Q.29 (A) → S; (B) → P and R; (C) → R; (D) → Q and S

Q.30 (A) S, Q ;(B) Q; (C) P, Q; (D) Q, R **or** (A) S, (B) Q, (C) P, (D) R Q.31 A

Q.32	D	Q.33	C	Q.34	B	Q.35	C
Q.36	(A) q (B) p, r (C) p, s (D) q, s			Q.37	B, D	Q.38	B, D
Q.39	9						

OBJECTIVE QUESTION BANK

ONLY ONE OPTION IS CORRECT.

Q.1	C	Q.2	A	Q.3	C	Q.4	D	Q.5	B	Q.6	C	Q.7	A
Q.8	A	Q.9	A	Q.10	A	Q.11	B	Q.12	B	Q.13	A	Q.14	B
Q.15	A	Q.16	D	Q.17	A	Q.18	C	Q.19	D	Q.20	B	Q.21	D
Q.22	A	Q.23	C	Q.24	A	Q.25	C	Q.26	D	Q.27	B	Q.28	A
Q.29	C	Q.30	C	Q.31	A	Q.32	B	Q.33	A	Q.34	C	Q.35	D
Q.36	A	Q.37	B	Q.38	C	Q.39	C	Q.40	C	Q.41	C	Q.42	D
Q.43	D	Q.44	A	Q.45	A	Q.46	D	Q.47	A	Q.48	C	Q.49	D
Q.50	D	Q.51	D	Q.52	A	Q.53	A	Q.54	C	Q.55	C	Q.56	A
Q.57	A	Q.58	C	Q.59	D	Q.60	A	Q.61	A	Q.62	B	Q.63	A
Q.64	B	Q.65	A	Q.66	B	Q.67	C	Q.68	B	Q.69	A	Q.70	A
Q.71	C	Q.72	D	Q.73	C	Q.74	B	Q.75	D				

ONE OR MORE THAN ONE OPTION MAY BE CORRECT

Q.1	D	Q.2	A, C	Q.3	A, B	Q.4	D	Q.5	A, B
Q.6	A, B, C, D	Q.7	D	Q.8	A, C	Q.9	C	Q.10	D
Q.11	B, D	Q.12	C	Q.13	A, D	Q.14	D	Q.15	C, D
Q.16	D	Q.17	D	Q.18	A, D	Q.19	B	Q.20	C
Q.21	A, D	Q.22	D	Q.23	A	Q.24	A, B, C	Q.25	C
Q.26	A, B	Q.27	B						

ANSWER KEY

EXERCISE – I

Q.1 65°C Q.2 5°C Q.3 7/2 Q.4 (4/3) ω

Q.5 10.34 cm Q.6 2 : 1 Q.7 $\left(\frac{6}{\pi}\right)^{1/3}$ Q.8 80 k cal/kg

Q.9 3025 K Q.10 10 sec Q.11 327 °C Q.12 4/3

Q.13 74.9 cm Q.14 4 : 1 Q.15 1.25×10^4 N/m^2

Q.16 (i) $P_1 < P_2$, $T_1 < T_2$; (ii) $T_1 = T_2 < T_3$; (iii) $V_2 > V_1$; (iv) $P_1 > P_2$

Q.17 1.84P, 10V/3, 8V/3 (adiabatic), 13P/6, 30V/13, 48V/13 (isothermal)

Q.18 $\frac{3}{2}\rho_0$ Q.19 1.5 Q.20 1.5 Q.21 $\frac{mRT_0}{V_0}\left(1+\frac{T_0 m}{V_0}\right)R$

Q.22 The molar mass of the gas is 40 gm, the number of degrees of freedom of the gas molecules is 6

Q.23 100 J Q.24 3600 R Q.25 400 K Q.26 12600 J

Q.27 50 calorie Q.28 $R\Delta T\left(\frac{3-2\gamma}{\gamma-1}\right)$ Q.19 $RT\left[1-\frac{1}{n}\right]$ Q.30 P/n

Q.31 5R Q.32 $C_V + \frac{R}{\alpha V}$ Q.33 $\frac{R}{2}$ Q.34 (i) $\left(\frac{\gamma+1}{\gamma-1}\right)4aV_0^2$, (ii) $\left(\frac{\gamma+1}{\gamma-1}\right)\frac{R}{2}$

Q.35 $1 - \frac{3\left(1-\frac{1}{2^{1/3}}\right)}{\ln 2}$

EXERCISE – II

Q.1 $\frac{a^2 s}{2K}\log_e\left(\frac{b}{a}\right)\log_e\left(\frac{T_0-T_1}{T_0-T_2}\right)$ Q.2 $\frac{l_1}{l} = \frac{k(T_1-T_m)}{k(T_1-T_m)+(T_m-T_2)}$

Q.3 (a) –100 °C/m, (b) 1000 J Q.4 166.3 sec Q.5 10 minutes

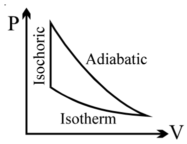
Q.6 (i) 74 cm, (ii) 73.94 cm, (iii) 69.52 cm

Q.7 $p_1 = p_{H_2} \simeq 1.25 \times 10^6$ Pa ; $p_2 = p_{H_2} + p_{O_2} + p_{N_2} \simeq 2.8125 \times 10^6$ Pa ; $p_3 = p_{H_2} + p_{N_2} \simeq 1.5625 \times 10^6$ Pa

Q.8 750 K Q.9 $31P_0V_0$; $-5P_0V_0$

Q.10 (ii) $P_b = P_c = 2$ atm, (iii) $T_b = 300$ K, $T_c = 600$ K, (iv) $V_c = 8$ litre

Q.11 1.6 m, 364 K Q.12 1.63 Q.13 8000 cal.



Q.18 A mixture of ideal gases 7 kg of nitrogen and 11 kg of CO_2. Then
(A) equivalent molecular weight of the mixture is 36.
(B) equivalent molecular weight of the mixture is 18.
(C) γ for the mixture is 5/2
(D) γ for the mixture is 47/35.
(Take γ for nitrogen and CO_2 as 1.4 and 1.3 respectively)

Q.19 Select the incorrect statement about ideal gas.
(A) Molecules of a gas are in incessant random motion colliding against one another and with the walls of the container.
(B) The gas is not isotropic and the constant (1/3) in equation $P = (1/3)\rho\, v_{rms}^2$ is result of this property
(C) The time during which a collision lasts is negligible compared to the time of free path between collisions.
(D) There is no force of interaction between molecules among themselves or between molecules and the wall except during collision.

