Unit 1

SOME BASIC CONCEPTS OF CHEMISTRY

I. Multiple Choice Questions (Type-I)

1. Two students performed the same experiment separately and each one of them recorded two readings of mass which are given below. Correct reading of mass is 3.0 g. On the basis of given data, mark the correct option out of the following statements.

Student	Readings (i)	Readings (ii)
A	3.01	2.99
B	3.05	2.95

(i) Results of both the students are neither accurate nor precise.

(ii) Results of student A are both precise and accurate.

(iii) Results of student B are neither precise nor accurate.

(iv) Results of student B are both precise and accurate.

2. A measured temperature on Fahrenheit scale is 200 °F. What will this reading be on Celsius scale?

(i) 40 °C

(ii) 94 °C

(iii) 93.3 °C

(iv) 30 °C

3. What will be the molarity of a solution, which contains 5.85 g of NaCl(s) per 500 mL?

(i) 4 mol L^{-1}

(ii) 20 mol L^{-1}

(iii) $0.2\ \text{mol}\ L^{-1}$

(iv) $2\ \text{mol}\ L^{-1}$

4. If 500 mL of a 5M solution is diluted to 1500 mL, what will be the molarity of the solution obtained?

(i) 1.5 M

(ii) 1.66 M

(iii) 0.017 M

(iv) 1.59 M

5. The number of atoms present in one mole of an element is equal to Avogadro number. Which of the following element contains the greatest number of atoms?

(i) 4g He

(ii) 46g Na

(iii) 0.40g Ca

(iv) 12g He

6. If the concentration of glucose ($C_6H_{12}O_6$) in blood is $0.9\ g\ L^{-1}$, what will be the molarity of glucose in blood?

(i) 5 M

(ii) 50 M

(iii) 0.005 M

(iv) 0.5 M

7. What will be the molality of the solution containing 18.25 g of HCl gas in 500 g of water?

(i) 0.1 m

(ii) 1 M

(iii) 0.5 m

(iv) 1 m

8. One mole of any substance contains 6.022×10^{23} atoms/molecules. Number of molecules of H_2SO_4 present in 100 mL of 0.02M H_2SO_4 solution is ______.

(i) 12.044×10^{20} molecules

(ii) 6.022×10^{23} molecules

(iii) 1×10^{23} molecules

(iv) 12.044×10^{23} molecules

9. What is the mass percent of carbon in carbon dioxide?

(i) 0.034%

(ii) 27.27%

(iii) 3.4%

(iv) 28.7%

10. The empirical formula and molecular mass of a compound are CH_2O and 180 g respectively. What will be the molecular formula of the compound?

(i) $C_9H_{18}O_9$

(ii) CH_2O

(iii) $C_6H_{12}O_6$

(iv) $C_2H_4O_2$

11. If the density of a solution is 3.12 g mL^{-1}, the mass of 1.5 mL solution in significant figures is _______.

(i) 4.7g

(ii) 4680×10^{-3}g

(iii) 4.680g

(iv) 46.80g

12. Which of the following statements about a compound is incorrect?

(i) A molecule of a compound has atoms of different elements.

(ii) A compound cannot be separated into its constituent elements by physical methods of separation.

(iii) A compound retains the physical properties of its constituent elements.

(iv) The ratio of atoms of different elements in a compound is fixed.

13. Which of the following statements is correct about the reaction given below:

$$4Fe(s) + 3O_2(g) \longrightarrow 2Fe_2O_3(g)$$

(i) Total mass of iron and oxygen in reactants = total mass of iron and oxygen in product therefore it follows law of conservation of mass.

(ii) Total mass of reactants = total mass of product; therefore, law of multiple proportions is followed.

(iii) Amount of Fe_2O_3 can be increased by taking any one of the reactants (iron or oxygen) in excess.

(iv) Amount of Fe_2O_3 produced will decrease if the amount of any one of the reactants (iron or oxygen) is taken in excess.

14. Which of the following reactions is not correct according to the law of conservation of mass.

(i) $2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$

(ii) $C_3H_8(g) + O_2(g) \longrightarrow CO_2(g) + H_2O(g)$

(iii) $P_4(s) + 5O_2(g) \longrightarrow P_4O_{10}(s)$

(iv) $CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O\ (g)$

15. Which of the following statements indicates that law of multiple proportion is being followed.

(i) Sample of carbon dioxide taken from any source will always have carbon and oxygen in the ratio 1:2.

