CHAPTER 2

Behaviour of Gases, Mole Concept and Stoichiometry

SYNOPSIS

- **Kinetic molecular theory of gases**
  1. All gases are made up of tiny particles known as **molecules.**
  2. The huge intermolecular spaces make the forces of attraction between the gas molecules negligible.
  3. The molecules are in constant random motion. During motion, the molecules collide with each other and also with the walls of the container. These collisions being perfectly elastic transfer of momentum takes place among colliding molecules. The pressure exerted by a gas is due to the collisions of the molecules with the walls of the container.
  4. The average kinetic energy of gas molecules is proportional to the absolute temperature of the gas.
- Pressure, temperature and volume are taken as measurable properties of gases
- The S.I units of pressure, volume and temperature are Nm^{-2}, m^3 and Kelvin respectively.
- **Boyle's law:** The volume of a given mass of a gas is inversely proportional to the pressure exerted by the gas at constant temperature.

$$V \propto \frac{1}{P} \text{ (T is constant)} \Rightarrow V = \frac{K}{P}; PV = K \text{ (constant)}$$

- If at constant temperature, a gas occupies a volume V_1 at a pressure P_1 and a volume V_2 at a pressure P_2, $P_1V_1 = P_2V_2$ (T is constant).
- According to Boyles law, $P_1V_1 = P_2V_2$

$$\Rightarrow \frac{P_1m}{d_1} = \frac{P_2m}{d_2} = \frac{P_1}{d_1} = \frac{P_2}{d_2} \Rightarrow \frac{P}{d} = \text{constant}$$

$$\Rightarrow P \propto d$$

- Charle's law can be stated as the volume occupied by a given mass of a gas is directly proportional to the absolute temperature of the gas at constant pressure.
- If V_1 and V_2 are the volumes occupied by a given mass of gas at temperatures T_1 and T_2 respectively. $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (P is constant)
- If the volume is kept constant, increase in temperature results in increase in pressure which is known as **Charle's – Gay Lussac's Law**. $P \alpha T$ (Volume is constant). If P_1 and P_2 are the pressures of given mass of gas at temperatures T_1 and T_2, respectively. $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ (V is constant).
- The lowest temperature that can be attained theoretically is called **absolute zero or zero kelvin.**

- Temperature below 0°C are also possible and they are positive in Kelvin scale. It is not possible to attain a temperature lower than 0K.
- Standard temperature = 0°C = 273K; Standard pressure = 760 mm of Hg = 76 cm of Hg = 1 atm
- Gay-Lussac's law states that when gases chemically react, they do so in volumes which bear a simple whole number ratio to each other and to the volumes of the products, provided the products are also in gaseous state under similar conditions of temperature and pressure.
- Avogadro's law states that equal volumes of all gases contain equal number of molecules under similar conditions of temperature and pressure.

  If n is the number of molecules present in volume V of any gas at temperature T and pressure P, then $V \propto n$ when T and P are constant.

  $V = K.n$, K is constant

  If at constant temperature and pressure, n_1 molecules of a gas occupies a volume V_1 and n_2 molecules of gas occupies a volume V_2, then $\frac{V_1}{n_1} = \frac{V_2}{n_2}$.
- Relative molecular mass = 2 × V.D that is relative molecular mass is twice the vapour density of the gas or vapour.
- Gram molecular volume (GMV): One gram atom or one gram molecule of any gas at STP occupies 22.4 ℓ. This is called Gram molecular volume.
- Scientists experimentally determined that the number of atoms present in 12 g of carbon that is, one gram atom of carbon – 12 isotope is 6.023×10^{23}.
- The avogadro number that is, 6.023×10^{23} is taken as the unit to measure the amount of substances and is called **mole**.
- A mole is defined as the quantity of substance which contains the same number of elementary particles or chemical units as the number of atoms present in 12 g of C – 12 isotope. Hence, 1 mole of any substance contains avogadro number of elementary particles or units. The elementary particles can be atoms, molecules, ions etc.
- Number of moles = $\frac{\text{Mass of substancs}}{\text{GMM or GAM}}$
- 1 gram mole of any dry gas occupies 22.4 ℓ volume at STP. Hence 22.4 ℓ of a dry gas at STP contains 6.023×10^{23} molecules that is avogadro number of molecules.
- Combining the three gas laws, that is Boyle's law, Charle's law and Avogadro's law.

  $V \propto \frac{nT}{P}$ [when all the functions vary independently]

  or $PV \propto nT$ or $PV = nRT$ [R is a constant] A hypothetical gas called ideal gas obeys the equation under all conditions of temperature and pressure. Hence this equation is called **ideal gas equation** and R is called universal gas constant.
- All gases show nearly ideal behaviour under the conditions of low pressure and high temperature and hence are considered as ideal gases. Under the conditions when they deviate from ideal behaviour, they are called **real gases**.
- When one mole of a gas is considered, the equation becomes $PV = RT \Rightarrow R = PV/T$

  The value of 'R' depends upon the units in which pressure and volume are taken. Value of R → 1.987 cal/°C/mole or 8.314×10^7 erg/°C/mole or 8.314 joule/°C/mole or 0.0821 ℓ -atm/°C/mole

  P_1, V_1, T_1 are initial conditions, P_2, V_2, T_2 are final conditions $\therefore \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
- The total pressure exerted by a mixture of non-reacting gases taken in a container at a given temperature is the sum of the pressures that each gas would exert if it were taken alone in that container. This statement is known as **Dalton's law of partial pressure.**
- **Partial pressure** is the pressure exerted by each constituent of the gaseous mixture when they are kept individually in the same container. If the partial pressures of the constituents of the gaseous mixture are p_1, p_2, p_3 …… and so on, then according to Dalton's law of partial pressures, the total pressure $P = p_1 + p_2 + p_3$ ……….
- Partial pressure (p_1) = Mole fraction (n_1/n) × total pressure of the gas (P)
- **Mole fraction** is the ratio of number of moles of an individual gas to the total number of moles of all gases in a mixture.