Q.20 A gas is enclosed in a vessel at a constant temperature at a pressure of 5 atmosphere and volume 4 litre. Due to a leakage in the vessel, after some time, the pressure is reduced to 4 atmosphere. As a result, the
(A) volume of the gas decreased by 20%
(B) average K.E. of gas molecule decreases by 20%
(C) 20% of the gas escaped due to the leakage
(D) 25% of the gas escaped due to the leakage

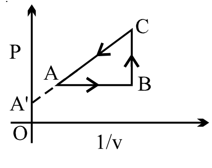
Q.21 A container holds 10^{26} molecules/m^3, each of mass 3×10^{-27} kg. Assume that 1/6 of the molecules move with velocity 2000 m/s directly towards one wall of the container while the remaining 5/6 of the molecules move either away from the wall or in perpendicular direction, and all collisions of the molecules with the wall are elastic
(A) number of molecules hitting 1 m^2 of the wall every second is 3.33×10^{28}.
(B) number of molecules hitting 1 m^2 of the wall every second is 2×10^{29}.
(C) pressure exerted on the wall by molecules is 24×10^5Pa.
(D) pressure exerted on the wall by molecules is 4×10^5Pa.

Q.22 A student records ΔQ, ΔU & ΔW for a thermodynamic cycle $A \to B \to C \to A$. Certain entries are missing. Find correct entry in following options.

	AB	BC	CA
ΔW	40J		30J
ΔU		50J	
ΔQ	150J	10J	

(A) $W_{BC} = -70$ J
(B) $\Delta Q_{CA} = 130$ J
(C) $\Delta U_{AB} = 190$ J
(D) $\Delta U_{CA} = -160$ J

Q.23 An enclosed ideal gas is taken through a cycle as shown in the figure. Then



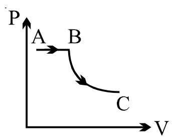
(A) Along AB, temperature decreases while along BC temperature increases
(B) Along AB, temperature increases while along BC the temperature decreases.
(C) Along CA work is done by the gas and the internal energy remains constant.
(D) Along CA work is done on the gas and internal energy of the gas increases.

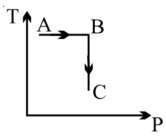
Q.6 If the temperature of the body is raised to a higher temperature T', then choose the correct statement(s)
(A) The intensity of radiation for every wavelength increases
(B) The maximum intensity occurs at a shorter wavelength
(C) The area under the graph increases
(D) The area under the graph is proportional to the fourth power of temperature

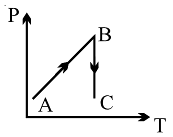
Q.7 A black body is at a temperature of 2880 K. The energy of radiation emitted by this object with wavelength between 499 nm and 500 nm is U_1, between 999 nm and 1000 nm is U_2 and between 1499 nm and 1500 nm is U_3. The Wien constant $b = 2.88 \times 10^6$ nm K. Then
(A) $U_1 = 0$ (B) $U_3 = 0$ (C) $U_1 > U_2$ (D) $U_2 > U_1$

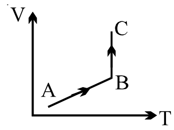
Q.8 50 gm ice at – 10°C is mixed with 20 gm steam at 100°C. When the mixture finally reaches its steady state inside a calorimeter of water equivalent 1.5 gm then : [Assume calorimeter was initially at 0°C, Take latent heat of vaporization of water = 540 cal/gm, Latent heat of fusion of water = 80 cal/gm, specific heat capacity of water = 1 cal/gm-°C, specific heat capacity of ice = 0.5 cal/gm °C]
(A) Mass of water remaining is : 67.4 gm
(B) Mass of water remaining is : 67.87 gm
(C) Mass of steam remaining is : 2.6 gm
(D) Mass of steam remaining is : 2.13 gm

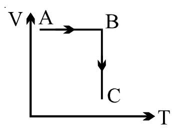
Q.9 A process is shown in the diagram. Which of the following curves may represent the same process ?



(A) 

(B) 

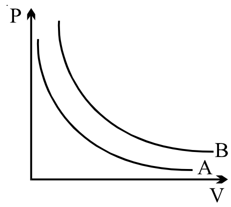
(C) 

(D) 

Q.10 An ideal gas expands in such a way that PV^2 = constant throughout the process.
(A) The graph of the process of T-V diagram is a parabola.
(B) The graph of the process of T-V diagram is a straight line.
(C) Such an expansion is possible only with heating.
(D) Such an expansion is possible only with cooling.

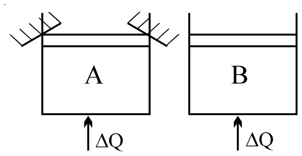
Q.11 A gas expands such that its initial and final temperature are equal. Also, the process followed by the gas traces a straight line on the P-V diagram :
(A) The temperature of the gas remains constant throughout.
(B) The temperature of the gas first increases and then decreases
(C) The temperature of the gas first decreases and then increases
(D) The stright line has a negative slope.

Q.12 Figure shows the pressure P versus volume V graphs for two different gas sample at a given temperature. M_A and M_B are masses of two samples, n_A and n_B are numbers of moles. Which of the following ***must be incorect.***



(A) $M_A > M_B$ (B) $M_A < M_B$
(C) $n_A > n_B$ (D) $n_A < n_B$

Q.68 Two identical vessels A & B contain equal amount of ideal monoatomic gas. The piston of A is fixed but that of B is free. Same amount of heat is absorbed by A & B. If B's internal energy increases by 100 J the change in internal energy of A is

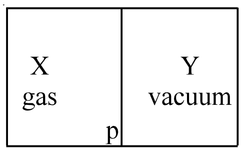


(A) 100 J (B) $\frac{500}{3}$ J
(C) 250 J (D) none of these

Q.69 An ideal gas undergoes an adiabatic process obeying the relation $PV^{4/3}$ = constant. If its initial temperature is 300 K and then its pressure is increased upto four times its initial value, then the final temperature is (in Kelvin):

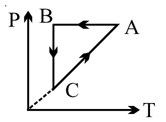
(A) $300\sqrt{2}$ (B) $300\sqrt[3]{2}$ (C) 600 (D) 1200

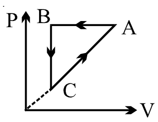
Q.70 A closed container is fully insulated from outside. One half of it is filled with an ideal gas X separated by a plate P from the other half Y which contains a vacuum as shown in figure. When P is removed, X moves into Y. Which of the following statements is correct?

