PHYSICS

Crash Course for
JEE Main 2020

HEAT TRANSFER,
KINETIC THEORY OF GASES
&
THERMODYNAMICS

HEAT & THERMODYNAMICS

Total translational K.E. of gas = $\frac{1}{2}M < V^2 > = \frac{3}{2}$ PV = $\frac{3}{2}$ nRT

$< V^2 > = \frac{3P}{\rho}$ $\quad V_{rms} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3RT}{M_{mol}}} = \sqrt{\frac{3KT}{m}}$

Important Points :

$- V_{rms} \propto \sqrt{T}$ $\quad \overline{V} = \sqrt{\frac{8KT}{\pi m}} = 1.59\sqrt{\frac{KT}{m}}$ $\quad V_{rms} = 1.73\sqrt{\frac{KT}{m}}$

Most probable speed $V_p = \sqrt{\frac{2KT}{m}} = 1.41\sqrt{\frac{KT}{m}}$ $\therefore V_{rms} > \overline{V} > V_{mp}$

Degree of freedom :
Mono atomic f = 3
Diatomic f = 5
polyatomic f = 6

Maxwell's law of equipartition of energy :
Total K.E. of the molecule = 1/2 f KT
For an ideal gas :

Internal energy $U = \frac{f}{2}$ nRT

Workdone in isothermal process : $W = [2.303\ nRT \log_{10}\frac{V_f}{V_i}]$

Internal energy in isothermal process : $\Delta U = 0$

Work done in isochoric process : dW = 0
Change in int. energy in isochoric process :

$\Delta U = n\frac{f}{2}R\Delta T$ = heat given

Isobaric process :
Work done $\Delta W = nR(T_f - T_i)$
change in int. energy $\Delta U = nC_V \Delta T$
heat given $\Delta Q = \Delta U + \Delta W$

Specific heat : $C_V = \frac{f}{2}R$ $\quad Cp = \left(\frac{f}{2}+1\right)R$

Molar heat capacity of ideal gas in terms of R :

(i) for monoatomic gas : $\frac{C_p}{C_v} = 1.67$

(ii) for diatomic gas : $\frac{C_p}{C_v} = 1.4$

(iii) for triatomic gas : $\frac{C_p}{C_v} = 1.33$

In general : $\gamma = \frac{C_p}{C_v} = \left[1 + \frac{2}{f}\right]$

Mayer's eq. $\Rightarrow C_p - C_v = R$ for ideal gas only

Adiabatic process :

Work done $\Delta W = \frac{nR(T_i - T_f)}{\gamma - 1}$

In cyclic process :

$\Delta Q = \Delta W$

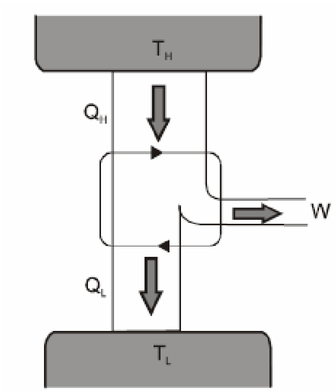
In a mixture of non-reacting gases :

Mol. wt. = $\frac{n_1 M_1 + n_2 M_2}{n_1 + n_2}$

$C_v = \frac{n_1 C_{v_1} + n_2 C_{v_2}}{n_1 + n_2}$

$\gamma = \frac{C_{p(mix)}}{C_{v(mix)}} = \frac{n_1 C_{p_1} + n_2 C_{p_2} + ...}{n_1 C_{v_1} + n_2 C_{v_2} + ...}$

Heat Engines



Efficiency , $\eta = \frac{\text{work done by the engine}}{\text{heat supplied to it}}$

$= \frac{W}{Q_H} = \frac{Q_H - Q_L}{Q_H} = 1 - \frac{Q_L}{Q_H}$

Second law of Thermodynamics

- **Kelvin- Planck Statement**

It is impossible to construct an engine, operating in a cycle, which will produce no effect other than extracting heat from a reservoir and performing an equivalent amount of work.

