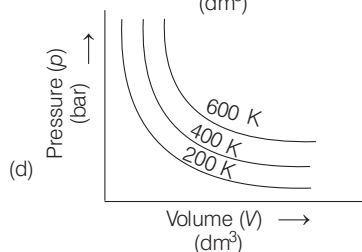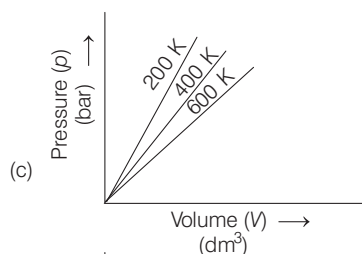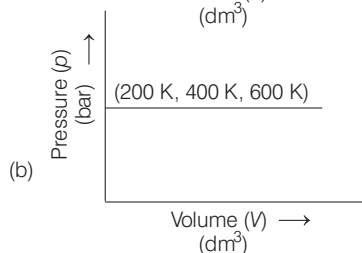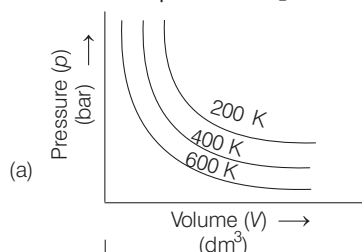# 5

States of Matter

TOPIC 1
Gaseous State

01 Choose the correct option for graphical representation of Boyle's law, which shows a graph of pressure *vs* volume of a gas at different temperatures **[NEET 2021]**
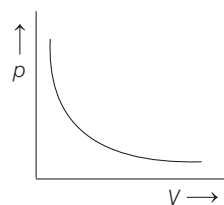
(a)

(b)

(c)

(d)

Ans. *(d)*

Boyle's law states, that at constant temperature, pressure of a gas of fixed amount varies inversely with volume.
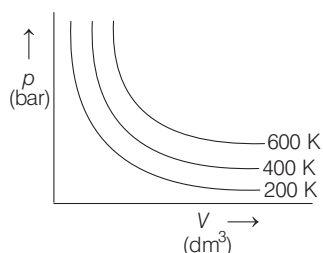
$$p \propto \frac{1}{V}$$

$$p = \frac{\lambda}{V}, (\lambda \text{ is a constant})$$

$$pV = \lambda$$

As temperature increases, gas expands i.e. volume of gas increases.

So, the product pV increases and the p vs V curve of Boyle's law shifts upwards.

02 Choose the correct option for the total pressure (in atm) in a mixture of $4g\,O_2$ and $2\,g\,H_2$ confined in a total volume of one litre at 0°C is [Given, $R = 0.082$ L atm $mol^{-1}K^{-1}$, $T = 273K$] **[NEET 2021]**

(a) 2.518   (b) 2.602
(c) 25.18   (d) 26.02

Ans. *(c)*

Given, mass of $O_2 = 4g$
Molar mass of $O_2 = 32\,g\,mol^{-1}$
Number of moles of O_2,

$$n_{O_2} = \frac{\text{Mass of } O_2}{\text{Molar mass of } O_2} = \frac{4}{32} = \frac{1}{8} \text{mol}$$

Given, mass of $H_2 = 2g$
Molar mass of $H_2 = 2\,g\,mol^{-1}$
Number of moles of H_2,

$$n_{H_2} = \frac{\text{Mass of } H_2}{\text{Molar mass of } H_2}$$

$$= \frac{2}{2} = 1 \text{mol}$$

Total number of moles of mixture,

$$n_T = n_{O_2} + n_{H_2}$$

$$n_T = \frac{1}{8} + 1 = \frac{9}{8} \text{mol}$$

Ideal gas equation;

$$pV = nRT$$

$$\begin{pmatrix} \text{Given, } R = 0.082 \text{ L atm mol}^{-1} K^{-1} \\ T = 0°C = 273K, \ V = 1L \end{pmatrix}$$

$$p \times 1 = \frac{9}{8} \times 0.082 \times 273$$

$$\Rightarrow \quad p = 25.18 \text{ atm}$$

03 The minimum pressure required to compress 600 dm^3 of a gas at 1 bar to 150 dm^3 at 40°C is **[NEET (Oct.) 2020]**

(a) 4.0 bar   (b) 0.2 bar
(c) 1.0 bar   (d) 2.5 bar

Ans. *(a)*

$$p_1 = 1 \text{bar}, \ p_2 = ?$$
$$V_1 = 600 \text{ dm}^3$$
$$V_2 = 150 \text{ dm}^3$$

