Long Answer Type Questions

[5 marks]

Q. 1. Arrange the following in order of decreasing masses:
(i) 10^{23} molecules of CO_2 gas **(ii) 0.1 g atom of silver**
(iii) 1 gram of carbon **(iv) 0.1 mole of H_2SO_4**
(v) 10^{23} atoms of calcium.
(Given Atomic masses: Ag = 108 u, S = 32 u, N = 14 u, Ca = 40 u)

Ans. (i) 1 mole of CO_2 = 44 g = 6.02 x 10^{23} molecules

i.e., 6.02 x 10^{23} molecules of CO_2 = 44 g of CO_2

10^{23} molecules of $CO_2 = \frac{44}{6.02 \times 10^{23}}$ x 10^{23} = 7.31 g

(ii) 1 g atoms of Ag = Gram atomic mass of Ag = 108 g

∴ 0.1 g atom of Ag = 0.1 × 108 g = 10.8 g

(iii) 1 g of carbon = 1g

(iv) 1 mole of H_2SO_4 = Gram molecular mass
= 2 x 1+ 32 + 4 x 16 = 98 g
∴ 0.I mole of H_2SO_4 = 0.1 x 98 g = 9.8 g

(v) 1 mole of Ca = 40 g = 6.02 × 10^{23} atoms of Ca

i.e., 6.02 x 10^{23} atoms of Ca have mass = 40 g

∴ 10^{23} atoms of Ca have mass = $\frac{40}{6.02 \times 10^{23}}$ x 10^{23}

= 6.64 g

Thus, masses in the decreasing order are:
0.1 g atom of Ag > 0.1 mole of H_2SO_4 > 10^{23} molecules of CO_2 > 10^{23} atoms of Ca > I g of carbon

Q.2. Calculate the number of aluminium ions (Al^{3+}) in 0.056 g of alumina (Al_2O_3).

Ans. Molecular mass of alumina (Al_20_3) = 2 × Al^{3+} + 3 × 0^{2-}
= 2 × 27 u + 3 × 16u
= 102 u
Gram molecular mass = 102 g
I mol of alumina (Al_20_3) = 102 g
102 g of Al_2O_3 = 1 mol
∴ 0.056 g of $Al_2O_3 = \frac{1 \times 0.056}{102}$ mol

$= 5.49 \times 10^{-4}$ mol

We know that one mol of alumina contains 2 mol of Al^{3+} ions.

∴ 5.49×10^{-4} mol of Al_2O_3 contains $2 \times 5.49 \times 10^{-4}$ mol of Al^{3+} ions

∴ Number of Al^{3+} ions in 0.056 g = $2 \times 5.49 \times 10^{-4} \times 6.022 \times 10^{23}$

$= 6.613 \times 10^{20}$ ions of Al^{3+}

Q. 3. Calculate the mass per cent of each element present in the molecule of calcium carbonate.

Ans. Molecular formula of calcium carbonate = $CaCO_3$

Molecular mass of $CaCO_3 = 1 \times Ca + 1 \times C + 3 \times 0$

$= 1 \times 40$ u $+ 1 \times 12$ u $+ 3 \times 16$ u $= 100$ u

Gram molecular mass = 100 g/mol

1 mol of $CaCO_3$ = 100 g

(a) Mass % of Ca in $CaCO_3 = \frac{\text{Mass of Ca}}{\text{Molecular mass of } CaCO_3} \times 100$

$= \frac{40g}{100g} \times 100 =$ **40%**

(b) Mass % of carbon in $CaCO_3 = \frac{\text{Mass of Cabon}}{\text{Molecular mass of } CaCO_3} \times 100$

$= \frac{12g}{100g} \times 100 =$ **12%**

(c) Mass % of oxygen in $CaCO_3 = \frac{\text{Mass of oxygen}}{\text{Molecular mass of } CaCO_3} \times 100$

$= \frac{48g}{100g} \times 100 =$ **48%**

Q. 4. Verify by calculating that

(a) 5 moles of CO_2 and 5 moles of H_2O do not have the same mass.

(b) 240 g of calcium and 240 g of magnesium elements have a mole ratio of 3 : 5.