• **Rudlope Classius Statement**
It is impossible to make heat flow from a body at a lower temperature to a body at a higher temperature without doing external work on the working substance

Entropy

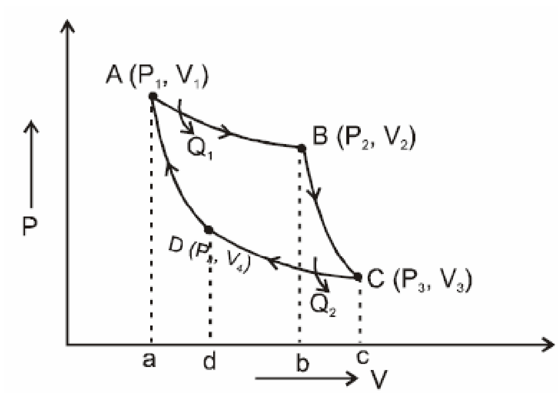
• change in entropy of the system is $\Delta S = \frac{\Delta Q}{T} \Rightarrow S_f - S_i = \int_i^f \frac{\Delta Q}{T}$

• In an adiabatic reversible process, entropy of the system remains constant.

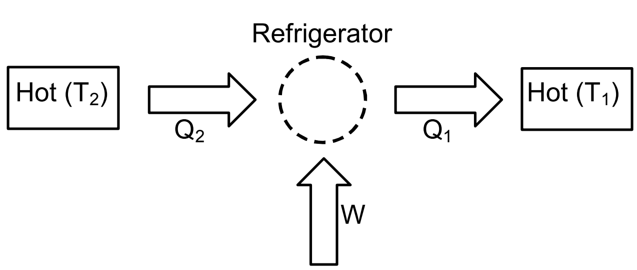
Efficiency of Carnot Engine
(1) Operation I (Isothermal Expansion)
(2) Operation II (Adiabatic Expansion)
(3) Operation III (Isothermal Compression)
(4) Operation IV (Adiabatic Compression)

Thermal Efficiency of a Carnot engine

$$\frac{V_2}{V_1} = \frac{V_3}{V_4} \Rightarrow \frac{Q_2}{Q_1} = \frac{T_2}{T_1} \Rightarrow \eta = 1 - \frac{T_2}{T_1}$$



Refrigerator (Heat Pump)



• Coefficient of performance, $\beta = \frac{Q_2}{W} = = \frac{1}{\frac{T_1}{T_2} - 1} = = \frac{1}{\frac{T_1}{T_2} - 1}$

Calorimetry and thermal expansion
Types of thermometers :

(a) Liquid Thermometer : $T = \left[\frac{\ell - \ell_0}{\ell_{100} - \ell_0}\right] \times 100$

(b) Gas Thermometer :

Constant volume : $T = \left[\frac{P - P_0}{P_{100} - P_0}\right] \times 100$; $P = P_0 + \rho g h$

Constant Pressure : $T = \left[\frac{V}{V - V'}\right] T_0$

(c) Electrical Resistance Thermometer :

$$T = \left[\frac{R_t - R_0}{R_{100} - R_0}\right] \times 100$$

Thermal Expansion :
(a) Linear :

$\alpha = \frac{\Delta L}{L_0 \Delta T}$ or $L = L_0 (1 + \alpha \Delta T)$

(b) Area/superficial :

$\beta = \frac{\Delta A}{A_0 \Delta T}$ or $A = A_0 (1 + \beta \Delta T)$

(c) volume/ cubical :

$r = \frac{\Delta V}{V_0 \Delta T}$ or $V = V_0 (1 + \gamma \Delta T)$

$$\boxed{\alpha = \frac{\beta}{2} = \frac{\gamma}{3}}$$

Thermal stress of a material :

$$\frac{F}{A} = Y \frac{\Delta \ell}{\ell}$$

Energy stored per unit volume :

