

- 1. Molar Volume
- 2. Molar Concentration

Molar Volume

WHAT IS VOLUME?

- The amount of space that an object takes up
- A solid's or liquid's volume is determined by the size and space of its particles
- At higher temperatures, particles are moving faster, hitting each other and bouncing further apart
- Volume is greater at higher temperatures

Mass of a mole of substance is called:
molar mass
Volume of a mole of substance is called:
molar volume

Avogadro's Hypothesis

- Equal volumes of different gases, measured at the same temperature and pressure, have equal number of particles
- Standard Temperature & Pressure (STP)
 - 0°C
 - 101.3 kPa

The molar volume at STP is:
22.4 L
Conversion Factor:
1 mol = 22.4 L @ STP

Example:

1. What is the volume of 1.3 mol of NO₂ at STP?

$$1.3 \cancel{\text{mol NO}_2} \times \frac{22.4 \text{ L}}{1 \cancel{\text{mol}}} = \underline{29 \text{ L NO}_2}$$

2. What volume of oxygen gas at STP contains 2.33 mol of O₂?

$$2.33 \cancel{\text{mol O}_2} \times \frac{22.4 \text{ L}}{1 \cancel{\text{mol}}} = \underline{52.2 \text{ L O}_2}$$

3. Natural gas is used to heat many homes. It consists primarily of methane, CH₄. What is the mass of 8.9 L of CH₄ at STP?

$$\text{CH}_4 = 16.05 \text{ g/mol}$$

$$8.9 \text{ L}_{\text{CH}_4} \times \frac{1 \text{ mol}}{22.4 \text{ L}} \times \frac{16.05 \text{ g}}{1 \text{ mol}} = \boxed{6.4 \text{ g CH}_4}$$

4. How many moles of SO₂ are in 9.5 L of SO₂ at STP?

$$9.5 \text{ L}_{\text{SO}_2} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = \boxed{0.42 \text{ mol SO}_2}$$

5. 6.00 L of air at STP is compressed into a scuba tank. How many moles of air are in the tank?

$$6.00 \text{ L}_{\text{air}} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = \boxed{0.268 \text{ mol air}}$$

6. Silicon dioxide, better known as quartz, has a molar volume of 22.8 cm³/mol. What is the volume of 0.39 mol of SiO₂?

*not at STP!

↑
volume

$$0.39 \text{ mol}_{\text{SiO}_2} \times \frac{22.8 \text{ cm}^3}{1 \text{ mol}} = \boxed{8.9 \text{ cm}^3 \text{ SiO}_2}$$

7. H₂S gas is released from rotten eggs. What volume of H₂S gas at STP contains 17.0 g H₂S?

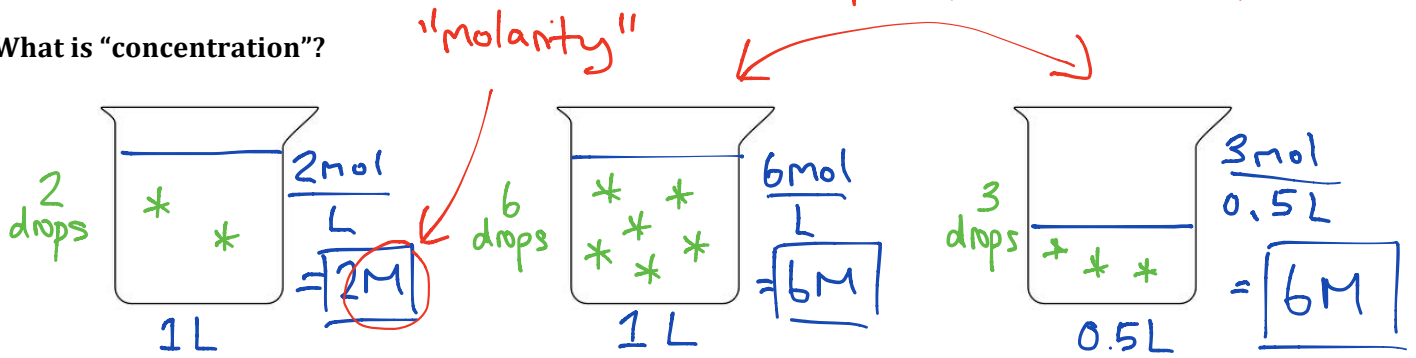
$$\text{H}_2\text{S} = 34.09 \text{ g/mol}$$

$$17.0 \text{ g}_{\text{H}_2\text{S}} \times \frac{1 \text{ mol}}{34.09 \text{ g}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = \boxed{11.2 \text{ L H}_2\text{S}}$$

Molar Concentration

equal concentration

What is "concentration"?



Solute = the dissolved substance (ex. food colouring, salt)

Solvent = the liquid in which the solute dissolves (ex. water)

Molarity (M) = number of moles of the chemical per litre of solution

Conversion factor = $\frac{\text{mol}}{1 \text{ L}}$

Example 1:

What does 2.0 M NaOH mean?

2.0 moles of NaOH per 1 liter of solution

Example 2:

Which solution has more solvent per litre: 5.0 M HCl or 10. M HCl?

They have the same!

$\frac{5.0 \text{ mol}}{1 \text{ L}}$ $\frac{10.0 \text{ mol}}{1 \text{ L}}$

Which solution is more concentrated?

10. M HCl (it has more solute)

Example 3:

The average concentration of seawater is 0.60M. How many moles of salt are in a bucket containing 435 mL of seawater?

$\frac{0.60 \text{ mol}}{1 \text{ L}}$ Convert to L

$435 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.60 \text{ mol}}{1 \text{ L}} = 0.26 \text{ mol of seawater}$

Example 4:

What volume of 3.0M HCl should a chemist dispense to obtain 0.25 mol HCl?

$$0.25 \text{ mol HCl} \times \frac{1 \text{ L}}{3.0 \text{ mol}} = 0.083 \text{ L HCl} = 83 \text{ mL HCl}$$

Example 5:

How many mol are in 0.72 L of 2.5 M of NaOH?

$$0.72 \text{ L NaOH} \times \frac{2.5 \text{ mol}}{1 \text{ L}} = 1.8 \text{ mol NaOH}$$

Example 6:

What molar concentration of KCl is produced by measuring out 1.0 g KCl and adding water to make a .350 L solution?

$$\frac{1.0 \text{ g}}{0.350 \text{ L}} \times \frac{1 \text{ mol}}{74.55 \text{ g}} = \frac{0.038 \text{ mol}}{\text{L}} = 0.038 \text{ M KCl}$$

Practice Problems:

8. What mass of calcium chloride would you need to prepare 500.0 mL with a concentration of 1.5 M?

$$500.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1.5 \text{ mol}}{1 \text{ L}} \times \frac{110.98 \text{ g}}{\text{mol}} = 83 \text{ g CaCl}_2$$

9. What mass of KCl would be recovered if 55 mL of 0.20 M KCl were "evaporated to dryness"?

KCl = 74.55g/mol

$$55 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.20 \text{ mol}}{1 \text{ L}} \times \frac{74.55 \text{ g}}{1 \text{ mol}} = 0.82 \text{ g KCl}$$

10. What molar concentration of silver nitrate is produced by measuring out 1.8 g and then adding water to make 75 mL of solution?

AgNO₃ = 169.88g/mol

$$\frac{1.8 \text{ g}}{75 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ mol}}{169.88 \text{ g}} = \frac{0.14 \text{ mol}}{\text{L}} \text{ AgNO}_3 = 0.14 \text{ M AgNO}_3$$