ATOMS AND MOLECULES

1. A 0.24g sample of compound of Oxygen and Boron was found by analysis to contain 0.096g of boron and 0.144g of oxygen. Calculate the percentage composition of the compound by weight.

A. The mass of sample of compound = 0.24g
The mass of Boron = 0.096g
The mass of Oxygen = 0.144g

Percentage of Boron in the sample = $\frac{0.096}{0.24} \times 100 = 0.4 \times 100 = 40$

Percentage of Oxygen in the sample = $\frac{0.144}{0.24} \times 100 = 0.6 \times 100 = 60$

The sample of compound contains 40% Boron and 60% Oxygen by weight.

2. When 3.0g Carbon is burnt in 8.00g of Oxygen, 11.00g of Carbon dioxide is produced. What mass of Carbon dioxide will be formed when 3.00g of Carbon is burnt in 50.00g of Oxygen? Which law of chemical combination will govern your answer?

A. Ratio by mass of Carbon and Oxygen in Carbon dioxide is 3: 8 that means 3g of Carbon combining with 8g of Oxygen to give 11g of Carbon dioxide. According to law of constant proportions in the second case also 3g of Carbon must combine with 8g of Oxygen to give 11g of Carbon dioxide. This means that
(50 – 8) g = 42g of Oxygen will remain unreacted. This indicates law of definite proportions which say that in compounds, the combining elements are present in definite proportions by mass.

3. What are polyatomic ions? Give examples.

A. A group of atoms carrying a charge is known as a polyatomic ion (or) Clusters of atoms that carrying a fixed charge are known as polyatomic ions. Examples are Ammonium NH_4^+, Hydroxide OH^-, Nitrate NO_3^-, Hydrogen Carbonate HCO_3^-,...etc.

4. Write the chemical formulae of the following.

a) Magnesium chloride
b) Calcium oxide
c) Copper nitrate
d) Aluminium chloride
e) Calcium carbonate

A.
a) Magnesium chloride – $MgCl_2$
b) Calcium oxide – CaO
c) Copper (I) nitrate – $CuNO_3$
Copper (II) nitrate – $Cu(NO_3)_2$
d) Aluminium chloride – $AlCl_3$
e) Calcium Carbonate – $CaCO_3$

5. Give the names of the elements present in the following compounds.

a) Quick lime b) Hydrogen bromide c) Baking soda d) Potassium sulphate
e) Baking powder

A.
a) Quick lime – CaO – Calcium and Oxygen
b) Hydrogen bromide – HBr – Hydrogen and bromine

c) Baking soda – $NaHCO_3$ – Sodium, Hydrogen, Carbon and Oxygen.

d) Potassium sulphate – K_2SO_4 – Potassium, sulphur and oxygen.

e) Baking powder – Baking soda + Tartaricacid / citric acid. constituents Na, H, C, O

6. Calculate the molar mass of the following substances

a) Ethyne, C_2H_2 (atomic mass of C – 12, H – 1)

b) Sulphur molecule, S_8 (atomic mass of S – 32)

c) Phosphorus molecule, P_4 (atomic mass of phosphorus = 31)

d) Hydrochloric acid (HC*l*) (atomic mass of H – 1, C*l* – 35.5)

e) Nitric acid (HNO_3) (atomic mass of H – 1, N – 14, O – 16)

A. **Hint:** Mass of 1 mole of a substance is called its molarmass

a) Ethyne, $C_2H_2 = 2 \times 12 + 2 \times 1 = 24 + 2 = 26$

Molar mass of $C_2H_2 = 26g$

b) Sulphur molecule, $S_8 = 8 \times 32 = 256$

Molar mass of $S_8 = 256g$

c) Phosphorus molecule, $P_4 = 4 \times 31 = 124$

Molar mass of $P_4 = 124g$

d) Hydro chloric acid, HC*l* $= 1 \times 1 + 1 \times 35.5 = 1 + 35.5 = 36.5$

Molar mass of HC*l* $= 36.5g$

e) Nitric acid, $HNO_3 = 1 \times 1 + 1 \times 14 + 3 \times 16 = 1 + 14 + 48 = 63$

Molar mass of $HNO_3 = 63g$

7. What is the mass of

a) 1 mole of Nitrogen atoms?

b) 4 moles of Aluminium atoms (Atomic mass of aluminium = 27)?

c) 10 moles of Sodium sulphite (Na_2SO_3)?

