A First Year blog on Calculations in Chemistry: Part 4, 16th March 2019

(This is a **revision** blog. It is merely a *summary* of some of the things that you need to know. *Everything in this blog can be found in Chapters 38-41 of the First Year, Foundation Chemistry Book*.)

In Part 1 I told you about Moles, and
in Part 2 I told you about Relative Atomic Mass (RAM), and
in Part 3 I told you about Relative Molecular Mass and Relative Formula Mass.
Could you now please read Chapters 38-41 of the First Year foundation book because that will take you through *every single calculation* for Solids/Liquids/and Gases that you are likely to encounter in your First Year exams, and now
in Part 4 I will tie everything up.

A reaction equation tells you the **Mole Reaction Ratio** for a reaction. It does **not** tell you the Mass Reaction Ratio for Solids, nor does it tell you the Volume Reaction Ratio for Liquids.
It tells you the MOLE REACTION RATIO for a reaction equation.

The most important rule that you need to know for doing any calculation in Chemistry is

START WITH A MOLE REACTION RATIO

You won't ever forget that will you? Oh, and could you also remember that

For SOLIDS
M= N x RAM (or RMM or RFM – depending on whether you are dealing with Molecular or ionic units)

For LIQUIDS
C = N ÷ V (and always convert your cm^3 into dm^3), and

For GASES (and only for Gases)
VOLUME Reaction Ratios work out **EXACTLY** the same as MOLE Reaction Ratios.

Let us start by reminding ourselves of the principles that underlie the calculations involving solids/liquids/and gases.

The first thing that you have to remember is that you cannot do any calculation in Chemistry without either a **FORMULA** or a **REACTION EQUATION**. Every reaction has its own specific reaction equation, therefore there is no one reaction equation that encapsulates all reactions – but when it comes to formulae, you need to know only five formulae or five pieces of information, and then (with the relevant reaction equation) you can do almost any calculation involving solids/liquids/or gases.

A) **FORMULAE**

SOLIDS
There is only **one formula** that you need for calculations involving Solids viz.
M = N x RAM (or RMM or RFM – whichever is appropriate).

LIQUIDS
There is only **one formula** that you need for calculations involving Liquids viz.

$$C = \frac{N}{V \text{ in } dm^3}, \qquad V \text{ in } dm^3 = \frac{N}{C} \qquad \text{and} \qquad N = C \times V \text{ in } dm^3$$

GASES
There are only three things that you need to know about Gases viz. that

a **1 mole of ANY gas occupies 24.4 dm^3 at** **RTP** (20-25˚C/1atm)[1]/and **22.4 dm^3 at** **STP** (0˚C/1atm)
[and then you can do a Simple Proportion Calculation to work out the Volume], and

b **Equal volumes of gases always contain the same number of moles**,
and the reverse is also true viz.

c **Equal numbers of moles of gases always occupy the same volume!**
[Please do not confuse the "Volume" of a **Liquid** with the "Volume" for a **Gas**!
One is a Liquid volume (where V in dm^3 = N ÷ C) , while the other is a Gaseous volume.]

If you learn the five pieces of information above by heart, then you will have the tools to do probably 80% of all First Year 'A' Level solid/liquid/and gas calculations.

B) **THE CALCULATIONS THEMSELVES**

Please remember your UNITS!

Mass	**is "always" designated in**	**g**
N (Amount)	**........................**	**mol**
RAM/RMM/RFM	**should always be designated in**	**g mol^{-1}**
C (Concentration)	**........................**	**mol dm^{-3}**
V (Volume)	**........................**	**dm^3 (and MUST be converted from cm^3)**

Please obey the rule for significant figures (because a chain is as strong only as its **weakest** link viz. it will snap at the point where you have a weak link *irrespective of how strong all the other links are*). If you give your answer to any more than this number of significant figures, then you are invoking "spurious accuracy" i.e. accuracy that is totally unjustified. (However, keep your **workings** to at least one more significant figure than you need to do, and at the end of your calculations only **then** round your answer to the number of significant figures that you need. By doing this, you will avoid having a "rounding error".)

ALWAYS START WITH THE APPROPRIATE REACTION EQUATION!

However, please remember that a Reaction Equation tells you about the ratio of the number of **MOLECULES** that are reacting with each other in the reaction, and it therefore *also* tells you about the ratio of **the number of MOLES OF MOLECULES** that are reacting with each other in the reaction.

What a Reaction Equation DOES **NOT** tell you is

a the **Mass** Reaction Ratio for SOLID substances, nor
b the **Volume** Reaction Ratio for LIQUID substances,
c BUT, because "Equal numbers of moles of GASES always occupy the same volume", then for **gases only** the Mole RR = the Volume RR!

[1] "Room temperature" can be either 20˚C/293K or 25˚C/298K. 1 mole of any gas will occupy **22.4 dm^3** at 0˚C and 1atm, and **24.4 dm^3** at 25˚C and 1atm.

