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Some Basic Concepts *of* Chemistry

Multiple Choice Questions (MCQs)

Q. 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

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

(a) Results of both the students are neither accurate nor precise
(b) Results of student *A* are both precise and accurate
(c) Results of student *B* are neither precise nor accurate
(d) Results of student *B* are both precise and accurate

Thinking Process

Look at the reading of students A and B given in the question while keeping in mind the concept of precision and accuracy i.e.,
(i) Closeness of reading is precision, and
(ii) If mean of reading is exactly same as the correct value then it is known as accuracy.

Ans. *(b)* Average of readings of student, $A = \frac{3.01 + 2.99}{2} = 3.00$

Average of readings of student, $B = \frac{3.05 + 2.95}{2} = 3.00$

Correct reading = 3.00

For both the students, average value is close to the correct value. Hence, readings of both are accurate.

Readings of student *A* are close to each other (differ only by 0.02) and also close to the correct reading, hence, readings of *A* are precise also. But readings of *B* are not close to each other (differ by 0.1) and hence are not precise.

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

(a) 40 °C (b) 94 °C (c) 93.3 °C (d) 30 °C

Ans. *(c)* There are three common scales to measure temperature °C (degree celsius), °F (degree fahrenheit) and K (kelvin). The K is the SI unit.

The temperatures on two scales are related to each other by the following relationship.

$$°F = \frac{9}{5}t°C + 32$$

Putting the values in above equation

$$200 - 32 = \frac{9}{5}t°C$$

$$\Rightarrow \quad \frac{9}{5}t°C = 168$$

$$\Rightarrow \quad t°C = \frac{168 \times 5}{9} = 93.3° C$$

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

(a) 4 mol L^{-1} (b) 20 mol L^{-1} (c) 0.2 mol L^{-1} (d) 2 mol L^{-1}

Ans. *(c)* Since, molarity (M) is calculated by following equation

$$\text{Molarity} = \frac{\text{weight} \times 1000}{\text{molecular weight } \times \text{volume (mL)}}$$

$$= \frac{5.85 \times 1000}{58.5 \times 500} = 0.2 \text{ mol L}^{-1}$$

Note *Molarity of solution depends upon temperature because volume of a solution is temperature dependent.*

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

(a) 1.5 M (b) 1.66 M (c) 0.017 M (d) 1.59 M

Thinking Process

In case of solution, molarity is calculated by using molarity equation, $M_1V_1 = M_2V_2$, we have, V_1 (before dilution) and V_2 (after dilution), so calculate molarity of the given solution from this equation.

Ans. *(b)* Given that,

$$M_1 = 5\text{ M}$$
$$V_1 = 500\text{ mL}$$
$$V_2 = 1500\text{ mL}$$
$$M_2 = M$$

For dilution, a general formula is

$$\underset{\text{(Before dilution)}}{M_1V_1} = \underset{\text{(After dilution)}}{M_2V_2}$$

$$500 \times 5\text{M} = 1500 \times M$$

$$M = \frac{5}{3} = 1.66\text{M}$$

Q. 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?**

(a) 4 g He (b) 46 g Na (c) 0.40 g Ca (d) 12 g He

Thinking Process

The number of atoms is related to Avogadro's number (N_A) by

Number of atoms = moles × N_A

The number of atoms of elements can be compared easily on the basis of their moles only because N_A is a constant value. Thus, element with large number of moles will possess greatest number of atoms.

Ans. *(d)* For comparing number of atoms, first we calculate the moles as all are monoatomic and hence, moles × N_A = number of atoms.

$$\text{Moles of 4 g He} = \frac{4}{4} = 1\,\text{mol}$$

$$\text{46 g Na} = \frac{46}{23} = 2\,\text{mol}$$

$$\text{0.40 g Ca} = \frac{0.40}{40} = 0.1\,\text{mol}$$

$$\text{12 g He} = \frac{12}{4} = 3\,\text{mol}$$

Hence, 12 g He contains greatest number of atoms as it possesses maximum number of moles.