$\Rightarrow$ From Boyle's law (Temperature, 40ºC is constant)

$$p_1 V_1 = p_2 V_2$$

$$\Rightarrow p_2(\min) = \frac{p_1 V_1}{V_2} = \frac{1 \times 600}{150} = 4 \text{bar}$$

04 A gas at 350 K and 15 bar has molar volume 20 percent smaller than that for an ideal gas under the same conditions. The correct option about the gas and its compressibility factor (Z) is **[NEET (National) 2019]**

(a) $Z > 1$ and repulsive forces are dominant
(b) $Z < 1$ and attractive forces are dominant

(c) $Z < 1$ and repulsive forces are dominant

(d) $Z > 1$ and attractive forces are dominant

Ans. *(b)*

Compressibility factor (Z) is the factor which decides the extent of deviation of real gases from ideal gases.

$$Z = \frac{V_{real}}{V_{ideal}}$$

Real gases deviate from ideal gas behaviour because for ideal gas it is considered that there is no force of attraction between gas molecules.

Also, for ideal gas, volume of gas molecules is negligible as compared to volume of gas container.

Given, $\qquad V_{real} < V_{ideal}$

$\therefore \qquad\qquad Z < 1$

If $Z < 1$, the gas is more compressible than expected from ideal behaviour. As a result, attractive forces are present between molecules and are dominant.

---

05 The volume occupied by 1.8 g of water vapour at 374°C and 1 bar pressure will be

$\left[\text{Use } R = 0.083 \text{ bar L K}^{-1} \text{mol}^{-1}\right]$

[NEET (Odisha) 2019]

(a) 96.66 L $\qquad$ (b) 55.87 L

(c) 3.10 L $\qquad$ (d) 5.37 L

Ans. *(d)*

According to ideal gas equation,

$pV = nRT$

or $\quad V = \dfrac{nRT}{p} = \dfrac{w}{M.wt}\dfrac{RT}{p}$ ...(i) $\left[\because n = \dfrac{w}{M.wt}\right]$

Given, $w = 1.8$ g, $T = 374^\circ$ C

$\qquad = (374 + 273)$ K $= 647$ K

$p = 1$ bar, $R = 0.083$ bar LK^{-1} mol^{-1}

On substituting the given values in Eq. (i), we get

$V = \dfrac{1.8\,g}{18\,g\,mol^{-1}}$

$\qquad \times \dfrac{0.083\,bar\,LK^{-1}\,mol^{-1} \times 647\,K}{1\,bar}$

$\qquad = 5.37$ L

---

06 Given van der Waals' constant of NH_3, H_2, O_2 and CO_2 are respectively 4.17, 0.244, 1.36 and 3.59, which one of the following gases is most easily liquefied?

[NEET 2018]

(a) O_2 $\qquad$ (b) H_2

(c) NH_3 $\qquad$ (d) CO_2

Ans. *(c)*

In the van der Waals' equation,

$$\left[p + \frac{an^2}{V^2}\right](V - nb) = nRT$$

'a' and 'b' are known as van der Waals' constant.

'a' is the measure of force of attraction between gas molecules. Greater the value of a, easier the liquefaction of the gas.

Thus, among NH_3(4.17), H_2(0.244), O_2(1.36) and CO_2(3.59), the value of a is greatest in NH_3, hence it is most easily liquefied.

---

07 The correction factor 'a' to the ideal gas equation corresponds to

[NEET 2018]

(a) electric field present between the gas molecules

(b) volume of the gas molecules

(c) density of the gas molecules

(d) forces of attraction between the gas molecules

Ans. *(d)*

According to van der Waals' equation,

$$\left[P + \frac{an^2}{V^2}\right](V - nb) = nRT$$

where, a and b are called van der Waals' constant.

$\dfrac{an^2}{V^2}$ is called internal pressure of the gas

where, 'a' is a measure of force of attraction between gas molecules.

'b' is also called co-volume or excluded volume.

The constants 'a' and 'b' are expressed in atm L^2 mol^{-2} and L mol^{-1}, respectively.