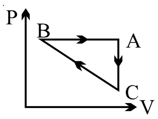


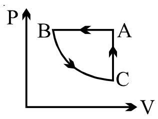
(A) No work is done by X (B) X decreases in temperature
(C) X increases in internal energy (D) X doubles in pressure

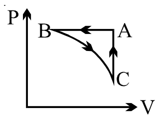
Q.71 A cyclic process ABCA is shown in PT diagram. When presented on PV, it would



(A) 

(B) 

(C) 

(D) 

Q.72 1 kg of a gas does 20 kJ of work and receives 16 kJ of heat when it is expanded between two states. A second kind of expansion can be found between the initial and final state which requires a heat input of 9 kJ. The work done by the gas in the second expansion is :
(A) 32 kJ (B) 5 kJ (C) – 4 kJ (D) 13 kJ

Q.73 A vessel contains an ideal monoatomic gas which expands at constant pressure, when heat Q is given to it. Then the work done in expansion is :

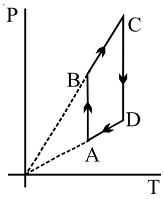
(A) Q (B) $\frac{3}{5}$Q (C) $\frac{2}{5}$Q (D) $\frac{2}{3}$Q

Q.74 One mole of an ideal gas at temperature T_1 expends according to the law $\frac{P}{V^2}$ = a (constant). The work done by the gas till temperature of gas becomes T_2 is :

(A) $\frac{1}{2}R(T_2 - T_1)$ (B) $\frac{1}{3}R(T_2 - T_1)$ (C) $\frac{1}{4}R(T_2 - T_1)$ (D) $\frac{1}{5}R(T_2 - T_1)$

Q.75 The adiabatic Bulk modulus of a diatomic gas at atmospheric pressure is
(A) 0 Nm^{-2} (B) 1 Nm^{-2} (C) 1.4×10^4 Nm^{-2} (D) 1.4×10^5 Nm^{-2}

Q.54 Pressure versus temperature graph of an ideal gas is shown in figure



(A) During the process AB work done by the gas in positive
(B) during the process CD work done by the gas is negative
(C) during the process BC internal energy of the gas is increasing
(D) None

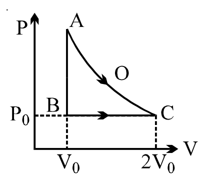
Q.55 A reversible adiabatic path on a P-V diagram for an ideal gas passes through state A where $P=0.7\times10^5\ N/m^{-2}$ and $v = 0.0049\ m^3$. The ratio of specific heat of the gas is 1.4. The slope of path at A is :
(A) $2.0 \times 10^7\ Nm^{-5}$ (B) $1.0 \times 10^7\ Nm^{-5}$ (C) $-2.0 \times 10^7\ Nm^{-5}$ (D) $-1.0 \times 10^7\ Nm^{-5}$

Q.56 An ideal gas at pressure P and volume V is expanded to volume 2V. Column I represents the thermodynamic processes used during expansion. Column II represents the work during these processes in the random order.

Column I	Column II
(p) isobaric	(x) $\frac{PV(1-2^{1-\gamma})}{\gamma-1}$
(q) isothermal	(y) PV
(r) adiabatic	(z) PV ln 2

The correct matching of column I and column II is given by :
(A) p-y, q-z, r-x (B) p-y, q-x, r-z (C) p-x, q-y, r-z (D) p-z, q-y, r-x

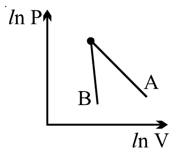
Q.57 An ideal gas is taken from point A to point C on P-V diagram through two process AOC and ABC as shown in the figure. Process AOC is isothermal



(A) Process AOC requires more heat than process ABC.
(B) Process ABC requires more heat than process AOC.
(C) Both process AOC & ABC require same amount of heat.
(D) Data is insufficient for comparison of heat requirement for the two processes.

Q.58 One mole of an ideal gas is contained with in a cylinder by a frictionless piston and is initially at temperature T. The pressure of the gas is kept constant while it is heated and its volume doubles. If R is molar gas constant, the work done by the gas in increasing its volume is
(A) RT ln2 (B) 1/2 RT (C) RT (D) 3/2 RT

Q.59 The figure, shows the graph of logarithmic reading of pressure and volume for two ideal gases A and B undergoing adiabatic process. From figure it can be concluded that



(A) gas B is diatomic (B) gas A and B both are diatomic
(C) gas A is monoatomic (D) gas B is monoatomic & gas A is diatomic

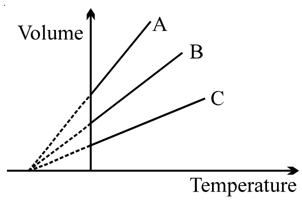
Q.60 Monoatomic, diatomic and triatomic gases whose initial volume and pressure are same, are compressed till their volume becomes half the initial volume.
(A) If the compression is adiabatic then monoatomic gas will have maximum final pressure.
(B) If the compression is adiabatic then triatomic gas will have maximum final pressure.
(C) If the compression is adiabatic then their final pressure will be same.
(D) If the compression is isothermal then their final pressure will be different.

Q.35 28 gm of N_2 gas is contained in a flask at a pressure of 10 atm and at a temperature of 57°. It is found that due to leakage in the flask, the pressure is reduced to half and the temperature reduced to 27°C. The quantity of N_2 gas that leaked out is
(A) 11/20 gm (B) 20/11 gm (C) 5/63 gm (D) 63/5 gm

Q.36 The temperature of a gas is doubled (i) on absolute scale (ii) on centigrade scale. The increase in root mean square velocity of gas will be
(A) More in case (i) (B) More in case (ii) (C) Same in both case (D) Information not sufficient

Q.37 12gms of gas occupy a volume of 4×10^{-3} m^3 at a temperature of 7ºC. After the gas is heated at constant pressure its density becomes 6×10^{-4}gm/cc. What is the temperature to which the gas was heated.
(A) 1000K (B) 1400K (C) 1200K (D) 800K

Q.38 The expansion of an ideal gas of mass m at a constant pressure P is given by the straight line B. Then the expansion of the same ideal gas of mass 2 m at a pressure 2P is given by the straight line
(A) C (B) A (C) B (D) none



Q.39 A vessel contains 1 mole of O_2 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
(A) P/8 (B) P (C) 2P (D) 8P