$E = \frac{1}{2} K (\Delta L)^2$ or $E = \frac{1}{2} \frac{AY}{L} (\Delta L)^2$

Variation of time period of pendulum clocks :

$$\Delta T = \frac{1}{2} \alpha \Delta \theta T$$

T’ < T - clock-fast : time-gain
T’ > T - clock slow : time-loss

CALORIMETRY :

Specific heat $S = \frac{Q}{m.\Delta T}$

Molar specific heat $C = \frac{\Delta Q}{n.\Delta T}$

Water equivalent $= m_W S_W$

HEAT TRANSFER

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

Thermal Resistance : $R = \frac{\ell}{KA}$

Series and parallel combination of rod :

(i) **Series :** $\frac{\ell_{eq}}{K_{eq}} = \frac{\ell_1}{K_1} + \frac{\ell_2}{K_2} + \ldots\ldots$ (when $A_1 = A_2 = A_3 = \ldots\ldots$)

(ii) **Parallel :** $K_{eq} A_{eq} = K_1 A_1 + K_2 A_2 + \ldots\ldots$ (when $\ell_1 = \ell_2 = \ell_3 = \ldots\ldots$)

for absorption, reflection and transmission

$r + t + a = 1$

Emissive power : $E = \frac{\Delta U}{\Delta A\,\Delta t}$

Spectral emissive power : $E_\lambda = \frac{dE}{d\lambda}$

Emissivity : $e = \frac{\text{E of a body at T temp.}}{\text{E of a black body at T temp.}}$

Kirchoff's law : $\frac{E(\text{body})}{a(\text{body})} = E$ (black body)

Wein's Displacement law : $\lambda_m . T = b.$

$b = 0.282$ cm-k

Stefan Boltzmann law :

$u = \sigma T^4$ $\quad$ $s = 5.67 \times 10^{-8}$ W/m^2 k^4

$\Delta u = u - u_0 = e\,\sigma A\,(T^4 - T_0^4)$

Newton's law of cooling : $\frac{d\theta}{dt} = k(\theta - \theta_0)$; $\quad \theta = \theta_0 + (\theta_i - \theta_0)\,e^{-kt}$

OBJECTIVE QUESTION BANK

ONLY ONE OPTION IS CORRECT.

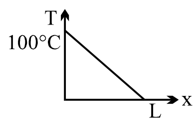
Take approx. 2 minutes for answering each question.

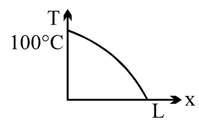
Q.1 Four rods of same material with different radii r and length l are used to connect two reservoirs of heat at different temperatures. Which one will conduct most heat ?

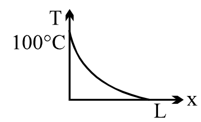
(A) r =2cm, l =0.5m (B) r = 2cm, l = 2m

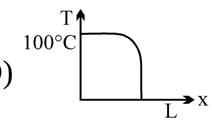
(C) r =0.5cm, l =0.5m (D) r = 1 cm, l = 1 m

Q.2 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

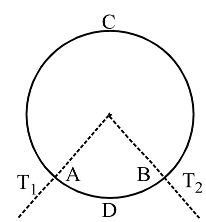
(A) 

(B) 

(C) 

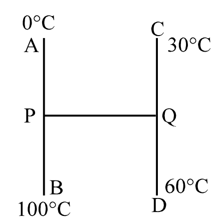
(D) 

Q.3 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 T_1 and T_2 constant. The heat carried increases to 2H. What should be the conductivity of the new ADB part? Given $\frac{ACB}{ADB} = 3$:



(A) $\frac{7}{3}$k (B) 2 k (C) $\frac{5}{2}$ k (D) 3 k

Q.4 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

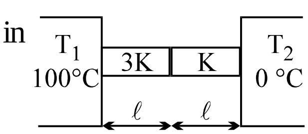


(A) from P to Q (B) from Q to P

(C) heat does not flow in PQ (D) data not sufficient

Question No. 5 to 7 (3 questions)