---

08 Equal moles of hydrogen and oxygen gases are placed in container with a pin-hole through which both can escape. What fraction of the oxygen escapes in the time required for one-half of the hydrogen to escape?

[NEET 2016, Phase I]

(a) 1/4 $\qquad$ (b) 3/8

(c) 1/2 $\qquad$ (d) 1/8

Ans. *(d)*

Given, number of moles of hydrogen (n_{H_2}) and that of oxygen (n_{O_2}) are equal.

$\therefore$ We have, the relation between ratio of number of moles escaped and ratio of molecular mass.

$$\frac{n_{O_2}}{n_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}}$$

where, $M = $ Molecular mass of the molecule.

$\Rightarrow \qquad \dfrac{n_{O_2}}{n_{H_2}} = \sqrt{\dfrac{2}{32}}$

$\Rightarrow \qquad \dfrac{n_{O_2}}{n_{H_2}} = \sqrt{\dfrac{1}{16}}$

$\Rightarrow \qquad \dfrac{n_{O_2}}{0.5} = \dfrac{1}{4}$

$\Rightarrow \qquad n_{O_2} = \dfrac{0.5}{4} = \dfrac{1}{8}$

---

09 A mixture of gases contains H_2 and O_2 gases in the ratio of 1 : 4 (w/w). What is the molar ratio of the two gases in the mixture?

[CBSE AIPMT 2015]

(a) 1 : 4 $\quad$ (b) 4 : 1 $\quad$ (c) 16 : 1 $\quad$ (d) 2 : 1

Ans. *(b)*

Let the mass of H_2 gas be xg and mass of O_2 gas 4xg

Molar	H_2	:	O_2
mass	2	:	32
i.e.	1	:	16

$\therefore$ Molar ratio $= \dfrac{n_{H_2}}{n_{O_2}}$

$\qquad = \dfrac{x/2}{4x/32}$

$\qquad = \dfrac{x \times 32}{2 \times 4x} = \dfrac{4}{1} = 4 : 1$

---

10 Equal masses of H_2, O_2 and methane have been taken in a container of volume V at temperature 27°C in identical conditions. The ratio of the volumes of gases $H_2 : O_2 : CH_4$ would be

[CBSE AIPMT 2014]

(a) 8 : 16 : 1 $\qquad$ (b) 16 : 8 : 1

(c) 16 : 1 : 2 $\qquad$ (d) 8 : 1 : 2

Ans. *(c)*

According to Avogadro's hypothesis,

Volume of a gas $(V) \propto$ number of moles (n)

Therefore, the ratio of the volumes of gases can be determined in terms of their moles.

$\therefore$ The ratio of volumes of $H_2 : O_2 :$ methane (CH_4) is given by

$V_{H_2} : V_{O_2} : V_{CH_4} = n_{H_2} : n_{O_2} : n_{CH_4}$

$\Rightarrow V_{H_2} : V_{O_2} : V_{CH_4} := \dfrac{m_{H_2}}{M_{H_2}} : \dfrac{m_{O_2}}{M_{O_2}} : \dfrac{m_{CH_4}}{M_{CH_4}}$

Given, $m_{H_2} = m_{O_2} = m_{CH_4} = m$

$\left[\because n = \dfrac{mass}{molar\ mass}\right]$

Thus, $V_{H_2} : V_{O_2} : V_{CH_4} = \dfrac{m}{2} : \dfrac{m}{32} : \dfrac{m}{16}$

$= 16 : 1 : 2$

11 Maximum deviation from ideal gas is expected from **[NEET 2013]**
(a)$H_2(g)$ (b)$N_2(g)$ (c)$CH_4(g)$ (d)$NH_3(g)$

Ans. *(d)*

The extent to which a real gas deviates from ideal behaviour can be understood by a quantity 'Z' called the **compressibility factor**. Easily liquifiable gases like NH_3, SO_2 etc. exhibit maximum deviation from ideal gas as for them $Z <<< 1$.

CH_4 also exhibits deviation but it is less as compared to NH_3.