  Dalton's law of partial pressure is not applicable to gaseous mixture in which the component gases react with each other chemically.
- The number of gas molecules that pass through a unit area in unit time at a given temperature and pressure is called its **rate of diffusion**. In other words, the volume of the gas that diffuses in unit time at constant temperature and pressure is called its **rate of diffusion**.
- According to Graham's law of diffusion, under similar conditions of temperature and pressure, the rates of

diffusion of different gases are inversely proportional to the square root of their densities. That is $r \propto \frac{1}{\sqrt{d}}$

$\therefore \frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$ where r_1 and r_2 are the rates of diffusion of two gases and their molecular mass are M_1 and M_2 respectively.

- **Percentage composition of a compound:** Percentage composition is the mass of each constituent element present in 100 g of a compound. Percentage of an element present in a compound

$$= \frac{\text{Weight of the element in one mole of the compound}}{\text{GMM of the compound}} \times 100$$

- **Empirical formula** gives the simplest integral ratio of the number of atoms of different constituent elements present in one molecule of the compound. **Molecular formula** represents the exact number of atoms of different elements present in one molecule of the compound.

Molecular formula = Empirical formula × n

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}}; \text{ Molecular mass} = 2 \times \text{V.D}$$

- **Molarity:** It is the most convenient and commonly used unit for expressing the concentration of a solution. **Molarity** can be defined as the number of moles of a solute present in one litre of a solution. It is denoted by 'M'.

- $M = \frac{n}{V} = \frac{W}{GMM} \times \frac{1}{V \text{ in } \ell}$ or $M = \frac{W}{GMM} \times \frac{1000}{V \text{ in } m\ell}$.

In case of dilution, $M_1V_1 = M_2V_2$, M_1 and M_2 are molarities before and after dilution respectively.

V_1 and V_2 are volumes before and after dilution respectively.

- Mole fraction of a component in a solution can be defined as the ratio of the number of moles of that component to the total number of moles of all the components of the solution. If 'x' represents mole fraction,

$$x_{solute} = \frac{n_{solute}}{n_{solute} + n_{solvent}}, \quad x_{solvent} = \frac{n_{solvent}}{n_{solute} + n_{solvent}}$$

where n represents number of moles

The sum of mole fractions of all components in a solution is equal to unity. For a binary solution, $x_{solute} + x_{solvent} = 1$

- **Weight percentage (w/W):** The mass of a solute expressed in grams present in 100 g of a solution is called the **weight percentage** of the solute in the solution.

Weight percentage of the solute

$$= \frac{\text{Weight of the solute}}{\text{Weight of the solution}} \times 100$$

- **Weight/volume percentage (w/V):** The mass of a solute expressed in grams present in 100 ml. of a solution is called the **weight/volume percentage** of the solute in the solution.

Weight/volume percentage of the solute

$$= \frac{\text{Mass of the solute (g)}}{\text{Total volume of the solution } (m\ell)} \times 100$$

- **Volume percentage (v/V):** The volume of the liquid in mℓ present in a 100 mℓ solution is called the **volume percentage** of the solute in the solution.

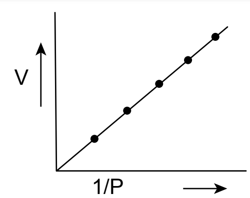
Volume percentage of the solute

$$= \frac{\text{Volume of the solute}}{\text{Volume of the solution}} \times 100$$

- Stoichiometric relationship among the reactants and products can be used for the calculation of quantities of respective substances involved in the reaction.

Solved Examples

1. The slope of a given straight line graph with constant temperature is found to be 0.2 ℓ atm at 5 atmospheric pressure. Calculate the volume of gas at that pressure.



Solution: Slope = 0.2 ℓ atm, P = 5 atm.

According to Boyle's law,

$$P \propto \frac{1}{V}, \; P = \text{constant} \times \frac{1}{V} = \text{slope} \times \frac{1}{V}$$

$$0.2 \times \frac{1}{V} = 5 \times V = \frac{0.2}{5}$$

$= 0.04\ \ell$

2. A cylinder was filled with a gas at 2 atm pressure at 27°C and can withstand a pressure of 12 atm. At what temperature the cylinder bursts when the building catches fire?

Solution: $P_1 = 2$ atm, $P_2 = 12$ atm

$T_1 = 27 + 273 = 300$ K, $T_2 = ?$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow T_2 = \frac{T_1 P_2}{P_1} \Rightarrow T_2 = \frac{12 \times 300}{2} = 1800\ \text{K}$$

$= 1527°\text{C}$

∴ Cylinder bursts at or above 1527°C

3. Calculate the weight of
   - **(a)** single atom of nitrogen.
   - **(b)** single atom of carbon.
   - **(c)** 1.5 × 1021 atoms of sodium.
   - **(d)** single molecule of carbon monoxide.

