Jupiter Academy

Subjects : Physics　　PRACTICE PAPER 09

Total Marks : 180　　(Solutions)

Physics - Section A (MCQ)

1. Kinetic theory of gases provide a base for

A) Charle's law
B) Boyle's law
C) Charle's law and Boyle's law
D) None of these

Solution : (Correct Answer: C)

Kinetic theory of gases state that anerage kinetic energy (KE) of the gas molecules is directly proportional to the absolute temperature.

$PV=\frac{1}{3} mnV_{rms}^{2}=\frac{2}{3} \times \frac{1}{2} mnv_{\text{rms}}^{2} \; =\frac{2}{3} kT$

Boyle's law state that at constant temperature average KE is constant, So, v_{rms} Memains unchanged. If volume increases pressure of gas decreases.

i.e., $PV=$ constant .

Charle's law state that if we allow the volume to change to maintain constant pressure the volume will increase with increasing temperature

i.e., $V=KT$

$\therefore$ Option (c) is correct.

2. $3 \, moles$ of an ideal gas at a temperature of $27^{\circ} \, C$ are mixed with $2 \; moles$ of an ideal gas at a temperature $227^{\circ} \, C$, determine the equilibrium temperature $\left({ }^{o} C\right)$ of the mixture, assuming no loss of energy.

A) 327　B) 107　C) 318　D) 410

Solution : (Correct Answer: B)

(b)

Energy possessed by the ideal gas at $27^{\circ} \, C$ is

$E_{1}=3\left(\frac{3}{2} R \times 300\right)=\frac{2700 R}{2}$

Energy possessed by the ideal gas at $227^{\circ} C$ is

$E_{2}=2\left(\frac{3 R}{2} \times 500\right)=1500 \, R$

If T be the equilibrium temperature, of the mixture, then its energy will be $E_{m}=5\left(\frac{3 R T}{2}\right)$

Since, energy remains conserved,

$E_{m}=E_{1}+E_{2}$

or $5\left(\frac{3 R T}{2}\right)=\frac{2700 R}{2}+1500 R$ or $T=380 K$ or $107^{\circ} \, C$

3. $50 \, cal$ of heat is required to raise the temperature of 1 mole of an ideal gas from $20^{\circ} C$ to $25^{\circ} C$, while the pressure of the gas is kept constant. The amount of heat required to raise the temperature of the same gas through same temperature range at constant volume is .... cal $(R=2 \, cal / mol-K)$

A) 70　B) 60　C) 40　D) 50

Solution : (Correct Answer: C)

(c)

$C_{P}=\frac{50}{n T}=10 \, cal K^{-1} mol^{-1}$

$C_{P}=C_{V}+R$

$C_{V}=C_{P}-R$

$C_{V}=40 \, cal K^{-1} mol^{-1}$

4. The temperature (T) of one mole of an ideal gas varies with its volume (V) as $T=-\alpha V^{3}+\beta V^{2}$, where α and β are positive constants. The maximum pressure of gas during this process is ....

A) $\frac{\alpha \beta}{2 R}$　B) $\frac{\beta^{2} R}{4 \alpha}$
C) $\frac{(\alpha+\beta) R}{2 \beta^{2}}$　D) $\frac{\alpha^{2} R}{2 \beta}$

Solution : (Correct Answer: B)

(b)

$T=-\alpha V^{3}+\beta V^{2} \quad \ldots(i)$

and $PV=nRT \quad \ldots(ii)$

$n=1$

So, $P=\frac{R T}{V}$

Multiplying $\frac{R}{V}$ in (i)

