

Chapter	4 Stoichiometry	Class	1 st Year	Subject	Chemistry
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Give Short Answers of the Following Questions

1. How is the concept of mole derived from Avogadro's number?

Ans. Amedeo Avogadro proposed that:

"Equal volumes of gases, at the same temperature and pressure, contain equal numbers of molecules."

$$N_A = 6.02214076 \times 10^{23} \text{ particles per mole}$$

The mole (mol) was then defined as:

"The amount of substance containing exactly N_A elementary entities (atoms, molecules, ions etc)."

This means:

$$1 \text{ mol} = N_A \text{ particles} = 6.022 \times 10^{23} \text{ particles}$$

Derivation of molar mass

- The atomic mass unit (u) is defined based on ^{12}C ($12 \text{ u} = \text{mass of one } ^{12}\text{C} \text{ atom}$).
- Since N_A atoms of ^{12}C weigh 12 grams, the molar mass (mass per mole) is numerically equal to the atomic/molecular mass in u:

$$\text{Molar mass of } ^{12}\text{C} = 12 \text{ g/mol}$$

We can calculate the number of moles by dividing the number of particles by Avogadro's number.

2. Define the following terms with one example in each case.

(a) Molar Mass (b) Molar volume (c) Molar concentration

Ans. (a) Molar Mass

The mass of one mole of a substance expressed in grams is called molar mass.

$$\text{Molar mass of } \text{CCl}_4 = \text{Molar mass of one C} + \text{Molar mass of C} \times 4$$

$$\text{Molar mass of } \text{CCl}_4 = 12.0 \times 1 + 35.5 \times 4$$

$$\text{Molar mass of } \text{CCl}_4 = 12.0 + 142.0 = 154.0 \text{ g}$$

(b) Molar VOLUME

The volume of one mole of an ideal gas at STP (Standard temperature and pressure) is called molar volume. Its value is equal to 22.414 dm^3 . The value of molar volume is commonly rounded to 22.4 dm^3 . It is denoted by V_m . By using molar volume relationship, mass or mole of a gas at STP can be

converted into volume, and vice versa.

(c) Molar Concentration

Molar concentration of solutions is given as mol/dm^3 , which is the number of moles of a substance (reactant or product) dissolved per volume of a solution in dm^3 . The relationship between number of moles and molar concentration is given by

$$n = C \times V$$

$$C = \frac{n}{V}$$

where C is the molar concentration and V is the volume of the solution.

$$\text{Molar Concentration (C)} = \frac{\text{Number of moles (n)}}{\text{Volume in } \text{dm}^3 \text{ (V)}}$$

3. What do you mean by molar volume of a gas? How Avogadro's number is related with molar volume?

Ans. Molar Volume of a Gas:

The molar volume of a gas is the volume occupied by one mole of any ideal gas at standard

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temperature and pressure (STP).

- At STP (0°C or 273.15 K and 1 atm pressure),
- 1 mole of any ideal gas occupies 22.414 dm³ (or liters).

Relation with Avogadro's Number:

Avogadro's number (6.022×10^{23} particles/mol) tells us that 1 mole of gas contains this many molecules. Therefore, 22.414 dm³ of any ideal gas at STP contains exactly 6.022×10^{23} molecules.

Conclusion:

- Molar volume links the physical volume of a gas to the number of particles (via Avogadro's number) under standard conditions.

4. 39 g of potassium and 56 g of iron have equal number of atoms in them. Justify.

Ans. Molar mass of K (potassium) = 39 g/mol

Molar mass of Fe (iron) = 56 g/mol

It means Moles of K = $39 \text{ g/mol} / 39 \text{ g} = 1 \text{ mol}$

Moles of Fe = $56 \text{ g/mol} / 56 \text{ g} = 1 \text{ mol}$

We know that 1 mole of any element contains Avogadro's number of atoms = 6.022×10^{23} atoms Thus,

39 g of K = 1 mol = 6.022×10^{23}

56 g of Fe = 1 mol = 6.022×10^{23}

In short, 39 g of potassium and 56 g of iron contain an equal number of atoms, because both represent 1 mole of their respective elements.

5. 4 g of He, 17 g of NH₃ and 64 g of SO₂ occupy separately the volumes of 22.414 dm³ although the sizes and masses of molecules of three gases are very different from each other. Explain.