Solution: **(a)** 14 g of nitrogen → 6.023 × 10^{23} atoms

x ← 1 atom

$$x = \frac{14}{6.023 \times 10^{23}} = 2.3 \times 10^{-23}\ \text{g}$$

(b) 12 g of carbon → 6.023 × 10^{23} atoms

x ← 1 atom

$$x = \frac{12}{6.023 \times 10^{23}} = 2 \times 10^{-23}\ \text{g}$$

(c) 23 g of sodium → 6.023 × 10^{23} atoms

x ← 15 × 10^{21} atoms

$$x = \frac{23 \times 15 \times 10^{21}}{6.023 \times 10^{23}} = 57.5 \times 10^{-2} = 0.0575\ \text{g}$$

(d) Molecular weight of CO = 12 + 16 = 28

28 g of CO → 6.023 × 10^{23} molecules

x ← 1 molecule

$$\therefore x = \frac{28}{6.023 \times 10^{23}} = 4.6 \times 10^{-23}\ \text{g}$$

4. Calculate the number of particles present in
   - **(a)** a sample of bell metal (Cu → 80%, Sn → 20%) of 100 g mass.
   - **(b)** 2 ℓ of H_2 at 5 atm pressure and 273 °C temperature.

Solution: **(a)** The number of copper atoms present in 100 g of bell metal $= \dfrac{100 \times \frac{80}{100}}{63.5} \times 6 \times 10^{23} = 7.55 \times 10^{23}$

The number of tin atoms present in 100 g of bell metal

$$= \frac{100 \times \frac{20}{100}}{118} \times 6 \times 10^{23} = 1.01 \times 10^{23}$$

(b) $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2} \;\therefore\; \dfrac{5 \times 2}{546} = \dfrac{1 \times V_2}{273} \;\therefore V_2 = 5\ \ell.$

At STP, 22.4 ℓ H_2 contains 6 × 10^{23} molecules

At STP 5 ℓ H_2 contains?

$$= \frac{6 \times 5}{22.4} \times 10^{23}\ \text{molecules}$$

= 1.3 × 10^{23} molecules

5. Rate of diffusion of a saturated hydrocarbon is about 1/6th of that of hydrogen under similar conditions of temperature and pressure. What is the molecular formula of that hydrocarbon?

Solution: Let the molecular mass of the hydrocarbon be M_x and its rate of diffusion be r_x

$$\frac{r_{H_2}}{r_x} = \sqrt{\frac{M_x}{M_{H_2}}},\; r_x = 1/6\ r_{H_2} \;\therefore\; \frac{r_{H_2}}{r_x} = 6 = \sqrt{\frac{M_x}{2}}$$

$\Rightarrow 36 \times 2 = M_x \Rightarrow M_x = 72$

Molecular mass of the saturated hydrocarbon is 72.

Let the number of carbon atoms present in one molecule of the hydrocarbon be m.

Since the hydrocarbon is saturated, the number of hydrogen atoms present in that hydrocarbon molecule is 2m + 2

∴ (12 × m) + (2m + 2) = 72 ⇒ 14m + 2 = 72

⇒ m = 5

∴ Molecular formula of the hydrocarbon is C_5H_{12}.

6. Calculate the weight of 80% pure limestone required to produce 11 g of CO_2 gas.

Solution: $\underset{\text{1 mole}}{CaCO_3} \rightarrow CaO + \underset{\text{1 mole}}{CO_2}$

44 g of CO_2 is produced from 100 g of $CaCO_3$

$\therefore$ 11 g of CO_2 is produced from $\frac{100}{44} \times 11 = 25$ g of $CaCO_3$

As the limestone is 80% pure,

$\therefore$ The weight of impure limestone required = $\frac{100}{80} \times 25$ g = 31.2 g.

7. Calculate the amount of sodium oxide formed when 2.3 g of sodium reacts with 3.2 g of oxygen.

Solution: $\underset{\text{4 moles}}{4Na} + \underset{\text{1 mole}}{O_2} \rightarrow \underset{\text{2 moles.}}{2Na_2O}$

4 × 23 g of sodium reacts with 32 g of O_2 2.3 g of sodium reacts with $\frac{2.3 \times 32}{4 \times 23} = 0.8$ g of O_2

8. Specific gravity of 84% (w/W) pure HNO_3 is 1.54. What volume of HNO_3 is required to prepare one litre of 0.5M HNO_3 solution?

Solution: specific gravity of HNO_3 = 1.54

$$M = \frac{w}{GMM} \times \frac{1000}{V} \times 0.5 = \frac{x}{63} \times \frac{1000}{1000}$$

$\Rightarrow x = 31.5$ g

31.5 g of HNO_3 is present in 1 ℓ of solution.

84 g is present in 100 g of solution

31.5 g is present in ? g of solution

$$= \frac{31.5 \times 100}{84} = 37.5 \text{ g}$$

Density = ${}^{\text{weight}}/_{\text{volume}} \Rightarrow 1.54 = {}^{37.5}/_{\text{volume}}$

$\Rightarrow V = {}^{37.5}/_{1.54} = 24.35$ m ℓ

24.35 ml of given HNO_3 is required.

9. Calculate the percentage composition of sodium carbonate.

Solution: Amount of sodium in 106 g of Na_2CO_3 = 46 g

Amount of sodium in 100 g of Na_2CO_3

$$= \frac{46 \times 00}{106} = 43.39\%$$

Amount of corbon in 106 g of Na_2CO_3 = 12 g

Amount of corbon in 100 g of Na_2CO_3

$$= \frac{12 \times 100}{106} = 11.32\%$$

Amount of oxygen in 106 g of Na_2CO_3 = 48 g

Amount of oxygen 100 g of Na_2CO_3

$$= \frac{48 \times 100}{106} = 45.28\%$$

10. Calculate the volume of gaseous products at STP in the following reactions (for one mole each).

(a) Decomposition of magnesium nitrate.