A. a) 1 Mole of Nitrogen atoms = 1gram atomic mass of Nitrogen atoms = 14g

b) 4 Moles of Aluminium atoms = 4 × gram atomic mass of A*l* $= 4 \times 27g = 108g$

c) 1 Mole of Na_2SO_3 = Gram molecular mass of $Na_2SO_3 = 2 \times 23 + 1 \times 32 + 3 \times 16$

1 Mole of $Na_2SO_3 = 46 + 32 + 48 = 126$ g

Then 10 Mole $Na_2SO_3 = 10 \times 126g = 1260g$

HINT: 1 mole = Gram atomic mass (for atoms)

1 mole = Gram molecular mass (for molecules of compounds and elements)

8. Convert into mole. (a) 12g of oxygen gas (b) 20g of water (c) 22g of carbon dioxide

A. a) 1 mole of Oxygen gas $(O_2) = 2 \times 16g = 32g$

32g of Oxygen = 1 mole

then 12 g of Oxygen –?

$$= \frac{1 \times 12}{32} = \frac{3}{8} = 0.375$$

12g of Oxygen gas = 0.375 moles of Oxygen gas

b) 1 mole of water (H_2O) = $2 \times 1 + 1 \times 16 = 18g$

18g of water = 1 mole

then 20g of water –?

$$= \frac{1 \times 20}{18} = 1.11$$

20g of water = 1.11 moles of water

c) 1 mole of Carbon dioxide (CO_2) = $1 \times 12 + 2 \times 16 = 44g$

44g of Carbon dioxide = 1 mole

then 22g of Carbon dioxide –?

$$= \frac{1 \times 22}{44} = \frac{1}{2} = 0.5$$

22g of Carbon dioxide = $\frac{1}{2} = 0.5$ moles of Carbon dioxide

9. What is the mass of

a) 0.2 mole of Oxygen atoms?

b) 0.5 mole of water molecules?

A. a) 1 Mole of Oxygen atoms = 1 Gram atomic mass of Oxygen atoms

1 Mole of Oxygen atoms = 16g

then 0.2 mole of Oxygen atoms = $0.2 \times 16g = 3.2$ g

b) 1 Mole of water molecules = 1 Gram molecular mass

(H_2O) = $2 \times 1 + 1 \times 16 = 18g$

Then 0.5 moles of water molecules = $0.5 \times 18 = 9$.

10. Calculate the number of molecules of sulphur (S_8) present in 16g of solid sulphur.

A. 1 Mole of Sulphur (S_8) = $8 \times 32 = 256$ g

1 Mole of Sulphur (S_8) = 6.022×10^{23} S_8 molecules

That means 256g of Sulphur (S_8) = 6.022×10^{23} S_8 molecules

then 16g of Sulphur (S_8) =?

$$= \frac{16 \times 6.022 \times 10^{23}}{256} = 0.3763 \times 10^{23}$$

16g of sulphur (S_8) has = 3.763×10^{22} molecules

11. Calculate the number of Aluminium ions present in 0.051g of Aluminium Oxide.

(**Hint:** The mass of an ion is the same as that of an atom of the same element, Atomic mass of Al = 27U)

$$\underset{1\text{Mole}}{Al_2O_3} \rightarrow \underset{2\text{Moles}}{2Al^{+3}} + \underset{3\text{Moles}}{3O^{-2}}$$

1 Mole of $Al_2O_3 = 2 \times 27 + 3 \times 16 = 54 + 48 = 102g$

1 Mole of Al_2O_3 has = 2 mole Al^{+3} ions

i,e; 102g of Al_2O_3 has = 2 mole Al^{+3} ions

102g of Al_2O_3 has = $2 \times 6.022 \times 10^{23}$ Al^{+3} ions

then 0.051g of Al_2O_3 has =?