Ans. Molar Masses: He (helium) 4 g/mol, NH₃ (ammonia) 17 g/mol, SO₂ (sulfur dioxide) 64 g/mol At STP (Standard Temperature and Pressure), 1 mole of any ideal gas occupies: 22.414 dm³

Even though the masses and sizes of individual He, NH₃, and SO₂ molecules differ:

The **number of molecules** in each case is the same:

1 mol = 6.022×10^{23} molecules

The volume a gas occupies depends mainly on:

- Number of particles (moles)
- Temperature
- Pressure

It does not depend on mass or size of individual molecules (according to ideal gas behaviour).

Although He, NH₃, and SO₂ differ in molecular mass:

If you take **1 mole of each**, they will all occupy **22.414 dm³** at STP.

Because the **volume of a gas** is determined by **number of moles**, not the mass of molecules.

6. Do you think 1 mole of H₂ and 1 mole of NH₃ at 0 °C and 1 atm will have Avogadro's number of particles?

Ans. According to Avogadro's Law:

Equal volumes of all gases at the same temperature and pressure contain an equal number of molecules. 1 mole of H₂ (hydrogen gas) and 1 mole of NH₃ (ammonia gas) at 0°C and 1 atm will each contain Avogadro's number of particles, i.e.: 6.022×10^{23} molecules

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1 mole of H₂ gas = 6.022 x 10²³ H₂ molecules,

1 mole No side reaction occurs of NH₃ gas = 6.022 x 10²³ NH₃, molecules.

7. What is stoichiometry? Give the basic assumptions of stoichiometric calculations.

Ans. Stoichiometry

Stoichiometry is a branch of chemistry which tells us the quantitative relationship between reactants and products in a balanced chemical equation.

Assumptions of Stoichiometry:

The following assumptions must be made while performing stoichiometric calculations:

- All the reactants are completely converted into the products.
- Law of conservation of mass and law of definite proportions are obeyed.
- No side reaction occurs.

8. What is a limiting reactant? How does it control the quantity of the product for

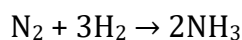
Ans. The limiting reactant (or limiting reagent) is the reactant that is completely consumed first during a chemical reaction. Once it is used up, the reaction stops, and no more product can form, even If other reactants are still available.

Chemical reactions require specific mole ratios between reactants.

If one reactant runs out, the remaining reactants can't react further - they become excess.

The amount of product is directly determined by how much of the limiting reactant was present at the start.

Example:



Suppose we have:

1 mole of N₂ and 2 moles of H₂. According to the equation, we need 3 moles of H₂ for every 1 mole of N₂. But we only have 2 moles of H₂. Thus H₂ is the limiting reactant.

9. Differentiate theoretical and actual yields. How is the percentage yield of a reaction calculated?

Ans. Differentiate Between Theoretical and Actual Yield

Theoretical yield	Actual yield
1. The amount of product calculated from a balanced chemical equation is called theoretical yield.	1. The amount of product obtained while performing a chemical reaction is called actual yield.
2. It is also called expected yield or calculated yield.	2. It is also called experimental yield.
3. Theoretical yield is always greater than actual yield.	3. Actual yield is always lesser than theoretical yield.
4. There is no need to perform experiment. It is easily calculated from balanced chemical equation.	4. In order to get actual yield experiment has to be performed.

We can calculate the percentage yield of a chemical reaction with the help of actual yield and theoretical yield of the reaction. The efficiency of a reaction is also expressed in the form of percentage yield.

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$$\text{Percentage yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

Greater the percentage yield, more amount of reactants will convert into product and high will be the efficiency of the reaction i.e. % age yield $\propto$ Efficiency of the reaction.

10. What are the factors which are mostly responsible for the low yield of the products in chemical reactions?

Ans. Actual yield of a chemical reaction is usually lesser than theoretical yield due to many reasons. The reasons are:

- i. Practically inexperienced worker has many shortcomings and cannot get expected yield.
- ii. Mechanical loss during experimentation e.g., filtration, separation by distillation or by a separating funnel, washing, drying and crystallization if not properly carried out, decrease the yield.
- iii. Some of the reactants might take part in a competing side reaction.
- iv. The reaction might be reversible.
- v. The reactants might be impure.
- vi. Sometimes the reaction conditions are not suitably maintained.