$\frac{R T}{V}=\left(-\alpha V^{2}+\beta V\right) R$

or $P=\left(-\alpha V^{2}+\beta V\right) R \ldots(iii)$

$\frac{d P}{d V}=(-2 \alpha V+\beta) R$

Maxima is when $\frac{d P}{d V}=0$ and $\frac{d^{2} P}{d V^{2}}$ in negative, so

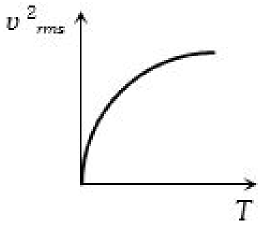
$O=(-2 \alpha V+\beta) R$

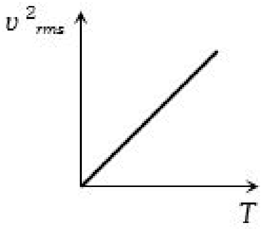
$V=\frac{\beta}{2 \alpha}$

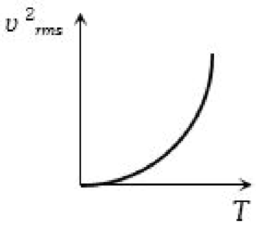
Put in value of V in equation (iii)

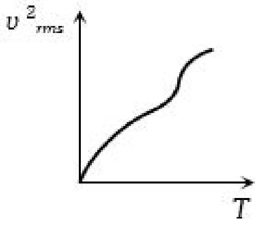
$P=\left(-\alpha \frac{\beta^{2}}{4 \alpha^{2}}+\frac{\beta^{2}}{2 \alpha}\right) R \Rightarrow P=\frac{\beta^{2} R}{4 \alpha}$

5. The curve between absolute temperature and $v^2{}_{rms}$ is

A) 

B) 

C) 

D) 

Solution : (Correct Answer: B)

$v_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow v_{rms}^2 \propto T$

6. $125\, ml$ of gas A at 0.60 atmosphere and $150\, ml$ of gas B at 0.80 atmosphere pressure at same temperature is filled in a vessel of 1 litre volume. What will be the total pressure of mixture at the same temperature .... atmosphere

A) 0.140 B) 0.120
C) 0.195 D) 0.212

Solution : (Correct Answer: C)

$V_1 = 125ml \quad V_2 = 150m1$

$P_1 = 0.60 \quad P_2 = 0.80$

we know that,

$P_1 v_1 + P_2 v_2 = P\left(v_1 + v_2\right)$

$0.60 \times 125 + 0.80 \times 150 = P(125 + 150)$

$0.60 \times 0.125 + 0.80 \times 0.150 = P(0.125 + 0.150)$

$0.195 = P00.275$

$P = 0.709$

7. At NTP the mass of one litre of air is $1.293\ gm$. The value of specific gas constant will be ...... $J/K - gm$

A) 0.29 B) 4.2 C) 8.3 D) 16.5

Solution : (Correct Answer: A)

The conditions given are in NTP.

At NTP,

Pressure, $P = 1\ atm = 101325Pa$

Temperature, $T = 20^{\circ}C = \left(20 + 273.15^{-}\right) K = 293.15K$

Volume given, $V = 1$ litre $= 10^{-3} m^3$

mass, $m = 1.293gm$

USe equation, $PV = mRT$

$(101325)\left(10^{-3}\right)$

$= (1.293) \cdot R \cdot (293.15)$

$R = 0.2673\ J/K - gm$

8. The temperature at which root mean square speed of a gas will be half of its value at $0\,^oC$ is .... ^oC

A) -86.4 B) -204.75
C) -104.75 D) -68.25

Solution : (Correct Answer: B)

$\mathrm{v_{rms}} \propto \sqrt{\mathrm{T}}$

rms speed will becomes half, its temperature will becomes one—fourth.

