PREPARING FOR A LEVEL CHEMISTRY PART 3

MOLES AND EQUATIONS

MOVING FORWARD

WITH EACH OF THESE LESSONS PLEASE FOLLOW THE PRESCRIBED FORMAT.

1. WATCH THE VIDEO LINKED ON THE VLE
2. READ THROUGH THE POWERPOINT
3. HAVE A GO AT ALL THE QUESTIONS

THE TOPICS MAY SEEM BASIC TO YOU BUT THE QUESTIONS SHOULD TEST YOU AT EACH STAGE.

THIS TOPIC IS DIFFICULT BUT YOU NEED TO GET YOUR HEAD ROUND IT AS MUCH AS POSSIBLE

WHAT IS A MOLE?

A mole is a number

It is a way for chemists to work out how much of something is reacting or being produced.

A mole is a number much like the following:

A dozen = 12

A week = 7 days

An hour = 60 mins

6.02×10^{23}

1 mole is just a very big number. 1 mole = 6.02×10^{23}.

1 mole of any substance will contain 6.02×10^{23} particles of that substance.

E.g 1 mole of water contains 6.02×10^{23} water molecules

This is known as Avogadro's constant.

HOW MANY MOLES?

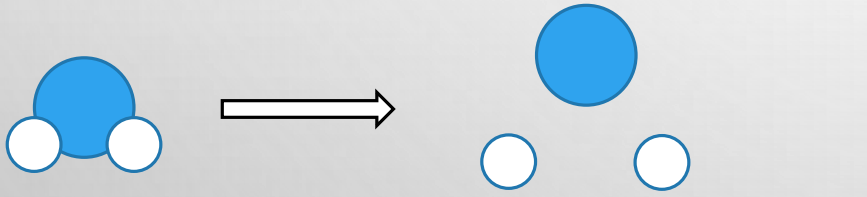
How many Hydrogen atoms in 1 mole of water?

Well if you took 1 mole of water (6.02×10^{23} molecules) and split them up into atoms you would have 3 x as many atoms as you had molecules to start with.

So you would have $3 \times 6.02 \times 10^{23}$ or 1.80×10^{24} atoms but only $2 \times 6.02 \times 10^{23}$ or 1.204×10^{22} Hydrogen atoms.

Unlike equations the number of moles can change during a reaction or in the way a question is asked

Think about these 2 examples



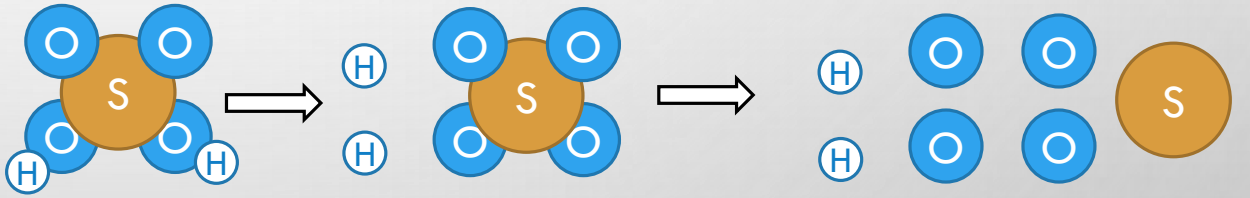
1 water molecule

Or

1 mole of water

3 atoms
(1 oxygen and 2 hydrogen)

3 moles of atoms
(1 mole of oxygen atoms and 2 moles of hydrogen atoms)



1 molecule of sulphuric acid (H_2SO_4)
Or
1 mole of sulphuric acid

3 ions
(2 hydrogen ions (H^+) and 1 sulpjhate ion (SO_4^{2-}))
Or
3 moles of ions
(2 hydrogen ions (H^+) and 1 sulpjhate ion (SO_4^{2-}))

7 atoms
(2 hydrogen (H), 4 Oxygen (O) and 1 sulphur atom (S))
Or
7 moles of atoms
(2 hydrogen (H), 4 Oxygen (O) and 1 sulphur atom (S))

HOW DO EQUATIONS SHOW MOLES?

When you balance an equation you are actually ststing how many moles of a substabnce will react.