Q.40 A container X has volume double that of contianer Y and both are connected by a thin tube. Both contains same ideal gas. The temperature of X is 200K and that of Y is 400K. If mass of gas in X is m then in Y it will be:
(A) m/8 (B) m/6 (C) m/4 (D) m/2

Q.41 An ideal gas of Molar mass M is contained in a vertical tube of height H, closed at both ends. The tube is accelerating vertically upwards with acceleration g. Then, the ratio of pressure at the bottom and the mid point of the tube will be
(A) exp[2MgH/RT] (B) exp[–2MgH/RT] (C) exp[MgH/RT] (D) MgH/RT

Q.42 The ratio of average translational kinetic energy to rotational kinetic energy of a diatomic molecule at temperature T is
(A) 3 (B) 7/5 (C) 5/3 (D) 3/2

Q.43 One mole of an ideal gas at STP is heated in an insulated closed container until the average speed of its molecules is doubled. Its pressure would therefore increase by factor.
(A) 1.5 (B) $\sqrt{2}$ (C) 2 (D) 4

Q.44 Three particles have speeds of 2u , 10u and 11u. Which of the following statements is correct?
(A) The r.m.s. speed exceeds the mean speed by about u.
(B) The mean speed exceeds the r.m.s. speed by about u.
(C) The r.m.s. speed equals the mean speed.
(D) The r.m.s. speed exceeds the mean speed by more than 2u.

Q.14 A black metal foil is warmed by radiation from a small sphere at temperature 'T' and at a distance 'd'. It is found that the power received by the foil is P. If both the temperature and distance are doubled, the power received by the foil will be :
(A) 16 P (B) 4 P (C) 2 P (D) P

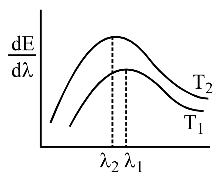
Q.15 The rate of emission of radiation of a black body at 273°C is E, then the rate of emission of radiation of this body at 0°C will be
(A) $\frac{E}{16}$ (B) $\frac{E}{4}$ (C) $\frac{E}{8}$ (D) 0

Q.16 The power radiated by a black body is P and it radiates maximum energy around the wavelength λ_0. If the temperature of the black body is now changed so that it radiates maximum energy around wavelength $3/4\lambda_0$, the power radiated by it will increase by a factor of
(A) 4/3 (B) 16/9 (C) 64/27 (D) 256/81

Q.17 Star S_1 emits maximum radiation of wavelength 420 nm and the star S_2 emits maximum radiation of wavelength 560 nm, what is the ratio of the temperature of S_1 and S_2 :
(A) 4/3 (B) $(4/3)^{1/4}$ (C) 3/4 (D) $(3/4)^{1/2}$

Q.18 Spheres P and Q are uniformly constructed from the same material which is a good conductor of heat and the radius of Q is thrice the radius of P. The rate of fall of temperature of P is x times that of Q when both are at the same surface temperature. The value of x is :
(A) 1/4 (B) 1/3 (C) 3 (D) 4

Q.19 The spectral emissive power E_λ for a body at temperature T_1 is plotted against the wavelength and area under the curve is found to be A. At a different temperature T_2 the area is found to be 9A. Then λ_1/λ_2 =
(A) 3 (B) 1/3 (C) $1/\sqrt{3}$ (D) $\sqrt{3}$

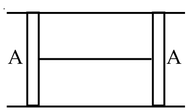


Q.20 A black body calorimeter filled with hot water cools from 60°C to 50°C in 4 min and 40°C to 30°C in 8 min. The approximate temperature of surrounding is :
(A) 10°C (B) 15°C (C) 20°C (D) 25°C

Q.21 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) 100J/°C (B) 300J/°C (C) 750J/°C (D) 1500J/°C

Q.22 Find the approx. number of molecules contained in a vessel of volume 7 litres at 0°C at 1.3×10^5 pascal
(A) 2.4×10^{23} (B) 3×10^{23} (C) 6×10^{23} (D) 4.8×10^{23}

Q.23 A cylindrical tube of cross-sectional area A has two air tight frictionless pistons at its two ends. The pistons are tied with a straight two ends. The pistons are tied with a straight piece of metallic wire. The tube contains a gas at atmospheric pressure P_0 and temperature T_0. If temperature of the gas is doubled then the tension in the wire is
(A) $4 P_0 A$ (B) $P_0A/2$
(C) $P_0 A$ (D) $2 P_0 A$



Q.24 An ideal gas mixture filled inside a balloon expands according to the relation $PV^{2/3}$ = constant. The temperature inside the balloon is
(A) increasing (B) decreasing (C) constant (D) can't be said

OBJECTIVE QUESTION BANK

ONLY ONE OPTION IS CORRECT.

Take approx. 2 minutes for answering each question.

Q.1 One end of a 2.35m long and 2.0cm radius aluminium rod ($K = 235\ W.m^{-1}K^{-1}$) is held at 20^0C. The other end of the rod is in contact with a block of ice at its melting point. The rate in $kg.s^{-1}$ at which ice melts is
(A) $48\pi \times 10^{-6}$ (B) $24\pi \times 10^{-6}$ (C) $2.4\pi \times 10^{-6}$ (D) $4.8\pi \times 10^{-6}$

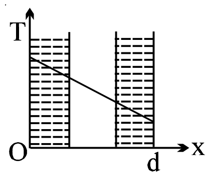
[Take latent heat of fusion for ice as $\frac{10}{3} \times 10^5\ J.kg^{-1}$]

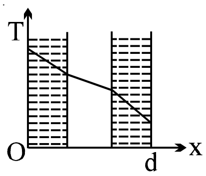
Q.2 Four rods of same material with different radii r and length l are used to connect two reservoirs of heat at different temperatures. Which one will conduct most heat ?
(A) r =2cm, l =0.5m (B) r = 2cm, l = 2m
(C) r =0.5cm, l =0.5m (D) r = 1 cm, l = 1 m

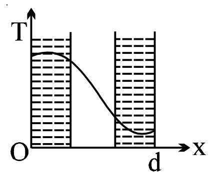
Q.3 A cylinder of radius R made of a material of thermal conductivity k_1 is surrounded by a cylindrical shell of inner radius R and outer radius 2R made of a material of thermal conductivity k_2. The two ends of the combined system are maintained at different temperatures. There is no loss of heat from the cylindrical surface and the system is in steady state. The effective thermal conductivity of the system is

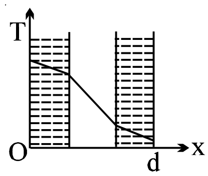
(A) $k_1 + k_2$ (B) $\frac{k_1k_2}{k_1 + k_2}$ (C) $\frac{1}{4}(k_1 + 3k_2)$ (D) $\frac{1}{4}(3k + k_2)$

Q.4 The wall with a cavity consists of two layers of brick separated by a layer of air. All three layers have the same thickness and the thermal conductivity of the brick is much greater than that of air. The left layer is at a higher temperature than the right layer and steady state condition exists. Which of the following graphs predicts correctly the variation of temperature T with distance d inside the cavity?