$\left(\frac{273}{4} - 273\right)^{\circ}\mathrm{C} = -204.75^{\circ}\mathrm{C}$

9. A certain amount of an ideal monatomic gas needs $20\ J$ of heat energy to raise its temperature by $10^{\circ}C$ at constant pressure. The heat needed for the same temperature rise at constant volume will be .... J

A) 30 B) 12 C) 200 D) 215.3

Solution : (Correct Answer: B)

(b)

$\Delta Q = nC_P \Delta T$

$20 = nC_P \times 10 \quad \ldots (1)$

$\Delta U = nC_V \Delta T$

$\Delta U = n\frac{C_P}{\gamma}\Delta T\ \{\because \gamma_{\text{mono}} = 5/3\}$

$\Delta U = 12\, J$

10. If the $r.m.s.$ velocity of a gas at a given temperature (Kelvin scale) is $300\ m/sec$. What will be the $r.m.s.$ velocity of a gas having twice the molecular weight and half the temperature on Kelvin scale .... m/sec

A) 300 B) 600 C) 75 D) 150

Solution : (Correct Answer: D)

(d) $v_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow v_{rms} \propto \sqrt{\frac{T}{M}}$

$\frac{v_2}{v_1} = \sqrt{\frac{M_1}{M_2} \times \frac{T_2}{T_1}} = \sqrt{\frac{1}{2} \times \frac{1}{2}}$==> $v_2 = \frac{v_1}{2} = \frac{300}{2} = 150m/sec$

11. If the mean free path of atoms is doubled then the pressure of gas will become

A) $P/4$ B) $P/2$ C) $P/8$ D) P

Solution : (Correct Answer: B)

Mean force path, $\lambda = \frac{11}{P}\sqrt{\frac{\pi RT}{2M}}$

where, $\mu =$ viscerity $P =$ Pressure $R =$ gass constant $T =$ Temperature $M =$Molecular weight

$\Rightarrow \lambda \alpha \frac{1}{p}$

If $p \propto \frac{1}{\lambda}$

If we double the mean force

Path, the pressure will be $1/2$.

So, The correct answer is $\frac{p}{2}$

12. A monoatomic gas molecule has

A) Three degrees of freedom
B) Four degrees of freedom
C) Five degrees of freedom
D) Six degrees of freedom

Solution : (Correct Answer: A)

An atomic gas molecule has only three transferable degrees of freedom.

13. The root mean square speed of the molecules of a gas is

A) Independent of its pressure but directly proportional to its Kelvin temperature
B) Directly proportional to the square roots of both its pressure and its Kelvin temperature
C) Independent of its pressure but directly proportional to the square root of its Kelvin temperature
D) Directly proportional to both its pressure and its Kelvin temperature

Solution : (Correct Answer: C)

$v_{r.m.s.}$ Velocity depends only on temperature $v_{rms} \propto \sqrt{T}$

14. Under which of the following conditions is the law $PV = RT$ obeyed most closely by a real gas

A) High pressure and high temperature
B) Low pressure and low temperature
C) Low pressure and high temperature
D) High pressure and low temperature

Solution : (Correct Answer: C)

At low pressure and high temperature real gas obey $PV = RT$ i.e. they behave as ideal gas because at high temperature we can assume that there is no force of attraction or repulsion works among the molecules and the volume occupied by the molecules is negligible in comparison to the volume occupied by the gas

15. The average kinetic energy of a gas molecule can be determined by knowing

A) The number of molecules in the gas
B) The pressure of the gas only
C) The temperature of the gas only
D) None of the above is enough by itself

Solution : (Correct Answer: C)

Kenetic energy $\propto$ Temperature

16. If a Vander-Waal's gas expands freely, then final temperature is

A) Less than the initial temperature
B) Equal to the initial temperature
C) More than the initial temperature
D) Less or more than the initial temperature depending on the nature of the gas

Solution : (Correct Answer: A)

On free expansion of van der Waals gases final temperature will be less than initial temperature.

