MOLAR GAS VOLUME

- ✓ The **molar volume** of a gas is the _____ occupied by _____ of the gas.
- ✓ At *room conditions*, r.t.p. (i.e. 25 ^{o}C and 1 atmosphere), one mole of gas has a volume of 24 dm^3 or 24 000 cm^3.

Remember this:

24 dm^3 = 24 000 cm^3

1 dm^3 = 1000 cm^3 = 1000 ml

Formula for finding the number of moles (n) of a gas:

$$\text{No. of moles (n)} = \frac{\text{Volume in } cm^3}{24\,000}$$

$$\text{No. of moles (n)} = \frac{\text{Volume in } dm^3}{24}$$

$$\text{No. of moles (n)} = \frac{\text{mass of gas (g)}}{\text{Molar mass / } M_r}$$

Example 1

A gas jar (240cm^3) is full of chlorine gas. What is the number of moles of chlorine, Cl_2, at room conditions?

Solution

$$\text{Number of moles of } Cl_2 = \frac{\text{Volume of } Cl_2}{\text{Molar volume of a gas}}$$

= _____ = _____ mol.

Example 2

What is the volume of 7g of nitrogen, N_2, at room conditions?

Solution – **Step 1**

Write down the molar mass of nitrogen.

Molar mass = _____ g = _____ g.

Step 2 Find the number of moles of nitrogen.

Number of moles = Mass

Molar volume of a gas

= _____ = _____ mol.

Step 3 Find the volume of nitrogen.

Number of moles = Volume of N_2

Molar volume of a gas

❖ Therefore, volume of N_2 = No. of moles x Molar volume of a gas

= _____ x _____

= _____ dm^3 (or _____ cm^3)

Example 3

What is the mass in grams of $3dm^3$ of carbon dioxide gas, CO_2, at room conditions?

Solution – ***Step 1***

Find the number of moles of carbon dioxide.

Number of moles = Volume of CO_2

Molar volume of a gas

= _____ = _____ mol.

Step 2 Write down the molar mass of carbon dioxide.

Molar mass = _____ = _____ g.

Step 3 Find the mass of carbon dioxide.

$$\text{No. of moles of } CO_2 = \frac{\text{Mass of } CO_2}{\text{Molar mass of } CO_2}$$

❖ So, mass of CO_2 = Number of moles of CO_2 x Molar mass of CO_2

= _____ x _____ = _____ g

Exercise 1: Calculate the number of moles present in the following gases.

240 dm^3 of Bromine gas, Br_2	
96 cm^3 of Neon gas, Ne	
2.4 dm^3 of carbon dioxide, CO_2	
900 cm^3 of ammonia gas, NH_3	

Exercise 2: Calculate the volume of the following gases.

2 moles of hydrogen gas in cm^3	
0.01 moles of nitrogen gas in dm^3	
4g of oxygen gas, O2 in dm^3	
1.7g of ammonia gas, NH3 in dm^3	

Exercise 3: More calculations on Molar gas volume

Show your working clearly.

1. Methane reacts with steam to form hydrogen and carbon monoxide as shown below.
   $CH_4 + H_2O \rightarrow CO + 3H_2$
   What volume of hydrogen can be obtained from 100 cm^3 of methane at r.t.p.?

2. Sodium hydrogen carbonate decomposes on heating:
   $2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$
   In an experiment, a 5 mol sample of sodium hydrogen carbonate was heated. What volume of carbon dioxide, measured at r.t.p., would be evolved?

3. For the reaction: $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
   a) Calculate the volume of CO required to react completely with 8g of Fe_2O_3.

   b) Calculate the volume of CO_2 produced during the reaction in a)?

MOLAR SOLUTION

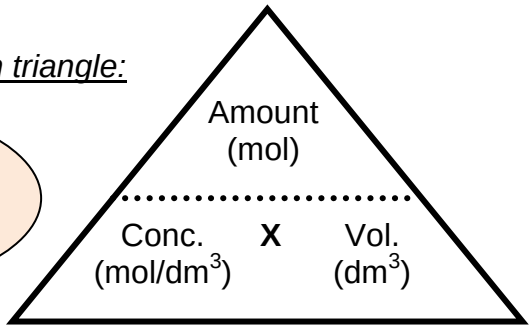
- ✓ The **concentration** of a solution tells us the amount of _____ in a unit volume of a solution.
- ✓ Concentration uses the _____ of the solute and the _____ of the solution.

