GCSE to A Level

Chemistry

Bridging Course

Name ______________________________

Bridging the gap – GCSE to A Level

Chemistry

Pre-course summer work information

Hi

Well done for choosing A-level chemistry. However, be aware that it is quite a demanding course and so, to get you into the A level workload style, we will require you to complete some bridging work over the summer holiday to prepare you for the the first topics studied when you begin the course in September and the extra work required throughout the 2-year OCR course.

Part 1 of the bridging work is simplistically GCSE calculation and quantitative work, that then links into some AS-level calculation work, each with tasks to complete.

Part 2 is a research project and you get to choose which way you want to present it (e.g. Powerpoint, posters, Prezi etc.)

So, over the summer holidays you must have completed the full booklet, and ready to show / present your research project on the first lesson of Year 12 chemistry. In this lesson we will go over some aspects of the calculation work, then move onto the projects.

If you need any extra help, you could buy CGP 'New Head Start to A-level Chemistry' or 'Summer Start for A-Level Chemistry' books on Amazon.

Alternatively, if you have any questions, see or email the course leader / one of the A-level teachers:

Enjoy the summer holidays,

- the chemistry department!

Quantitative Chemistry Bridging

INTRODUCTION

- Chemists use quantitative analysis to determine the formulae of compounds and the equations for reactions
- After they have this information, they can use quantitative methods to determine purity of samples, and monitor yields of chemical reactions

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Key Idea 1: Conservation of Mass

'no atoms (mass) are gained or lost in a chemical reaction' – i.e: the mass on one side on the left-hand side of the equation would equal the mass on the right-hand side

The r________________ atoms get re-arranged into the m____________ or c_______________ called the products

We can show the conservation of mass by b_____________ symbolic reactions

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FORMULAE BASICS

H_2 means…….
Al_2O_3 means……
$(NH_4)_3$ means….

TYPES OF CHEMICAL REACTION

5 types of chemical reaction can take place: (add notes)

1. Synthesis (combination)
2. Decomposition
3. Displacement (single- and double-displacement)
4. Acid-base
5. Combustion

Complete the following word equations: and what type of reaction is each one?

1) Hydrogen + oxygen → ___________________

2) Iron + _____________ → iron sulphide

3) Copper + ___________ → copper oxide

4) Copper (II) carbonate → ______________ + ________________

5) ______________ + hydrochloric acid → magnesium chloride + _______________

Now: symbol equations

These involve the SYMBOLS of compounds and molecules involved in the reaction

We balance these to show the law of conservation of mass

Eg hydrogen + oxygen → water … becomes … $H_2 + O_2 \rightarrow H_2O$

But there's an imbalance of Oxygen atoms (i.e 2 atoms on LHS, 1 atom on RHS)

So we must add coefficients (big numbers) to make each side have equal mass/atoms to show the conservation of mass

Take: $H_2 + O_2 \rightarrow H_2O$

Add a 2 to H_2O to get same amount of oxygens on both side: $H_2 + O_2 \rightarrow 2H_2O$

Add a 2 to H_2 to get amount of hydrogens on both sides: $2H_2 + O_2 \rightarrow 2H_2O$ *<< we now have 4 H's on both sides, and 2 O's on both side – balanced!*

Balance the following:

1) $C_2H_6 + O_2 \rightarrow H_2O + CO_2$

2) $NH_3 + O_2 \rightarrow H_2O + NO$

3) $Zn + HCl \rightarrow ZnCl_2 + H_2$

4) $TiCl_4 + H_2O \rightarrow TiO_2 + HCl$

5) $(NH_4)_3PO_4 + Pb(NO_3)_4 \rightarrow Pb_3(PO_4)_4 + NH_4NO_3$

RELATIVE FORMULA MASS

Also called 'M_r', this is simply the sum of all masses of all atoms in the formula given

Eg, what's the M_r of CO_2?