Q. 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?**

(a) 5 M (b) 50 M (c) 0.005 M (d) 0.5 M

Ans. *(c)* In the given question, 0.9 g L^{-1} means that 1000 mL (or 1L) solution contains 0.9 g of glucose.

$$\therefore \text{Number of moles} = 0.9\,\text{g glucose} = \frac{0.9}{180}\,\text{mol glucose}$$

$$= 5 \times 10^{-3}\,\text{mol glucose}$$

(where, molecular mass of glucose ($C_6H_{12}O_6$) = 12 × 6 + 12 × 1 + 6 × 16 = 180 u)

i.e., 1L solution contains 0.05 mole glucose or the molarity of glucose is 0.005 M.

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

(a) 0.1 m (b) 1 M (c) 0.5 m (d) 1 m

Ans. *(d)* Molality is defined as the number of moles of solute present in 1 kg of solvent. It is denoted by *m*.

Thus, $$\text{Molality } (m) = \frac{\text{Moles of solute}}{\text{Mass of solvent (in kg)}} \qquad \ldots\text{(i)}$$

Given that, Mass of solvent (H_2O) = 500 g = 0.5 kg

Weight of HCl = 18.25 g

Molecular weight of HCl = 1 × 1 + 1 × 35.5 = 36.5g

$$\text{Moles of HCl} = \frac{18.25}{36.5} = 0.5$$

$$m = \frac{0.5}{0.5} = 1\,\text{m} \qquad \text{[from Eq. (i)]}$$

Q. 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 ....

(a) 12.044×10^{20} molecules
(b) 6.022×10^{23} molecules
(c) 1×10^{23} molecules
(d) 12.044×10^{23} molecules

Ans. *(a)* One mole of any substance contains 6.022×10^{23} atoms/molecules.

Hence, Number of millimoles of H_2SO_4

$$= \text{molarity} \times \text{volume in mL}$$
$$= 0.02\times 100 = 2 \text{ millimoles}$$
$$= 2\times 10^{-3} \text{ mol}$$

$$\text{Number of molecules} = \text{number of moles} \times N_A$$
$$= 2\times 10^{-3}\times 6.022\times 10^{23}$$
$$= 12.044\times 10^{20} \text{ molecules}$$

Q. 9 What is the mass per cent of carbon in carbon dioxide?

(a) 0.034% (b) 27.27% (c) 3.4% (d) 28.7%

Ans. *(b)* Molecular mass of $CO_2 = 1\times 12 + 2\times 16 = 44\text{g}$

1 g molecule of CO_2 contains 1g atoms of carbon

$\because$ 44 g of CO_2 contain C = 12 g atoms of carbon

$\therefore$ $\%$ of C in $CO_2 = \frac{12}{44}\times 100 = 27.27\%$

Hence, the mass per cent of carbon in CO_2 is 27.27%.

Q. 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?

(a) $C_9H_{18}O_9$ (b) CH_2O (c) $C_6H_{12}O_6$ (d) $C_2H_4O_2$

Thinking Process

(i) Empirical formula shows that number of moles of different elements present in a molecule, so find the number of moles by dividing molecular mass with empirical formula mass.

(ii) To calculate the molecular formula of the compound, multiply the number of moles with empirical formula.

Ans. *(c)* Empirical formula mass = CH_2O

$$= 12 + 2\times 1 + 16 = 30$$

Molecular mass = 180

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}}$$
$$= \frac{180}{30} = 6$$

$\therefore$ Molecular formula $= n\times$ empirical formula

$$= 6\times CH_2O$$
$$= C_6H_{12}O_6$$

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

(a) 4.7 g (b) 4680×10^{-3}g (c) 4.680 g (d) 46.80 g

Ans. *(a)* Given that, density of solution = 3.12 g mL^{-1}

Volume of solution = 1.5 mL

For a solution, Mass = volume × density

$= 1.5 \text{ mL} \times 3.12 \text{ g mL}^{-1} = 4.68 \text{ g}$

The digit 1.5 has only two significant figures, so the answer must also be limited to two significant figures. So, it is rounded off to reduce the number of significant figures. Hence, the answer is reported as 4.7 g.

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

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

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

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

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

Ans. *(c)* A compound is a pure substance containing two or more than two elements combined together in a fixed proportion by mass and which can be decomposed into its constituent elements by suitable chemical methods.