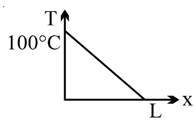
(A) 

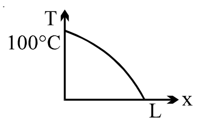
(B) 

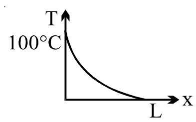
(C) 

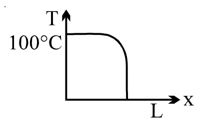
(D) 

Q.5 A rod of length L and uniform cross-sectional area has varying thermal conductivity which changes linearly from 2K at end A to K at the other end B. The ends A and B of the rod are maintained at constant temperature 100°C and 0°C, respectively. At steady state, the graph of temperature : T = T(x) where x = distance from end A will be

(A) 

(B) 

(C) 

(D) 

Q.6 A wall has two layer A and B each made of different material, both the layers have the same thickness. The thermal conductivity of the material A is twice that of B. Under thermal equilibrium the temperature difference across the wall B is 36°C. The temperature difference across the wall A is
(A) 6°C (B) 12°C (C) 18°C (D) 72°C

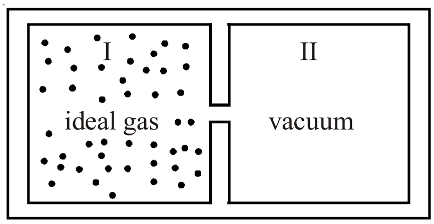
Q.34 STATEMENT-1
The total translational kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume
because
STATEMENT-2
The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.
(A) 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 [JEE 2007]

Q.35 An ideal gas is expanding such that PT^2 = constant. The coefficient of volume expansion of the gas is : [JEE 2008]

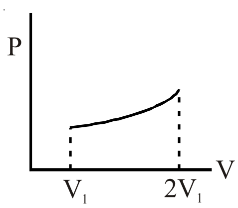
(A) $\frac{1}{T}$ (B) $\frac{2}{T}$ (C) $\frac{3}{T}$ (D) $\frac{4}{T}$

Q.36 **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. [JEE 2008]

Column I	Column II
(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..	(p) The temperature of the gas decreases



Column I	Column II
(B) An ideal monoatomic gas expands to twice its original volume such that pressure $P \propto \frac{1}{V^2}$, where V is the volume of the gas.	(q) The temperature of the gas increases or remains constant
(C) An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^{4/3}}$, where V is its volume.	(r) The gas loses heat
(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



Q.23 In which of the following phenomenon heat convection does not take place
(A) land and sea breeze (B) boiling of water [JEE' 2005 (Scr)]
(C) heating of glass surface due to filament of the bulb (D) air around the furance

Q.24 A spherical body of area A, and emissivity e = 0.6 is kept inside a black body. What is the rate at which energy is radiated per second at temperature T [JEE' 2005 (Scr)]
(A) 0.6 σAT^4 (B) 0.4 σAT^4 (C) 0.8 σAT^4 (D) 1.0 σAT^4

Q.25 An ideal gas is filled in a closed rigid and thermally insulated container. A coil of 100Ω resistor carrying current 1A for 5 minutes supplies heat to the gas. The change in internal energy of the gas is
(A) 10 KJ (B) 20 KJ (C) 30 KJ (D) 0 KJ
[JEE' 2005 (Scr)]

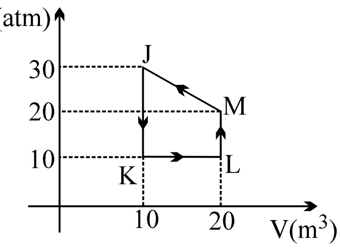
Q.26 When the pressure is changed from $p_1 = 1.01 \times 10^5$ Pa to $p_2 = 1.165 \times 10^5$ a then the volume changes by 10%. The bulk modulus is
(A) 1.55×10^5Pa (B) 0.0015×10^5Pa (C) 0.015×10^5Pa (D) none of these
[JEE' 2005 (Scr)]

Q.27 A cylinder of mass 1 kg is given heat of 20000 J at atmospheric pressure. If initially temperature of cylinder is 20°C, find
(a) final temperature of the cylinder
(b) work done by the cylinder.
(c) change in internal energy of the cylinder.
(Given that specific heat of cylinder = 400 J kg^{-1} $°C^{-1}$, Coefficient of volume expansion $= 9\times10^{-5}$ $°C^{-1}$, Atmospheric pressure = 10^5 N/m^2 and density of cylinder = 9000 kg/m^3) [JEE 2005]

Q.28 In a dark room with ambient temperature T_0, a black body is kept at a temperature T. Keeping the temperature of the black body constant (at T), sunrays are allowed to fall on the black body through a hole in the roof of the dark room. Assuming that there is no change in the ambient temperature of the room, which of the following statement(s) is/are correct?
(A) The quantity of radiation absorbed by the black body in unit time will increase.
(B) Since emissivity = absorptivity, hence the quantity of radiation emitted by black body in unit time will increase.
(C) Black body radiates more energy in unit time in the visible spectrum.
(D) The reflected energy in unit time by the black body remains same. [JEE 2006]

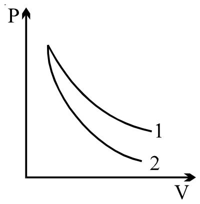
Q.29 Match the following for the given process :

Column 1		Column 2
(A) Process J → K	(P)	w > 0
(B) Process K → L	(Q)	w < 0
(C) Process L → M	(R)	Q > 0
(D) Process M → J	(S)	Q < 0



[JEE 2006]

Q.7 P-V plots for two gases during adiabatic processes are shown in the figure. Plots 1 and 2 should correspond respectively to
(A) He and O_2 (B) O_2 and He
(C) He and Ar (D) O_2 and N_2

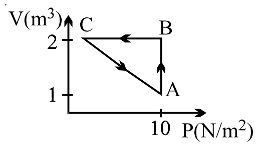


[JEE' 2001]