Ans. (a) CO_2 has molar mass = 44 g mol^{-1}

5 moles of Co_2 have molar mass = 44 x 5 = 220 g

H_20 has molar mass = 18 g mol^{-1}

5 moles of H_2O have mass = 18×5 g = 90 g

(b) Number of moles in 240 g Ca metal = $\frac{240}{40} = 6$

Number of moles in 240 g of Mg metal = $\frac{240}{24} = 10$

Ratio is 6 : 10

Or, 3 : 5

Q.5. Find the ratio of mass of the combining elements in the following compounds:

(a) $CaCO_3$ (b) $MgCl_2$ (c) H_2SO_4

(d) C_2H_5OH (e) NH_3 (f) $Ca(OH)_2$

Ans. (a) $CaCO_3$

Ca : C : O × 3

40 : 12 : 16 x 3

40 : 12 : 48

10 : 3 : 12

(b) $MgCl_2$

Mg : Cl × 2

24 : 35.5 × 2

24 : 71

(c) H_2SO_4

H × 2 : S : O × 4

1 × 2 : 32 : 16 × 4

2 : 32 : 64

1 : 16 : 32

(d) C_2H_5OH

C × 2 : H × 6 : O

12 × 2 : 1 × 6 : 16

24 : 6 : 16

12 : 3 : 8

(e) NH_3

N : H × 3

14 : 1 × 3

14 : 3

(f) $Ca(OH)_2$

Ca : O × 2 : H × 2

40 : 16 × 2 : 1 × 2

40 : 32 : 2

20 : 16 : 1

Q. 6. Calcium chloride when dissolved in water dissociates into its ions according to the following equation.

$CaCl_2$ (aq) → Ca^{2+} (aq) + 2Cl^- (aq)

Calculate the number of ions obtained from $CaCl_2$ when 222 g of it is dissolved in water.

Ans. I mole of calcium chloride = 111 g

∴ 222 g of $CaCl_2$ is equivalent to 2 moles of $CaCl_2$

Since 1 formula unit $CaCl_2$ gives 3 ions, therefore, 1 mole of $CaCl_2$ will give 3 moles of ions.

2 moles of $CaCl_2$ would give 3 x 2 = 6 moles of ions.

Number of ions = Number of moles of ions x Avogadro number

$= 6 \times 6.022 \times 10^{23}$

$= 36.132 \times 10^{23}$

$= 3.6132 \times 10^{24}$ ions.

Q. 7. What is a mole? What is the unit of mole? How many molecules are there in a certain mass of a substance?

Ans. A mole is the amount of a substance which contains the same number of chemical units (atoms,molecules or ions) as there are atoms in exactly 12 g of carbon-12. The unit of mole is given by the symbol 'mol'.

We know that Avogadro number is 6.022×10^{23}

Number of molecules in a certain mass

$$= \frac{\text{Mass of the substance}}{\text{Molar mass}} \times N_A$$

$$= \frac{W}{M} \times 6.022 \times 10^{23} \text{ molecules}$$

where 'W' is the mass of the substance in which number of molecules is to be calculated and 'M' is the molecular mass of the substance.

Q. 8. The difference in the mass of 100 moles each of sodium atoms and sodium ions is 5.48002 g. Compute the mass of an electron.

Ans. A sodium atom and ion differ by one electron. For 100 moles each of sodium atoms and ions there would be a difference of 100 moles of electrons.
Mass of 100 moles of electrons = 5.48002 g

Mass of 1 mole of electron = $\frac{5.48002}{100}$ g

Mass of one electron = $\frac{5.48002}{100 \times 6.022 \times 10^{23}}$

$= 9.1 \times 10^{-28}$ g

$= 9.1 \times 10^{-31}$ kg

Q.9. The mass of one steel screw is 4.11g. Find the mass of one mole of these steel screws. Compare this value with the mass of the Earth (5.98×10^{24}kg). which one of the two is heavier and by how many times?

Ans. 1 mole of steel screws = 6.022×10^{23} screws

Mass of 1 screw = 4.11g

∴ Mass of 1 mole of screws = $4.11 \times 6.022 \times 10^{23}$ g

$= 24.75 \times 10^{23}$ g

$= 2.475 \times 10^{24}$ g

One mole of screw weighs = 2.475×10^{24} g = 2.475×10^{21} kg

$$\frac{\text{Mass of the substance}}{\text{Molar mass}} = \frac{5.98 \times 10^{24}\ \text{kg}}{2.475 \times 10^{21}\ \text{kg}} = 2.4 \times 10^{3}$$

Mass of Earth is 2.4×10^3 times the mass of screws.
The Earth is 2400 times heavier than one mole of screws.

Q.10. Compute the number of ions present in 5.85 g of sodium chloride.

Ans. 5.85 g of NaCl = $\frac{5.85}{58.5}$ = 0.1 moles

or 0.1 moles of NaCl particle.

Each NaCl particle is equivalent to 2 ions, *i.e.,* one Na^+ and one Cl^-

⇒ Total moles of ions = 0.1 × 2 = 0.2 moles

Number of ions = $0.2 \times 6.022 \times 10^{23}$

$= 1.2042 \times 10^{23}$ ions

Q. 11. A gold sample contains 90% of gold and the rest copper. How many atoms of gold are present in one gram of this sample of gold?