Further, the properties of a compound are quite different from the properties of constituent elements. *e.g.*, water is a compound containing hydrogen and oxygen combined together in a fixed proportionation. But the properties of water are completely different from its constituents, hydrogen and oxygen.

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

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

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

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

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

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

Thinking Process

This problem is based upon the law of conservation of mass as well as limiting reagent.

(i) Law of conservation of mass is that in which total mass of reactants is equal to total mass of products.

(ii) Limiting reagent represents the reactant which reacts completely in the reaction.

Ans. *(a)* According to the law of conservation of mass,

Total mass of reactants = Total mass of products

Amount of Fe_2O_3 is decided by limiting reagent.

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

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

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

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

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

Ans. ***(b)*** In this equation,

$$\underset{44g}{C_3H_8(g)} + \underset{32g}{O_2(g)} \longrightarrow \underset{44\,g}{CO_2(g)} + \underset{18\,g}{H_2O(g)}$$

i.e., mass of reactants ≠ mass of products.

Hence, law of conservation of mass is not followed.

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

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

(b) 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

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

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

Ans. ***(b)*** The element, carbon, combines with oxygen to form two compounds, namely, carbon dioxide and carbon monoxide. In CO_2, 12 parts by mass of carbon combine with 32 parts by mass of oxygen while in CO, 12 parts by mass of carbon combine with 16 parts by mass of oxygen.

Therefore, the masses of oxygen combine with a fixed mass of carbon (12 parts) in CO_2 and CO are 32 and 16 respectively. These masses of oxygen bear a simple ratio of 32 : 16 or 2 : 1 to each other.

This is an example of law of multiple proportion.

Multiple Choice Questions (More Than One Options)

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

(a) 6.022×10^{23} molecules of oxygen

(b) 6.022×10^{23} atoms of oxygen

(c) 16 g of oxygen

(d) 32 g of oxygen

Ans. ***(a, d)***

1 mole of O_2 gas at STP = 6.022×10^{23} molecules of O_2 (Avogadro number) = 32 g of O_2

Hence, 1 mole of oxygen gas is equal to molecular weight of oxygen as well as Avogadro number.

Q. 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

(a) 0.1 mol L^{-1} (b) 7.10 g

(c) 0.025 mol L^{-1} (d) 3.55 g

Ans. ***(b, c)***

For the reaction, $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

1L of 0.1 M H_2SO_4 contains = 0.1 mole of H_2SO_4

1L of 0.1 M NaOH contains = 0.1 mole of NaOH

According to the reaction, 1 mole of H_2SO_4 reacts with 2 moles of NaOH. Hence, 0.1 mole of NaOH will react with 0.05 mole of H_2SO_4 (and 0.05 mole of H_2SO_4 will be left unreacted), *i.e.*, NaOH is the limiting reactant. Since, 2 moles of NaOH produce 1 mole of Na_2SO_4.

Hence, 0.1 mole of NaOH will produce 0.05 mole of Na_2SO_4.

$$\text{Mass of } Na_2SO_4 = \text{moles} \times \text{molar mass}$$
$$= 0.5 \times (46 + 32 + 64)\,g$$
$$= 7.10\,g$$

Volume of solution after mixing = 2 L

Since, only 0.05 mole of H_2SO_4 is left behind as NaOH completely used in the reaction. Therefore, molarity of the given solution is calculated from moles of H_2SO_4.

H_2SO_4 left unreacted in the solution = 0.05 mole

$$\therefore \quad \text{Molarity of the solution} = \frac{0.05}{2} = 0.025\,\text{mol L}^{-1}$$

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

(a) 16 g of $O_2(g)$ and 4 g of $H_2(g)$

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

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

(d) 12 g of C(*s*) and 23 g of Na(*s*)

Ans. ***(c, d)***

(c) Number of atoms in 28 g of $N_2 = \frac{28}{28} \times N_A \times 2 = 2\,N_A$ (where, N_A = Avogadro number)

