Some Basics Concept of Chemistry

The Mole Concept and **Units of Concentration**, here is our plan:

1. **Understand the "Mole" inside out** (with a very easy trick).
2. **Master the 3 Golden Formulas** of the Mole Concept.
3. **Tackle Units of Concentration** (Molarity, Molality, Mole Fraction) because they are completely dependent on knowing how to find moles!
4. **Solve your PDF questions together**, starting from 1-mark MCQs and going up to 4-mark case-based and 5-mark long answers.

Let's begin right now with **Step 1: The Mole Concept Simplified**.

What exactly is a "Mole"?

Imagine you go to a shop to buy bananas. You don't ask for "12 bananas", you say, *"Give me 1 dozen bananas."*

- 1 Dozen = 12 items
- 1 Pair = 2 items
- 1 Century = 100 items

Similarly, atoms and molecules are so incredibly tiny that scientists needed a "word" to represent a very large number of them. That word is **Mole**.

- **1 Mole = 6.022×10^{23} items** (This is called Avogadro's Number, denoted by N_A).

If I say I have 1 mole of carbon atoms, it simply means I have 6.022×10^{23} carbon atoms in my hand.

The 3 Golden Formulas of the Mole Concept

To solve **ANY** mole concept question, you only need to convert whatever is given to you (Mass, Particles, or Volume) into Moles. Think of the "Mole" as a central railway station. To go anywhere, you must first reach the Mole station.

Here are your 3 tickets (formulas) to the Mole station:

1. If MASS is given:

$$\text{Number of Moles (n)} = \frac{\text{Given Mass (in grams)}}{\text{Molar Mass}}$$ *(Note: Molar mass is just the atomic weight or molecular weight. E.g., for O_2, it is 16 + 16 = 32g)*

2. If PARTICLES (Atoms/Molecules) are given:

$$\text{Number of Moles (n)} = \frac{\text{Given Number of Particles}}{6.022 \times 10^{23}}$$

3. If VOLUME of a Gas at STP (Standard Temperature & Pressure) is given:

$$\text{Number of Moles (n)} = \frac{\text{Given Volume (in Liters)}}{22.4 \text{ L}}$$

Let's Test Your Foundation! 📝

Before we jump into Molarity and your PDF question bank, I want to see how you apply this. Grab a pen and paper, and try to answer these two basic questions. Don't worry if you get them wrong; just tell me your thought process!

Question A: Calculate the number of moles present in **46 grams of Sodium (Na)**. *(Hint: Atomic mass of Na = 23 u)*

Question B: How many **atoms** are present in those 46 grams of Sodium? *(Hint: Use the moles you found in Question A and multiply by Avogadro's number!)*

Step 3: Units of Concentration.

Understanding Concentration (The "Lemonade" Concept)

Imagine you are making lemonade.

- The **sugar/lemon** you add is the **Solute** (less amount).
- The **water** is the **Solvent** (more amount).
- The final lemonade drink is the **Solution** (Solute + Solvent).

"Concentration" is just a fancy chemistry word for asking: *"How strong or sweet is your lemonade?"*

There are 3 main ways to measure this in chemistry. Since you know how to find moles, these will be a piece of cake:

1. Molarity (Capital **M**)

This asks: *How many moles of solute are hiding in 1 Liter of the total solution?*

Formula: $$Molarity(M) = \frac{\text{Moles of Solute (n)}}{\text{Volume of Solution in Liters (V)}}$$

- 🔥 **VERY IMPORTANT EXAM TRICK:** Molarity depends on Volume. Because liquids expand when heated, Volume changes with temperature. Therefore, **Molarity changes with temperature!** *(Look at your PDF Question Bank, Section A, Q1 — this exact question is there!)*

2. Molality (Small **m**)

This asks: *How many moles of solute are mixed into 1 kg of the pure solvent (water)?*