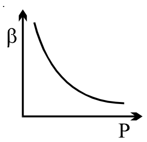
Q.8 In a given process on an ideal gas, dW = 0 and dQ < 0. then for the gas
(A) the temperature will decrease. (B) the volume will increase
(C) the pressure will remain constant (D) the temperature will increase [JEE' 2001]

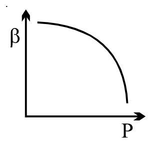
Q.9 An ideal black body at room temperature is thrown into a furnace. It is observed that
(A) initially it is the darkest body and at later times the brightest.
(B) it the darkest body at all times
(C) it cannot be distinguished at all times.
(D) initially it is the darkest body and at later times it cannot be distinguished. [JEE(Scr)2002]

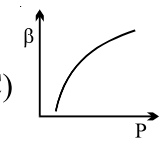
Q.10 An ideal gas is taken through the cycle $A \rightarrow B \rightarrow C \rightarrow A$, as shown in the figure. If the net heat supplied to the gas in the cycle is 5J, the work done by the gas in the process $C \rightarrow A$ is [JEE(Scr)2002]
(A) –5J (B) –10 J
(C) –15 J (D) –20 J

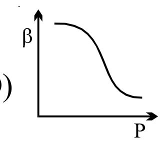


Q.11 Which of the following graphs correctly represents the variation of $\beta = -(dV/dP)/V$ with P for an ideal gas at constant temperature? [JEE (Scr)2002]

(A) 

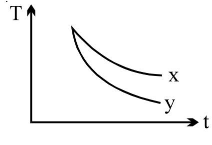
(B) 

(C) 

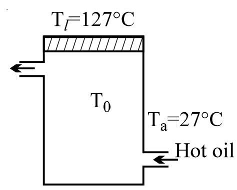
(D) 

Q.12 A cubical box of side 1 meter contains helium gas (atomic weight 4) at a pressure of 100 N/m^2. During an observation time of 1 second, an atom travelling with the root mean square speed parallel to one of the edges of the cube, was found to make 500 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. [JEE'2002]
(a) Evaluate the temperature of the gas ; (b) Evaluate the average kinetic energy per atom
(c) Evaluate the total mass of helium gas in the box.

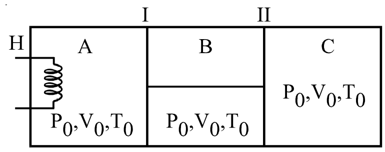
Q.13 If emissivity of bodies X and Y are e_x and e_y and absorptive power are A_x and A_y then [JEE' (Scr) 2003]
(A) $e_y > e_x$; $A_y > A_x$ (B) $e_y < e_x$; $A_y < A_x$
(C) $e_y > e_x$; $A_y < A_x$ (D) $e_y = e_x$; $A_y = A_x$



Q.14 Hot oil is circulated through an insulated container with a wooden lid at the top whose conductivity K = 0.149 J/(m-°C-sec), thickness t = 5 mm, emissivity = 0.6. Temperature of the top of the lid in steady state is at $T_l = 127°$. If the ambient temperature $T_a = 27°C$. Calculate
(a) rate of heat loss per unit area due to radiation from the lid.
(b) temperature of the oil. (Given $\sigma = \frac{17}{3} \times 10^{-8}$) [JEE' 2003]

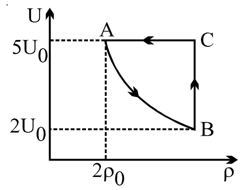


Q.16 The figure shows an insulated cylinder divided into three parts A, B and C. Pistons I and II are connected by a rigid rod and can move without friction inside the cylinder. Piston I is perfectly conducting while piston II is perfectly insulating. The initial state of the gas ($\gamma = 1.5$) present in each compartment A, B and C is as shown. Now, compartment A is slowly given heat through a heater H such that the final volume of C becomes $\frac{4V_0}{9}$. Assume the gas to be ideal and find.



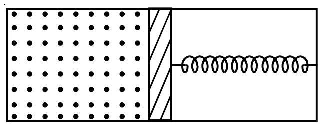
(a) Final pressures in each compartment A, B and C
(b) Final temperatures in each compartment A, B and C
(c) Heat supplied by the heater
(d) Work done by gas in A and B.
(e) Heat flowing across piston I.

Q.17 Figure shows the variation of the internal energy U with the density ρ of one mole of ideal monoatomic gas for a thermodynamic cycle ABCA. Here process AB is a part of rectangular hyperbola.



(a) Draw the P-V diagram for the above process.
(b) Find the net amount of heat absorbed by the system for the cyclic process.
(c) Find the work done in the process AB.

Q.18 A thermally insulated vessel is divided into two parts by a heat-insulating piston which can move in the vessel without the friction. The left part of the vessel contains one mole of an ideal monatomic gas, & the right part is empty. The piston is connected to the right wall of the vessel through a spring whose length in free state is equal to the length of the vessel as shown in the figure. Determine the heat capacity C of the system, neglecting the heat capacities of the vessel, piston and spring.

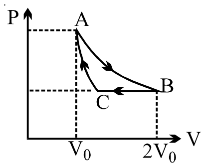


Q.19 A weightless piston divides a thermally insulated cylinder into two parts of volumes V and 3V. 2 moles of an ideal gas at pressure P = 2 atmosphere are confined to the part with volume V = 1 litre. The remainder of the cylinder is evacuated. The piston is now released and the gas expands to fill the entire space of the cylinder. The piston is then pressed back to the initial position. Find the increase of internal energy in the process and final temperature of the gas. The ratio of the specific heat of the gas $\gamma = 1.5$.

Q.20 A gaseous mixture enclosed in a vessel of volume V consists of one gram mole of a gas A with $\gamma = Cp/Cv = 5/3$ & another gas B $\gamma = 7/5$ with at a certain temperature T. The gram molecular weights of the gases A & B are 4 & 32 respectively. The gases A & B do not react with each other and are assumed to be ideal. The gaseous mixture follows the equation; $PV^{19/13}$ = const. in adiabatic processes.
(a) Find the number of gram moles of the gas B in the gaseous mixture.
(b) Compute the speed of sound in the gaseous mixture at T = 300 K.
(c) If T is raised by 1 K from 300 K, find the percentage change in the speed of sound in the gaseous mixture.
(d) The mixture is compressed adiabatically to 1/5 its initial volume V . Find the change in its adiabatic compressibility in terms of the given quantities.