E.G Take the Haber process:

$$3H_2 + N_2 \rightarrow 2NH_3$$

Yes it is balanced but what it is saying is:

3 moles of hydrogen react with 1 mole of nitrogen to produce 2 moles of ammonia

What this allows us to do is start quantifying, how much, amounts in a reaction.

E.G If I had 6 moles of hydrogen how much ammonia could I make? Answer 4 moles

If I had 1.5 moles of hydrogen how much nitrogen would be required to fully react with it? Answer 0.5 moles

How much nitrogen would you need ot make 10 moles of ammonia? Answer 5 moles.

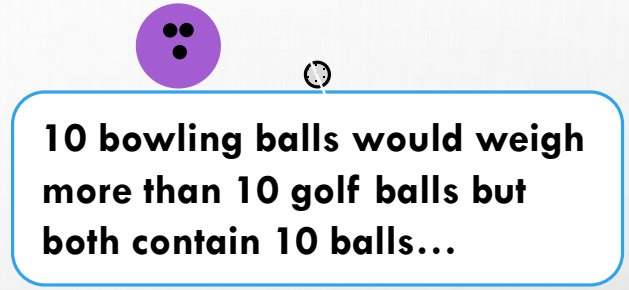
See if you can see where these numbers come from.

The answer is that the numbers that balance an equation are just a RATIO of the particles involved.

MOLES AND MASSES

So how much does a mole weigh?

Well it depends on the element. 1 Carbon atom is 12 times heavier that 1 hydrogen atom so 1 mole of each will both contain 6.02×10^{23} atoms, so 1 mole of Carbon will be 12 times heavier than 1 mole of hydrogen.

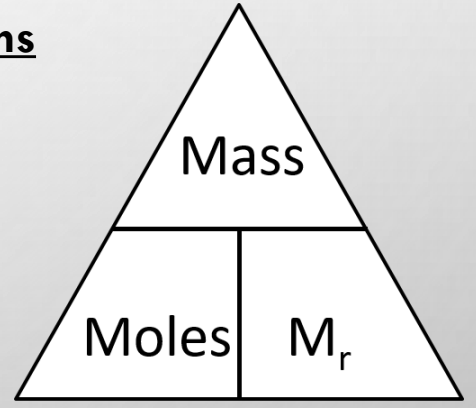


<u>1 mole of a substance is equal to its atomic mass in grams</u>

E.G 1 mole of oxygen atoms (O) = 16g

1 mole of water molecules (H_2O) = 18g

1 mole of oxygen molecules (O_2) = 32g



This allows us to come up with the equation: Moles = mass / M_r or →

(M_r = Relative mass could also write RAM or RFM but M_r is used most at A level.)

MOLES AND EQUATIONS

Combining information in the last couple of slides allows chemists to calculate various masses.

E.G If I had 10g of zinc powder how much copper could I make if I reacted it with excess copper sulphate.

Step 1. Write out a balanced symbol equation

$$Zn + CuSO_4 \rightarrow Cu + ZnSO_4$$

Step 2. Write out the information you have (I always use a table to do this)

	Zn	+	$CuSO_4$	→	Cu	+	$ZnSO_4$
Mass	10		(Not needed in this question as the question gives information on zinc and asks for information about copper)		9.71		
M_r	65.4				63.5		
Moles	10 / 65.4 = 0.15				0.15		

Step 3 identify which box is the answer you want – in red

Step 4. Calculate the moles of each.

In this example they are in a 1 : 1 ratio so moles of zinc used will = moles of copper made

Step 5. Calculate the answer and check the units. Moles = Mass / M_r so 0.15 x 63.5 = 9.71g

MOLES AND EQUATIONS

Example 2

E.G If you react 3g of sodium metal with excess oxygen what mass of sodium oxide would be made?

