DATE: 20/9/2024 Friday

# Topic:- "Stoichiometery"

* Give short answer.

i) What is mole?

**Definition:**

A mole is an amount of a substance that contains $6.022 \times 10^{23}$ particles of that substance. This experimentally determined number is known as Avogadro's Number. It is represented by $N_A$. It is used for chemical entities that are difficult to measu through other units already existing.

**Example:**

1 mole of C = $6.022 \times 10^{23}$ atoms.

ii) Diferentiate between empirical formula and molecular formula.

| Empirical Formula | Molecular Formula |
|---|---|
| * Empirical formula gives the simplest whole number ratio of atoms of each element of a compound. | Molecular formula shows the actual number of atoms of each element present in a compound. |
| * It does not show | It gives the exac |

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| | |
|---|---|
| atual number of atoms. **Example:** Empirical formula of glucose $CH_2O$. | composition of molecule or compound. **Example:** Molecular formula of glucose is $C_6H_{12}O_6$. |

**iii) What is the number of molecules in 9.0g of steam?**

**Solution:**

Mass in grams = 9.0g

Molar mass of steam ($H_2O$) = 2x1 + 16

= 18g

Avogadro's number = $6.022 \times 10^{23}$

Number of molecules = ?

$$\text{Number of molecules} = \frac{\text{Mass}}{\text{Molar Mass}} \times N_A$$

$$= \frac{9}{18} \times 6.022 \times 10^{23}$$

$$= 3.011 \times 10^{23} \text{ molecules.}$$

**iv) What are the molar masses of Uranium$^{-238}$ and Uranium$^{-235}$?**

Molar mass = Atomic mass

Molar mass of uranium$^{-238}$ = 238g/mol

Molar mass of uranium$^{-235}$ = 235 g/mol

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**v) Why one mole of hydrogen molecules and one mole of H-atoms have different masses.**

## Hydrogen Molecules:

One mole of hydrogen molecule ($H_2$) contains two hydrogen atoms, its molar mass is $1 \times 2 = 2g$

## Hydrogen Atoms:

One mole of hydrogen atom contains only one hydrogen atom, its molar mass $1 \times 1 = 1g$.

That's why one mole of hydrogen molecules and on mole of hydrogen atoms have different masses.

**Q3:- Define:**

## Ion:

Ion is charged specie formed from an atom or chemically bonded group of atoms by adding or removing electrons. Ion may have positive or negative charge.

## Molecular Ion:

When a molecule losses or gains electrons, the resulting specie is called Molecular ion. These are short lived specie and only exist at high temperature. Molecular ions do not form ionic compounds.

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## Formula Unit:

The simplest unit which represents an ionic compound is called formula unit.

## Free Radical:

Free radical is an atom or group of atoms that contains an unpaired electron. Free radical bear no charge.

## Atomic Number:

The number of protons in the nucleus of an atom is known as atomic number. It is indicated by the symbol "Z".

## Mass Number:

The total number of protons and neutrons in an atom is known as its mass number.

## Atomic Mass Unit:

One atomic mass unit (amu) is defined as a mass exactly equal to one twelfth the mass of one C-12 atom.

Mass of one C-12 atom = 12 amu.

$$1 \text{ amu} = \frac{\text{Mass of one C-12 atom}}{12}$$

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**Q4:- Describe how Avogadro's number is related to a mole of any substance.**

Avogadro's number is related to mole of any substance by a relation.

$$\text{no. of moles of a substance} = \frac{\text{no. of molecules of a substance}}{\text{Avogadro's number}}$$

**Q5:- Calculate the no. of moles of each substance in sample with the following masses:**

**a) 2.4g of He:**

Mass of He = 2.4g

Molar Mass of He = 4g

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

$$= \frac{2.4}{4}$$

$$= 0.6 \text{ moles.}$$

**b) 250mg of Carbon:**

Mass of C = 250mg

$$= \frac{250}{1000} \text{ g}$$

$$= 0.25 \text{ g}$$

Molar Mass of C = 12g

$$\text{Number of moles} = \frac{\text{Mass}}{\text{Molar Mass}}$$

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$= \frac{0.25}{12}$

$= 0.021$ moles.