$$= \frac{0.051 \times 2 \times 6.022 \times 10^{23}}{102} = \frac{51 \times 2 \times 6.022 \times 10^{-3} \times 10^{23}}{102}$$

0.051g of Al_2O_3 has = 6.022×10^{20} Al^{+3} ions

1. In a reaction 5.3g of sodium carbonate reacted with 6g of ethanoic acid. The products were 2.2g of carbon dioxide, 0.9g of water and 8.2g of sodium ethanoate. Show that these observations are in agreement with the law of conservation of mass.

Sodium carbonate + Ethanoic acid $\rightarrow$ Sodium ethanoate + Carbon dioxide + Water

A. According to law of conservation of mass.
Total mass of reactants = Total mass of products that means
Total mass of reactants (Sodium carbonate + Ethanoic acid) = 5.3 + 6 = 11.3 g
Total mass of products = 8.2 + 2.2 + 0.9 = 11.3 g
(Sodium ethanoate + Carbon dioxide + water)
Therefore these observations are in agreement with the law of conservation of mass.

2. Hydrogen and Oxygen combine in the ratio of 1: 8 by mass to form water. What mass of oxygen gas would be required to react completely with 3g of Hydrogen gas?

The chemical equation: $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$

A. The combining ratio of Hydrogen and Oxygen in water is 1: 8 by mass.
That means 1g Hydrogen gas is required to combine 8g of Oxygen
Then the amount of Oxygen gas required to combine with 3g of Hydrogen is

The mass of Oxygen required = $\frac{3 \times 8}{1} = 24g$

3. Which postulate of Dalton's atomic theory is the result of the law of conservation of mass?

A. The Dalton's atomic theory postulates that "Atoms are indivisible particles, which cannot be created or destroyed in a chemical reaction".

4. Which postulate of Dalton's atomic theory can explain the law of definite proportions?

A. "Atoms combine in the ratio of small whole numbers to form compounds. The relative number and kinds of atoms are constant in a given compound "is the result of law of definite proportions.

5. Define the atomic mass unit.

A. One atomic mass unit is defined as "A mass unit equal to exactly one twelvth 1/12th the mass of one atom of carbon – 12".

6. Why is it not possible to see an atom with naked eyes?

A. Atoms are very small, they are smaller than anything that we can imagine or compare with. The radius of an atom is of the order of, which is too small to be seen with a naked eye. More than millions of atoms when stacked would make a layer barely as thick as this sheet of paper.

7. Write down the formula of
i) Sodium Oxide **ii) Aluminium Chloride**
iii) Sodium Sulphide **v) Magnesium Hydroxide**

A.

i)	Sodium Oxide	Na_2O
ii)	Aluminium Chloride	$AlCl_3$
iii)	Sodium Sulphide	Na_2S
iv)	Magnesium Hydroxide	$Mg(OH)_2$

8. Write down the names of compounds represented by the following formulae:
i) $Al_2(SO_4)_3$ **ii) $CaCl_2$** **iii) K_2SO_4** **iv) KNO_3** **v) $CaCO_3$**

A.

i)	$Al_2(SO_4)_3$	Aluminium Sulphate
ii)	$CaCl_2$	Calcium Chloride
iii)	K_2SO_4	Potassium Sulphate
iv)	KNO_3	Potassium Nitrate
v)	$CaCO_3$	Calcium Carbonate

9. What is meant by the term chemical formula?

A. The chemical formula of a compound is a symbolic representation of its composition.

Ex: 1) The chemical formula of Hydrogen sulphide is H_2S

2) The chemical formula of Carbon dioxide is CO_2

10. How many atoms are present in a (i) H_2S molecule and (ii) PO_4^{-3} ion?

A. i) The number of atoms present in H_2S molecule is 3, i.e., two 'H' atoms and one 'S' atom.

ii) The number of atoms present in is 5, i.e., one 'P' atom and four 'O' atoms.