All we'd do is using our periodic table, add the mass of 1 Carbon with the mass of 2 Oxygens

i.e 12 + 16 + 16 = 44

So, CO_2's M_r is 44

Try RFM of:

1. Silica, SiO_2 ____
2. Carbon monoxide, CO ____
3. Diaminomaleonitrile, $C_4H_4N_4$ ____
4. Hydrogen cyanide, HCN ____
5. Ethanoic acid, CH_3COOH ____
6. Iron III hydroxide, $Fe(OH)_3$ ____
7. Ammonium sulphate, $(NH_4)_2SO_4$ ____

MOLES

In chemistry, we measure the amount of stuff in moles (unit: mol)

The mass of one mole of a substance in g is equal to that substance's M_r

Eg 1 mole of CO_2 is 44g (since the M_r is 44)

The number of atoms, ions, or molecules in a mole of a substance is called the A_______________ constant

This value is __________________ per mol

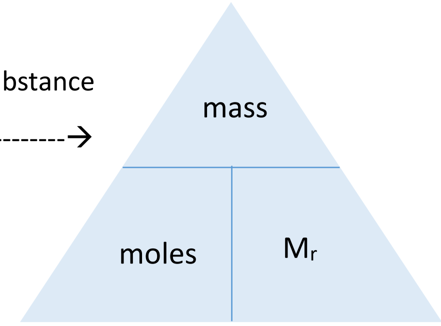
What mass in:

- 2 moles of Al_2O_3? ____
- 1 mole of HCl?____
- 5 moles of H_2O ____

MOLE CALCUATIONS

We need to be able to calculate the moles, Mr and mass of any substance

SO we use a triangle to make it easy: --→



(just cover up what you want to work out)

Example calculations:

1) **what's the mass of 0.5 moles of water, H_2O?**

Mass = moles x Mr

= 0.5 x (1+1+16)

= 0.5 x 18

= 9 grams

2) **calculate the moles in 234g of NaCl**

Moles = mass / Mr

= 234g / (23+35.5)

= 234g / 58.5

= 4 moles

3) **a sodium-containing compound has 2 elements: with 2 Na atoms in it, and 1 unknown atom. If the mass of the compound is 124, and contains 2 moles, find the unknown element in the compound.**

Mr = mass / moles

= 124g / 2

= 62

62 minus 46 (the 2 Na atoms) = 16

16 is the Mr of the unknown element

SO the unknown element must be oxygen

TRY:

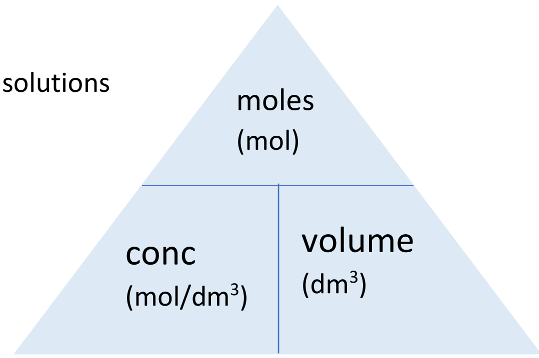
1) work out number of moles in 50g of oxygen gas, O_2

2) find the mass of 2 moles of calcium carbonate, $CaCO_3$

3) 3 moles of an unknown acid has a mass of 294g. Deduce if the acid is sulphuric acid (H_2SO_4), oxalic acid ($H_2C_2O_4$), or 2-hydroxy-1,2,3-propanetricarboxylic acid ($H_3C_6H_5O_7$)

MOLE CALCUATIONS pt2

We can also use moles to calculate volumes and concentrations of solutions



WARNING – the volume in the triangle is in dm^3

SO if you calculate using cm^3 you must divide by 1000 as well

Example calculations

1) Calculate concentration when 0.5 moles of KNO_3 is dissolved in $250dm^3$ of water

Conc = mole / vol

= 0.5 / 250

= 2×10^{-3} mol/dm^3

2) Calculate the moles in $250cm^3$ of 1.5 mol/dm^3 solution

SINCE it's cm^3 → Mole = c x v / 1000

= 1.5 x 250 / 1000

= 0.375 moles

Try:

1) The concentration of sodium hydroxide in 4 moles of 360dm^3

2) The volume of a 2 mol/dm^3 solution that has 0.5 moles in it

3) The number of moles in 50cm^3 of a 0.5 mol/dm3 solution

- We can also express concentration in g/dm^3 – grams per cubic decimetre
- All we do to find this is multiply the concentration in mol/dm^3 by the ___________ of the solution