(b) Decomposition of sodium nitrate.

Solution: **(a)** $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$

2 moles of magnesium nitrate

$\rightarrow$ 4 moles NO_2 + 1 mole O_2

1 mole $2Mg(NO_3)_2$

$\rightarrow$ 2 moles NO_2 + 0.5 mole O_2

2 moles $NO_2 \rightarrow 2 \times 22.4$ ℓ = 44.8 ℓ volume at STP

0.5 mole $O_2 \rightarrow$ 11.2 ℓ volume at STP

Total volume of gaseous product

= 44.8 ℓ +11.2 ℓ = 56 ℓ

(b) $2NaNO_3 \rightarrow 2NaNO_2 + O_2$

2 moles $NaNO_3 \rightarrow$ 1 mole O_2

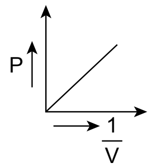
1 mole $NaNO_3 \rightarrow$ 0.5 mole O_2

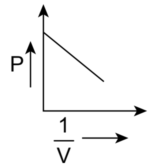
0.5 mole $O_2 \rightarrow$ 11.2 ℓ at STP

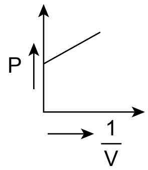
PRACTICE EXERCISE 2 (A)

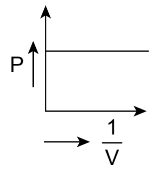
Directions for questions 1 to 45: For each of the questions, four choices have been provided. Select the correct alternative.

1. The graph of P vs 1/V at a constant temperature is ______.

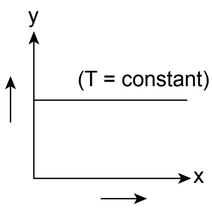
(1) 

(2) 

(3) 

(4) 

2. If the given graph represents Boyle's law, parameters which are reflected along x axis and y axis are ______ and ______respectively.



(1) P, V (2) P, PV

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

3. The minimum possible temperature is ______

(1) 0°F (2) 0°C
(3) 0K (4) –273 K

4. The values of boiling point of water and freezing point of water in Kelvin scale are ______ and ______ respectively.

(1) 173K, 273K (2) 273K, 173K
(3) 273K, 373K (4) 373K, 273K

5. At absolute zero, gases lose their characteristic properties. Which of the following sequence of explanation is correct for justifying the above fact?

(a) The value of zero for volume coordinate shows that gases occupy no volume.
(b) Volume occupied by a gas decreases with decrease in temperature.
(c) At –273.15°C (absolute zero), the plot of V vs t °C intersects the temperature axis.
(d) A gas occupying zero volume means that the matter does not exist in the gaseous state.

(1) a b c d (2) b a c d
(3) b c a d (4) d c b a

6. Children brought some balloons each of 2ℓ capacity to a chemist and asked him to fill them with hydrogen gas. The chemist possessed an 8ℓ cylinder containing hydrogen at 10 atm pressure at room temperature. How many balloons could he fill with hydrogen gas at normal atmospheric pressure at the same temperature?

(1) 40 (2) 36
(3) 32 (4) 28

7. Calculate the number of molecules present in 16.8 ℓ of gas 'X' at STP.

(1) 1.2×10^{23} (2) 4.52×10^{23}
(3) 3×10^{23} (4) 6×10^{23}

8. Calculate the volume occupied by 200 g of SO_3 gas at STP.

(1) 44.8 ℓ (2) 33.6 ℓ
(3) 56 ℓ (4) 67.2 ℓ

9. Calculate the mass of 30.1×10^{23} molecules of carbon dioxide gas.

(1) 88 g (2) 132 g
(3) 176 g (4) 220 g

10. STP conditions are ______.

(1) 273K, 760 mm of Hg
(2) –273K, 760 mm of Hg
(3) –273K, 1 mm of Hg
(4) 273K, 1 mm of Hg

11. The volume ratio of SO_2, O_2 and SO_3 in the reaction for the formation of SO_3 is ______.

(1) 1 : 2 : 2 (2) 2 : 2 : 1
(3) 2: 1 : 2 (4) 1: 1: 2

12. 2 moles of CO_2 gas contains the same number of atoms as ______ moles of CO.

(1) 0.5 (2) 1
(3) 2 (4) 3

13. The number of moles of 7 g of nitrogen gas is ______.

(1) 0.25 (2) 0.5
(3) 0.75 (4) 1

14. The number of atoms present in 78 g of potassium is equal to the number of potassium ions present in ______ g of potassium chloride.

(1) 74.5 (2) 37.25
(3) 223.5 (4) 149

15. 4 moles of oxygen atoms are present in ______ g of NO_2 gas.

(1) 46 (2) 92
(3) 69 (4) 23

16. The ratio of the volumes of 11 g of CO_2 and 28 g of CO at STP is ______.

(1) 1 : 2 (2) 2 : 3
(3) 3 : 4 (4) 1 : 4

17. 0.5 moles of a salt contains '3N' oxygen atoms. Identify the formula of the salt.

(1) MXO_3 (2) MX_2O_3
(3) M_2XO_3 (4) $M(XO_3)_2$

18. Identify the chemical equation for which Gay Lussac's law of combining volumes is not applicable.

(1) $C + O_2 \rightarrow CO_2$
(2) $N_2 + 3H_2 \rightarrow 2\ NH_3$
(3) $2CO + O_2 \rightarrow 2CO_2$
(4) $2SO_2 + O_2 \rightarrow 2SO_3$

19. A gas at a pressure of 2.0 atm is heated from 0°C to 273°C and the volume compressed to 1/4th of its original volume. Find the final pressure.