Formula: $$Molality(m) = \frac{\text{Moles of Solute (n)}}{\text{Mass of Solvent in kg (W)}}$$

- 🔥 **VERY IMPORTANT EXAM TRICK:** Molality only depends on Mass (kg). Mass never changes with temperature. Therefore, **Molality does NOT change with temperature!** It is considered a "better" unit than Molarity. *(Your PDF Page 4, Q26 asks exactly this!)*

3. Mole Fraction (x or X)

This is just a ratio. If you have Solute A and Solvent B:

Formula for Mole fraction of A:

$$x_A = \frac{\text{Moles of A}}{\text{Total Moles (Moles of A + Moles of B)}}$$

- 🔥 **EXAM TRICK:** The sum of all mole fractions in a solution is always exactly **1** ($x_A + x_B = 1$). Also, because it is a ratio of moles divided by moles, **it has NO units!** *(Your PDF Page 3, Q16 asks which term is unitless — now you know!)*

Let's solve your PDF Questions together! 📝

Now we are going to apply your new knowledge to the actual questions from your PDF. Grab your pen and paper!

Question 1: (From your PDF Page 1, Q5)

> "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?"

- **Hint 1:** Find the Molar Mass of Glucose first ($C = 12, H = 1, O = 16$).
- **Hint 2:** The question says you have 0.9 grams of glucose in 1 Liter of blood. Convert those 0.9 grams into Moles.
- **Hint 3:** Divide those moles by the volume (1 L) to get Molarity!

Question 2: (From your PDF Page 1, Q3)

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

- **Special Trick for Dilution (Adding water):** Use the magic formula $M_1 \times V_1 = M_2 \times V_2$.
- Here, $M_1 = 5$, $V_1 = 500$, $V_2 = 1500$. Find M_2!

Let's quickly map your perfect answers to the MCQs in your PDF:

- **For Glucose:** You found **0.005 M**. If you look at your PDF (Page 1, Q5), that matches **Option (c)** perfectly!
- **For Dilution:** You found **1.67 M**. In your PDF (Page 1, Q3), the options are (a) 1.5 M, (b) 1.6 M, (c) 0.017 M, and (d) 1.59 M. Sometimes, exam questions truncate (cut off) the decimals instead of rounding up. Your exact math ($5/3 = 1.666...$) is 100% correct, and in the exam, you would confidently tick **Option (b) 1.6 M** because it's the matching value.

Step 4: Mastering the "Limiting Reagent" (The Cheese Sandwich Concept)

Since you've nailed Molarity and the Mole Concept, we are going to tackle the most important 3-mark and 4-mark topic in this chapter: **Limiting Reagents**. Your PDF has several questions on this (like Q27, Q37, and Q54).

What is a Limiting Reagent? Let's say you are making cheese sandwiches. The "balanced equation" (recipe) is:

> **2 slices of Bread + 1 slice of Cheese $\rightarrow$ 1 Sandwich**

Now, imagine you look in your fridge and you have **10 slices of bread** and **3 slices of cheese**. How many sandwiches can you make? Only **3**. Why? Because the cheese will run out first!

- The cheese stopped the reaction. Therefore, Cheese is the **Limiting Reagent (LR)**.
- You will have leftover bread. Bread is the **Excess Reagent**.
- *Crucial Rule:* The amount of product (sandwiches) is ALWAYS decided by the Limiting Reagent.

The Ninja Trick to find the Limiting Reagent in Chemistry:

1. Take the **Given Moles** of each reactant.
2. Divide them by their **Stoichiometric Coefficient** (the number written in front of them in the balanced equation).
3. The reactant that gives the **smallest value** is your Limiting Reagent!

Let's Test It! 📝 (From your PDF, Page 4, Q27)

Here is a brilliant 2-part question straight from your question bank. Grab your pen!