(ii) Carbon forms two oxides namely CO_2 and CO, where masses of oxygen which combine with fixed mass of carbon are in the simple ratio 2:1.

(iii) When magnesium burns in oxygen, the amount of magnesium taken for the reaction is equal to the amount of magnesium in magnesium oxide formed.

(iv) At constant temperature and pressure 200 mL of hydrogen will combine with 100 mL oxygen to produce 200 mL of water vapour.

II. Multiple Choice Questions (Type-II)

In the following questions two or more options may be correct.

16. One mole of oxygen gas at STP is equal to _______.

(i) 6.022×10^{23} molecules of oxygen

(ii) 6.022×10^{23} atoms of oxygen

(iii) 16 g of oxygen

(iv) 32 g of oxygen

17. Sulphuric acid reacts with sodium hydroxide as follows :

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

When 1L of 0.1M sulphuric acid solution is allowed to react with 1L of 0.1M sodium hydroxide solution, the amount of sodium sulphate formed and its molarity in the solution obtained is

(i) 0.1 mol L^{-1}

(ii) 7.10 g

(iii) 0.025 mol L^{-1}

(iv) 3.55 g

18. Which of the following pairs have the same number of atoms?

(i) 16 g of O_2(g) and 4 g of H_2(g)

(ii) 16 g of O_2 and 44 g of CO_2

(iii) 28 g of N_2 and 32 g of O_2

(iv) 12 g of C(s) and 23 g of Na(s)

19. Which of the following solutions have the same concentration?

(i) 20 g of NaOH in 200 mL of solution

(ii) 0.5 mol of KCl in 200 mL of solution

(iii) 40 g of NaOH in 100 mL of solution

(iv) 20 g of KOH in 200 mL of solution

20. 16 g of oxygen has same number of molecules as in

(i) 16 g of CO

(ii) 28 g of N_2

(iii) 14 g of N_2

(iv) 1.0 g of H_2

21. Which of the following terms are unitless?

(i) Molality

(ii) Molarity

(iii) Mole fraction

(iv) Mass percent

22. One of the statements of Dalton's atomic theory is given below:

"Compounds are formed when atoms of different elements combine in a fixed ratio"

Which of the following laws is **not** related to this statement?

(i) Law of conservation of mass

(ii) Law of definite proportions

(iii) Law of multiple proportions

(iv) Avogadro law

III. Short Answer Type

23. What will be the mass of one atom of C-12 in grams?

24. How many significant figures should be present in the answer of the following calculations?

$$\frac{2.5 \times 1.25 \times 3.5}{2.01}$$

25. What is the symbol for SI unit of mole? How is the mole defined?

26. What is the difference between molality and molarity?

27. Calculate the mass percent of calcium, phosphorus and oxygen in calcium phosphate $Ca_3(PO_4)_2$.

28. 45.4 L of dinitrogen reacted with 22.7 L of dioxygen and 45.4 L of nitrous oxide was formed. The reaction is given below:

$$2N_2(g) + O_2(g) \longrightarrow 2N_2O(g)$$

Which law is being obeyed in this experiment? Write the statement of the law?

29. If two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element, are in whole number ratio.

(a) Is this statement true?

(b) If yes, according to which law?

(c) Give one example related to this law.

30. Calculate the average atomic mass of hydrogen using the following data :

Isotope	% Natural abundance	Molar mass
^{1}H	99.985	1
^{2}H	0.015	2

31. Hydrogen gas is prepared in the laboratory by reacting dilute HCl with granulated zinc. Following reaction takes place.

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

Calculate the volume of hydrogen gas liberated at STP when 32.65 g of zinc reacts with HCl. 1 mol of a gas occupies 22.7 L volume at STP; atomic mass of Zn = 65.3 u.

32. The density of 3 molal solution of NaOH is 1.110 g mL^{-1}. Calculate the molarity of the solution.

33. Volume of a solution changes with change in temperature, then, will the molality of the solution be affected by temperature? Give reason for your answer.

34. If 4 g of NaOH dissolves in 36 g of H_2O, calculate the mole fraction of each component in the solution. Also, determine the molarity of solution (specific gravity of solution is 1g mL^{-1}).