c) **15g of Sodium Chloride:**

Mass of NaCl = 15g

Molar Mass of NaCl = 23 + 35.5

= 58.5g

Number of moles = $\frac{\text{Mass}}{\text{Molar Mass}}$

$= \frac{15}{58.5}$

= 0.256 moles.

d) **40g of Sulphur:**

Mass of S = 40g

Molar mass of S = 32g

Number of moles = $\frac{\text{Mass}}{\text{Molar Mass}}$

$= \frac{40}{32}$

= 1.25 moles

e) **1.5kg of MgO:**

Mass of MgO = 1.5 kg

= 1.5 x 1000

= 1500g

Molar Mass of MgO = 24 + 16

= 40g

Number of moles = $\frac{\text{Mass}}{\text{Molar Mass}}$

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$= \frac{1500}{40}$

$= 37.5$ moles.

**Q6: Calculate the mass in grams of each of the following samples**

**a) 1.2 moles of K:**

Number of moles of K = 1.2 moles

Molar Mass of K = 39g

Mass = Number of moles x Molar Mass

$= 1.2 \times 39$

$= 46.8g$

**b) 75 moles of $H_2$:**

Number of moles of $H_2$ = 75 moles

Molar mass of $H_2 = 2 \times 1 = 2g$

Mass = Number of moles x Molar mass

$= 75 \times 2$

$= 150g$

**c) 0.25 moles of steam:**

Number of moles of $H_2O$ = 0.25 moles

Molar Mass of $H_2O = 2 \times 1 + 16$

$= 18g$

Mass = Number of moles x Molar Mass

$= 0.25 \times 18$

$= 4.5g$

**d) 1.05 moles of $CUSO_4 \cdot 5H_2O$**

Number of moles of $CUSO_4 \cdot 5H_2O = 1.05$ mo

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Molar Mass of $CUSO_4 \cdot 5H_2O = 63.5 + 32 + 4 \times 16 + 5 \times (2 \times 1 + 16)$

$= 249.5 g$

Mass = Number of moles x Molar Mass

$= 1.05 \times 249.5$

$= 261.96 g$

**e) 0.15 moles of $H_2SO_4$**

Number of moles of $H_2SO_4 = 0.15$ moles

Molar mass of $H_2SO_4 = 2 \times 1 + 32 + 4 \times 16$

$= 98 g$

Mass = Number of moles x Molar Mass

$= 0.15 \times 98$

$= 14.7 g$

**Q7:- Calculate the number of molecules present in each of the following samples:**

**a) 2.5 moles of Carbon dioxide:**

Number of moles = 2.5 moles

Avogadro's number = $6.022 \times 10^{23}$

Number of molecules = ?

Number of molecules = Number of moles $\times N_A$

$= 2.5 \times 6.022 \times 10^{23}$

$= 1.505 \times 10^{24}$ molecules

**b) 3.4 moles of $NH_3$:**

Number of moles = 3.4 moles

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Avogadro's Number = $6.022 \times 10^{23}$
Number of Molecules = ?
Number of Molecules = Number of moles × $N_A$.
$= 3.4 \times 6.022 \times 10^{23}$
$= 2.05 \times 10^{24}$ molecules

c) **1.09 moles of $C_6H_6$:**
Number of moles = 1.09 moles
Avogadro's number = $6.022 \times 10^{23}$
Number of molecules = ?
Number of molecules = Number of moles × $N_A$.
$= 1.09 \times 6.022 \times 10^{23}$
$= 6.56 \times 10^{23}$ molecules.

d) **0.01 moles of $CH_3COOH$:**
Number of moles = 0.01 moles
Avogadro's number = $6.022 \times 10^{23}$
Number of molecules = ?
Number of molecules = Number of moles × $N_A$.
$= 0.01 \times 6.022 \times 10^{23}$
$= 6.022 \times 10^{21}$

28:- **Decide whether or not each of the following is an example of empirical formula:**

a) **$Al_2Cl_6$**
This formula is not in its simplest form, so this is not an empirical formula.

