Chemistry Department

National 5

Unit 1

Chemical Changes & Structure

Section 1.6

The Mole and Solution Chemistry

Summary Notes

Name _____

Learning Outcomes

After completing this section you should be able to :

1	Calculate the formula mass from chemical formulae
2	Define what a mole of a substance is.
3	Convert mass into moles
4	Convert moles into mass
5	Calculate concentrations for solutions using the formula c= n/v
6	Describe how to make up a standard solution
7	Calculate the mass required to make up standard solutions of known concentration
8	Carry out experimental procedures to make up standard solutions.
9	Calculate unknowns for chemical reactions using calculations from equations.

Formula Mass

The formula mass of a substance can be calculated using the Relative Atomic Masses given on P 4 of the data book

EXAMPLES

Calculate **the formula mass** for the following element:

Magnesium Mg

1 x 24 =24 amu

AMU stands for Atomic Mass Units.

Calculate the formula mass for the following compound:

Sodium Chloride Na Cl

1 x 35.5 = 35.5

1 x 23 = 23

58.5 amu

The Mole

Mole Definition!!

A mole is the formula mass of a substance expressed in grams.

1 mole of carbon = 12g

2 moles of carbon = 24g

1 mole of sodium = 23g

4 moles of sodium = 23g

Relative Atomic Masses are found on **p4** of the data book

The Mole

When we are looking at compounds we need to add up the masses of all the elements in the chemical formula. This gives us the **gram formula mass or GFM, where the GFM is the mass of one mole of a substance expressed in grams.**

Examples

H_2O

1 x 16 = 16

2 x 1 = 2

18g

$Mg(NO_3)_2$

6x 16 = 96

2 x 14 = 28

1 24.5 = 24.5

148.5g

Calculating Numbers of Moles

What is the mass of the following:

2 moles of H_2O

Calculate the mass of 1 mole of H_2O

H_2O

1 x 16 = 16

2 x 1 = 2

18g

2 moles = 2 x 18 = 36g

3 moles of HCl

Calculate the mass of 1 mole of HCl

HCl

1 x 35.5 = 35.5

1 x 1 = 1

= 36.5g

3 moles = 3 x 36.5= 109.5g

Changing Moles to Mass/ Mass to Moles

To calculate the **mass** of a substance we have simply multiplied the **number of moles** by the GFM, this leads to the expression:

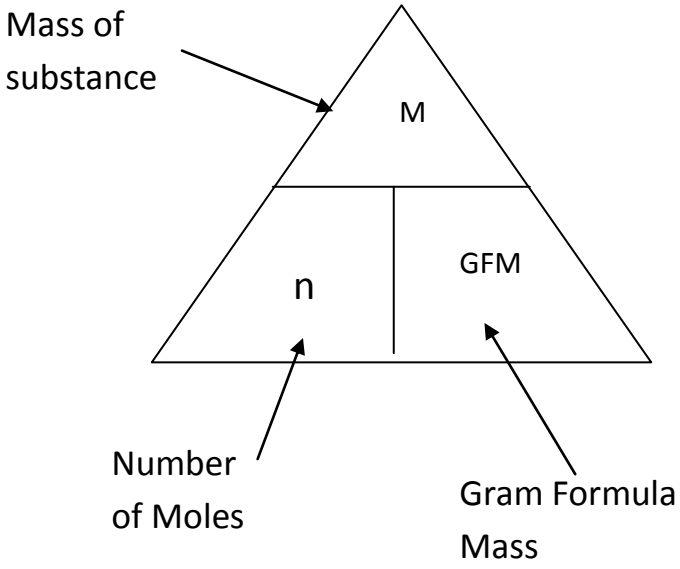
mass = number of moles x GFM

Or **m = n x GFM**

We can rearrange the formula to find the number of **moles** of a substance if we know its mass:

number of moles = $\frac{\text{mass}}{\text{GFM}}$

Or **$n = \frac{m}{GFM}$**



What is the mass of the following?