35. The reactant which is entirely consumed in reaction is known as limiting reagent. In the reaction $2A + 4B \rightarrow 3C + 4D$, when 5 moles of A react with 6 moles of B, then

(i) which is the limiting reagent?

(ii) calculate the amount of C formed?

IV. Matching Type

36. Match the following:

(i)	88 g of CO_2	(a)	0.25 mol
(ii)	6.022×10^{23} molecules of H_2O	(b)	2 mol
(iii)	5.6 litres of O_2 at STP	(c)	1 mol
(iv)	96 g of O_2	(d)	6.022×10^{23} molecules
(v)	1 mol of any gas	(e)	3 mol

37. Match the following physical quantities with units

	Physical quantity		Unit
(i)	Molarity	(a)	$g\ mL^{-1}$
(ii)	Mole fraction	(b)	mol
(iii)	Mole	(c)	Pascal
(iv)	Molality	(d)	Unitless
(v)	Pressure	(e)	$mol\ L^{-1}$
(vi)	Luminous intensity	(f)	Candela
(vii)	Density	(g)	$mol\ kg^{-1}$
(viii)	Mass	(h)	Nm^{-1}
		(i)	kg

V. Assertion and Reason Type

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

38. ***Assertion (A) :*** The empirical mass of ethene is half of its molecular mass.

Reason (R) : The empirical formula represents the simplest whole number ratio of various atoms present in a compound.

(i) Both A and R are true and R is the correct explanation of A.

(ii) A is true but R is false.

(iii) A is false but R is true.

(iv) Both A and R are false.

39. ***Assertion (A) :*** One atomic mass unit is defined as one twelfth of the mass of one carbon-12 atom.

Reason (R) : Carbon-12 isotope is the most abundant isotope of carbon and has been chosen as standard.

(i) Both A and R are true and R is the correct explanation of A.

(ii) Both A and R are true but R is not the correct explanation of A.

(iii) A is true but R is false.

(iv) Both A and R are false.

40. ***Assertion (A) :*** Significant figures for 0.200 is 3 where as for 200 it is 1.

Reason (R) : Zero at the end or right of a number are significant provided they are not on the right side of the decimal point.

(i) Both A and R are true and R is correct explanation of A.

(ii) Both A and R are true but R is not a correct explanation of A.

(iii) A is true but R is false.

(iv) Both A and R are false.

41. ***Assertion (A) :*** Combustion of 16 g of methane gives 18 g of water.

Reason (R) : In the combustion of methane, water is one of the products.

(i) Both A and R are true but R is not the correct explanation of A.

(ii) A is true but R is false.

(iii) A is false but R is true.

(iv) Both A and R are false.

VI. Long Answer Type

42. A vessel contains 1.6 g of dioxygen at STP (273.15K, 1 atm pressure). The gas is now transferred to another vessel at constant temperature, where pressure becomes half of the original pressure. Calculate

(i) volume of the new vessel.

(ii) number of molecules of dioxygen.

43. Calcium carbonate reacts with aqueous HCl to give $CaCl_2$ and CO_2 according to the reaction given below:

$$CaCO_3\,(s) + 2HCl\,(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

What mass of $CaCl_2$ will be formed when 250 mL of 0.76 M HCl reacts with 1000 g of $CaCO_3$? Name the limiting reagent. Calculate the number of moles of $CaCl_2$ formed in the reaction.

44. Define the law of multiple proportions. Explain it with two examples. How does this law point to the existance of atoms?

45. A box contains some identical red coloured balls, labelled as A, each weighing 2 grams. Another box contains identical blue coloured balls, labelled as B, each weighing 5 grams. Consider the combinations AB, AB_2, A_2B and A_2B_3 and show that law of multiple proportions is applicable.

ANSWERS

I. Multiple Choice Questions (Type-I)

1. (ii)	2. (iii)	3. (iii)	4. (ii)	5. (iv)	6. (iii)
7. (iv)	8. (i)	9. (ii)	10. (iii)	11. (i)	12. (iii)
13. (i)	14. (ii)	15. (ii)			

II. Multiple Choice Questions (Type-II)

16. (i), (iv)	17. (ii), (iii)	18. (iii), (iv)
19. (i), (ii)	20. (iii), (iv)	21. (iii), (iv)
22. (i), (iv)		

III. Short Answer Type

23. 1.992648×10^{-23} g $\approx 1.99 \times 10^{-23}$ g

24. 2

25. Symbol for SI Unit of mole is mol.

One mole is defined as the amount of a substance that contains as many particles or entities as there are atoms in exactly 12 g (0.012 kg) of the ^{12}C isotope.