In general, the formula for calculating concentration of a solution in moles per dm^3 is:

$$\text{Concentration (mol/dm}^3\text{)} = \frac{\text{Amount of solute (mol or g)}}{\text{Volume of solution (dm}^3\text{)}}$$

Use the calculation triangle:

Cover the one you want to find – and you'll see how to calculate it. ☺

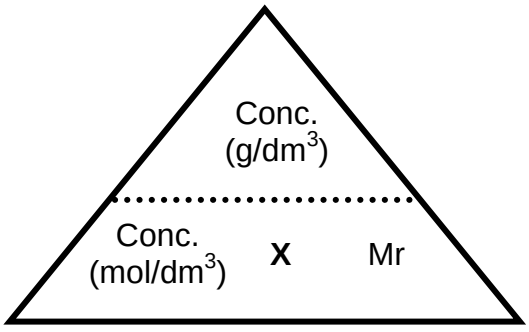


Remember

1 dm^3 = 1 litre = 1000cm^3 = 1000ml

All these means the same thing:

Moles per dm^3
Mol / dm^3
Mol dm^{-3}
Moles per litre



Example 1

A solution contains 10g of sodium hydroxide, NaOH, in 200 cm^3 of solution. Calculate the concentration in (a) g/dm^3, and (b) mol/dm^3.

Solution

a) Mass of solute: _____
Volume of solution: _____ cm^3 = _____ dm^3

Concentration = $\frac{\text{Mass (g)}}{\text{Vol. of solution } (dm^3)}$ = _____

= _____ g/dm^3

b) Molar mass of NaOH = _____.

Number of moles of NaOH = $\frac{\text{Mass (g)}}{\text{Molar Mass}}$ = _____

= _____ mol.

Concentration = $\frac{\text{No. of moles}}{\text{Volume}}$ = _____

= _____ mol/dm^3.

Example 2

Calculate the mass of solute in 600 cm^3 of 1.5 mol/dm^3 sodium hydroxide solution.

Solution

Volume of solution = _____ cm3 = _____ dm3
Number of moles of NaOH = Concentration (mol/dm^3) x volume (dm^3)

= _____ x _____

= _____ mol.

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

Mass of NaOH = Number of moles x Molar mass

= 0.90 x 40 = _____ g.

Exercise 1: How many moles are there in each of the following solutions?

1000 cm^3 0.5M copper (II) sulphate solution.	
5 dm^3 2M nitric acid	
10 cm^3 0.01M copper (II) chloride solution.	
2 dm^3 1M ammonia solution	
2000 cm^3 2M sodium chloride solution	

Exercise 2: What is the concentration of each of the following solutions in mol/dm^3?

1000 cm^3 sodium chloride solution containing 2 moles.	
2 dm^3 silver nitrate solution containing 0.08 moles	
3.65g of HCl in 4 dm^3	
9.5g of MgCl2 in 500 cm^3	
2 dm^3 nitric acid containing 4 moles	
50 cm^3 potassium hydroxide solution containing 0.002 moles	

Exercise 3: Further calculations on concentrations of solutions

1. A 2dm^3 sample of a solution contains 0.5 mole of sodium hydroxide.

   a) What is the concentration of sodium hydroxide in moles/dm^3?

   _____

   b) I) what is the relative molecular mass of NaOH?

   _____

   II) What is the concentration of sodium hydroxide in g/dm^3?

   _____

2. A 500 cm^3 sample of a solution contains 49g of phosphoric acid.

   a) What is the concentration of the phosphoric acid, H_3PO_4, in g/dm^3?

   _____

   b) I) What is the relative molecular mass of H3PO4?

   _____

   II) What is the concentration of the phosphoric acid in mol/dm3?

   _____

3. A solution of ethanedioic acid, $(COOH)_2$, has a concentration of 18g/dm^3.

   a) What is the relative molecular mass M_r, of ethanedioic acid, $(COOH)_2$?

   _____

   b) What is the concentration of ethaneioic acid in mol/dm^3?

   _____

   c) How many moles of ethanedioic acid are there in 20 dm^3 of the solution?

   _____