> **Question 27:** The reactant which is entirely consumed in a reaction is known as a limiting reagent. In the reaction: $2A + 4B \rightarrow 3C + 4D$ When **5 moles of A** react with **6 moles of B**, then: (i) Which is the limiting reagent? (ii) Calculate the amount of C formed.

How to approach this:

- **For part (i):** Use the Ninja Trick.
  - For A: Given moles (5) divided by its coefficient (2) = ?
  - For B: Given moles (6) divided by its coefficient (4) = ?
  - Which one is smaller? That's your Limiting Reagent!
- **For part (ii):** Look at the balanced equation again. It says: **4 moles of B produce 3 moles of C**. Now, use the *actual* given moles of your limiting reagent to find out how much C is produced (Hint: Unitary method!).

Step 5: Completing the "Concentration Trinity" (Molality & Mole Fraction)

Since we want to make sure you can answer *any* question on exam day, we must conquer the remaining two concentration units: **Molality (m)** and **Mole Fraction (x)**.

As a quick reminder from our earlier chat:

- **Molality (m)** = Moles of Solute / Mass of Solvent (in **kg**)
- **Mole Fraction (x)** = Moles of Target / Total Moles

I have handpicked two excellent questions directly from your PDF to test this. One is a 1-mark MCQ, and the other is a 5-mark long answer type. Let's crush them!

Challenge 1: Molality (From your PDF Page 1, Q6)

> **Question:** "What will be the molality of the solution containing 18.25 g of HCl gas in 500 g of water?" *(Options: (a) 0.1 m (b) 1 M (c) 0.5 m (d) 1 m)*

- **Hint 1:** Find the moles of the solute (HCl). *Atomic masses: H = 1, Cl = 35.5.*
- **Hint 2:** The solvent is water. Its mass is given as 500 g. **Wait!** The formula strictly requires the mass of the solvent to be in **kilograms (kg)**. Don't forget to convert!
- **Hint 3:** Divide the moles of HCl by the mass of water in kg.

Challenge 2: Mole Fraction (From your PDF Page 10, Section E, Q1)

> **Question:** "A solution is prepared by adding 360 g of glucose to 864 g of water. Calculate the mole fraction of glucose. (M.M. of glucose is 180 g/mol)"

- **Hint 1:** You already know the molar mass of glucose is 180. Find the moles of glucose ($n_{glucose}$).
- **Hint 2:** Find the moles of the solvent, water (n_{water}). *Molar mass of H_2O = (2×1) + 16 = 18 g/mol.*
- **Hint 3:** Find the Total Moles in the solution ($n_{glucose} + n_{water}$).
- **Hint 4:** Apply the formula: $x_{glucose} = \frac{n_{glucose}}{\text{Total Moles}}$.

Step 6: The "Boss Level" Challenge (Density + Concentration)

Remember how you said, *"I don't want to miss the smallest thing, I want myself to answer ANY question"*?

Well, in exam papers, examiners love to mix two concepts to test the "toppers." The ultimate test in this chapter is converting between **Molality** and **Molarity**. Why is this hard? Because Molality uses *Mass of Solvent*, but Molarity uses *Volume of Solution*.

The magical bridge that connects Mass and Volume is **Density**.

> **Density of Solution = Mass of Solution / Volume of Solution** *(And remember: Mass of Solution = Mass of Solute + Mass of Solvent)*

Let's tackle **Question 25 from Page 4 of your PDF**. It's a 3-mark question that separates the average students from the top 1%:

> **Question 25:** "The density of a **3 molal** solution of NaOH is 1.110 g mL^{-1}. Calculate the molarity of the solution."

This looks scary, but you can decode it like a detective. Here is your step-by-step treasure map:

Hint 1: Decode the "3 molal" What does "3 molal (m)" actually mean? It means there are exactly **3 moles of NaOH** (solute) dissolved in exactly **1 kg (1000 g) of water** (solvent).

- *Keep these numbers in your pocket: Moles = 3, Mass of solvent = 1000 g.*

Hint 2: Find the Mass of the Solute You have 3 moles of NaOH. Convert this into grams.