Ans. One gram of gold sample will contain $\frac{90}{100}$ = 0.9 g of gold

Number of moles of gold = $\frac{\text{Mass of gold}}{\text{Atomic mass of gold}}$

$= \frac{0.9}{197} = 0.0046$

One mole of gold contains N_A atoms = 6.022×10^{23}

∴ 0.0046 mole of gold will contain = $0.0046 \times 6.022 \times 10^{23}$

= 2.77×10^{21} atoms

Q. 12. Compute the difference in masses of one mole each of aluminium atoms and one mole of its ions. (Mass of an electron is 9.1×10^{-28} g). Which one is heavier?

Ans. Mass of 1 mole of aluminium atom = Molar mass of aluminium = 27 g mol^{-1}.

An aluminium atom needs to lose three electrons to become an ion, Al^{3+}.

For one mole of Al^{3+} ion, three moles of electrons are to be lost.

The mass of three moles of electrons = $3 \times (9.1 \times 10^{-28}) \times 6.022 \times 10^{23}$ g

$= 27.3 \times 6.022 \times 10^{-5}$g

$= 164.400 \times 10^{-5}$ g = 0.00164 g

Molar mass of Al^{3+} = (27- 0.00164) g mol^{-1}

= 26.9984 g mol^{-1}

Difference = 27- 26.9984

= 0.0016 g

Q. 13. A silver ornament of mass '*m*' gram is polished with gold equivalent to 1% of the mass of silver. Compute the ratio of the number of atoms of gold and silver in the ornament.

Ans. Mass of silver = m g

Mass of gold = $\frac{m}{100}$ g

Number of atoms of silver = $\frac{\text{Mass}}{\text{Atomic mass}} \times N_A = \frac{m}{108} \times N_A$

Number of atoms of gold = $\frac{m}{100 \times 197} \times N_A$

Ratio of number of atoms of gold to silver = Au : Ag

$= \frac{m}{100 \times 197} \times N_A : \frac{m}{108} \times N_A$

= 108 : 100 x 197

= 108 : 19700

= 1 : 182.41

Q.14. A sample of ethane (C_2H_6) gas has the same mass as 1.5×10^{20} molecules of methane (CH_4). How many C_2H_6 molecules does the sample of gas contain?

Ans. Mass of 1 molecule of CH_4 = $\frac{16\ g}{N_A}$

Mass of 1.5 x 10^{20} molecules of methane = $\frac{1.5 \times 10^{20} \times 16}{N_A}$ g

Mass of 1 molecule of C_2H_6 = $\frac{30}{N_A}$ g

Mass of molecules of C_2H_6 = $\frac{1.5 \times 10^{20} \times 16}{N_A}$ g

∴ Number of molecules of ethane = $\frac{1.5 \times 10^{20} \times 16}{N_A} \times \frac{N_A}{30}$ = **0.8 × 10^{20}**

Q. 15. In photosynthesis, 6 molecules of carbon dioxide combine with an equal number of water molecules through a complex series of reactions to give a molecule of glucose having a molecular formula $C_6H_{12}O_6$. How many grams of water would be required to produce 18 g of glucose? Compute the volume of water so consumed assuming the density of water to be 1g cm^{-3}.

Ans. $6CO_2 + 6\ H_2O \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6O_2$

1 mole of glucose needs 6 moles of water

180 g of glucose needs (6 × 1 8) g of water

Ig of glucose will need $\frac{108}{180}$ g of water.

18 g of glucose would need $\frac{108}{180}$ × 18 g of water = 10.8 g

Volume of water used = $\frac{\text{Mass}}{\text{Density}}$

= $\frac{10.8\ g}{1\ g\ cm^{-3}}$ = **10.8 cm^3**

Q. 16. Calculate the ratio between the mass of one atom of hydrogen and mass of one atom of silver.

Ans. 1 mole of H atoms = 1 g

1 mole of H atoms = 6.022 × 10^{23} atoms.

Mass of 6.022 x 10^{23} atoms of H = 1g

∴ Mass of one atom of H = $\frac{1}{6.022 \times 10^{23}}$ g

= 1.66 x 10^{-24} g

1 mole of silver atoms = 108 g

1 mole of silver contains 6.022 × 10^{23} atoms

∴ 6.022 x 10^{23} atoms of silver = 108 g

∴ Mass of one atom of silver atom = $\frac{108}{6.022 \times 10^{23}}$ g

$= 1.793 \times 10^{-22}\text{g}$

Ratio between masses of silver and hydrogen atoms

$$= \frac{1.793 \times 10^{-22}\text{g}}{1.66 \times 10^{-24}\text{g}}$$

$$= \mathbf{1.080 \times 10^{2}}$$