12 50 mL of each gas A and of gas B takes 150 and 200 s respectively for effusing through a pin hole under the similar conditions. If molecular mass of gas B is 36, the molecular mass of gas A will be
[CBSE AIPMT 2012]
(a) 96   (b) 128   (c) 32   (d) 64

Ans. *(*)*

Given, $V_A = V_B = 50$ mL
            $T_A = 150$ s
            $T_B = 200$ s
            $M_B = 36$
            $M_A = ?$

From Graham's law of effusion

$\dfrac{r_B}{r_A} = \sqrt{\dfrac{M_A}{M_B}} = \dfrac{V_B T_A}{T_B V_A} \Rightarrow \sqrt{\dfrac{M_A}{36}} = \dfrac{V_A \times 150}{200 \times V_A}$

or $\sqrt{\dfrac{M_A}{36}} = \dfrac{15}{20} = \dfrac{3}{4} \Rightarrow \dfrac{M_A}{36} = \dfrac{9}{16}$

$M_A = \dfrac{9 \times 36}{16} = \dfrac{9 \times 9}{4} = \dfrac{81}{4} = 20.2$

* According to question, no option is correct in this condition, answer any option.

NOTE

If $T_A = 200$ s and $T_B = 150$ s then $M_A = 64$

13 A gaseous mixture was prepared by taking equal moles of CO and N_2. If the total pressure of the mixture was found 1 atom, the partial pressure of the nitrogen (N_2) in the mixture is **[CBSE AIPMT 2011]**
(a) 0.8 atm   (b) 0.9 atm
(c) 1 atm   (d) 0.5 atm

Ans. *(d)*

Equal moles of CO and N_2
$n_{CO} = n_{N_2}$

then, according to ideal gas equation, pressure of both gases CO and N_2 becomes equal

$\therefore \qquad p_{CO} = p_{N_2}$

Given, $p_{CO} + p_{N_2} =$ Total pressure of mixture.

or $2p_{N_2} = 1$ atm or $p_{N_2} = 0.5$ atm

14 Two gases A and B having the same volume diffuse through a porous partition in 20 and 10 s respectively. The molecular mass of A is 49 u. Molecular mass of B will be **[CBSE AIPMT 2011]**
(a) 12.25 u   (b) 6.50 u
(c) 25.00 u   (d) 50.00 u

Ans. *(a)*

According to Graham's law of diffusion, rate of diffusion

$r \propto \dfrac{1}{\sqrt{M}}, r \propto \dfrac{V}{t}$

where, V is the volume of the gas diffused in time t.

$\dfrac{r_A}{r_B} = \sqrt{\dfrac{M_B}{M_A}}$ or $\dfrac{V_A}{t_A} \times \dfrac{t_B}{V_B} = \sqrt{\dfrac{M_B}{M_A}}$

Given, $V_A = V_B$

$\therefore \qquad \dfrac{10}{20} = \sqrt{\dfrac{M_B}{49}} \Rightarrow \dfrac{1}{4} = \dfrac{M_B}{49}$

$M_B = \dfrac{49}{4} = 12.25$ u

15 If a gas expands at constant temperature, it indicates that **[CBSE AIPMT 2008]**
(a) kinetic energy of molecules decreases
(b) pressure of the gas increases
(c) kinetic energy of molecules remains the same
(d) number of the molecules of gas increases

Ans. *(c)*

$KE = \dfrac{3}{2} RT$ (for one mole of a gas)

As, the kinetic energy of a gaseous molecule depends only on temperature, thus at constant temperature, the kinetic energy of the molecules remains the same.

16 van der Waals' real gas, act as an ideal gas, at which condition? **[CBSE AIPMT 2002]**
(a) High temperature, low pressure
(b) Low temperature, high pressure
(c) High temperature, high pressure
(d) Low temperature, low pressure

Ans. *(a)*

At higher temperature and low pressure real gas acts as an ideal gas and obey $pV = nRT$ relation.

17 The beans are cooked earlier in pressure cooker, because **[CBSE AIPMT 2001]**
(a) boiling point increases with increasing pressure
(b) boiling point decreases with increasing pressure
(c) extra pressure of pressure cooker, softens the beans
(d) internal energy is not lost while cooking in pressure cooker

Ans. *(b)*

The beans are cooked earlier in pressure cooker because boiling point decreases with increasing pressure.