(1) 12 atm (2) 8 atm
(3) 16 atm (4) 20 atm

20. A two litre flask contains 22 g of carbon dioxide and 1 g of helium at 20°C. Calculate the partial pressure exerted by CO_2 and He if the total pressure is 3 atm.

(1) 2.25 atm, 0.75 atm (2) 1.5 atm, 1.5 atm
(3) 2.5 atm, 0.5 atm (4) 2 atm, 1 atm

21. Dalton's law of partial pressures cannot hold good for

(1) $NO_2 + O_2$ (2) $H_2 + Cl_2$
(3) $CO_2 + O_2$ (4) NH_3 + He

22. Rate of diffusion of gas X is 1/4th of rate of diffusion of gas Y. Identify X and Y.

(1) SO_2, CH_4 (2) CH_4, H_2
(3) SO_2, He (4) H_2, O_2

23. A solution is prepared by dissolving 9.8 g of H_2SO_4 in 54 g of water. What is the mole fraction of H_2SO_4?

(1) 0.03 (2) 0.04
(3) 0.01 (4) 0.02

24. What is the percentage by weight of sulphuric acid if 13 g of H_2SO_4 is dissolved to make 78 g of solution?

(1) 23.4 (2) 20
(3) 16.6 (4) 13.2

25. If 40 g of ethyl alcohol is dissolved in 50 mℓ. of water, then calculate the weight/volume percentage of ethyl alcohol present in the solution? [Density of ethyl alcohol = 0.8 g/ml]

(1) 40% (2) 30%
(3) 25% (4) 35%

26. Semimolar solution contains how many moles of solute in 1 ℓ of solution?

(1) 1 (2) 0.1
(3) 0.5 (4) 0.01

27. When 180 g of glucose is subjected to combustion, the volume of CO_2 liberated at STP is

(1) 22.4 ℓ (2) 67.2 ℓ
(3) 44 ℓ (4) 134.4 ℓ

28. Which among the following is having maximum molarity?

(1) 20 g of NaOH in 500 ml solution
(2) 49 g of H_2SO_4 250 ml solution
(3) 7.4 g of $Ca(OH)_2$ in 100 ml solution
(4) 73 g of HCl in 2000 ml solution

29. The molarity of a 300 mℓ solution is 0.75 M. The amount of solute present in it is ______ g (molecular mass of solute = 58)

(1) 13.05 g (2) 12.35 g
(3) 13.33 g (4) 12.33 g

30. An organic compound contains x% of carbon, y% of hydrogen and the remaining of oxygen. The molecular weight of the compound is given. What sequence of steps is followed for the calculation of molecular formula of the organic compound?

(a) Calculation of empirical formula weight
(b) Calculation of simplest ratio by dividing
(c) Calculation of atomic ratio by dividing the percentages
(d) Multiplying the empirical formula by the ratio of molecular weight and empirical formula weight

(1) b a c d (2) c b a d
(3) c b a d (4) d c b a

31. What is the mass of the solvent present in 200 g of 25% (w/W) calcium hydroxide solution?
(1) 150 g (2) 125 g
(3) 175 g (4) 100 g

32. Calculate the (w/W) % of 10 g of potassium hydroxide in 40 g of solvent.
(1) 25% (2) 20%
(3) 30% (4) 40%

33. The molarity of a 350 mℓ solution is 0.5M. Calculate the amount of solute present in it (molecular mass of solute = 98)
(1) 17.15 g (2) 12.5 g
(3) 16.2 g (4) 13.05 g

34. The specific gravity of sulphuric acid is 1.8. What volume of this sample of concentrated H_2SO_4 is required to prepare 500 mℓ 0.9M H_2SO_4 solution?
(1) 23.5 mℓ (2) 24.5 mℓ
(3) 25.5 mℓ (4) 26.5 mℓ

35. Calculate the mole fraction of glucose in an aqueous solution that contains 45 g of glucose in 45 g of water. Find out the weight of NaOH required to be dissolved in 90 g of water in order to get a solution of the same mole fraction.
(1) $\frac{1}{11}$, 20 g (2) $\frac{1}{11}$, 10 g
(3) $\frac{1}{10}$, 10 g (4) $\frac{1}{10}$, 20 g

36. The number of constituent particles present in 5 ℓ of air containing 80% N_2 and 20% O_2 by volume at 27°C and 3 atmosphere pressure.
(1) $N_2 \rightarrow 1.92 \rightarrow 10^{23}$; $O_2 \rightarrow 7.68 \rightarrow 10^{23}$
(2) $N_2 \rightarrow 7.68 \rightarrow 10^{23}$; $O_2 \rightarrow 1.92 \rightarrow 10^{23}$
(3) $N_2 \rightarrow 0.75 \rightarrow 10^{23}$; $O_2 \rightarrow 3 \rightarrow 10^{23}$
(4) $N_2 \rightarrow 3 \rightarrow 10^{23}$; $O_2 \rightarrow 0.75 \rightarrow 10^{23}$

37. 4.8 g of magnesium on burning with same amount of oxygen gives magnesium oxide.
Calculate the amount of product formed.
(1) 6 g (2) 4 g
(3) 12 g (4) 8 g