Number of atoms in 32 g of $O_2 = \frac{32}{32} \times N_A \times 2 = 2N_A$

(d) 12 g of C(*s*) contains atoms $= \frac{12}{12} \times N_A \times 1 = N_A$

Number of atoms in 23 g of Na (*s*) $= \frac{23}{23} \times N_A \times 1 = N_A$

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

(a) 20 g of NaOH in 200 mL of solution (b) 0.5 mol of KCl in 200 mL of solution
(c) 40 g of NaOH in 100 mL of solution (d) 20 g of KOH in 200 mL of solution

Ans. *(a, b)*

(a) Molarity $(M) = \dfrac{\text{weight of NaOH} \times 1000}{\text{Molecular weight of NaOH} \times V(\text{mL})}$

$$= \frac{20 \times 1000}{40 \times 200} = 2.5\,\text{M}$$

(b) $M = \dfrac{0.5 \times 1000}{200} = 2.5\,\text{M}$

(c) $M = \dfrac{40 \times 1000}{10 \times 100} = 10\,\text{M}$

(d) $M = \dfrac{20 \times 1000}{56 \times 200} = 1.785\,\text{M}$

Thus, 20 g NaOH in 200 mL of solution and 0.5 mol of KCl in 200 mL have the same concentration.

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

(a) 16 g of CO (b) 28 g of N_2 (c) 14 g of N_2 (d) 1.0 g of H_2

Ans. *(c, d)*

The number of molecules can be calculated as follows

Number of molecules $= \dfrac{\text{Mass}}{\text{Molar mass}} \times$ Avogadro number (N_A)

Number of molecules, in 16 g oxygen $= \dfrac{16}{32} \times N_A = \dfrac{N_A}{2}$

In 16 g of CO $= \dfrac{16}{28} \times N_A = \dfrac{N_A}{1.75}$

In 28 g of $N_2 = \dfrac{28}{28} \times N_A = N_A$

In 14 g of $N_2 = \dfrac{14}{28} \times N_A = \dfrac{N_A}{2}$

In 1 g of $H_2 = \dfrac{1}{2} \times N_A = \dfrac{N_A}{2}$

So, 16 g of O_2 = 14 g of N_2 = 1.0 g of H_2

Q. 21 Which of the following terms are unitless?

(a) Molality (b) Molarity (c) Mole fraction (d) Mass per cent

Ans. *(c, d)*

Both mole fraction and mass per cent are unitless as both are ratios of moles and mass respectively.

$$\text{Mole fraction} = \frac{\text{Number of moles of solute}}{\text{Number of moles of solution}} = \frac{\text{moles}}{\text{moles}}$$

$$= \frac{\text{Number of moles of solvent}}{\text{Number of moles of solution}} = \frac{\text{moles}}{\text{moles}}$$

$$\text{Mass per cent} = \frac{\text{Mass of solute in gram}}{\text{Mass of solution in gram}} \times 100$$

Q. 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?

(a) Law of conservation of mass
(b) Law of definite proportions
(c) Law of multiple proportions
(d) Avogadro law

Ans. ***(a, d)***

Law of conservation of mass is simply the law of indestructibility of matter during physical or chemical changes. Avogadro law states that equal volumes of different gases contain the same number of molecules under similar conditions of temperature and pressure.

Short Answer Type Questions

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

Ans. The mass of a carbon-12 atom was determined by a mass spectrometer and found to be equal to 1.992648×10^{-23}g. It is known that 1 mole of C-12 atom weighing 12 g contains N_A number of atoms. Thus,

$$1 \text{ mole of C-12 atoms} = 12 \text{ g} = 6.022 \times 10^{23} \text{ atoms}$$

$\Rightarrow$ 6.022×10^{23} atoms of C-12 have mass = 12 g

$\therefore$ 1 atom of C-12 will have mass $= \dfrac{12}{6.022 \times 10^{23}}$ g

$$= 1.992648 \times 10^{-23} \text{g} \approx 1.99 \times 10^{-23} \text{ g}$$

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

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

Thinking Process

(i) To answer the given calculations, least precise term decide the significant figures.

(ii) To round up a number, left the last digit as such, if the digit next to it is less than 5 and increase it by 1, if the next digit is greater than 5.