17. Five moles of helium are mixed with two moles of hydrogen to form a mixture. Take molar mass of helium $M_1 = 4\ g$ and that of hydrogen $M_2 = 2\ g$ The equivalent value of γ is

A) 1.59 B) 1.53 C) 1.56 D) none

Solution : (Correct Answer: C)

$= C_{V_{\text{mtx}}} = \frac{\frac{5}{2}\times 2R + \frac{3}{2}\times 5R}{7}, C_{P_{mtx}} = \frac{\frac{7}{2}\times 2R + \frac{5}{2}\times 5R}{7} \gamma_{\text{mtx}} = \frac{C_{Pmtx}}{C_{Vmtx}} = 1.56$

18. The average degree of freedom per molecule of a gas is 6. The gas performs $25\ J$ work, while expanding at constant pressure. The heat absorbed by the gas is .... J

A) 75 B) 100 C) 150 D) 125

Solution : (Correct Answer: B)

$f = 6$

$\gamma = 1 + \frac{2}{f} = 1 + \frac{2}{6} = \frac{4}{3}$

$\frac{\Delta W}{\Delta Q} = \left(1 - \frac{1}{\gamma}\right)$

==> $\frac{25}{\Delta Q} = \left(1 - \frac{1}{4/3}\right)$

$= 1 - \frac{3}{4} = \frac{1}{4}$

==> $\Delta Q = 25 \times 4 = 100\ Joule$

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

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

Solution : (Correct Answer: B)

$\mathrm{PV} = \frac{4}{\mathrm{M}}\mathrm{RT} \ldots (i)$

$\mathrm{PV} = \frac{(4-0.8)}{\mathrm{M}}\mathrm{R}(\mathrm{T}+50)$

$= \frac{3.2\mathrm{R}}{\mathrm{M}}(\mathrm{T}+50) \ldots (ii)$

By (i) and (ii) we get,

$\frac{4}{M}RT = \frac{3.2R}{M}(T+50)$

$\Rightarrow 4T = 3.2T + 3.2 \times 50$

$\Rightarrow \mathrm{T} = 200\mathrm{K}$

20. 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

Solution : (Correct Answer: D)

We know

$\mathrm{v_{rms}} = 1.085\mathrm{v_{avg}}$

$\Rightarrow \sqrt{\frac{3P}{\rho}} = 1.085\mathrm{v_{avg}}$; ρ is density

In this case ρ is constant

$\therefore P \propto (V_{\text{avg}})^2$

$\therefore \frac{P_f}{P_i} = \left[\frac{(v_{\text{avg}})_f}{(v_{\text{avg}})_i}\right]^2 = 4$

21. Which of the following statements about kinetic theory of gases is wrong

A) The molecules of a gas are in continuous random motion

B) The molecules continuously undergo inelastic collisions

C) The molecules do not interact with each other except during collisions

D) The collisions amongst the molecules are of short duration

Solution : (Correct Answer: B)

According to the teimetic theory of gases.

The molecules of a gas are in Continuous random motion because gas is not a fin state.

The molecules do not interact os in contact with each othes ercept collisions.

It is experimentally proved that the collisions amongst the molecules are of short duration. because collisions occurs very East.

but the statement that the molecule Continously undergo inelastic collision is wrong or incorrect. Because it is not must that collision be elastic or inelastic. It is depend on the conditions.

oplion B is incorrect

22. When an air bubble of radius 'r' rises from the bottom to the surface of a lake, its radius becomes $5r/4$ (the pressure of the atmosphere is equal to the $10\,m$ height of water column). If the temperature is constant and the surface tension is neglected, the depth of the lake is .... m

A) 3.53 B) 6.53 C) 9.53 D) 12.53

Solution : (Correct Answer: C)

In this case, $(4/3)\pi r^3(p_0 + p_1) = (4/3)\pi r^3(5^3/4^3)P_0$

where, $P_0 =$ atm pressure, $P_1 =$ water pressure

Rearranging, we get, $P_1 = [(5^3/4^3) - 1]P_0$

Or, $\rho g H = (\frac{61}{64})P_0$

Or, $H = \frac{(\frac{61}{64})P_0}{\rho g}$

$P_0 = 10g$ and ρ of water $= 1$

Putting these values we get, $H = 9.53\,m$

23. $14\,g$ of CO at $27^\circ C$ is mixed with $16g$ of O_2 at $47^\circ C$. The temperature of mixture is .... $^\circ C$ (vibration mode neglected)

A) -5 B) 32 C) 37 D) 27

Solution : (Correct Answer: C)

(c)

1 mole of CO and 1 mole of O_2 are mixed.