a. **2 moles of Na Cl**

M = n x GFM

M = 2 x 58.5

= 117g

b. **0.2 moles of CaF_2**

M = n x GFM

M = 3 x 78

= 234g

Solution Chemistry

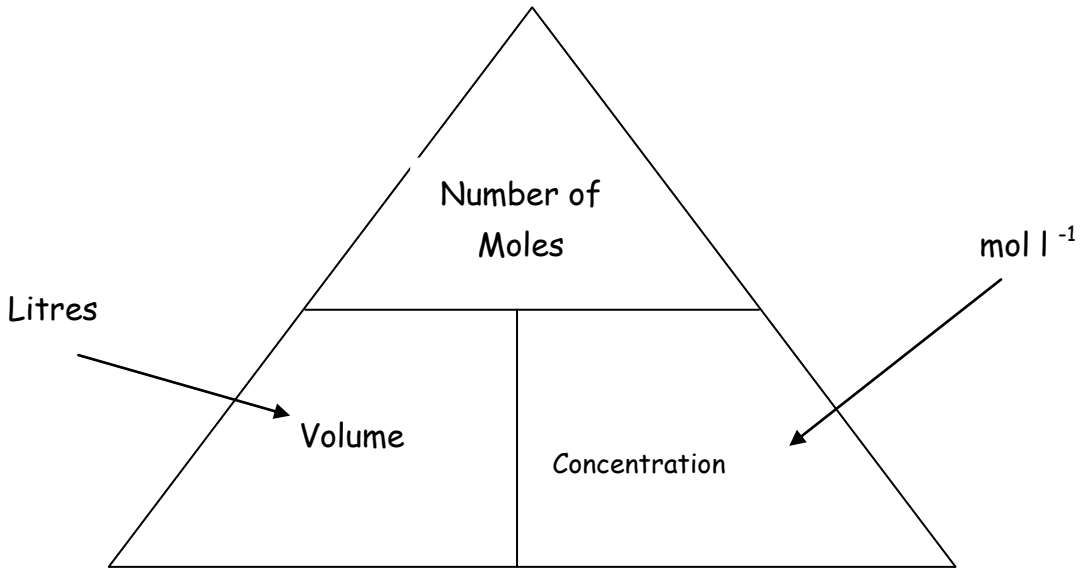
When you make up a solution you are dissolving a substance (**solute**) in water (**solvent**). The more substance you dissolve the more concentrated the **solution**. Alternatively we could dissolve the same mass of solid but reduce the volume of water used which would also make the solution more concentrated.

So **Concentration** depends on the **mass of solid** dissolved and the **volume of water** used.

The following formula is used to calculate the concentration of a solution :-

Number of Moles = Volume x Concentration
(litres) (mol l^{-1})

Remember! Always change volume to **litres** before putting it in this formula.



The units of concentration are **moles per litre** written as:

moll^{-1} or **mol/l**

Solution Chemistry

In order to calculate the **concentration** of a solution you need to know two things:

- **How many moles are dissolved in the solution**
- **What the volume of the solution is**

Example

Calculate the **concentration** of a solution if 5 moles of solute are dissolved in 2 litres of water?

$$\text{Concentration} = \frac{\text{Moles}}{\text{Volume}}$$

$$C = \frac{5}{2}$$

$$C = \mathbf{2.5\ moll\text{-}1}$$

The relationship between concentration, moles and volume allows you to calculate any of the three if you know the other two values.

Example

Calculate the number of **moles** of sodium chloride in 500 cm^3 of a 0.2 moll-1 solution?

$$\text{Moles} = \text{Volume} \times \text{Concentrtion}$$

$$= 0.5 \times 0.2$$

$$= \mathbf{0.1\ moles}$$

Calcualte the volume of solution required to dissolve 4 moles of sodium chloride to obtain a concentration of 0.1 moll-1?

$$\text{Volume} = \frac{\text{Moles}}{\text{Concentration}}$$

$$= \frac{4}{0.1}$$

$$= \mathbf{40\ litres}$$

Standard Solutions

To make a standard solution the following method should be followed:

1. Calculate the mass of solute you require.
2. Weigh this out accurately using a mass balance
3. Dissolve in a small volume of water in a beaker.
4. Pour into a standard flask.
5. Rinse the beaker and the stirring rod. Add the rinsings to the standard flask.
6. Fill up to the calibration mark with water (deionised).
7. Stopper the standard flask and invert a few times to ensure mixing.
8. Label with correct concentration.

Calculating Mass of Solute required

To calculate the mass of solute required to make up a solution the following method should be used:

How many grams of solute are required to make the following solution?

500 cm^3 of 0.1 $moll^{-1}$ copper chloride solution.

moles = volume x concentration

0.5 x 0.1

= 0.05 moles

Formula for solute

Cu Cl_2

2_x 35.5 = 71

1 x 63.5 =63.5

Calculating mass required.

134.5 g

0.05 X 134.5 =**6.725g**

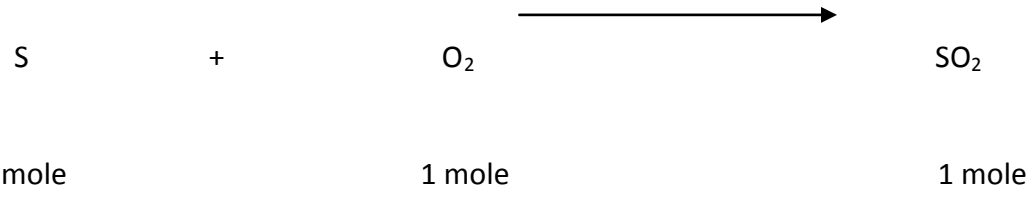
Calculations from Equations

It is possible to use a balanced chemical equation to work out how much product is produced during a chemical reaction or how much reactant is needed to produce a certain amount of product.

Step 1 – Ensure equation is balanced
Step 2 -Write down the mole to mole relationship between the reactant you have been given information about and the product you want to know about.
Step 3 – Work out how many moles of reactant you have by dividing the mass by the mass of 1 mole.
Step 4 - Use proportion to work out how many moles of product would form.
Step 5 – Change the number of moles of product into a mass.

EXAMPLE

Find the mass of sulphur dioxide produced when 4 g of sulphur are burned?



Calculate number of moles of sulphur reacting:

Mass to moles

4 g ⟶ 4/ 32

⟶ 0.25 moles

0.25 moles ⟶ 0.25 moles

0.25 moles of SO_2 formed

Mass = Moles x GFM
= 0.25 x 64g
= **16g**