38. A gas cylinder is filled with hydrogen gas which weighs 40 g. The same cylinder holds 880 g of a gas 'A' and 560 g of a gas 'B' under the same conditions of temperature and pressure. Calculate the relative molecular masses of A and B
(1) A $\rightarrow$ 44, B $\rightarrow$ 28 (2) A $\rightarrow$ 32, B $\rightarrow$ 64
(3) A $\rightarrow$ 46, B $\rightarrow$ 28 (4) A $\rightarrow$ 44, B $\rightarrow$ 32

39. What is the volume of 50% (w/V) H_2SO_4 required for the liberation of 5.6 ℓ of hydrogen gas at STP on its reaction with magnesium?
(1) 49 mℓ (2) 24.5 mℓ
(3) 98 mℓ (4) 73.5 mℓ

40. Calculate the molarity of 30% (w/W) NaOH solution, if the density of the solution is 1.05 g/cc.
(1) 7.5 M (2) 3.75 M
(3) 7.88 M (4) 3.94 M

41. Identify the compound one mole of which on thermal decomposition liberates different amount of O_2.
(1) $KMnO_4$ (2) KNO_3
(3) $KClO_3$ (4) H_2O_2

42. A certain mass of gas occupied a volume of 640 ml at a certain temperature and pressure. If the temperature is decreased by 40%, what will be the volume occupied by the same mass of gas under the same pressure?
(1) 256 mℓ (2) 1600 mℓ
(3) 1066 mℓ (4) 384 mℓ

43. Calculate the volume of CO_2 formed at STP when 2.32 g of zinc carbonate decomposes with no further loss in weight.
(1) 0.205 ℓ (2) 0.41 ℓ
(3) 0.82 ℓ (4) 1.23 ℓ

44. One mole of hydrocarbon X is subjected to combustion. The product obtained is condensed and the resulting gaseous product occupied a volume of 89.6 ℓ at STP. Oxygen required for this combustion is 145.6 ℓ. at STP. What should be the molecular formula of X?
(1) C_2H_6 (2) C_4H_{10}
(3) C_3H_8 (4) CH_4

45. Identify the true statements among the following.
(A) 4 g of helium and 2 g of hydrogen contain the same number of molecules.
(B) If 1.1 g of a gas occupied a 560 mℓ of volume, its vapour density is 22.
(C) Both 1 mole of sulphuric acid 1 mole of ammonium hydroxide contains the same number of hydrogen atoms.
(D) 48 g of oxygen and ozone occupy same volume under similar conditions.
(1) (B) and (C) (2) (A) and (B)
(3) (B) and (D) (4) (A) and (D)

PRACTICE EXERCISE 2 (B)

Directions for questions 1 to 45: For each of the questions, four choices have been provided. Select the correct alternative.

1. 5 ℓ of methane gas at 2 atm pressure is compressed to 1.6 ℓ at constant temperature. Calculate the final pressure.

(1) 0.64 atm (2) 6.25 atm
(3) 4 atm (4) 16 atm

2. The pressure of a certain volume V of gas is reduced to half of its initial pressure at constant temperature. Calculate its new volume.

(1) 2V (2) $\frac{V}{2}$
(3) 4V (4) $\frac{V}{4}$

3. At a certain pressure, the volume occupied by a given mass of a gas is 10 ℓ at 0°C, calculate the volume occupied by the gas at 91°C at the same pressure.

(1) 5.83 ℓ (2) 20.8 ℓ
(3) 7.5 ℓ (4) 13.33 ℓ

4. Calculate the temperature at which the volume of a given mass of gas gets reduced to 3/5th of original volume at 10° C without any change in pressure.

(1) −171° C (2) 513° C
(3) −198° C (4) −103.2° C

5. A certain mass of a gas taken in 1 litre cylinder exerts a pressure of 500 mm Hg at a certain temperature. If the gas is transferred to another cylinder where it exerts 20% more pressure, calculate the volume of the cylinder at the same temperature.

(1) 1200 cc (2) 833 cc
(3) 1440 cc (4) 695 cc

6. Considering a given mass of a gas by keeping the third variable constant, identify the wrong statements regarding an ideal gas.

(A) With increase in pressure, volume decreases.
(B) With increase in temperature, pressure decreases.
(C) With increase in temperature, volume increases.

(1) (A) & (B) (2) (B) & (C)
(3) (A) only (4) (B) only

7. How many molecules would be there in 0.01 moles of sodium hydroxide?

(1) 6.023×10^{23} (2) 6.023×10^{21}
(3) 6.023×10^{22} (4) 6.023×10^{20}

8. Number of moles of calcium ions and phosphate ions present in half mole of calcium phosphate are respectively.

(1) 3, 2 (2) 2, 3
(3) 1.5, 1 (4) 1, 1.5

9. The volumes of certain gases occupied at STP are given below. Arrange the substances in the increasing order of their weights.

(a) 22400 cm^3 of SO_2
(b) 224 cm^3 of H_2O
(c) 2240 cm^3 of O_3

(1) a < b < c (2) c < b < a
(3) b < a < c (4) b < c < a

10. What is the volume occupied by 30 g of neon gas at 67°C and 750 mm of Hg?

(1) 16.72 ℓ (2) 42.43 ℓ
(3) 8.36 ℓ (4) 21.21 ℓ

11. What is the ratio of the rate of diffusion of helium gas to that of oxygen under identical conditions?

(1) 1 : 8 (2) 8 : 1
(3) $2\sqrt{2} : 1$ (4) $1 : 2\sqrt{2}$

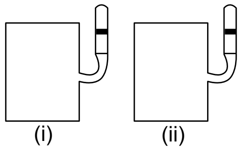
12. Match the items in column I with those in column II.