Two rods A and B of same cross-sectional are A and length *l* connected in series between a source (T_1 = 100°C) and a sink (T_2 = 0°C) as shown in figure. The rod is laterally insulated



Q.5 The ratio of the thermal resistance of the rod is

(A) $\frac{R_A}{R_B} = \frac{1}{3}$ (B) $\frac{R_A}{R_B} = 3$ (C) $\frac{R_A}{R_B} = \frac{3}{4}$ (D) $\frac{4}{3}$

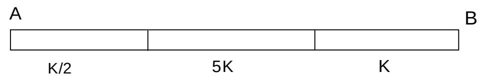
Q.6 If T_A and T_B are the temperature drops across the rod A and B, then

(A) $\frac{T_A}{T_B} = \frac{3}{1}$ (B) $\frac{T_A}{T_B} = \frac{1}{3}$ (C) $\frac{T_A}{T_B} = \frac{3}{4}$ (D) $\frac{T_A}{T_B} = \frac{4}{3}$

Q.7 If G_A and G_B are the temperature gradients across the rod A and B, then

(A) $\frac{G_A}{G_B} = \frac{3}{1}$ (B) $\frac{G_A}{G_B} = \frac{1}{3}$ (C) $\frac{G_A}{G_B} = \frac{3}{4}$ (D) $\frac{G_A}{G_B} = \frac{4}{3}$

Q.8 A composite rod made of three rods of equal length and cross-section as shown in the fig. The thermal conductivities of the materials of the rods are K/2, 5K and K respectively. The end A and end B are at constant temperatures. All heat entering the face A goes out of the end B there being no loss of heat from the sides of the bar. The effective thermal conductivity of the bar is



(A) 15K/16 (B) 6K/13 (C) 5K/16 (D) 2K/13

Q.9 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

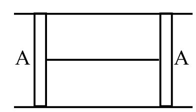
Q.10 A system S receives heat continuously from an electrical heater of power 10W. The temperature of S becomes constant at 50°C when the surrounding temperature is 20°C. After the heater is switched off, S cools from 35.1°C to 34.9°C in 1 minute. The heat capacity of S is

(A) 100J/°C (B) 300J/°C (C) 750J/°C (D) 1500J/°C

Q.11 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.12 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) $P_0 A/2$

(C) $P_0 A$ (D) $2 P_0 A$

Q.13 At a temperature T K, the pressure of 4.0g argon in a bulb is p. The bulb is put in a bath having temperature higher by 50K than the first one. 0.8g of argon gas had to be removed to maintained original pressure. The temperature T is equal to

(A) 510 K (B) 200 K (C) 100 K (D) 73 K

Q.14 When 2 gms of a gas are introduced into an evacuated flask kept at 25^0C the pressure is found to be one atmosphere. If 3 gms of another gas added to the same flask the pressure becomes 1.5 atmospheres. The ratio of the molecular weights of these gases will be

(A) 1 : 3 (B) 3 : 1 (C) 2 : 3 (D) 3 : 2

Q.15 An open and wide glass tube is immersed vertically in mercury in such a way that length 0.05 m extends above mercury level. The open end of the tube is closed and the tube is raised further by 0.43 m. The length of air column above mercury level in the tube will be : Take P_{atm} = 76 cm of mercury

(A) 0.215 m (B) 0.2 m (C) 0.1 m (D) 0.4 m

Q.16 During an experiment an ideal gas obeys an addition equation of state P^2V = constant. The initial temperature and pressure of gas are T and V respectively. When it expands to volume 2V, then its temperature will be :

(A) T (B) $\sqrt{2}$ T (C) 2 T (D) $2\sqrt{2}$ T

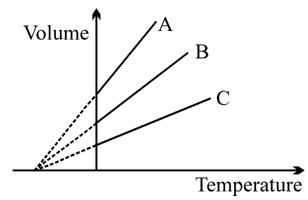
Q.17 A barometer tube, containing mercury, is lowered in a vessel containing mercury until only 50 cm of the tube is above the level of mercury in the vessel. If the atmospheric pressure is 75 cm of mercury, what is the pressure at the top of the tube ?