Net internal energy $= \frac{f_1}{2}RT_{CO} + \frac{f_2}{2}RT_{O_2}$

$= \frac{5}{2}R300 + \frac{5}{2}R350$

$= \frac{5}{2}R(650)$

$= 5R(325)$

$= 1625R$

$1625 = \frac{5}{2}RT_{\text{final}} \times n_{\text{final}}$

$\frac{1625\times 2}{5} = T_{\text{final}} \times n_{\text{final}}$

$325 \times 2 = T_{\text{final}} \times 2$

$T_{\text{final}} = 325K$

$T_{\text{final}} = 37^\circ C$

24. Two closed containers of equal volume filled with air at pressure P_0 and temperature T_0. Both are connected by a narrow tube. If one of the container is maintained at temperature T_0 and other at temperature T, then new pressure in the containers will be

A) $\frac{2P_0T}{T+T_0}$ B) $\frac{P_0T}{T+T_0}$

C) $\frac{P_0T}{2(T+T_0)}$ D) $\frac{T+T_0}{P_0}$

Solution : (Correct Answer: A)

(a)

$\frac{P}{T} = \text{constant}$

Initially $\frac{P_0}{T_0} + \frac{P_0}{T_0} = \frac{2P_0}{T_0}$

For two containers

$\frac{P_0}{T_0} + \frac{P}{T} = \frac{2P_0}{T_0}$

$P = \frac{2P_0 \times T \times T_0}{T_0(T+T_0)}$

or $P = \frac{2P_0 T}{(T+T_0)}$

25. The average kinetic energy of a helium atom at $30^o C$ is

A) Less than $1\, eV$ B) A few keV
C) $50 - 60 eV$ D) $13.6 eV$

Solution : (Correct Answer: A)

Average Kientic energy $E = \frac{f}{2}kT = \frac{3}{2}kT$

$\Rightarrow E = \frac{3}{2} \times (1.38 \times 10^{-23})(273 + 30) = 2.09 \times 10^{-21}\, J$

$= 0.013\, eV < 1\, eV$

26. The capacity of a vessel is 3 litres. It contains $6\, gm$ oxygen, $8\, gm$ nitrogen and $5\, gm\ CO_2$ mixture at $27\ °C$. If $R\ = 8.31\ J/mole\ \times\ kelvin$, then the pressure in the vessel in N/m^2 will be (approx.)

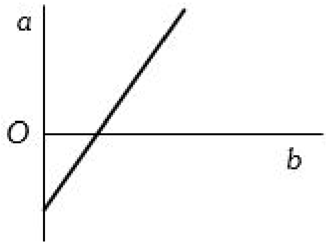
A) 5×10^5 B) 5×10^4
C) 10^6 D) 10^5

Solution : (Correct Answer: A)

by partial pressure law $P_{total} = (n_1 + n_2 + n_3)\frac{RT}{V}$

$= \left(\frac{6}{32} + \frac{8}{28} + \frac{5}{44}\right) \times \frac{8.31 \times 300}{3 \times 10^{-3}} = 5 \times 10^5 N/m^2$

27. The expansion of unit mass of a perfect gas at constant pressure is shown in the diagram. Here



A) $a =$ volume, $b =°C$ temperature
B) $a =$ volume, $b = K$ temperature
C) $a =°C$ temperature, $b =$ volume
D) $a = K$ temperature, $b =$ volume

Solution : (Correct Answer: C)