Ans. Least precise term 2.5 or 3.5 has two significant figures.
Hence, the answer should have two significant figures

$$\frac{2.5 \times 1.25 \times 3.5}{2.01} \approx 5.4415 = 5.4$$

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

Ans. Symbol for SI unit of mole is mol.
One mole is defined as the amount of a substance that contains as many particles and there are atoms in exactly 12 g (0.012 kg) of the ^{12}C- isotope.

$$\frac{1}{12} \text{g of } {}^{12}\text{C-isotope} = 1 \text{ mole}$$

Q. 26 What is the difference between molality and molarity?

Ans. **Molality** It is defined as the number of moles of solute dissolved in 1 kg of solvent. It is independent of temperature.

Molarity It is defined as the number of moles of solute dissolved in 1L of solution. It depends upon temperature (because, volume of solution $\propto$ temperature).

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

Thinking Process

To calculate the mass per cent of atom, using the formula

Mass per cent of an element

$$= \frac{\text{Atomic mass of the element present in the compound}}{\text{Molar mass of the compound}} \times 100$$

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

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

Mass per cent of oxygen $= \dfrac{8\times \text{(atomic mass of oxygen)}}{\text{molecular mass of } Ca_3(PO_4)_2} \times 100$

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

Q. 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?

Ans. For the reaction,

$$\underset{2\text{ V}}{2N_2(g)} + \underset{1\text{ V}}{O_2(g)} \longrightarrow \underset{2\text{ V}}{2N_2O(g)}$$

$$\frac{45.4}{22.7} = 2 \quad \frac{22.7}{22.7} = 1 \quad \frac{45.4}{22.7} = 2$$

Hence, the ratio between the volumes of the reactants and the product in the given question is simple *i.e.*, 2 : 1 : 2. It proves the Gay-Lussac's law of gaseous volumes.

Note *Gay-Lussac's law of gaseous volumes, when gases combine or are produced in a chemical reaction, they do so in a simple ratio by volume provided all gases are at same temperature and pressure.*

Q. 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.

Ans. **(a)** *Yes*, the given statement is true.

(b) According to the law of multiple proportions

(c) $\underset{2g}{H_2} + \underset{16g}{O_2} \longrightarrow \underset{18g}{H_2O}$

$\underset{2g}{H_2} + \underset{32g}{O_2} \longrightarrow \underset{34g}{H_2O_2}$

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.

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

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

Ans. Many naturally occurring elements exist as more than one isotope. When we take into account the existence of these isotopes and their relative abundance (per cent occurrence), the average atomic mass of the element can be calculated as

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

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

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

Q. 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 = 65.3u

Ans. Given that, Mass of Zn = 32.65 g

1mole of gas occupies = 22.7L volume at STP

Atomic mass of Zn = 65.3u

The given equation is

$$\underset{65.3\text{ g}}{Zn} + 2HCl \longrightarrow ZnCl_2 + \underset{1\text{ mol} = 22.7\text{ L at STP}}{H_2}$$

From the above equation, it is clear that

65.3 g Zn, when reacts with HCl, produces = 22.7 L of H_2 at STP

$\therefore$ 32.65 g Zn, when reacts with HCl, will produce $= \frac{22.7 \times 32.65}{65.3} = 11.35$ L of H_2 at STP.

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

Thinking Process

Determine the mass of solution from the given molality of the solution followed by volume of solution relating mass and density to each other, i.e.,

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}}$$

Then, calculate the molarity of solution as

$$\text{Molarity} = \frac{\text{Number of moles}}{\text{Volume in litres}}$$

Ans. 3 molal solution of NaOH means 3 moles of NaOH are dissolved in 1 kg solvent. So, the mass of solution = 1000 g solvent + 120 g NaOH = 1120 g solution

(Molar mass of NaOH = 23 + 16 + 1 = 40 g and 3 moles of NaOH = 3 × 40 = 120 g)

$$\text{Volume of solution} = \frac{\text{Mass of solution}}{\text{Density of solution}} \qquad \left(\because d = \frac{m}{V}\right)$$

$$V = \frac{1120 \text{ g}}{1.110 \text{ g mL}^{-1}} = 1009 \text{ mL}$$

$$\text{Molarity} = \frac{\text{Moles of solute} \times 1000}{\text{Volume of solution (mL)}}$$

$$= \frac{3 \times 1000}{1009} = 2.973 \text{ M} \approx 3\text{M}$$

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

Ans. *No*, molality of solution does not change with temperature since mass remains unaffected with temperature.

$$\text{Molality, } m = \frac{\text{moles of solute}}{\text{weight of solvent (in g)}} \times 1000$$

Q. 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 1 g mL^{-1}).

Thinking Process

(i) *To proceed the calculation, first calculate the number of moles of* NaOH *and* H_2O.