	Column I		**Column II**
1.	0.01 M solution	A.	1.58 g HNO_3 in 100 ml
2.	0.25 M solution	B	0.42 g $NaHCO_3$ in 250 ml
3.	0.05 M solution	C	0.4 g Na OH in 100 ml
4.	0.02 M solution	D	2.25 g glucose in 250 ml

Which of the following shows correct matching?

(1) $1 \to C; 2 \to B; 3 \to A; 4 \to D$
(2) $1 \to B; 2 \to A; 3 \to D; 4 \to B$
(3) $1 \to B; 2 \to C; 3 \to D; 4 \to A$
(4) $1 \to C; 2 \to A; 3 \to D; 4 \to B$

13. Asmi and Susmi have taken two containers of same volume attached with two narrow tubes containing small amounts of coloured liquid as shown in the given figures. One container is filled with ideal gas and the other one is filled with real gas. If the number of moles of gases present in two containers are same and their temperatures are also same, identify the container which contains ideal gas.



(1) (i) (2) (ii)
(3) both (i) and (ii) (4) can't be predicted

14. A certain amount of oxygen is prepared by the thermal decomposition of potassium chlorate and is collected by downward displacement of water. The pressure of the gas collected is measured with the help of a manometer. The pressure recorded is found to be more than the pressure recorded for the same volume of oxygen cylinder containing same amount of oxygen under the same conditions. How do you account for this deviation?

(1) Due to the formation of Cl_2 gas during decomposition.
(2) Due to the presence of water vapour along with oxygen.
(3) The temperature of oxygen liberated is relatively high.
(4) All the above

15. Which of the following pairs of gases corresponds to the ratio of the rates of diffusion as $\sqrt{2} : 1$?

(1) H_2 and He (2) He and CH_4
(3) H_2 and CH_4 (4) CH_4 and SO_2

16. The empirical formula of a compound is CH_2O. If its vapour density is 90, find out the molecular formula of the compound.

(1) $C_5H_{10}O_5$ (2) $C_4H_8O_4$
(3) $C_6H_{12}O_6$ (4) $C_3H_6O_3$

17. Calculate the weight of zinc required for the liberation of 10 g of hydrogen gas on reaction with H_2SO_4.

(1) 655 g (2) 163.7 g
(3) 491.25 g (4) 327.5 g

18. Calculate the weight of sodium bicarbonate to be dissociated to give 0.56 ℓ of CO_2 gas.

(1) 4.2 g (2) 2.1 g
(3) 1.05 g (4) 3.15 g

19. What is the molarity of a solution containing 15 g of NaOH dissolved in 500 ml. of solution?

(1) 1 M (2) 0.5 M
(3) 0.75 M (4) 0.25 M

20. What is the percentage by weight of sulphuric acid if 13 g of H_2SO_4 is dissolved to make 78 g of solution?

(1) 13.2% (2) 14.28%
(3) 20% (4) 16.6%

21. Which of the following is/are consequences of Charle's law?

(a) Bursting of balloon on blowing it strongly.
(b) Bursting of balloon on its exposure to sunlight.
(c) Expulsion of gas from cooking gas cylinder by keeping cylinder in hot water.
(d) Usage of hot air balloons.

(1) (a), (b), (d) (2) (d) only
(3) (b), (c), (d) (4) (b), (c)

22. Identify the correct statements among the following.

(a) 32 g of oxygen and 64 g of sulphurdioxide contains the same number of oxygen atoms.
(b) Vapour density of a gas is half of the mass of 11.2 ℓ of gas at STP.
(c) 1 mole of each calcium carbonate and calcium nitrate STP have equal number of oxygen atoms.
(d) 56 g of nitrogen and 56 g carbon monoxide occupy the same volume at STP.

(1) (A) & (C) (2) (A) & (D)
(3) (A) , (C) & (D) (4) (B) & (C)

23. Calculate the amount of lime obtained by heating 400 kg of limestone.

(1) 56 kg (2) 112 kg
(3) 224 kg (4) 280 kg

24. The w/W % of 25 g of calcium hydroxide in 50 g of solvent is _______ %

(1) 40 (2) 33.33
(3) 36.3 (4) 30

25. The solution of 0.5 moles of NaCl in 1ℓ solution is called _______ solution.

(1) molar (2) decimolar
(3) semimolar (4) centimolar

26. What is the molarity of 25% $\left(\frac{W}{V}\right)$ solution of HCl?

(1) 0.3245 M (2) 3.425 M
(3) 0.685 M (4) 6.85 M

27. Which among the following has minimum molarity?

(1) 10 g of NaOH in 100 mℓ solution.
(2) 49 g of H_2SO_4 in 500 mℓ solution.

(3) 73 g of HCl in 1000 mℓ solution.
(4) 74 g of $Ca(OH)_2$ in 2000 mℓ solution.

28. A certain amount of potassium chlorate on thermal decomposition gives oxygen which is sufficient for the combustion of ethane. When the products are cooled, the volume of the gaseous product is v ml. Identify the correct sequence of steps for the calculation of the mass of potassium chlorate.

(a) Calculation of oxygen required for the combustion of ethane.
(b) Calculation of the amount of the ethane subjected to combustion from the volume of gaseous product.
(c) Calculation of potassium chlorate which can give the required amount of oxygen.
(d) Identification of the products of combustion of ethane and the product left after the cooling of products.

(1) a b c d (2) d b a c
(3) b c a d (4) d a c b

29. In a binary solution, mole fraction of solute is found to be 0.4. What could be the mole fraction of the solvent in the solution?