26. Molality is the number of moles of solute present in one kilogram of solvent but molarity is the number of moles of solute dissolved in one litre of solution.

Molality is independent of temperature whereas molarity depends on temperature.

27. Mass percent of calcium $= \dfrac{3 \times \text{(atomic mass of calcium)}}{\text{molecular mass of } Ca_3(PO_4)_2} \times 100$

$$= \frac{120\text{ u}}{310\text{ u}} \times 100 = 38.71\%$$

Mass percent of phosphorus $= \dfrac{2 \times \text{(atomic mass of phosphorus)}}{\text{molecular mass of } Ca_3(PO_4)_2} \times 100$

$$= \frac{2 \times 31\text{ u}}{310\text{ u}} \times 100 = 20\%$$

$$\text{Mass percent of oxygen} = \frac{8 \times (\text{Atomic mass of oxygen})}{\text{molecular mass of } Ca_3(PO_4)_2} \times 100$$

$$= \frac{8 \times 16\text{ u}}{310\text{ u}} \times 100 = 41.29\%$$

28. According to Gay Lussac's law of gaseous volumes, gases combine or are produced in a chemical reaction in a simple ratio by volume, provided that all gases are at the same temperature and pressure.

29. (a) Yes

(b) According to the law of multiple proportions

(c)

H_2	+	O_2	$\rightarrow$	H_2O
2 g		16 g		18 g

(c)

H_2	+	O_2	$\rightarrow$	H_2O_2
2 g		32 g		34 g

Here masses of oxygen, (i.e., 16 g in H_2O and 32 g in H_2O_2) which combine with fixed mass of hydrogen (2 g) are in the simple ratio i.e., 16 : 32 or 1 : 2

30. $$\text{Average Atomic Mass} = \frac{\{(\text{Natural abundance of } ^1H \times \text{molar mass}) + (\text{Natural abundance of } ^2H \times \text{molar mass of } ^2H)\}}{100}$$

$$= \frac{99.985 \times 1 + 0.015 \times 2}{100}$$

$$= \frac{99.985 + 0.030}{100} = \frac{100.015}{100} = 1.00015\text{ u}$$

31. From the equation, 63.5 g of zinc liberates 22.7 litre of hydrogen. So 32.65 g of zinc will liberate

$$32.65\text{ g Zn} \times \frac{22.7\text{ L } H_2}{65.3\text{ g Zn}} = \frac{22.7}{2}\text{ L} = 11.35\text{ L}$$

32. 3 molal solution of NaOH means that 3 mols of NaOH are dissolved in 1000 g of solvent.

$\therefore$ Mass of Solution = Mass of Solvent + Mass of Solute

$= 1000\text{ g} + (3 \times 40\text{ g}) = 1120\text{ g}$

$$\text{Volume of Solution} = \frac{1120}{1.110}\text{ mL} = 1009.00\text{ mL}$$

(Since density of solution = 1.110g mL^{-1})

Since 1009 mL solution contains 3 mols of NaOH

$$\therefore \text{ Molarity } = \frac{\text{Number of moles of solute}}{\text{Volume of solution in litre}}$$

$$= \frac{3 \text{ mol}}{1009.00} \times 1000 = 2.97 \text{ M}$$

33. No, Molality of solution does not change with temperature since mass remains unaffected with temperature.

34. Mass of NaOH = 4 g

$$\text{Number of moles of NaOH} = \frac{4 \text{ g}}{40 \text{ g}} = 0.1 \text{ mol}$$

Mass of H_2O = 36 g

$$\text{Number of moles of } H_2O = \frac{36 \text{ g}}{18 \text{ g}} = 2 \text{ mol}$$

$$\text{Mole fraction of water} = \frac{\text{Number of moles of } H_2O}{\text{No. of moles of water + No. of moles of NaOH}}$$

$$= \frac{2}{2 + 0.1} = \frac{2}{2.1} = 0.95$$

$$\text{Mole fraction of NaOH} = \frac{\text{Number of moles of NaOH}}{\text{No. of moles of NaOH + No. of moles of water}}$$

$$= \frac{0.1}{2 + 0.1} = \frac{0.1}{2.1} = 0.047$$

Mass of solution = mass of water + mass of NaOH = 36 g + 4 g = 40 g

Volume of solution = 40 × 1 = 40 mL

(Since specific gravity of solution is = 1 g mL^{-1})

$$\text{Molarity of solution} = \frac{\text{Number of moles of solute}}{\text{Volume of solution in litre}}$$

$$= \frac{0.1 \text{ mol NaOH}}{0.04 \text{ L}} = 2.5 \text{ M}$$

35. $2A + 4B \rightarrow 3C + 4D$

According to the above equation, 2 mols of 'A' require 4 mols of 'B' for the reaction.