Step 1. Write out a balanced symbol equation

Step 2. Write out the information you have

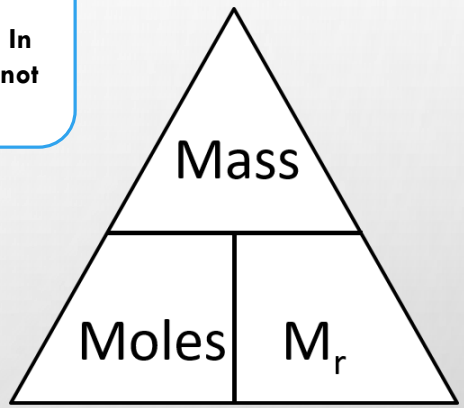
Step 3 identify which box is the answer you want – in red

Step 4. Calculate the moles of each.

Step 5. Calculate the answer and check the units.

Remember excess means there is more of it than you need. In other words not all of it will react. Where as the substance not in excess, you can assume will fully react. In moles calculations you always use the substance that is not in excess.

The units of mass are irrelevant. As long as the mass you finish with is in the same units as that in the question you do NOT need to convert units of mass. E.g it could be in grams, kilograms, tonnes etc.



$4Na + O_2 \rightarrow 2Na_2O$ (In this example 4 moles of sodium will produce 2 moles of sodium oxide or they react in a 4:2 / 2:1 Ratio)

KEY POINT: M_r is not multiplied by 4, we do not actually have 4 sodiums they just reat in a ratio of 4:2. This ratio is taken into account when moles move across the table.

Final answer = 4.04g

	4Na	+	O_2	→	$2Na_2O$
Mass	3		(Not needed in this question as the question gives information on sodium and asks for information about sodium oxide)		4.04
M_r	23				62
Moles	3 / 23 = 0.13				0.065

0.13/4 x 2 (or 0.13/2) Due to ratio in equation

MOLES AND CONCENTRATION

Final bit – Concentration

The measure of how much solute is dissolved in a solvent. E.g how much salt is dissolved in a set amount of water.

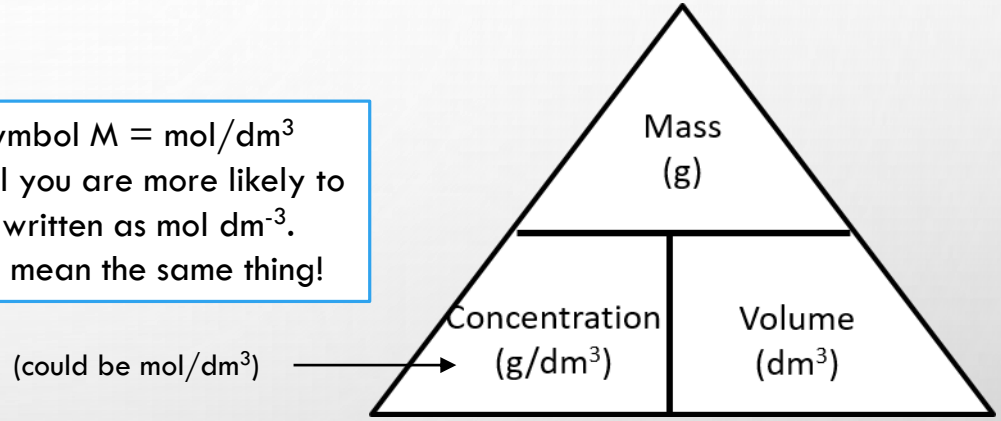
Two different appropriate units. g/dm^3 and mol/dm^3. Both use a value such as moles or mass / volume.

Both use dm^3. 1 dm^3 = 1000 cm^3. To convert cm^3 into dm^3 /1000.

You can practically change concentration by:

- Adding more solute – increasing concentration
- Evaporating solvent – decreasing concentration
- Adding more solvent – diluting, decreasing concentration

The symbol M = mol/dm^3
At A level you are more likely to see it written as mol dm^{-3}.
They all mean the same thing!



Example calculation. 5g of sodium chloride is dissolved in 250 cm^3 of water. What is the concentration of the solution?

1. Calculate moles — Moles = mass / M_r so $5/(23+35.5)_{(M_r \text{ of sodium chloride})}$ = 0.085 moles
2. Convert volume — 250 cm^3 / 1000 = 0.25 dm^3.
3. Calculate concentration — Moles / volume = concentration so 0.085 / 0.25 = 0.34 mol/dm^3