Q.21 Two moles of an ideal monoatomic gas are confined within a cylinder by a massless & frictionless spring loaded piston of cross-sectional area 4×10^{-3} m^2. The spring is, initially in its relaxed state. Now the gas is heated by an electric heated, 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 & the heat supplied by the heater. [$P_0 = 10^5$ Pa]

Q.35 In a cycle ABCA consisting of isothermal expansion AB, isobaric compression BC and adiabatic compression CA, find the efficiency of cycle (Given : $T_A = T_B = 400$ K, $\gamma = 1.5$)

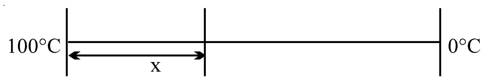


EXERCISE – II

Q.1 A highly conducting solid cylinder of radius a and length *l* is surrounded by a co-axial layer of a material having thermal conductivity K and negligible heat capacity. Temperature of surrounding space (out side the layer) is T_0, which is higher than temperature of the cylinder. If heat capacity per unit volume of cylinder material is s and outer radius of the layer is b, calculate time required to increase temperature of the cylinder from T_1 to T_2. Assume end faces to be thermally insulated.

Q.2 A vertical brick duct(tube) is filled with cast iron. The lower end of the duct is maintained at a temperature T_1 which is greater than the melting point T_m of cast iron and the upper end at a temperature T_2 which is less than the temperature of the melting point of cast iron. It is given that the conductivity of liquid cast iron is equal to k times the conductivity of solid cast iron. Determine the fraction of the duct filled with molten metal.

Q.3 A lagged stick of cross section area 1 cm^2 and length 1 m is initially at a temperature of 0°C. It is then kept between 2 reservoirs of tempeature 100°C and 0°C. Specific heat capacity is 10 J/kg°C and linear mass density is 2 kg/m. Find



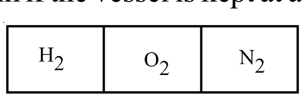
(a) temperature gradient along the rod in steady state.
(b) total heat absorbed by the rod to reach steady state.

Q.4 A cylindrical block of length 0.4 m an area of cross-section 0.04m^2 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 400K and the initial temperature of the disc is 300K. If the thermal conductivity of the material of the cylinder is 10 watt/m-K and the specific heat of the material of the disc in 600 J/kg-K, how long will it take for the temperature of the disc to increase to 350K? 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.

Q.5 A liquid takes 5 minutes to cool from 80°C to 50°C. How much time will it take to cool from 60°C to 30°C ? The temperature of surrounding is 20°C. Use exact method.

Q.6 A barometer is faulty. When the true barometer reading are 73 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?

Q.7 A vessel of volume V = 30*l* is seperated into three equal parts by stationary semipermeable thin membranes as shown in the Figure. The left , middle and right parts are filled with m_{H_2} =30g of hydorgen, m_{O_2} =160g of oxygen, and m_{N_2} = 70g of nitrogen respectively. The left partition lets through only hydrogen, while the right partition lets through hydrogen and nitrogen. What will be the pressure in each part of the vessel after the equilibrium has been set in if the vessel is kept at a constant temperature T = 300K?

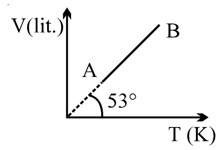


Q.12 Air at temperature of 400 K and atmospheric pressure is filled in a balloon of volume 1 m^3. If surrounding air is at temperature of 300 K, find the ratio of Buoyant force on balloon and weight of air inside

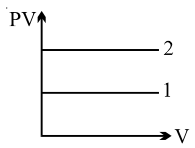
Q.13 The height of mercury is a faulty barometer is 75 cm and the tube above mercury having air is 10 cm long. The correct barometer reading is 76 cm. If the faulty barometer reads 74 cm, find the true barometer reading. (Assume constant temperature of air above mercury column.)

Q.14 A closed vessel of volume V_0 contains oxygen at a pressure P_0 and temperature T_0. Another closed vessel of the same volume V_0 contains helium at a pressure of P_0 and temperature $T_0/2$. Find the ratio of the masses of oxygen to the helium.

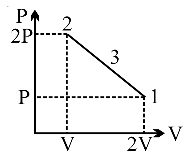
Q.15 V-T curve for 2 moles of a gas is straight line as shown in the graph here. Find the pressure of gas at A.



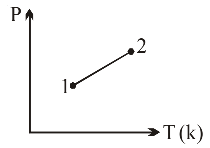
Q.16 Examine the following plots and predict whether in (i) $P_1 < P_2$ and $T_1 > T_2$, in (ii) $T_1 = T_2 < T_3$, in (iii) $V_1 > V_2$, in (iv) $P_1 > P_2$ or otherwise.



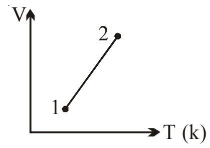
(i)



(ii)



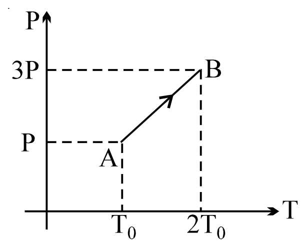
(iii)



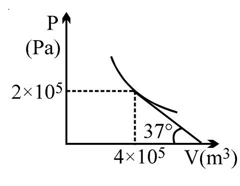
(iv)

Q.17 A piston divides a closed gas cylinder into two parts. Initially the piston is kept pressed such that one part has a pressure P and volume 5V and the other part has pressure 8P and volume V. The piston is now left free. Find the new pressures and volumes for the adiabatic and isothermal processes. For this gas $\gamma = 1.5$.

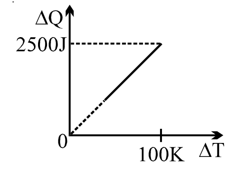
Q.18 Pressure versus temperature graph of an ideal gas is shown. Density of gas at point A is ρ_0. Find the density of gas at B.



Q.19 P-V graph for an ideal gas undergoing polytropic process PV^m = constant is shown here. Find the value of m.



Q.20 One mole of a gas mixture is heated under constant pressure, and heat required ΔQ is plotted against temperature difference acquired. Find the value of γ for mixture.



Q.21 A gas is undergoing an adiabatic process. At a certain stage A, the values of volume and temperature $\equiv (V_0, T_0)$ and the magnitude of the slope of V-T curve is m. Find the value of C_P and C_V.