Hence, for 5 mols of 'A', the moles of 'B' required = $5 \text{ mol of A} \times \frac{4 \text{ mol of B}}{2 \text{ mol of A}}$

$= 10 \text{ mol B}$

But we have only 6 mols of 'B', hence, 'B' is the limiting reagent. So amount of 'C' formed is determined by amount of 'B'.

Since 4 mols of 'B' give 3 mols of 'C'. Hence 6 mols of 'B' will give

$$6 \text{ mol of B} \times \frac{3 \text{ mol of C}}{4 \text{ mol of B}} = 4.5 \text{ mol of C}$$

IV. Matching Type

36. (i) → (b) (ii) → (c) (iii) → (a) (iv) → (e)
(v) → (d)

37. (i) → (e) (ii) → (d) (iii) → (b) (iv) → (g)
(v) → (c), (h) (vi) → (f) (vii) → (a) (viii) → (i)

V. Assertion and Reason Type

38. (i) 39. (ii) 40. (iii) 41. (iii)

VI. Long Answer Type

42. (i) p_1=1 atm, T_1=273 K, V_1=?

32 g of oxygen occupies 22.4 L of volume at STP*

Hence, 1.6 g of oxygen will occupy, $1.6 \text{ g oxygen} \times \frac{22.4 \text{ L}}{32 \text{ g oxygen}} = 1.12 \text{ L}$

V_1=1.12 L

$$p_2 = \frac{p_1}{2} = \frac{1}{2} = 0.5 \text{ atm.}$$

V_2=?

According to Boyle's law :

$p_1V_1 = p_2V_2$

$$V_2 = \frac{p_1 \times V_1}{p_2} = \frac{1 \text{ atm.} \times 1.12 \text{ L}}{0.5 \text{ atm.}} = 2.24 \text{ L}$$

* Old STP conditions 273.15 K, 1 atm, volume occupied by 1 mol of gas = 22.4 L.
New STP conditions 273.15 K, 1 bar, volume occupied by a gas = 22.7 L.

(ii) Number of molecules of oxygen in the vessel $= \dfrac{6.022 \times 10^{23} \times 1.6}{32}$

$= 3.011 \times 10^{22}$

43. Number of moles of HCl $= 250 \text{ mL} \times \dfrac{0.76 \text{ M}}{1000} = 0.19$ mol

Mass of $CaCO_3$ = 1000 g

Number of moles of $CaCO_3 = \dfrac{1000 \text{ g}}{100 \text{ g}} = 10$ mol

According to given equation 1 mol of $CaCO_3$ (s) requires 2 mol of HCl (aq). Hence, for the reaction of 10 mol of $CaCO_3$ (s) number of moles of HCl required would be:

$$10 \text{ mol } CaCO_3 \times \frac{2 \text{ mol HCl (aq)}}{1 \text{ mol } CaCO_3 \text{ (s)}} = 20 \text{ mol HCl (aq)}$$

But we have only 0.19 mol HCl (aq), hence, HCl (aq) is limiting reagent. So amount of $CaCl_2$ formed will depend on the amount of HCl available. Since, 2 mol HCl (aq) forms 1 mol of $CaCl_2$, therefore, 0.19 mol of HCl (aq) would give:

$$0.19 \text{ mol HCl (aq)} \times \frac{1 \text{ mol } CaCl_2 \text{ (aq)}}{2 \text{ mol HCl (aq)}} = 0.095 \text{ mol}$$

or $\quad 0.095 \times \text{molar mass of } CaCl_2 = 0.095 \times 111 = 10.54 \text{ g}$

45. (**Hint :** Show that the masses of B which combine with the fixed mass of A in different combinations are related to each other by simple whole numbers).