11. Calculate the molar mass of H_2, O_2, Cl_2, CO_2, CH_4, C_2H_6, C_2H_4, NH_3, CH_3OH.

A. The molar mass of H_2 = 2 × H atomic mass = 2 × 1U = 2U

The molar mass of O_2 = 2 × atomic mass of oxygen = 2 × 16U = 32U

The molar mass of Cl_2 = 2 × atomic mass of chlorine = 2 × 35.5U = 71U

The molar mass of CH_4 = atomic mass of C + 4 × atomic mass of H
= 12 U + 4 × 1U = 16U

The molar mass of CO_2 = atomic mass of C + 2 × atomic mass of O
= 12 + 2 × 16 = 44U

The molar mass of C_2H_6 = 2 × atomic mass of C + 6 × atomic mass of H
= 2 × 12U + 6 × 1U
= 24 U + 6U = 30U

The molar mass of C_2H_4 = 2 × atomic mass of C + 4 × atomic mass of H
= 2 × 12 + 4 × 1 = 24 + 4
= 28 U

The molar mass of NH_3 = 1 × atomic mass of N + 3 × atomic mass of H
= 1 × 14 + 3 × 1

$= 14 + 3 = 17U$

The molar mass of CH_3OH = 1× atomic mass of C + 4 × atomic mass of H + 1 × atomic mass of Oxygen

$= 1 \times 12 + 4 \times 1 + 1 \times 16 = 12 + 4 + 16$

The molecular mass of $CH_3OH = 32U$

12. Calculate the formula unit mass of Zn O, Na_2O, K_2CO_3, given atomic mass of Zn = 65U, Na = 23U, K = 39U, C = 12U and O = 16U.

A. The formula unit mass of ZnO = 65 + 16 = 81U

The formula unit mass of $Na_2O = 2 \times 23 + 1 \times 16$

$= 46 + 16 = 62$ U

The formula unit mass of $K_2CO_3 = 2 \times 39 + 1 \times 12 + 3 \times 16$

$= 78 + 12 + 48$

$= 138$ U

13. If one mole of carbon atoms weighs 12grams. What is the mass (in grams) of 1 atom of carbon?

A. 1 mole of carbon atoms = 12g

1 mole of carbon atoms = 6.022×10^{23} C atoms

that means 6.022×10^{23} carbon atoms – 12g

then 1 carbon atoms weight is –?

$$= \frac{1 \times 12}{6.022 \times 10^{23}}$$

The mass of 1 atom of carbon is 1.9926×10^{-23} g

14. Which has more number of atoms, 100g of sodium or 100 grams of iron (given, atomic mass of Na = 23U, Fe = 56 U)?

A. 1 mole of sodium atoms = atomic mass of sodium atoms in grams

1 mole of Na atoms = 23g

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

that means 23g of Na atoms = 6.022×10^{23} Na atoms

then in 100g of Na atoms =? Na atoms

$$= \frac{100 \times 6.022 \times 10^{23}}{23} \text{ Na atoms}$$

$$= \frac{6.022}{23} \times 10^2 \times 10^{23}$$

$= 0.2618 \times 10^{25}$ Na atoms

$= 2.618 \times 10^{24}$ Na atoms

1 Mole of Iron atoms = Atomic mass of Iron atoms in grams

1 Mole of Fe atoms = 56g

1 Mole of Fe atoms = 6.022×10^{23} Fe atoms

That means 56g of Fe atoms = 6.022×10^{23} Fe atoms

Then in 100g of Fe atoms =? Fe atoms

$$= \frac{100 \times 6.022 \times 10^{23}}{56} \text{ Fe atoms}$$

$= 0.1075 \times 10^2 \times 10^{23}$ Fe atoms

$= 0.1075 \times 10^{25}$ Fe atoms

$= 1.075 \times 10^{24}$ Fe atoms

Thus 100g of sodium has more atoms than 100g of Iron.

100g of sodium contains 2.618×10^{24} sodium atoms

and 100g of Iron contains 1.075×10^{24} Iron atoms.