18 Which of the following expressions correctly represents the relationship between the average molar kinetic energy, $\overline{KE}$ of CO and N_2 molecules at the same temperature?
(a)$\overline{KE}_{CO} < \overline{KE}_{N_2}$ **[CBSE AIPMT 2000]**
(b)$\overline{KE}_{CO} > \overline{KE}_{N_2}$
(c)$\overline{KE}_{CO} = \overline{KE}_{N_2}$
(d) Cannot be predicted unless volumes of the gases are given

Ans. *(c)*

$KE = \dfrac{3}{2} RT$ (for one mole of a gas)

The temperature is constant and kinetic energy is independent on molecular weights. So,

$\overline{KE}_{CO} = \overline{KE}_{N_2}$

19 Which one of the following statements is wrong for gases? **[CBSE AIPMT 1999]**
(a) Gases do not have a definite shape and volume
(b) Volume of the gas is equal to volume of container confining the gas
(c) Confined gas exerts uniform pressure on the walls of its container in all directions
(d) Mass of gas cannot be determined by weighing a container in which it is enclosed

Ans. *(d)*

Mass of gas can be determined by weighing a container in which it is enclosed as follows:

Mass of the gas = mass of the cylinder including gas – mass of empty cylinder
So, it is a wrong statement.

20 At 25°C and 730 mm pressure, 380 mL of dry oxygen was collected. If the temperature is constant, what volume will the oxygen occupy at 760 mm pressure?

[CBSE AIPMT 1999]

(a) 365 mL   (b) 2 mL
(c) 10 mL   (d) 20 mL

Ans. *(a)*

As the temperature is constant, Boyle's law is applicable.

$p_1V_1 = p_2V_2$
$V_1 = 380$ mL, $p_1 = 730$ mm , $V_2 = ?$,
$p_2 = 760$ mm
$730 \times 380 = 760 \times V_2$
$$V_2 = \frac{730 \times 380}{760} = 365 \text{ mL}$$

21 At which one of the following temperature pressure conditions, the deviation of a gas from ideal behaviour is expected to be minimum? **[CBSE AIPMT 1996]**

(a) 350 K and 3 atm
(b) 550 K and 1 atm
(c) 250 K and 4 atm
(d) 450 K and 2 atm

Ans. *(b)*

A real gas behave as an ideal gas at low pressure and high temperature. Among the given option 550K temperature is the highest and 1atm pressure is the lowest pressure.

22 Cyclopropane and oxygen at partial pressures 170 torr and 570 torr are mixed in a gas cylinder. What is the ratio of the number of moles of cyclopropane to the number of moles of oxygen? **[CBSE AIPMT 1996]**

(a) $\dfrac{170 \times 42}{570 \times 32} = 0.39$

(b) $\dfrac{170}{42} \bigg/ \left(\dfrac{170}{42} + \dfrac{570}{32}\right) \approx 0.19$

(c) $\dfrac{170}{740} = 0.23$

(d) $\dfrac{170}{570} = 0.30$

Ans. *(d)*

According to ideal gas equation,
$$p_1V = n_1RT \qquad \text{...(i)}$$

$$p_2V = n_2RT \qquad \text{...(ii)}$$

From Eqs. (i) and (ii)
$$\frac{p_1V}{p_2V} = \frac{n_1RT}{n_2RT} \implies \frac{p_1}{p_2} = \frac{n_1}{n_2}$$
$$\frac{n_1}{n_2} = \frac{p_1}{p_2} = \frac{170}{570} = 0.30$$

23 600 cc of a gas at a pressure of 750 mm is compressed to 500 cc. Taking the temperature to remain constant, the increase in pressure is **[CBSE AIPMT 1995]**

(a) 150 mm   (b) 250 mm
(c) 350 mm   (d) 450 mm

Ans. *(a)*

According to Boyle's law,
$$p_1V_1 = p_2V_2$$
$$750 \times 600 = p_2 \times 500$$
$$p_2 = \frac{750 \times 600}{500}$$
$$= 900 \text{ mm}$$
So, the increase in pressure
$$= 900 - 750 = 150 \text{ mm}$$

24 500 mL of nitrogen at 27°C is cooled to –5°C at the same pressure. The new volume becomes **[CBSE AIPMT 1995]**

(a) 326.32 mL
(b) 446.66 mL
(c) 546.32 mL
(d) 771.56 mL

Ans. *(b)*

Initial volume, $V_1 = 500$ mL
Initial temperature,
$T_1 = 27°C = 27 + 273 = 300$ K
Final temperature,
$T_2 = -5 + 273 = 268$ K
$V_2 = ?$
$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
$$V_2 = \frac{V_1 T_2}{T_1} = \frac{500 \times 268}{300}$$
$$= 446.66 \text{ mL}$$