(A) 33.3 kPa (B) 66.7 kPa (C) 3.33 MPa (D) 6.67 MPa

Q.18 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.19 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.20 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.21 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.22 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.23 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.

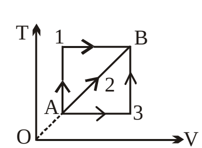
Q.24 Two monoatomic ideal gas at temperature T_1 and T_2 are mixed. There is no loss of energy. If the masses of molecules of the two gases are m_1 and m_2 and number of their molecules are n_1 and n_2 respectively. The temperature of the mixture will be :

(A) $\frac{T_1+T_2}{n_1+n_2}$ (B) $\frac{T_1}{n_1}+\frac{T_2}{n_2}$ (C) $\frac{n_2T_1+n_1T_2}{n_1+n_2}$ (D) $\frac{n_1T_1+n_2T_2}{n_1+n_2}$

Q.25 At temperature T, N molecules of gas A each having mass m and at the same temperature 2N molecules of gas B each having mass 2m are filled in a container. The mean sqaure velocity of molecules of gas B is v^2 and mean square of x component of 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

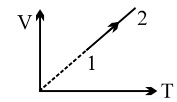
Q.26 A given mass of a gas expands from a state A to the state B by three paths 1, 2 and 3 as shown in T-V indicator diagram. If W_1, W_2 and W_3 respectively be the work done by the gas along the three paths, then



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

(C) $W_1 = W_2 = W_3$ (D) $W_1 < W_2$, $W_1 > W_3$

Q.27 An ideal gas undergoes the process $1 \rightarrow 2$ as shown in the figure, the heat supplied and work done in the process is ΔQ and ΔW respectively. The ratio $\Delta Q : \Delta W$ is

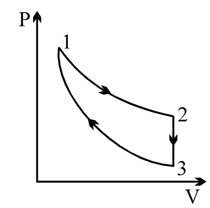


(A) $\gamma : \gamma - 1$ (B) γ
(C) $\gamma - 1$ (D) $\gamma - 1/\gamma$

Q.28 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) 2.0×10^7 Nm^{-5} (B) 1.0×10^7 Nm^{-5} (C) -2.0×10^7 Nm^{-5} (D) -1.0×10^7 Nm^{-5}

Q.29 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.30 Three processes form a thermodynamic cycle as shown on P-V diagram for an ideal gas. Process $1 \rightarrow 2$ takes place at constant temperature (300K). Process $2 \rightarrow 3$ takes place at constant volume. During this process 40J of heat leaves the system. Process $3 \rightarrow 1$ is adiabatic and temperature T_3 is 275K. Work done by the gas during the process $3 \rightarrow 1$ is

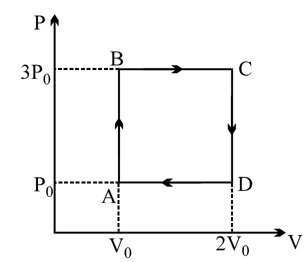


(A) –40J (B) –20J
(C) +40J (D) +20J

Q.31 When unit mass of water boils to become steam at 100^{0}C, it absorbs Q amount of heat. The densities of water and steam at 100^{0}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) $Q - p_0\left(\frac{1}{\rho_1} + \frac{1}{\rho_2}\right)$

Q.32 A ideal monoatomic gas is carried around the cycle ABCDA as shown in the fig. The efficiency of the gas cycle is



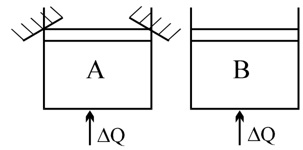
(A) $\frac{4}{21}$ (B) $\frac{2}{21}$

(C) $\frac{4}{31}$ (D) $\frac{2}{31}$

Q.33 In thermodynamic process pressure of a fixed mass of gas is changed in such a manner that the gas releases 30 joule of heat and 18 joule of work was done on the gas. If the initial internal energy of the gas was 60 joule, then, the final internal energy will be :
(A) 32 joule (B) 48 joule (C) 72 joule (D) 96 joule