SOLIDS

- For Solids, there are only two methodologies/two techniques

a If you are asked to calculate a Mass, then use the following methodology and write
Reaction Equation ....
Mole Reaction Ratio ....
Mass Reaction Ratio ....

b **If you are given the Masses involved**, and asked to ascertain the Empirical Formula or Molecular Formula – then reverse the order of the Mole RR and the Mass RR and get
Reaction Equation ....
Given **<u>Mass</u>** Reaction Ratio ....
Mole Reaction Ratio .... (but do NOT round off at this stage)
and then divide by the smallest number to obtain the Empirical Formula (and then you can round off in this line).

LIQUIDS

For Liquids, the technique is to
1 Write out the reaction equation.
2 Then calculate the number of moles of the liquid for which the C and the V are given.
3 Then write out the Mole Reaction Ratio of the two substances concerned.
4 Then use the Mole RR to calculate the Number of moles of the other Liquid.
5 Then use the formula $C = \frac{N}{V}$ to work out the unknown characteristic!

GASES

Gas calculations are the **ONLY** calculations where the Mole RR equals the Volume RR!!!!

I shall now do some worked examples for solids/liquids/and gases, and all the questions that I have used came from some excellent worksheets published by "Philip Allan, Publishers" (but the answers are mine). Please always
a) be neat and tidy, and always
b) start your answer with either an appropriate **Formula** or a **Reaction equation**.

PLEASE DO NOT JUST PUT DOWN THE ANSWER WHICH IS SHOWN ON YOUR CALCULATOR. You should always give your answer to the correct number of significant figures – and you **MUST** give your answers in significant figures in your Assessed Practicals/Coursework (or you will lose one mark)!

NB " ≈ " means "**is approximately equal to**".

Please try to do each of the questions below **before** you look at how I have done them – and then you will see how easy it is to do calculations using my methodology. Please also note that when you put in all the units that I mentioned on page 2, then you **inevitably** get the correct units for your answer. This is less critical in your First Year, but it becomes very important for your Second Year when you will start to do calculations with many different units in the numerator and in the denominator.

A) SOLIDS[2]

<u>QUESTION 1</u> : How many moles of molecules are there in (a) 4.0g of Methane , CH_4 (b) 6.4g of Sulphur Dioxide, SO_2 (c) 2.8g of Nitrogen, N_2 and (d) 190g of Fluorine, F (sic)[3] **?**

ANSWER 1: and please remember that answers a to c should be given to 2 significant figures with d to 3 s.f.

1a Since M = N x RMM, $N = \dfrac{M}{RMM} = \dfrac{4.0g}{[(1 \times 12.0) + (4 \times 1.0)]\ gmol^{-1}} = \dfrac{4.0}{16.0mol^{-1}} = 0.25\ mol$

1b Since M = N x RMM, $N = \dfrac{M}{RMM} = \dfrac{6.4g}{[(1 \times 32.1) + (2 \times 16.0)]\ gmol^{-1}} = \dfrac{6.4}{64.1mol^{-1}} \approx 0.10\ mol$

1c Since M = N x RMM, $N = \dfrac{M}{RMM} = \dfrac{2.8g}{[2 \times 14.0]\ gmol^{-1}} = \dfrac{2.8}{28.0mol^{-1}} = 0.10\ mol$

1d Write down "Fluorine can exist only as diatomic molecules, therefore for "F_2"
Since M = N x RMM, $N = \dfrac{M}{RMM} = \dfrac{190g}{[2 \times 19.0]\ gmol^{-1}} = \dfrac{190}{38.0mol^{-1}}$ = 5.00 mol of **F_2 molecules**"

<u>QUESTION 2</u> : Calculate the percentage by mass of (a) Carbon in Carbon Dioxide, CO_2 (b) Hydrogen in Pentane, C_5H_{12} , and (c) Oxygen in Chromium Nitrate, $Cr(NO_3)_2$?

ANSWER 2

2a % by Mass $= \dfrac{\text{mass of thing asked about}}{\text{total mass}} \times 100 = \dfrac{\text{mass of Carbon in 1 mole of } CO_2}{\text{mass of 1 mole of } CO_2} \times 100$

$= \dfrac{12.0g}{[12.0 + (2 \times 16.0)]g} \times 100 = \left[\dfrac{12.0 \times 100}{44.0}\right]\% \approx 27.3\ \%$

2b % by Mass $= \dfrac{\text{mass of thing asked about}}{\text{total mass}} \times 100 = \dfrac{\text{mass of H in 1 mole of } C_5H_{12} \times 100}{\text{mass of 1 mole of } C_5H_{12}}$

$= \dfrac{(12 \times 1.0)g}{[(5 \times 12.0) + (12 \times 1.0)]g} \times 100 = \left[\dfrac{12.0 \times 100}{72.0}\right]\% \approx 17\ \%$

(NB At 'A' Level the RAM of H is given to only 2 significant figures.)