25 The temperature of the gas is raised from 27°C to 927°C the root mean square velocity is **[CBSE AIPMT 1994]**

(a) $\sqrt{\dfrac{927}{27}}$ times of the earlier value
(b) same as before
(c) halved
(d) doubled

Ans. *(d)*

Root mean square velocity at T_1 temperature,
$$U_1 = \sqrt{\frac{3RT_1}{M}} = \sqrt{\frac{3R(27 + 273)}{M}} \qquad \text{...(i)}$$
Root mean square velocity at T_2 temperature,
$$U_2 = \sqrt{\frac{3RT_2}{M}} = \sqrt{\frac{3R(927 + 273)}{M}} \qquad \text{...(ii)}$$
Eq. (i) divided by Eq. (ii)
$$\frac{U_1}{U_2} = \sqrt{\frac{27 + 273}{927 + 273}}$$
$$= \sqrt{\frac{300}{1200}} = \frac{1}{2}$$
$$U_2 = 2U_1$$

26 When is the deviation more in the behaviour of a gas from the ideal gas equation $pV = nRT$?

[CBSE AIPMT 1993]

(a) At high temperature and low pressure
(b) At low temperature and high pressure
(c) At high temperature and high pressure
(d) At low temperature and low pressure

Ans. *(b)*

Gases show deviation from ideal gas behaviour when the temperature is low and pressure is high. At low temperature, the volume of one molecule is not negligible in comparison to total volume and intermolecular force of attraction is maximum at low temperature and high pressure.

27 The ratio among most probable velocity, mean velocity and root mean square velocity is given by

[CBSE AIPMT 1993]

(a) $1:2:3$ (b) $1:\sqrt{2}:\sqrt{3}$
(c) $\sqrt{2}:\sqrt{3}:\sqrt{\dfrac{8}{\pi}}$ (d) $\sqrt{2}:\sqrt{\dfrac{8}{\pi}}:\sqrt{3}$

Ans. *(d)*

Most probable velocity, $U_{mp} = \sqrt{\dfrac{2RT}{M}}$

Mean velocity, $U_{av} = \sqrt{\dfrac{8RT}{\pi M}}$

Root mean square velocity, $U_{rms} = \sqrt{\dfrac{3RT}{M}}$

so,
$$U_{mp} : U_{av} : U_{rms} = \sqrt{\frac{2RT}{M}} : \sqrt{\frac{8RT}{\pi M}} : \sqrt{\frac{3RT}{M}}$$
$$= \sqrt{2} : \sqrt{\frac{8}{\pi}} : \sqrt{3}$$

28 Internal energy and pressure of a gas per unit volume are related as

(a) $p = \frac{2}{3} E$ (b) $p = \frac{3}{2} E$

(c) $p = \frac{1}{2} E$ (d) $p = 2E$

Ans. *(a)*

The average translational kinetic energy of a gas molecule is $\frac{1}{2} m\bar{u}^2$ at a temperature, T. The total energy of the whole of the gas containing N molecules is

$$E_k = \frac{1}{2} mN\bar{u}^2 \qquad ...(i)$$

The kinetic gas equation is

$$pV = \frac{1}{3} mN\bar{u}^2 \qquad ...(ii)$$

$$pV = \frac{2}{3} \times \frac{1}{2} mN\bar{u}^2$$

$$pV = \frac{2}{3} E_k \qquad ...(iii)$$

so, $p = \frac{2}{3} E_k$ per unit volume.

29 Under what conditions will a pure sample of an ideal gas not only exhibit a pressure of 1 atm but also a concentration of 1 mol L^{-1}?
($R = 0.082$ L atm mol^{-1} deg^{-1})

(a) At STP
(b) When $V = 22.4$ L
(c) When $T = 12$ K
(d) Impossible under any conditions

Ans. *(c)*

According to ideal gas equation,
$$pV = nRT$$
$$p = \frac{n}{V} RT$$
$$1 \text{atm} = 1 \text{mol L}^{-1} \times 0.082 \times T$$
$$T = \frac{1}{0.082} = 12 \text{K}$$

30 Select the correct statement. In the gas equation $pV = nRT$

(a) n is the number of molecules of a gas
(b) V denotes volume of one mole of the gas
(c) n moles of the gas have a volume V
(d) p is the pressure of the gas when only one mole of the gas is present

Ans. *(c)*

The ideal gas equation is $pV = nRT$ where, V is the volume of n moles of a gas.