(ii) *Then, find mole fraction of* NaOH *and* H_2O *by using the formula,*

$$X_{NaOH} = \frac{n_{NaOH}}{n_{NaOH} + n_{H_2O}} \qquad \left(\text{or } X_{H_2O} = \frac{n_{H_2O}}{n_{NaOH} + n_{H_2O}}\right)$$

(iii) *Then, calculate molarity* $= \frac{W \times 1000}{m \times V}$, *so in order to calculate molarity we require volume of solution which is,* $V = \frac{m}{\text{specific gravity}}$.

Ans. Number of moles of NaOH,

$$n_{NaOH} = \frac{4}{40} = 0.1 \text{ mol} \qquad \left\{\because n = \frac{\text{Mass (g)}}{\text{Molar mass (g mol}^{-1})}\right\}$$

Similarly, $$n_{H_2O} = \frac{36}{18} = 2 \text{ mol}$$

Mole fraction of NaOH, $$X_{NaOH} = \frac{\text{moles of NaOH}}{\text{moles of NaOH} + \text{moles of } H_2O}$$

$$X_{NaOH} = \frac{0.1}{0.1 + 2} = 0.0476$$

Similarly, $$X_{H_2O} = \frac{n_{H_2O}}{n_{NaOH} + n_{H_2O}}$$

$$= \frac{2}{0.1 + 2} = 0.9524$$

$$\text{Total mass of solution} = \text{mass of solute} + \text{mass of solvent}$$
$$= 4 + 36 = 40 \text{ g}$$

$$\text{Volume of solution} = \frac{\text{Mass of solution}}{\text{specific gravity}} = \frac{40 \text{ g}}{1 \text{ g mL}^{-1}} = 40 \text{ mL}$$

$$\text{Molarity} = \frac{\text{Moles of solute} \times 1000}{\text{Volume of solution (mL)}}$$

$$= \frac{0.1 \times 1000}{40} = 2.5 \text{ M}$$

Q. 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

(a) which is the limiting reagent?

(b) calculate the amount of C formed?

Ans. $$2A + 4B \longrightarrow 3C + 4D$$

According to the given reaction, 2 moles of A react with 4 moles of B.

Hence, 5 moles of A will react with 10 moles of B $\left(\frac{5 \times 4}{2} = 10 \text{ moles}\right)$

(a) It indicates that reactant B is limiting reagent as it will consume first in the reaction because we have only 6 moles of B.

(b) Limiting reagent decide the amount of product produced.

According to the reaction,

4 moles of B produces 3 moles of C

$\therefore$ 6 moles of B will produce $\frac{3 \times 6}{4} = 4.5$ moles of C.

Note *Limiting reagent limits the amount of product formed because it is present in lesser amount and gets consumed first.*

Matching The Columns

Q. 36 Match the following.

A.	88 g of CO_2	1.	0.2 mol
B.	6.022×10^{23} molecules of H_2O	2.	2 mol
C.	5.6 L of O_2 at STP	3.	1 mol
D.	96 g of O_2	4.	6.022×10^{23} molecules
D.	1 mole of any gas	5.	3 mol

Ans. **A.** → (2) **B.** → (3) **C.** → (1) **D.** → (5) **E.** → (4)

A. Number of moles of CO_2 molecule $= \dfrac{\text{Weight in gram of } CO_2}{\text{Molecular weight of } CO_2} = \dfrac{88}{44} = 2$ mol