Given :- Pressure of perfect gas is constant i.e, $\frac{V}{T}$ is Constant

To Find :- Value of a and b in graph

Solution :- Since we know that Volume cannot be negative any more

$\therefore$ Here, (b) is Volume

($\because$ a also contains negative value)

Since we know that Kelvin Temperature cannot be negative

$\therefore$ a is temperature $(°C)$

28. Select the incorrect statement about Maxwell's speed distribution

A) The distribution function depends only on the absolute temperature
B) $V_{ms} > V_{av} > V_{mp}$
C) The area under the distribution curve gives total number of molecules of the gas
D) The distribution curve is symmetric about the most probable speed

Solution : (Correct Answer: D)

(d)

The Maxwell's speed distribution is asymmetric due to the fact that the lowest speed possible is zero. While the highest speed possible is infinity.

29. The ratio of specific heats (γ) of a ideal gas is given by

A) $\frac{1}{1-\frac{R}{C_P}}$ B) $1 + \frac{R}{C_V}$
C) $\frac{C_P}{C_P - R}$ D) All of these

Solution : (Correct Answer: D)

$\gamma = \frac{C_P}{C_V}$

and $C_P - C_V = R$

30. Let A and B the two gases and given : $\frac{T_A}{M_A} = 4.\frac{T_B}{M_B}$; where T is the temperature and M is molecular mass. If C_A and C_B are the $r.m.s.$ speed, then the ratio $\frac{C_A}{C_B}$ will be equal to

A) 2 B) 4 C) 1 D) 0.5

Solution : (Correct Answer: A)

$\frac{T_A}{M_A} = 4\frac{T_B}{M_B}$

$\Rightarrow \sqrt{\frac{T_A}{M_A}} = 2\sqrt{\frac{T_B}{M_B}}$

$\Rightarrow \sqrt{\frac{3RT_A}{M_A}} = 2\sqrt{\frac{3RT}{M_B}}$

$\Rightarrow C_A = 2C_B$

$\Rightarrow \frac{C_A}{C_B} = 2$

31. What is the ratio of specific heats of constant pressure and constant volume for NH_3

A) 1.33 B) 1.44 C) 1.28 D) 1.67

Solution : (Correct Answer: A)

NH_3 degree of freedom for $f = 6$

$\Rightarrow \frac{C_P}{C_V} = \gamma = 1 + \frac{2}{f} = 1 + \frac{2}{6} = \frac{4}{3} = 1.33$

32. Which of the following formulae is wrong

A) $C_V = \frac{R}{\gamma - 1}$
B) $C_P = \frac{\gamma R}{\gamma - 1}$
C) $C_p / C_v = \gamma$
D) $C_P - C_V = 2R$

Solution : (Correct Answer: D)

The difference between C_P and C_V is R, not $2R$.

33. The following sets of values for C_V and C_P of a gas has been reported by different students. The units are $cal/gm - mole - K$. Which of these sets is most reliable

A) $C_v = 3, C_p = 5$
B) $C_V = 4, C_P = 6$
C) $C_v = 3, C_p = 2$
D) $C_V = 3, C_P = 4.2$

Solution : (Correct Answer: A)

C_V and C_p for diatomic molecule are given by-

$C_V = \frac{3}{2} R$ and $C_p = \frac{5}{2} R$

Since, unites are in calories,

$\Rightarrow R = 2\ cal.$

$\Rightarrow C_V = 3$ and $C_p = 5$

34. The volume of a gas at $21°C$ temperature and 768 mm pressure is $1\ litre$. If the density of the gas is $1.2\ gm/litre$ at NTP, then its mass will be ..... gm

A) 4 B) 4.21 C) 1.13 D) 10

Solution : (Correct Answer: C)

We know that the gas follows Ideal gas law, which states $\frac{P}{\rho T}$ = constant or