Example:

In a sample of vinegar, the concentration of ethanoic acid, CH_3COOH, is 0.3 mol/dm^3 – find the concentration of the ethanoic acid in g/dm^3

g/dm^3 = mol/dm^3 x its Mr

= 0.3 x 60

= 18 g/dm^3

TRY:

1) The concentration of a sample of hydrochloric acid, HCl, was found to be 0.5mol/dm^3 – what is the concentration in g/dm^3

2) A 50dm^3 2-mole sample of Sodium hydroxide, NaOH, was found to neutralise a 45dm^3 sample of nitric acid. What is the concentration of the NaOH in g/dm^3

% by mass

- Really simple – basically, just how much of an element is in a compound, by mass

Equation:

$$\% \text{ by mass} = \frac{mass\ of\ element}{mass\ of\ whole\ compound} \times 100$$

Example

% by mass for Ca in CaO?

$$= \frac{mass\ of\ element}{mass\ of\ whole\ compound} \times 100$$

$$= \frac{40}{56} \times 100$$

$$= 71.4\ \%$$

Try:

1) % of Mg in $MgCl_2$

2) % of Br in LiBr

3) % of N in NH_4NO_3

TITRATIONS

- A titration is basically adding one solution to another solution very precisely – eg in acid-base reactions
- We can use titrations to test for purity of chemicals
- If we know the conc of one reactant in a titration, we can work out the conc of the other reactant

How to do titrations

1) Find the volume of sample of your first reactant
2) Use a pipette to accurately measure volume of a solution
3) Empty this solution into a conical flask
4) Add some indicator to the conical flask (this is so a colour change will be seen at the end-point of the titration)
5) Place the 2^{nd} reactant in the burette
6) Let a single drop from the burette into the conical flask, and swirl
7) Keep adding drops until there's a complete colour change
8) Note the volume of the solution used from burette
9) We can now use this data to find the concentration of the first reactant

Titration Calculations

Take the reaction of sulphuric acid and sodium hydroxide

25cm^3 of H_2SO_4 reacted with 28cm^3 solution of 1.5 mol/dm^3 of NaOH. Calculate the concentration of the sulphuric acid.

- IMPORTANT: Make sure you have your B____________ symbol equation

H_2SO_4 + __ NaOH → Na_2SO_4 + __ H_2O

Step 1: see what you are missing :

	Acid	**Alkali**
Conc	X	1.5 mol/dm^3
Vol	25 cm^3	28 cm^3
Moles	X	X

Step 2: calculate the side where you have 2 out of 3 known values

Step 3: find the molar ratio (just the big numbers in front of the compounds in the balanced symbol equation) – eg H_2SO_4 : NaOH = 1:2 ; and convert into the side you want (eg divide NaOH moles by 2 to get the H_2SO_4 moles)

Step 4: now, you can calculate what the question is asking for.

EXAMPLE

25cm^3 of H_2SO_4 reacted with 28cm^3 solution of 1.5 mol/dm^3 of NaOH. Calculate the concentration of the sulphuric acid:

Step 1

	Acid	Alkali
Conc	X	1.5 mol/dm^3
Vol	25 cm^3	28 cm^3
Moles	X	X

H_2SO_4 + 2NaOH

Step 2

mole = c x v /1000
= 1.5 x 28 /1000
=0.042 mol

We know 2/3 things for NaOH. So calculate the missing value ie moles

The vol is in cm^3 so we must divide by 1000 too!!

Step 3

0.021 mol

0.042 mol

Species ratio of acid:alkali is 1:2
So we have to divide the alkali by 2 to get the acid moles

Step 4

c = n x 1000 / v
= (0.021 x 1000) / 25
= 0.84 mol/dm^3

Now we have 2/3 things for the acid. So we can work out the missing value, ie the conc

The vol is in cm^3 so we must divide by 1000 too!!

Hence, the concentration of H_2SO_4 that reacted with the NaOH was 0.84 mol/dm^3

So…… what is the sulphuric acid's concentration in g/dm^3 ??