(1) 1 (2) 0.4
(3) 0.6 (4) 0.3

30. What is the volume of oxygen liberated at STP when 12.25 g of potassium chlorate is subjected to heating?

(1) 4.2 ℓ (2) 1.68 ℓ
(3) 2.24 ℓ (4) 3.36 ℓ

31. Empirical formula of a compound is C_2H_4O. If the empirical formula mass is equal to one half of its vapour density, find out the gram molecular mass of the compound.

(1) 176 (2) 66
(3) 44 (4) 88

32. A certain mass of a gas occupies a volume of 180 cc at a temperature of 47° C and 2 atm pressure. At what temperature the volume of the same mass of the gas becomes equal to 1000 cc when pressure is chanced to 5 atm kept constant?

(1) 7111 K (2) 1104°C
(3) 4444 K (4) 652°C

33. Find out the loss in weight when 75 g of calcium carbonate is subjected to decomposition completely.

(1) 66 g (2) 22 g
(3) 44 g (4) 33 g

34. ______ g of sodium hydroxide is present in 1 litre of 1M solution.

(1) 20 (2) 40
(3) 30 (4) 10

35. Calculate the mass of water which contains the same number of molecules as that of 667.5 g of aluminium chloride.

(1) 90 g (2) 72 g
(3) 54 g (4) 108 g

36. 480 cc of methane gas diffused in 40 minutes. If 1440 cc of another gas is diffused in 60 minutes under similar conditions of temperature and pressure then find out the gram molecular mass of the gas.

(1) 28 g (2) 20 g
(3) 4 g (4) 32 g

37. Two flasks A and B of equal volumes are kept under similar conditions of temperature and pressure. If flask A holds 16.2 g of gas X while flask B holds 1.012 g of hydrogen, calculate the relative molecular mass of gas X.

(1) 20 g (2) 32 g
(3) 28 g (4) 44 g

38. Empirical formula of a compound is AB_2. If its empirical formula weight is 2/3 times of its vapour density, calculate the molecular formula of the compound.

(1) A_3B_6 (2) A_2B_4
(3) A_6B_{12} (4) A_4B_8

39. 2 moles of chlorine atoms are present in ________ g of chlorine gas.

(1) 142 (2) 14.2
(3) 7.1 (4) 71

40. The volume of 8 g of hydrogen gas is ________ cm^3 at STP.

(1) 67200 (2) 56000
(3) 89600 (4) 78400

41. If gas A diffuses 9 times faster than B, then the ratio of the densities of A and B is _________.

(1) 9 : 1 (2) 1 : 9
(3) 81 : 1 (4) 1 : 81

42. The weight of 0.5 moles of calcium carbonate is ______.

(1) 75 g (2) 50 g
(3) 100 g (4) 80 g

43. For which of the following reactions, is Gay Lussac's law not applicable?

(1) Formation of HI from its constituents
(2) Formation of NH_3 from its constituents
(3) Formation of CO_2 from its constituents
(4) Formation of SO_3 from SO_2 and O_2

44. Arrange the relevant points in the proper sequence for explaining why Kelvin scale is preferred to Celsius scale in the study of gases.

(a) –273°C is the least possible temperature.
(b) A graph of volume vs temperature is a straight line passing through origin.
(c) A graph of volume vs temperature (°C) is a straight line which intersects volume axis at some point.
(d) Extrapolation of straight line touches the volume axis at – 237°C
(e) – 237°C is called absolute zero or 0 K.
(f) All values of temperature are positive in Kelvin scale.
(g) Usage of negative values for temperature gives negative values for other properties like pressure and volume.

(1) c d a e f
(2) b d a e f
(3) c d f e a g
(4) b d f e a b

45. Amount of sodium in 1 mole of sodium ________ g

(1) 23 (2) 11.5
(3) 34.5 (4) 46

ANSWER KEYS

PRACTICE EXERCISE 2 (A)

1. 1	**2.** 2	**3.** 3	**4.** 4	**5.** 3	**6.** 2	**7.** 2	**8.** 3	**9.** 4	**10.** 1
11. 3	**12.** 4	**13.** 1	**14.** 4	**15.** 2	**16.** 4	**17.** 4	**18.** 1	**19.** 3	**20.** 4
21. 2	**22.** 3	**23.** 1	**24.** 3	**25.** 1	**26.** 3	**27.** 4	**28.** 2	**29.** 1	**30.** 2
31. 1	**32.** 2	**33.** 1	**34.** 2	**35.** 1	**36.** 4	**37.** 4	**38.** 1	**39.** 1	**40.** 3
41. 3	**42.** 4	**43.** 2	**44.** 2	**45.** 2					

PRACTICE EXERCISE 2 (B)

1. 2	**2.** 1	**3.** 4	**4.** 4	**5.** 2	**6.** 4	**7.** 2	**8.** 3	**9.** 4	**10.** 2
11. 3	**12.** 4	**13.** 1	**14.** 2	**15.** 1	**16.** 3	**17.** 4	**18.** 1	**19.** 3	**20.** 4
21. 3	**22.** 2	**23.** 3	**24.** 2	**25.** 3	**26.** 4	**27.** 4	**28.** 2	**29.** 3	**30.** 4
31. 4	**32.** 3	**33.** 4	**34.** 2	**35.** 1	**36.** 3	**37.** 2	**38.** 1	**39.** 4	**40.** 3
41. 4	**42.** 2	**43.** 3	**44.** 1	**45.** 1					