$\frac{P_1}{\rho_1 T_1} = \frac{P_2}{\rho_2 T_2}$

Given that Density at NTP is $\rho_2 = 1.2\ g/L$

$T_2 = 20°C = 293.15K$ and $P_2 = 76\ cm$ of Hg

We have $T_1 = 21°C = 294.15\ K$ and $P_1 = 71.8\ cm$ of Hg

Thus $\rho_1 = \rho_2 \times \frac{T_2}{T_1} \times \frac{P_1}{P_2} = 1.2 \times \frac{293.15}{294.15} \times \frac{71.8}{76} = 1.13$ g/L

Thus mass of the gas $= \rho_2 \times V_2 = 1.13\ g/L \times 1L$ $= 1.13\ g$

35. The respective speeds of five molecules are $2, 1.5, 1.6, 1.6$ and $1.2\ km/sec$. The most probable speed in km/sec will be

A) 2 B) 1.58 C) 1.31 D) 1.6

Solution : (Correct Answer: C)

Most probable speed is calculated by -

$v_{mp} = \sqrt{2/3} \times v_{rms}$

$v_{mp} = 0.816 \times 1.6$

$v_{mp} = 1.306 \approx 1.31 km/s$

Therefore, the most probable speed of the gas is $1.31 km/s$.

36. In the relation $n = \frac{PV}{RT}, n =$

A) Number of molecules
B) Atomic number
C) Mass number
D) Number of moles

Solution : (Correct Answer: D)

$n = \frac{PV}{RT}$

Writing the units of all the terms of Right Hand Side, in SI units

$n = \frac{(Pa) \times (m^3)}{(J/mol/k) \cdot (k)}$

$n = \frac{\left(\frac{N}{m^2}\right) \cdot (m^3)}{\left(\frac{J}{\text{mol. K}}\right) \cdot (k.)}$

$n = \frac{\frac{kgm}{s^2 \cdot m^2} \cdot m^3}{\frac{kgm^2}{s^2 \cdot mol \cdot K} \cdot K.}$

$n = \text{mol}.$ [All other terms cancel out]

Correct choice - option - D

37. Kinetic theory of gases was put forward by

A) Einstein B) Newton C) Maxwell D) Raman

Solution : (Correct Answer: C)

Kinetic theory of gases was put forward by Maxwell. British Scientist Moxwell and Australian physicist Boltzmann, in the $19th$ century, led in establishing the theory.
It is a theory based on a simplified molecular or particle description of a gas, from which many gross properties of the gas can be derieved.
correct thoice- option-C

38. We write the relation for Boyle's law in the form $PV = C$ when the temperature remains constant. In this relation, the magnitude of C depends upon

A) The nature of the gas used in the experiment
B) The magnitude of g in the laboratory
C) The atmospheric pressure
D) The quantity of the gas enclosed

Solution : (Correct Answer: D)

In Boyle's law, while writing the reaction, the magnitude of C depends upon the quantity of gas enclosed within.

39. A gas at the temperature $250\ K$ is contained in a closed vessel. If the gas is heated through $1\ K$, then the percentage increase in its pressure will be .... %

A) 0.4 B) 0.2 C) 0.1 D) 0.8

Solution : (Correct Answer: A)

$P \propto T$

$\Rightarrow \frac{P_1}{P_2} = \frac{T_1}{T_2}$

$\Rightarrow \frac{P_2 - P_1}{P_1} = \frac{T_2 - T_1}{T_2}$

$\Rightarrow \left(\frac{\Delta P}{P}\right) \% = \left(\frac{251-250}{250}\right) \times 100 = 0.4\%$

40. Boyle's law holds for an ideal gas during

A) Isobaric changes B) Isothermal changes
C) Isochoric changes D) Isotonic changes

Solution : (Correct Answer: B)

Boyle's law states that at constant temperature, for a fixed mass of a gas, PV= constant

But if the temperature remains constant, it will be called as an isothermal change.