31 An ideal gas cannot be liquefied because

(a) its critical temperature is always above 0°C
(b) its molecules are relatively smaller in size
(c) it solidifies before becoming a liquid
(d) forces operating between its molecules are negligible

Ans. *(d)*

Gases can be liquefied by lowering the temperature and increasing the pressure. An ideal gas have no intermolecular force of attraction, so it cannot be liquefied by applying high pressure and decreasing temperature.

32 The correct value of the gas constant 'R' is close to

(a) 0.082 L atm K
(b) 0.082 L atm K^{-1} mol^{-1}
(c) 0.082 L atm^{-1} K mol^{-1}
(d) 0.082 L^{-1} atm^{-1} K mol

Ans. *(b)*

The numerical value of R depends upon the units in which pressure and volume are expressed. When pressure is expressed in atmosphere and volume in litres, then the value of R at STP for 1 mole of gas is

$$R = \frac{1 \text{atm} \times 22.414 \text{ L}}{1 \text{mole} \times 273.15 \text{ K}}$$

$$= 0.082 \text{ L atm K}^{-1} \text{mol}^{-1}$$

33 Which is not true in case of an ideal gas?

(a) It cannot be converted into a liquid
(b) There is no interaction between the molecules
(c) All molecules of the gas move with same speed
(d) At a given temperature, pV is proportional to the amount of the gas

Ans. *(c)*

A gas is a collection of tiny particles separated from one another by large empty space and moving rapidly at random in all the directions. In the course of their motion, they collide with one another and also with the walls of the container. Due to frequent collisions, speeds and direction of motion of molecules keeps on changing. Thus, all the molecules in a sample of a gas do not have same speeds.

34 The root mean square speeds at STP for the gases H_2, N_2, O_2 and HBr are in the order

(a) $H_2 < N_2 < O_2 < HBr$
(b) $HBr < O_2 < N_2 < H_2$
(c) $H_2 < N_2 = O_2 < HBr$
(d) $HBr < O_2 < H_2 < N_2$

Ans. *(b)*

The root mean square velocity of gas molecule at STP is given by

$$U_{rms} = \sqrt{\frac{3RT}{M}}$$

∴ As the molar mass of gas increases, then U_{rms} will decrease, so the order of U_{rms} of these gases is

$$HBr < O_2 < N_2 < H_2$$

35 At constant temperature, in a given mass of an ideal gas

(a) the ratio of pressure and volume always remains constant
(b) volume always remains constant
(c) pressure always remains constant
(d) the product of pressure and volume always remains constant

Ans. *(d)*

According to ideal gas equation,
$pV = nRT$
If T is constant and mass is constant, so number of moles (n) also constant
$\left[n = \frac{\text{mass}}{\text{molar mass}} \right]$,
therefore
$$pV = \text{constant}$$

36 In a closed flask of 5 L, 1.0 g of H_2 is heated from 300 to 600 K. Which statement is not correct?

(a) Pressure of the gas increases
(b) The rate of collision increases
(c) The number of moles of gas increases
(d) The energy of gaseous molecules increases

Ans. *(c)*

Here, volume is constant and mass of hydrogen gas is also fixed, therefore the number of moles remains same. Now as the temperature increases, then pressure also increases. This will lead to more collisions among the gaseous molecules and hence, the energy of molecules increases.

37 A gas is said to behave like an ideal gas when the relation $\frac{pV}{T}=$ constant. When do you expect a real gas to behave like an ideal gas?　　**[CBSE AIPMT 1991]**

(a) When the temperature is low
(b) When both the temperature and pressure are low
(c) When both the temperature and pressure are high
(d) When the temperature is high and pressure is low

Ans. *(d)*

As we know that the van der Waals' equation is

$$\left(p+\frac{a}{V^2}\right)(V-b)=RT$$

The real gases show ideal behaviour when pressure approaches zero and temperature is high. At this condition there is no force of attraction and repulsion between the molecules of gas.