TITRATION EXAM QUESTION

A student does a titration to find the concentration of a solution of hydrochloric acid. The student titrates 25.00 cm3 of hydrochloric acid with sodium hydroxide solution of concentration 0.200 moles per dm^3.

The equation for the reaction is: $HCl + NaOH \rightarrow NaCl + H_2O$

The student added 28.60 cm^3 of sodium hydroxide solution to neutralise the hydrochloric acid.

Calculate the concentration of the hydrochloric acid

PERCENTAGE YIELD

- 'yield' means the amount of product made
- Percentage yield is basically how much of something we actually make compared with the maximum amount of something that we could've made

Even though the conservation of mass states no atoms are lost in reactions, reactions don't go 100% completion, this could be because:

1. We have a R__________________ reaction

2. Some product might be lost when s____________________ from the reaction mixture

3. Some r______________ may react differently than expected

The equation to work out percentage yield is:

$$\%\ yield = \left(\frac{mass\ of\ product\ we\ actually\ made}{maximum\ theoretical\ mass\ we\ could've\ made}\right) \times 100$$

EXAMPLE:

When producing ammonia, the maximum mass I could've made was 6.6 tonnes. However, I only made 4.7 tonnes; what is my % yield?

$$\%\ yield = \left(\frac{mass\ of\ product\ we\ actually\ made}{maximum\ theoretical\ mass\ we\ could've\ made}\right) \times 100$$

$$\%\ yield = \frac{4.7}{6.6} \times 100$$

$$\boldsymbol{\%\ yield = 71.21\%}$$

TRY:

1. **% yield when I actually made 5.5g of CaO but could've made 7.5g**

2. **% yield when 60kg of $CuCO_3$ was made but 61kg could've been made**

3. **% yield when I could've made 12g of NaCl but only 0.8g was produced**

PERCENTAGE YIELD – HIGHER

- We can use moles and balanced symbol equations to calculate the maximum yield of a product that could be produced

Eg

Calculate the theoretical yield of Ammonia if we use 5g Nitrogen and excess Hydrogen

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

Moles of nitrogen = mass / mr

= 5g / 28

= 0.179 mol

Species RATIO $N_2 : 2NH_3$ = 1:2 So double the N_2 moles to get Ammonia moles (0.179 x 2 = 0.358)

Mass of ammonia = moles x mr

= 0.358 x 17

= 6.086g is our theoretical yield

Using 6.086g as our theoretical yield, calculate the % yield if we only made 4.9g of ammonia?

Exam questions on RFM, % by mass, reacting mases, theoretical yield and percent yield:

6 (b) Iron chloride has the formula $FeCl_3$

Relative atomic masses (A_r): Cl = 35.5; Fe = 56.

6 (b) (i) Calculate the relative formula mass (M_r) of iron chloride ($FeCl_3$).

....

....

....

Relative formula mass (M_r) of iron chloride = ...

(2 marks)

6 (b) (ii) Calculate the percentage of iron in iron chloride ($FeCl_3$).

....

....

....

Percentage of iron in iron chloride = ...%

(2 marks)

4 (b) (iii) A company made magnesium using this reaction.

Calculate the mass of magnesium oxide needed to produce 1.2 tonnes of magnesium.

Relative atomic masses (A_r): O = 16; Mg = 24

[3 marks]

....

....

....

....

Mass of magnesium oxide needed = ... tonnes

3 Ammonia is produced from nitrogen and hydrogen.

The equation for this reaction is:

$$N_2(g) \quad + \quad 3H_2(g) \quad \rightleftharpoons \quad 2NH_3(g)$$

3 (a) (i) A company wants to make 6.8 tonnes of ammonia.

Calculate the mass of nitrogen needed.

Relative atomic masses (A_r): H = 1; N = 14

....

....

....

....

....

Mass of nitrogen = ... tonnes

(3 marks)

3 (a) (ii) The company expected to make 6.8 tonnes of ammonia.

The yield of ammonia was only 4.2 tonnes.

Calculate the percentage yield of ammonia.

....

....

Percentage yield of ammonia = ... %

(2 marks)

3 (a) (iii) Use the equation above to explain why the percentage yield of ammonia was less than expected.