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b) $Hg_2Cl_2$

This formula is not in its simplest form, so this is not an empirical formula.

c) NaCl

This formula is in its simplest form, so this is an empirical formula.

d) $C_2H_6O$

This formula is in its simplest form, so this is an empirical formula.

**Q9:- TNT or trinitrotoluene is an explosive compound used in bombs. It contains 7 C-atoms, 6 H-atoms, 5 N-atoms and 6 O-atoms. Write its empirical formula.**

There are:

7 carbon (C) atoms

6 Hydrogen (H) atoms

5 Nitrogen (N) atoms

6 Oxygen (O) atoms

The empirical formula is the simplest whole-number ratio. Therefore, the empirical formula of trinitrotoluene (TNT) is:

$C_7H_6N_5O_6$

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**Q10: A molecules contains four**

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Phosphorus atoms and ten Oxygen atoms. Write the empiric formula of this compound. Also determine the molar mass of this molecule.

There are:

4 Phosphorus (P) atoms.

10 Oxygen (O) atoms.

**Molecular Formula:**

$P_4O_{10}$

**Molar Mass:**

Molar mass of $P_4O_{10} = 4 \times 31 + 10 \times 16$

$= 124 + 160$

$= 284g$

**Empirical Formula:**

The empirical formula is the simplest whole-number ratio. Therefore, the empirical formula of $P_4O_{10}$ is: $P_2O_5$.

Q11:- Indigo ($C_{16}H_{10}N_2O_2$) the dye used to colour blue jeans is derived from a compound known as indoxyl ($C_8H_7ON$). Calculate the molar masses of these compou Also write their empirical formula.

**Indigo ($C_{16}H_{10}N_2O_2$):**

Molar mass $= 16 \times 12 + 10 \times 1 + 2 \times 14 + 2 \times 16$

$= 262g$

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## Empirical Formula:

The empirical formula is the simplest whole-number ratio. Therefore, the empirical formula is: $C_8H_5NO$

## Indoxyl ($C_8H_7ON$):

Molar mass = $8\times12+7\times1+16+14$

= 133g

## Empirical Formula:

The empirical formula is the simplest whole-number ratio. Therefore the empirical formula is $C_8H_7ON$.

12. Identify the substances that has formula mass of 133.5amu

a) $MgCl_2$

Formula mass = $24+2\times35.5$

= $24+71$

= 95 amu

b) $S_2Cl_2$

Formula mass = $2\times32+2\times35.5$

= $64+71$

= 135 amu

c) $BCl_3$

Formula mass = $11+3\times35.5$

= $11+106.5$

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= 117.5 amu

d) $AlCl_3$

Formula mass = 27 + 3 × 35.5

= 27 + 106.5

= 133.5 amu

The substance with a formula mass of 133.5 amu is $AlCl_3$

**Q13: Calculate the number of atoms in each of the following samples**

a) **3.4 moles of nitrogen atoms:**

Number of moles = 3.4 moles

Number of atoms = No. of moles × $N_A$

= $3.4 \times 6.022 \times 10^{23}$

= $2.05 \times 10^{24}$ atoms

b) **23g of Na:**

Molar mass of Na = 23 g/mol

Number of moles = $\frac{23}{23}$ = 1 mole

Number of atoms = No. of moles × $N_A$

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

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

c) **5g of H atoms:**

Molar mass of H = 1 g/mol

Number of moles = $\frac{5}{1}$ = 5 moles

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Number of atoms = No. of moles × $N_A$