Thus, the effect of $\frac{a}{V^2}$ and b is negligible, i.e.

$$pV=RT$$
$$\frac{pV}{RT}=1$$

We also know $\frac{pV}{RT}=Z$ (for ideal gas $Z=1$)

(Z is compressibility factor)

Therefore an real gas behaves like ideal gas when the temperature is high and pressure is low.

38 In van der Waals' equation of state for a non-ideal gas, the term that accounts for inter molecular forces is　　**[CBSE AIPMT 1990]**

(a) $(V-b)$　　(b) $(RT)^{-1}$
(c) $\left(p+\frac{a}{V^2}\right)$　　(d) RT

Ans. *(c)*

The van der Waals' equation is

$$\left(p+\frac{a}{V^2}\right)(V-b)=RT$$

The term $\left(p+\frac{a}{V^2}\right)$ is used for pressure correction, it measures the intermolecular forces between the molecules of gas.

39 Absolute zero is defined as the temperature　　**[CBSE AIPMT 1990]**

(a) at which all molecular motion ceases
(b) at which liquid helium boils

(c) at which ether boils
(d) All of the above

Ans. *(a)*

At absolute zero temperature, the entropy of substance becomes zero, it means that all the molecular motions are stopped or ceased.

40 Root mean square velocity of a gas molecule is proportional to　　**[CBSE AIPMT 1990]**

(a) $m^{1/2}$　　(b) m^0
(c) $m^{-1/2}$　　(d) m

Ans. *(c)*

Root mean square speed is given by the expression

$$U_{rms}=\sqrt{\frac{3RT}{M}}\quad[\because M=mN]$$

$$\therefore\qquad U_{rms}\propto\sqrt{\frac{1}{m}}$$

$$\Rightarrow\qquad U_{rms}\propto(m)^{-1/2}$$

41 Pressure remaining the same, the volume of a given mass of an ideal gas increases for every degree centigrade rise in temperature by definite fraction of its volume at　　**[CBSE AIPMT 1989]**

(a) $0°C$
(b) absolute zero
(c) its critical temperature
(d) its Boyle's temperature

Ans. *(a)*

According to Charle's law "the volume of a fixed mass of a gas increases or decreases by $\frac{1}{273.15}$ of its volume at $0°C$ for each degree rise or fall of temperature, if pressure is kept constant".

42 If p, V, M, T and R are pressure, volume, molar mass, temperature and gas constant respectively, then for an ideal gas, the density is given by　　**[CBSE AIPMT 1989]**

(a) $\dfrac{RT}{pM}$　　(b) $\dfrac{p}{RT}$
(c) $\dfrac{M}{V}$　　(d) $\dfrac{pM}{RT}$

Ans. *(d)*

We know that ideal gas equation is
$$pV=nRT$$
$$pV=\frac{w}{M}RT$$

$$pM=\frac{w}{V}RT\qquad\left[\because \frac{w}{V}=d\right]$$
$$pM=dRT$$
$$\Rightarrow\qquad d=\frac{pM}{RT}$$

TOPIC 2
Liquid State

43 The surface tension of which of the following liquids is maximum?　　**[CBSE AIPMT 2005]**

(a) H_2O　　(b) C_6H_6
(c) CH_3OH　　(d) C_2H_5OH

Ans. *(a)*

Surface tension of H_2O is maximum due to maximum hydrogen bonding in comparison to C_6H_6, CH_3OH, C_2H_5OH. The order of H-bonding is $H_2O > CH_3OH > C_2H_5OH$
(Benzene does not form H-bond).

44 A liquid can exist only　　**[CBSE AIPMT 1994]**

(a) between triple point and critical temperature
(b) at any temperature above the melting point
(c) between melting point and critical temperature
(d) between boiling and melting temperature

Ans. *(d)*

A liquid below its melting point, is present in solid state and above its melting point, is present in vapour (gaseous) state, so a liquid can exist between melting point and boiling point.

45 A closed flask contains water in all its three states solid, liquid and vapour at $0°C$. In this situation, the average kinetic energy of water molecules will be　　**[CBSE AIPMT 1992]**

(a) the greatest in all the three states
(b) the greatest in vapour state
(c) the greatest in the liquid state
(d) the greatest in the solid state

Ans. *(b)*

In the three states of matter, the maximum kinetic energy is possessed by the gaseous molecules, so water vapour state has maximum kinetic energy in this situation.