....

....

(1 mark)

ATOM ECONOMY

- Simply a measure of the amount of reactants end up as useful products
- We need to use the BALANCED Symbol equation and BALANCED formuale for these calculations

Why is it important to have high atom economy?

The equation for this is:

$$atom\ economy = \left(\frac{Mr\ of\ useful\ product}{all\ the\ Mr's\ of\ the\ reactants}\right) \times 100$$

Example:

$CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + H_2O + CO_2$

Calculate the atom economy for making copper sulphate

$$atom\ economy = \left(\frac{Mr\ of\ useful\ product}{all\ the\ Mr's\ of\ the\ reactants}\right) \times 100$$

$$atom\ economy = \left(\frac{159.5}{(123.5 + 98)}\right) \times 100$$

$$atom\ economy = \left(\frac{159.5}{221.5}\right) \times 100$$

$$atom\ economy = 72\%$$

Example 2 (bit harder):

$CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$

Calculate the atom economy for copper chloride

$$atom\ economy = \left(\frac{Mr\ of\ useful\ product}{all\ the\ Mr's\ of\ the\ reactants}\right) \times\ 100$$

$$atom\ economy = \left(\frac{134.5}{[79.5 + 2(36.5)]}\right) \times\ 100$$

2 x 36.5 since there's 2 moles of HCl being reacted

$$atom\ economy = \left(\frac{134.5}{152.5}\right) \times\ 100$$

$$atom\ economy =\ 88.2\%$$

TRY

1) Atom economy for tungsten in:
   $WO_3 + 3H_2 \rightarrow W + 3H_2O$

2) Atom economy for iron in:
   $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

EMPIRICAL FORMULAE

- Simply, the simplest ratio of atoms in a formula
- From a molecular formula, we divide by an integer to get the simplest integer ratio possible

Eg, empirical formula of $C_6H_{12}O_6$ is CH_2O

Eg, empirical formula of Fe_2O_3 is just Fe_2O_3

The molecular formula shows the actual numbers of a__________ in a compound/molecule.

The empirical formula is the simplest integer formula of a compound.

Calculating empirical formula

Example

A sample of the solvent used in one perfume contained 0.60 g of carbon, 0.15 g of hydrogen and 0.40 g of oxygen. Calculate the empirical formula of the solvent.

NOTES			
Step 1: set out your elements like this	**C**	**H**	**O**
Step 2: find the moles (mass / mr)	0.6 / 12 = 0.05	0.15 / 1 = 0.15	0.4 / 16 = 0.025
Step 3: divide by the lowest mole number	0.05 / 0.025 = 2	0.15 / 0.025 = 6	0.025 / 0.025 = 1
Step 4: if there's some non-integers, multiply everything by a single integer to get all integers			
Step 5: place those new integers after the element	C_2	H_6	O
Step 6: check if anything else cancels			
Step 7: write your formula!	C_2H_6O		

Example 2 – bit tougher

A compound called phosgenite contains:

- 76.0% lead (Pb)
- 13.0% chlorine (Cl)
- 2.2% carbon (C)
- 8.8% oxygen (O)

Calculate the empirical formula of this compound

(hint: we act like the percentages are the mass)

NOTES				
Step 1: set out your elements like this	**Pb**	**Cl**	**C**	**O**
Step 2: find the moles (mass / mr)	76 / 207 = 0.367	13 / 35.5 = 0.366	2.2 / 12 = 0.183	8.8 / 16 = 0.55
Step 3: divide by the lowest mole number	0.367 / 0.183 ≈ 2	0.366 / 0.183 = 2	0.183 / 0.183 = 1	0.55 / 0.183 ≈ 3
Step 4: if there's some non-integers, multiply everything by a single integer to get all integers				
Step 5: place those new integers after the element	Pb_2	Cl_2	C	O_3
Step 6: check if anything else cancels				
Step 7: write your formula!	$Pb_2Cl_2CO_3$			

TRY, find empirical formula of:

1) Compound with 36% beryllium (Be), and 64% oxygen (O)

2) Compound with 4g of hydrogen (H) and 32g of oxygen (O)

3) Compound with 24g of calcium (Ca) and 5.6g of Nitrogen (N)

AS-level work:

On the final following pages there are 2 bits of AS-level quantitative work I'd like you try before you join in September.