So B is correct.

41. Assertion (A) : 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 volume.
Reason (R) : The molecules of gas collide with each other and the velocities of the molecules change due to the collision.

A) If both Assertion and Reason are true and Reason is correct explanation of Assertion.
B) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
C) If Assertion is true but Reason is false.
D) If both Assertion and Reason are false.

Solution : (Correct Answer: B)

(b)

42. At what temperature will the rms speed of oxygen molecules become just sufficient for escaping from the Earth's atmosphere ? (Given: Mass of oxygen molecule $(m) = 2.76 \times 10^{-26}$ kg Boltzmann's constant $k_B = 1.38 \times 10^{-23}\ JK^{-1}$)

A) $2.508 \times 10^4\ K$ B) $8.360 \times 10^4\ K$
C) $1.254 \times 10^4\ K$ D) $5.016 \times 10^4\ K$

Solution : (Correct Answer: B)

Escape velocity from the Earth's surface is

$v_{\text{escape}} = 11200 \mathrm{ms}^{-1}$

Say at temperature T, oxygen molecule attains escape velocity.

So, $v_{\text{escape}} = \sqrt{\frac{3k_BT}{m_{O_2}}} \Rightarrow 11200 = \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times T}{2.76 \times 10^{-26}}}$

On solving, $T = 8.360 \times 10^4 \mathrm{K}$

43. The amount of heat energy required to raise the temperature of $1\ g$ of Helium at NTP, from $T_1 K$ to $T_2 K$ is

A) $\frac{3}{8} N_a k_B (T_2 - T_1)$ B) $\frac{3}{2} N_a k_B (T_2 - T_1)$
C) $\frac{3}{4} N_a k_B (T_2 - T_1)$ D) $\frac{3}{4} N_a k_B \left(\frac{T_2}{T_1}\right)$

Solution : (Correct Answer: A)

As here volume of the gas remains constant, therefore the amount of heat energy required to raise the temperature of the gas is[

$\Delta Q = nC_v \Delta T$

Here, Number of moles, $n = \frac{1}{4}$

$C_V = \frac{3}{2} R \quad (\because He\, is\, a\, monatomic.)$

$$\Delta T = T_2 - T_1$$

$$\therefore \Delta Q = \frac{1}{4}\frac{3}{2} R (T_2 - T_1)$$
$$= \frac{3}{8} N_a k_B (T_2 - T_1)$$

$\left(k_B = \frac{R}{N_a}\right)$

44. One mole of an ideal gas requires $207\ J$ heat to raise the temperature by $10\ K$ when heated at constant pressure. If the same gas is heated at constant volume to raise the temperature by the same $10\ K$, the heat required is ...... J
(Given the gas constant $R = 8.3 J/mol{-}K$)

A) 198.7 B) 29 C) 215.3 D) 124

Solution : (Correct Answer: D)

$(\Delta Q)_P = \mu C_P \Delta T$

$\Rightarrow\ 207 = 1 \times C_P \times 10$

$\Rightarrow C_P = 20.7 \frac{Joule}{mol-K}$

$C_P - C_V = R$

$\Rightarrow C_V = C_P - R = 20.7 - 8.3 = 12.4 \frac{Joule}{mole-K}$

$(\Delta Q)_V = \mu C_V \Delta T = 1 \times 12.4 \times 10 = 124\ J$

45. The correct relation between the degree of freedom f and the ratio of specific heat γ is

A) $f = \frac{1}{\gamma+1}$ B) $f = \frac{2}{\gamma-1}$
C) $f = \frac{\gamma+1}{2}$ D) $f = \frac{2}{\gamma+1}$

Solution : (Correct Answer: B)

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

$\Rightarrow\ \gamma - 1 = \frac{2}{f}$

$\Rightarrow \frac{f}{2} = \frac{1}{\gamma - 1}$

$\Rightarrow f = \frac{2}{\gamma - 1}$