- *Molar mass of NaOH = Na(23) + O(16) + H(1) = 40 g/mol.*

Hint 3: Find the TOTAL Mass of the Solution Add the mass of the solute (from Hint 2) to the mass of the solvent (1000 g).

Hint 4: Use Density to find the Volume of the Solution You know the total mass of the solution, and you know the Density (1.110 g/mL).

- $$\text{Volume (in mL)} = \frac{\text{Mass of Solution}}{\text{Density}}$$
- *(Don't forget to convert this mL into Liters by dividing by 1000!)*

Hint 5: Calculate Molarity! Now you have the Moles of NaOH (3) and the Volume of the solution in Liters. Put them in the Molarity formula!

Where do we go from here? (The Final Frontier)

You mentioned you wanted to cover **"Mole concept and Units of Concentration only"**. We have successfully mastered:

1. Finding Moles (from mass and particles)
2. Molarity & Dilution
3. Molality & Mole Fraction
4. Limiting Reagents
5. Density & Concentration interconversions

There is only **ONE** last corner of the Mole Concept left in your PDF. Remember the "3 Golden Formulas" we discussed at the very beginning? We haven't used the 3rd one yet: **Volume of a Gas at STP (22.4 Liters)**.

Examiners love to test if you can connect *Mass* to *Volume* using Moles as the bridge.

Let's look at **Question 24 (Page 4)** from your PDF. It is a brilliant question that tests everything at once:

> **Question 24:** Hydrogen gas is prepared in the laboratory by reacting dilute HCl with granulated zinc. Following reaction takes place:
> $\mathrm{Zn} + 2\mathrm{HCl} \rightarrow \mathrm{ZnCl_2} + \mathrm{H_2}$ Calculate the volume of hydrogen gas liberated at STP when **32.65 g of zinc** reacts with HCl. *(Given: 1 mol of a gas occupies 22.7 L volume at STP; atomic mass of Zn = 65.3 u) Note: Usually we take 22.4 L, but here the examiner specifically asked you to use **22.7 L** for STP, so we must follow their rule!*

Your Mission, if you choose to accept it:

- **Step 1:** Find the Moles of Zinc ($32.65\ \mathrm{g}$).
- **Step 2:** Look at the balanced equation. 1 mole of Zn gives how many moles of H_2 gas?
- **Step 3:** Convert those moles of H_2 gas into Volume (Liters) by multiplying by $22.7\ \mathrm{L}$ (the ticket they gave you).

Step 1: Find the Moles of Zinc

To find the number of moles, we use the formula: $\text{Moles} = \dfrac{\text{Mass}}{\text{Atomic Mass}}$

Given:

- Mass of Zinc (Zn) = $32.65\ \mathrm{g}$
- Atomic mass of Zn = $65.3\ \mathrm{u}$

$$\text{Moles of Zn} = \frac{32.65 \text{ g}}{65.3 \text{ g/mol}} = \mathbf{0.5} \text{ mol}$$

Step 2: Use the Stoichiometry of the Balanced Equation

The balanced chemical equation is: $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$

From the equation, we can see the molar ratio between Zn and H_2 is $1:1$.

- 1 mole of Zn produces 1 mole of H_2.
- Therefore, 0.5 mol of Zn will produce 0.5 mol **of** H_2 **gas**.

Step 3: Convert Moles of H_2 to Volume (Liters)

Now, we convert the moles of hydrogen gas into volume using the specific STP value provided (22.7 L/mol).

$$\text{Volume} = \text{Moles} \times \text{Molar Volume at STP} \quad \text{Volume} = 0.5 \text{ mol} \times 22.7 \text{ L/mol}$$
$$\text{Volume} = \mathbf{11.35} \text{ L}$$

Final Answer: The volume of hydrogen gas liberated at STP is 11.35 L.