AS bit 1: molecular formula from empirical formula.

We can use the empirical formula of a compound and the Mr of the compound to work out what the molecular formula is. This is simply 1-2 extra steps from the GCSE calculation.

Worked example

In a compound the empirical formula is CH_2 and the molecular mass is 42, what is the molecular formula?

Empirical	Formula: CH_2	Mass: (12+2) = 14
Molecular	Formula: ?	Mass = 42

Now, take the molecular mass and divide it by the empirical mass,

(42 / 14) = 3. This is our multiplier.

So now we multiply the empirical formula by the multiplier, i.e: CH_2 x 3 = C_3H_6

So, C_3H_6 is our molecular formula.

You try:

1)

On a mass spectrometer, a hydrocarbon, with empirical formula C_3H_7, shows that the hydrocarbon has a molecular mass of 86. What is the molecular formula of this hydrocarbon.

2)

Determine the empirical formula of a compound with the following composition by mass:
48.0 % C, 8.0 % H, 28.0 % N and 16.0 % O.

If this compound has a molar mass of 200 g, what is its molecular formula?

3)

Determine the empirical formula of a compound with the following composition by mass:
60.0 % C, 12.0 % H and 28.0 % N.

If this compound has a molar mass of 300 g, what is its molecular formula?

AS bit 2: Hydrated salt calculations / water of crystallisation

Similar to empirical formula calculations, we can work out the formula of an unknown integer in formulas of hydrated salts, e.g $MgSO_4.7H_2O$.

The 7 tells us for every mole of $MgSO_4$ there is 7 moles of water 'attached'.

We can use this knowledge to apply it to many different types of exam question.

Worked example:

11.25 g of hydrated copper sulphate, $CuSO_4.xH_2O$, is heated until it loses all of its water. Its new mass is found to be 7.19 g. What is the value of x?

Work out the mass of the water and anhydrous salt – depending what's already given in the question.

So, in this question the anhydrous salt is 7.19g

The mass of water is = **mass of hydrated salt – mass of anhydrous salt** = 11.25g – 7.19g = **4.06g**

Now, work out Moles of anhydrous Salt and Moles of Water separately:

$CuSO_4$	H_2O
$CuSO_4$ moles = mass / Mr	H_2O moles = mass / Mr
= 7.19g / 159.5	= 4.06g / 18
=0.0451 mol 3sf	=0.226 mol 3sf

Empirical bit… *divide each by $CuSO_4$ to get a ratio for 1:x for $CuSO_4 : H_2O$*

$CuSO_4$	H_2O
0.0451 / 0.0451	0.226 / 0.0451
= 1	= 5.00

So as an integer, x = 5

Now we can write the formula as **$CuSO_4.5H_2O$**

You try:

1) A sample of hydrated magnesium sulphate, $MgSO_4.xH_2O$, is found to contain 51.1% water. What is the value of x?

2) A sample of hydrated calcium sulphate, $CaSO_4.xH_2O$, has a relative formula mass of 172. What is the value of x?

3) A hydrated carbonate of an unknown Group 1 metal has the formula $X_2CO_3.10H_2O$ and is found to have a relative formula mass of 286. What is the Group 1 metal?

<u>Summer bridging course</u>

Chemistry

Part 2 – Research Project

The second part of your summer course is to prepare you for atomic theory and bonding aspects of the AS course. I would like you to research and create a project on the following bits:

- History of the atom
- Types of bonding, (ICM), including the 'new' co-ordinate bond
- Melting points going down Group 2 (trend & why)
- Melting points of Period 3 elements, Na to Al only (trend & why)

Most of the above work should formed from the GCSE ideas, with AS-level knowledge being brought in on the co-ordinate bond, and for the explanations for melting points in terms of intermolecular forces and structures.

You can present this in anyway you want (e.g. posters, PowerPoint etc) – you may even want to do a demonstration in front of the class about what you've learnt!

Relax after you've completed this, enjoy your summer holiday!

- the chemistry department!