

- 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?

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

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

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

3. Natural gas is used to heat many homes. It consists primarily of methane, CH_4 . What is the mass of 8.9 L of CH_4 at STP?

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

4. How many moles of SO_2 are in 9.5 L of SO_2 at STP?

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

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

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

6. Silicon dioxide, better known as quartz, has a molar volume of $22.8\text{ cm}^3/\text{mol}$. What is the volume of 0.39 mol of SiO_2 ?

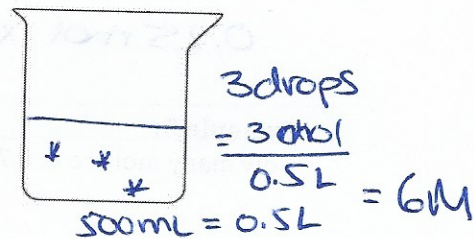
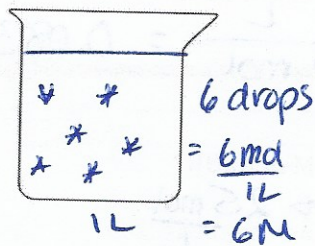
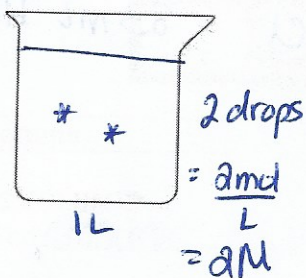
$$0.39\text{mol} \times \frac{22.8\text{cm}^3}{1\text{mol}} = 8.9\text{cm}^3$$

7. H_2S gas is released from rotten eggs. What volume of H_2S gas at STP contains 17.0 g H_2S ?

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

Molar Concentration

What is "concentration"?



Solute = the dissolved substance

Solvent = the liquid in which the solute dissolves.

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 liter of solution

Example 2:

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

They have the same!

$$\rightarrow \frac{5.0 \text{ mol}}{\text{L}} \rightarrow \frac{10. \text{ mol}}{\text{L}}$$

Which solution is more concentrated?

10. M HCl

Example 3:

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

$$\rightarrow \frac{0.60 \text{ mol}}{\text{L}}$$

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

Example 4:

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

↳ 3.0 mol/L

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

Example 5:

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

↳ 2.5 mol/L

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

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?

↳ mol/L

molar mass: 74.55 g/mol

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

$$= 0.038 \text{ M KCl}$$

Practice Problems:

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

CaCl₂

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

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

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

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

$$\frac{1.8 \text{ g}}{75 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ mol}}{169.87 \text{ g}} = 0.14 \text{ M AgNO}_3$$