$= 5 \times 6.022 \times 10^{23}$

$= 3.011 \times 10^{24}$ atoms

**Q14.. Calculate the mass of the following**

**a) $3.24 \times 10^{18}$ atoms of iron:**

Number of atoms = $3.24 \times 10^{18}$ atoms

Mass = $\frac{\text{No. of atoms} \times \text{Molar mass}}{N_A}$

$= \frac{3.24 \times 10^{18} \times 56}{6.022 \times 10^{23}}$

$= 3.01 \times 10^{-4}$ g

**b) $1 \times 10^{25}$ molecules water:**

Number of molecules = $1 \times 10^{25}$ molecules

Molar mass of $H_2O = 1 \times 2 + 16 = 18$ g

Mass = $\frac{\text{No. of atoms} \times \text{Molar mass}}{N_A}$

$= \frac{1 \times 10^{25} \times 18}{6.022 \times 10^{23}}$

$= 2.99 \times 10^{2}$ g

**c) $2 \times 10^{10}$ molecules of nitrogen gas:**

Number of molecules = $2 \times 10^{10}$ molecules

Molar mass of $N_2 = 2 \times 14 = 28$ g

Mass = $\frac{\text{No. of atoms} \times \text{Molar mass}}{N_A}$

$= \frac{2 \times 10^{10} \times 28}{6.022 \times 10^{23}}$

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$= 9.3 \times 10^{-3}$ g

d) $3 \times 10^6$ atoms of Al

Number of atoms = $3 \times 10^6$ atoms

Molar mass of Al = 27 g

$$\text{Mass} = \frac{\text{No. of atoms} \times \text{Molar mass}}{N_A}$$

$$= \frac{3 \times 10^6 \times 27}{6.022 \times 10^{23}}$$

$$= 1.346 \times 10^{-16} \text{ g}$$

Q15:- Balance the following chemical equations.

a) $Na_{(s)} + H_2O_{(l)} \longrightarrow NaOH_{(aq)} + H_{2(g)}$

Balanced Equation:-

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

b) $NH_{3(g)} \longrightarrow N_{2(g)} + H_{2(g)}$

Balanced Equation:-

$2NH_3 \rightarrow N_2 + 3H_2$

Q16:- Potassium is Group 1 element. It is silvery white metal. It burns in air and form both potassium oxide and potassium nitride. The nitride ion is $N^{3-}$.

a) Predict the formula of potassium

and potassium nitride.

When potassium burns in air, it reacts with both ($O_2$) and ($N_2$) to form potassium oxide ($K_2O$) and potassium nitride ($K_3N$). Here is how the reaction takes place.

## Formation of Potassium Oxide:

$$4K + O_2 \longrightarrow 2K_2O$$

In this reaction each potassium atom loses one $\bar{e}$ to form $K^+$ ions, while oxygen gains two $\bar{e}$ to form the oxide ion.

## Formation of Potassium Nitride:

$$6K + N_2 \longrightarrow 2K_3N$$

Each nitrogen atom gains 3 $\bar{e}$, resulting in the formation of nitride ions $N^{3-}$, while each K loses one $\bar{e}$ to form $K^+$ ions.

b) 0.5 g sample of K was added in 100 $cm^3$ of water.

$$K_{(s)} + H_2O_{(l)} \longrightarrow KOH_{(aq)} + H_{2(g)}$$

Show that $1.28 \times 10^{-2}$ mole of K were added to water.

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Mass of K = 0.5 g
Molar mass of K = 39 g/mol

Number of moles = Mass / Molar mass
= 0.5 / 39
= $1.28 \times 10^{-2}$ mole

**c) Balance the above equation.**

$2K_{(s)} + 2H_2O_{(l)} \rightarrow 2KOH_{(aq)} + H_{2(g)}$

**d) Transform above chemical equation into ionic equation**

Write the substances that are soluble in water in their dissociated form.

$K_{(s)} + H_2O_{(l)} \rightarrow K^+_{(aq)} + OH^-_{(aq)} + H_{2(g)}$

**e) Calculate the number of atoms present in the sample of K.**

Number of moles of K = $1.28 \times 10^{-2}$ moles
Avogadro's number = $6.022 \times 10^{23}$

Number of atoms = No. of moles $\times N_A$
= $1.28 \times 10^{-2} \times 6.022 \times 10^{23}$
= $7.7 \times 10^{21}$ atoms.

**f) Predict period number of potassium in the periodic table.**

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Atomic number of K = 19

Electronic configuration = $1s^2, 2s^2 2p^6, 3s^2, 3p^6, 4s^1$

Valence shell electronic configuration = $4s^1$

Period = n number of shell = 4rth

This element belongs to 4rth period in periodic table.