Q.34 A cylinder made of perfectly non conducting material closed at both ends is divided into two equal parts by a heat proof piston. Both parts of the cylinder contain the same masses of a gas at a temperature $t_0 = 27°$ and pressure $P_0 = 1$ atm. Now if the gas in one of the parts is slowly heated to t = 57°C while the temperature of first part is maintained at t_0 the distance moved by the piston from the middle of the cylinder will be (length of the cylinder = 84 cm)
(A) 3 cm (B) 5 cm (C) 2 cm (D) 1 cm

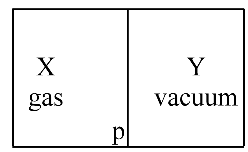
Q.35 Two identical vessels A & B contain equal amount of ideal monoatomic gas. The piston of A is fixed but that of B is free. Same amount of heat is absorbed by A & B. If B's internal energy increases by 100 J the change in internal energy of A is



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

Q.36 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.37 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.38 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.39 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.40 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}

ONE OR MORE THAN ONE OPTION MAY BE CORRECT

Take approx. 3 minutes for answering each question.

Q.1 Two metallic sphere A and B are made of same material and have got identical surface finish. The mass of sphere A is four times that of B. Both the spheres are heated to the same temperature and placed in a room having lower temperature but thermally insulated from each other.
(A) The ratio of heat loss of A to that of B is $2^{4/3}$.
(B) The ratio of heat loss of A to that of B is $2^{2/3}$.
(C) The ratio of the initial rate of cooling of A to that of B is $2^{-2/3}$.
(D) The ratio of the initial rate of cooling of A to that of B is $2^{-4/3}$.

Q.2 Two bodies A and B have thermal emissivities of 0.01 and 0.81 respectively. The outer surface areas of the two bodies are the same. The two bodies radiate energy at the same rate. The wavelength λ_B, corresponding to the maximum spectral radiancy in the radiation from B, is shifted from the wavelength corresponding to the maximum spectral radiancy in the radiation from A by 1.00 μm. If the temperature of A is 5802 K,
(A) the temperature of B is 1934 K (B) λ_B =1.5 μm
(C) the temperature of B is 11604 K (D) the temperature of B is 2901 K

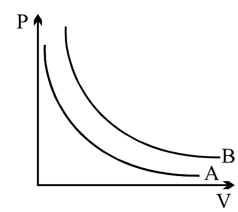
Q.3 Three bodies A, B and C have equal surface area and thermal emissivities in the ratio $e_A : e_B : e_C = 1 : \frac{1}{2} : \frac{1}{4}$. All the three bodies are radiating at same rate. Their wavelengths corresponding to maximum intensity are λ_A, λ_B and λ_C respectively and their temperatures are 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) $\sqrt{e_A \lambda_A T_A \cdot e_B \lambda_B T_B} = e_C \lambda_C T_C$

Q.4 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.5 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.6 The total kinetic energy of translatory motion of all the molecules of 5 litres of nitrogen exerting a pressure P is 3000 J.
(A) the total k.e. of 10 litres of N_2 at a pressure of 2P is 3000 J
(B) the total k.e. of 10 litres of He at a pressure of 2P is 3000 J
(C) the total k.e. of 10 litres of O_2 at a pressure of 2P is 20000 J
(D) the total k.e. of 10 litres of Ne at a pressure of 2P is 12000 J

Q.7 A vertical cylinder with heat-conducting walls is closed at the bottom and is fitted with a smooth light piston. It contains one mole of an ideal gas. The temperature of the gas is always equal to the surrounding's temperature, T_0. The piston is moved up slowly to increase the volume of the gas to η times. Which of the following is incorrect?
(A) Work done by the gas is $RT_0 \ln \eta$.
(B) Work done against the atmosphere is $RT_0(\eta - 1)$.
(C) There is no change in the internal energy of the gas.
(D) The final pressure of the gas is $\frac{1}{(\eta - 1)}$ times its initial pressure.