Isothermal Process (T = constant)

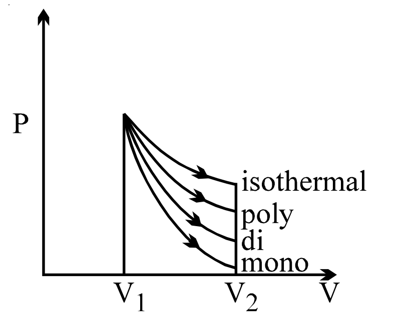
dT = 0 , dU = 0

$Q = W = (nRT) \int_{v_1}^{v_2} dV/V$

$$\boxed{W = nRT\, ln \frac{V_2}{V_1} = nRT\, ln \frac{P_1}{P_2}} \qquad \left(\frac{V_2}{V_1} = \frac{P_1}{P_2} = \text{compression ratio}\right)$$

Adiabatic Process dQ = 0 but if ΔQ = 0, it is not necessaserily adibatic.
dW = –dU By FLT

$$\boxed{W = \int_{T_1}^{T_2} \frac{nRdT}{\gamma - 1} = \frac{nR(T_1 - T_2)}{\gamma - 1} = \frac{P_1V_1 - P_2V_2}{\gamma - 1}}$$



So PdV + VdP = (γ–1) ....(ii)
For Adiabatic Process PV^{γ} = constant

Work done is least for monoatomic gas

$$\left|\frac{dP}{dV}\right|_{adiabatic} = \gamma \left|\frac{dP}{dV}\right|_{isothermal}$$

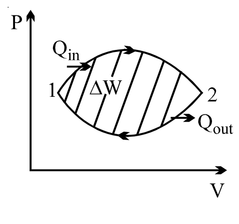
Polytropic process

PV^n= constant

$$\boxed{P = \frac{K}{V^n} \Rightarrow \frac{dP}{dV} = n\left|\frac{K}{V^{n+1}}\right|} \quad ; \qquad C = \frac{R}{\gamma - 1} + \frac{R}{1-n}$$

So C is constant for polytropic process

Efficiency of a cyclic process



ΔU = 0
so ΔQ = ΔW

Efficiency $\eta = \dfrac{\text{work done by gas}}{\text{heat input}}$

$$\eta = \frac{W}{Q_{in}} = 1 - \frac{Q_{out}}{Q_{in}}$$

4. Most Probable velocity – velocity which maximum number of molecules may have

$$v_{mp} = \sqrt{\frac{2RT}{M}}$$

5. Average velocity

$$v_{avg} = \frac{\vec{v}_1 + \vec{v}_2 + \dots\dots\dots + \vec{v}_n}{n} = 0$$

6. Average speed

$$v_{avg} = \frac{|\vec{v}_1| + |\vec{v}_2| + |\vec{v}_3| + \dots\dots + |\vec{v}_n|}{n} = \sqrt{\frac{8RT}{\pi M}}$$

7. Ideal gas equation

$PV = nRT$ (container form of gas law/ pressure volume form)

$P = \left(\frac{\rho}{M}\right)RT$ (open atmosphere / pressure density form)

8. Graham's law of diffusion :–

When two gases at the same pressure and tempearture are allowed to diffuse into each other the rate of diffusion of each gas is inversely proportional to the square root of the density of the gas

$r \propto v_{rms}$ where r = rate of diffusion

so, $$\frac{r_1}{r_2} = \sqrt{\frac{\rho_2}{\rho_1}}$$

9. Degree of Freedom (f) – No. of ways in which a gas molecule can distribute its energy

10. Law of equipartition of energy : – Energy in each degree of freedom = 1/2 KT joules

If degree of freedom is f. Energy = $\frac{f}{2}$ KT joules.

$$U = \frac{f}{2} KTnN_A = \frac{f}{2} nRT$$

11. Degree of freedom(f) in different gas molecules

Molecules	Translational	Rotational
Monoatomic	3	0
Diatomic	3	2
Polyatomic	3	2 (linear molecule) 3 (non-linear molecule)

Translational energy for all type of molecules = $\frac{3}{2}$ **(nRT)**

KEY CONCEPTS

HEAT - TRANSFER

(A) ***Conduction :*** Due to vibration and collision of medium particles.

(i) ***Steady State :*** In this state heat absorption stops and temperature gradient throughout the rod becomes constant i.e. $\frac{dT}{dx}$ = constant.

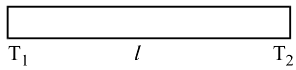
(ii) ***Before steady state :*** Temp of rod at any point changes

Note : If specific heat of any substance is zero, it can be considered always in steady state.

1. ***Ohm's law for Thermal Conduction in Steady State :***

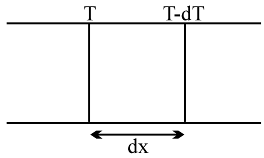
Let the two ends of rod of length l is maintained at temp T_1 and T_2($T_1 > T_2$)

Thermal current $\frac{dQ}{dT} = \frac{T_1 - T_2}{R_{Th}}$



Where thermal resistance $R_{Th} = \frac{1\,1}{K\,A}$

2. ***Differential form of Ohm's Law***



$\frac{dQ}{dT} = KA\frac{dT}{dx}$ $\qquad$ $\frac{dT}{dx}$ = temperature gradient

(B) ***Convection :*** Heat transfer due to movement of medium particles.

(C) ***Radiation:*** Every body radiates electromagnetic radiation of all possible wavelength at all temp>0 K.

1. Stefan's Law : Rate of heat emitted by a body at temp T K from per unit area $E = \sigma T^4$ J/sec/m^2

Radiation power $\frac{dQ}{dT} = P = \sigma A T^4$ watt

If a body is placed in a surrounding of temperature T_S

$$\frac{dQ}{dT} = \sigma A\,(T^4 - T_s^{\,4})$$

valid only for black body

Emissivity or emmisive power $e = \frac{\text{heat from general body}}{\text{heat from black body}}$

If temp of body falls by dT in time dt

$$\frac{dT}{dt} = \frac{eA\sigma}{mS}(T^4 - T_s^4) \qquad \text{(dT/dt = rate of cooling)}$$

2. ***Newton's law of cooling***

$$\frac{dT}{dt}\ \alpha\ (T - T_s)$$

3. ***Average form of Newtons law of cooling***

If a body cools from T_1 to T_2 in time δt

$$\frac{T_1 - T_2}{\delta t} = \frac{K}{mS}\left(\frac{T_1 + T_2}{2} - T_s\right) \qquad \text{(used generally in objective questions)}$$

$$\frac{dT}{dt} = \frac{K}{mS}(T - T_s) \qquad \text{(for better results use this generally in subjective)}$$