B. 1 mole of a substance $= N_A$ molecules $= 6.022 \times 10^{23}$ molecules

$=$Avogadro number

$= 6.022 \times 10^{23}$ molecules of $H_2O = 1$ mol

C. 22.4 L of O_2 at STP = 1 mol

5.6 L of O_2 at STP $= \dfrac{5.6}{22.4}$ mol $= 0.25$ mol

D. Number of moles of 96 g of $O_2 = \dfrac{96}{32}$ mol $= 3$ mol

E. 1 mole of any gas = Avogadro number $= 6.022 \times 10^{23}$ molecules

Q. 37 Match the following physical quantities with units.

	Physical quantity		Unit
A.	Molarity	1.	g mL^{-1}
B.	Mole fraction	2.	mol
C.	Mole	3.	Pascal
D.	Molality	4.	Unitless
E.	Pressure	5.	mol L^{-1}
F.	Luminous intensity	6.	Candela
G.	Density	7.	mol kg^{-1}
H.	Mass	8.	Nm^{-1}
		9.	kg

Ans. **A.** → (5) **B.** → (4) **C.** → (2) **D.** → (7) **E.** → (3) **F.** → (6) **G.** → (1) **H.** → (9)

A. Molarity = concentration in mol L^{-1}

$$\text{Molarity} = \frac{\text{Number of moles}}{\text{Volume in litres}}$$

B. Mole fraction = Unitless

C. Mole $= \dfrac{\text{Mass (g)}}{\text{Molar mass (g mol}^{-1})} =$ mol

D. Molality = concentration in mol per kg solvent

$$\text{Molality} = \frac{\text{Number of moles}}{\text{Mass of solvent (kg)}}$$

E. The SI unit for pressure is the pascal (Pa), equal to one newton per square metre (N/m^2 or kg. m^{-1} s^{-2}). This special name for the unit was added in 1971; before that, pressure in SI was expressed simply as N/m^2.

F. Unit of luminous intensity = candela.

The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

G. Density $= \frac{\text{mass}}{\text{volume}} = \text{g mL}^{-1}$

H. Unit of mass = kilogram

The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram

Assertion and Reason

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 in each question.*

Q. 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.

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

(b) A is true but R is false.

(c) A is false but R is true.

(d) Both A and R are false.

Ans. *(a)* Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

The molecular formula of ethene is C_2H_4 and its empirical formula is CH_2.

Thus, Molecular formula = Empirical formula × 2

Q. 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.

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

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

(c) A is true but R is false.

(d) Both A and R are false.

Ans. *(b)* Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

Atomic masses of the elements obtained by scientists by comparing with the mass of carbon comes out to be close to whole number value.

Q. 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.

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

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

(c) A is true but R is false.

(d) Both A and R are false.

Ans. *(c)* Assertion is true but Reason is false.

0.200 contains 3 while 200 contains only one significant figure because zero at the end or right of a number are significant provided they are on the right side of the decimal point.

Q. 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.

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

(b) A is true but R is false.

(c) A is false but R is true.

(d) Both A and R are false.

Ans. *(c)* Assertion is false but Reason is true.

Combustion of 16 g of methane gives 36 g of water.

$$\underset{\substack{1\text{mol}\\=16\text{g}}}{CH_4} + 2O_2 \longrightarrow CO_2 + \underset{\substack{2\text{ mol}\\=36\text{g}}}{2H_2O}$$

Long Answer Type Questions

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

(a) volume of the new vessel.

(b) number of molecules of dioxygen.

Ans. (a) $p_1 = 1\,\text{atm},\ p_2 = \frac{1}{2} = 0.5\,\text{atm},\ T_1 = 273.15,\ V_2 = ?,\ V_1 = ?$

32 g dioxygen occupies = 22.4 L volume at STP

$\therefore$ 1.6 g dioxygen will occupy $= \dfrac{22.4\text{ L} \times 1.6\text{ g}}{32\text{ g}} = 1.12\text{ L}$

$$V_1 = 1.12\text{ L}$$

From Boyle's law (as temperature is constant),

$$p_1V_1 = p_2V_2$$

$$V_2 = \frac{p_1V_1}{p_2}$$

$$= \frac{1\text{ atm} \times 1.12\text{ L}}{0.5\text{ atm}} = 2.24\text{ L}$$

(b) Number of moles of dioxygen $= \dfrac{\text{Mass of dioxygen}}{\text{Molar mass of dioxygen}}$

$$n_{O_2} = \frac{1.6}{32} = 0.05 \text{ mol}$$

1 mol of dioxygen contains $= 6.022 \times 10^{23}$ molecules of dioxygen

$\therefore$ 0.05 mol of dioxygen $= 6.022 \times 10^{23} \times 0.05$ molecule of O_2

