.3 g 9. $\frac{\text{Mv}_0^2}{3\text{R}}$ 10. (i) 595 W/m ² (ii) 162.6 ^o 11. 400 $\left(\frac{4}{3}\right)^{0.4}$ K



12. $\gamma_1 = 2\alpha_s$ **13.** $\frac{K}{4e\sigma LT_s^3 + K}$ **14.** (i) 70°C (ii) 0.05 J (iii) 19999.95 J **15.** 273 K **16.9 17.** 2 **18.** 2 **19.** 9 **20.** 3

MOCK TEST

1. B 2. D 3. D 4. A 5. C 6. B 7. B 8. D 9. D 10. B 11. A 12. C 13. D 14. D 15. C 16. C 17. B 18. A 19. A 20. C 21. C 22. A 23. A 24. C 25. B 26. A,B, C, D 27. B,D 28. A,D29. A, C 30. A,C 31. A,C,D 32. A,D 33. B,D 34. D 35. C 36. A 37. C 38. D 39. B 40. B 41. A 42. C 43. $A \rightarrow P,R,S; B \rightarrow Q,T; C \rightarrow P,R,S; D \rightarrow Q,R,T$ 44. $A \rightarrow S; B \rightarrow Q,T; C \rightarrow R,T; D \rightarrow Q,T$ 45. 75 46. 40 47. 4 48. 5