Q.8 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.9 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.10 Two gases have the same initial pressure, volume and temperatue. They expand to the same final volume, one adiabatically and the other isothermally

(A) The final temperature is greater for the isothermal process

(B) The final pressure is greater for the isothermal process

(C) The work done by the gas is greater for the isothermal process

(D) All the above options are incorrect

Q.11 The first law of thermodynamics can be written as $\Delta U = \Delta Q + \Delta W$ for an ideal gas. Which of the following statements is correct?

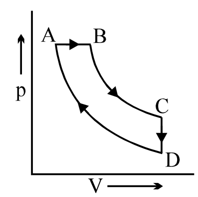
(A) ΔU is always zero when no heat enters or leaves the gas

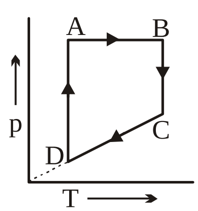
(B) ΔW is the work done by the gas in this written law.

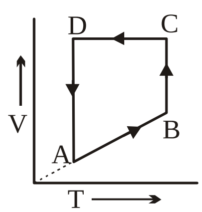
(C) ΔU is zero when heat is supplied and the temperature stays constant

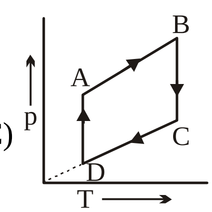
(D) $\Delta Q = -\Delta W$ when the temperature increases very slowly.

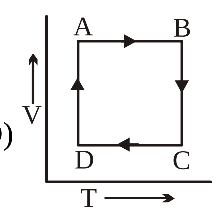
Q.12 A cyclic process ABCD is shown in the p-V diagram. Which of the following curves represents the same process if BC & DA are isothermal processes



(A) 

(B) 

(C) 

(D) 

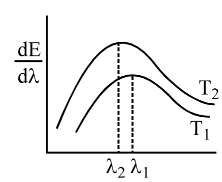
Q.13 2 moles of a monoatomic gas are expanded to double its initial volume, through a process P/V = constant. If its initial temperature is 300 K, then which of the following is not true.

(A) $\Delta T = 900$ K (B) $\Delta Q = 3200$ R (C) $\Delta Q = 3600$ R (D) W = 900 R

INTEGER TYPE

Q.1 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 (° C)

Q.2 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 =



Q.3 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 (° C)

Q.4 A rigid tank contains 35 kg of nitrogen at 6 atm. Sufficient quantity of oxygen is supplied to increase the pressure to 9 atm, while the temperature remains constant. Amount of oxygen supplied to the tank is :

Q.5 A polyatomic gas with six degrees of freedom does 25J of work when it is expanded at constant pressure. The heat given to the gas is (in J)

Q.6 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 xQ, find X ?

ANSWER KEY

OBJECTIVE QUESTION BANK

ONLY ONE OPTION IS CORRECT.

Q.1	A	Q.2	B	Q.3	A	Q.4	A	Q.5	A	Q.6	B
Q.7	B	Q.8	A	Q.9	A	Q.10	D	Q.11	A	Q.12	C
Q.13	B	Q.14	A	Q.15	C	Q.16	B	Q.17	A	Q.18	D
Q.19	C	Q.20	C	Q.21	C	Q.22	D	Q.23	A	Q.24	D
Q.25	D	Q.26	A	Q.27	A	Q.28	C	Q.29	C	Q.30	A
Q.31	B	Q.32	A	Q.33	B	Q.34	C	Q.35	B	Q.36	A
Q.37	A	Q.38	D	Q.39	B	Q.40	D				

ONE OR MORE THAN ONE OPTION MAY BE CORRECT

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

INTEGER TYPE

Q.1	18	Q.2	1.732	Q.3	15	Q.4	20	Q.5	100 J
Q.6	0.4								