$= 0.3011 \times 10^{23}$ molecules

$= 3.011 \times 10^{22}$ molecules

Q. 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.

Ans. Molar mass of $CaCO_3 = 40 + 12 + 3 \times 16 = 100 \text{ g mol}^{-1}$

Moles of $CaCO_3$ in 1000 g, $n_{CaCO_3} = \dfrac{\text{Mass (g)}}{\text{Molar mass}}$

$$n_{CaCO_3} = \frac{1000 \text{ g}}{100 \text{ g mol}^{-1}} = 10 \text{ mol}$$

$$\text{Molarity} = \frac{\text{Moles of solute (HCl)} \times 1000}{\text{Volume of solution}}$$

(It is given that moles of HCl in 250 mL of 0.76 M HCl $= n_{HCl}$)

$$0.76 = \frac{n_{HCl} \times 1000}{250}$$

$$n_{HCl} = \frac{0.76 \times 250}{1000} = 0.19 \text{ mol.}$$

$$\underset{1 \text{ mol}}{CaCO_3(s)} + \underset{2 \text{ mol}}{2HCl(aq)} \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

According to the equation,

1 mole of $CaCO_3$ reacts with 2 moles HCl

$\therefore$ 10 moles of $CaCO_3$ will react with $\dfrac{10 \times 2}{1} = 20$ moles HCl.

But we have only 0.19 moles HCl, so HCl is limiting reagent and it limits the yield of $CaCl_2$.

Since, 2 moles of HCl produces 1 mole of $CaCl_2$

0.19 mole of HCl will produce $\dfrac{1 \times 0.19}{2} = 0.095 \text{ mol } CaCl_2$

Molar mass of $CaCl_2 = 40 + (2 \times 35.5) = 111 \text{ g mol}^{-1}$

$\therefore$ 0.095 mole of $CaCl_2 = 0.095 \times 111 = 10.54$ g

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

Ans. *'Law of multiple proportions' was first studied by Dalton in* 1803 *which may be defined as follows*

When two elements combine to form two or more chemical compounds, then the masses of one of the elements which combine with a fixed mass of the other, bear a simple ratio to one another.

e.g., hydrogen combines with oxygen to form two compounds, namely, water and hydrogen peroxide.

$$\underset{2g}{\text{Hydrogen}} + \underset{16g}{\text{Oxygen}} \longrightarrow \underset{18\text{ g}}{\text{Water}}$$

$$\underset{2g}{\text{Hydrogen}} + \underset{32g}{\text{Oxygen}} \longrightarrow \underset{34g}{\text{Hydrogen peroxide}}$$

Here, the masses of oxygen (*i.e.*, 16 g and 32 g) which combine with a fixed mass of hydrogen (2 g) bear a simple ratio, *i.e.,* 16 : 32 or 1 : 2 .

As we know that, when compounds mixed in different proportionation, Then they form different compounds. In the above examples, when hydrogen is mixed with different proportion of oxygen, then they form water or hydrogen peroxide.

It shows that there are constituents which combine in a definite proportion. These constituents may be atoms. Thus, the law of multiple proportions shows the existence of atoms which combine into molecules.

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

Thinking Process

In this question, it is seen 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.

Ans.

Combination	Mass of *A* (*g*)	Mass of *B* (*g*)
AB	2	5
AB_2	2	10
A_2B	4	5
A_2B_3	4	15

Mass of *B* which is combined with fixed mass of *A* (say 1 g) will be 2.5 g, 5 g, 1.25 g and 3.75 g. They are in the ratio 2 : 4 : 1 : 3 which is a simple whole number ratio. Hence, the law of multiple proportions is applicable.