2c % by Mass $= \dfrac{\text{mass of thing asked about}}{\text{total mass}} \times 100 = \dfrac{\text{mass of O in 1 mole of } Cr(NO_3)_2}{\text{mass of 1 mole of } Cr(NO_3)_2} \times 100$

$= \dfrac{(2 \times 3 \times 16.0)g}{[52.0 + 2\{14.0 + (3 \times 16.0)\}]g} \times 100 = \left[\dfrac{96.0 \times 100}{176.0}\right]\% \approx 54.5\ \%$

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[2] Please set out your answers as I have shown them. **If you do that in the exam, it will save you a lot of time** – and do remember that a large number of students lose out on valuable marks in the exams because they do NOT finish their papers.

[3] "*sic*" is the Latin word for "thus", and if you see it printed, it means that the preceding word or phrase is being quoted **<u>exactly</u>** as it was given. In other words, here I am drawing your attention to the fact that the question asked for the number of moles of MOLECULES of "F" (but "F" is an atom, and NOT a molecule – therefore this is a badly worded question because F does not exist as atoms since Fluorine exists in nature only as diatomic molecules)! I think that the person who set the question was thinking about "F" as the symbol for the element Fluorine and forgot that "F" is the symbol for an atom of Fluorine and "F_2" is the symbol for a molecule of Fluorine.

QUESTION 3 : Work out the Empirical Formula of (a) an Oxide of Nitrogen in which 8.40g of Nitrogen combine with 4.80g of Oxygen (b) Iron Chloride if 0.86g of Iron react with 1.64g of Chlorine, and (c) Silicon Dioxide if 5.36g of the Oxide contain 2.50g of Silicon?

ANSWER 3

Please remember that in answering this sort of question, you are dealing with **ATOMS and not MOLECULES (even if the element concerned has a diatomic molecule)** , and you must divide across by the smallest number because you cannot have a fraction of an atom, and dividing across by the smallest number will (almost always) give the smallest whole number of atoms.

3a	Reaction Equation	xN	+	yO	—>	N_xO_y
	Use of the Conservation of Mass Rule will give					
	Mass Reaction Ratio	8.40g		4.80g		13.20g
	Mole RR (N = $\frac{M}{RAM}$)	$\frac{8.40g}{14.0gmol^{-1}}$		$\frac{4.80g}{16.0gmol^{-1}}$		
	=	0.600mol		0.300mol		
	Divide across by 0.3mol =	2		1	—>	N_2O

Now, I am going to do that question again because you can leave out irrelevant information and do Empirical Formulae sums in just FOUR lines (and Molecular Formulae sums in just 8 lines). Please use this technique in the exam because you can work out the answer in just two minutes, and thus save time for questions that might be difficult.

3a	Reaction Equation	xN	+	yO	—>	N_xO_y
	Mass Reaction Ratio	8.40g		4.80g		
	MOLE RR (N = $\frac{M}{RAM}$)	$\frac{8.40\ g}{14.0\ gmol^{-1}}$ = 0.6		$\frac{4.80\ g}{16.0\ gmol^{-1}}$ = 0.3		
	Divide across by 0.3 =	2 mol		1 mol	—>	N_2O
3b	Reaction Equation	xFe	+	yCl	—>	Fe_xCl_y
	Mass Reaction Ratio	0.86g		1.64g		2.50g
	MOLE RR (N = $\frac{M}{RAM}$)	$\frac{0.86\ g}{55.8\ gmol^{-1}}$ ≈ 0.0154		$\frac{1.64\ g}{35.5\ gmol^{-1}}$ ≈ 0.0462		
	Divide across by 0.0154 ≈	1 mol		3 mol	—>	$FeCl_3$

3c This one is slightly different, so please note the slight difference! The question says 5.36g of the OXIDE, so remember the Conservation of Mass Law! Please note that I do not round off in the Mole RR line, and do so only when I divide by the smallest number.

Reaction Equation	xSi	+	yO	—>	Si_xO_y
Mass Reaction Ratio	2.50g		2.86g		5.36g
MOLE RR (N = $\frac{M}{RAM}$)	$\frac{2.50\ g}{28.1\ gmol^{-1}}$ ≈ 0.089 mol		$\frac{2.86\ g}{16.0\ gmol^{-1}}$ ≈ 0.179 mol		
Divide across by 0.089 ≈	1 mol		2 mol	—>	SiO_2

NB If you wanted to do so, you could try doing the sum using the Reaction Equation "$Si + O_2 \rightarrow SiO_2$" and then see whether you get a different answer, and you will find that you get exactly the same answer (except that you would have had to remember that you are now dealing with O_2 molecules and not O atoms).

OK, this next calculation is *designed* to throw you off balance. At first glance it looks complicated! The next thing is that it seems to ask you to do the calculations in "tonnes" whereas you are normally asked to do your calculations in grams. In fact, this question is no more difficult than any standard question about the calculation of mass. The rules for this game are very simple at 'A' Level.

i) You must start with a reaction equation. (Without one, you can DO NOTHING.)

ii) A reaction equation tells you the MOLE REACTION RATIO. It does not tell you the Mass RR.

iii) Use Mass = Amount x (Atomic or Molecular or Ionic Mass)
viz. M = N x (RAM or RMM of RFM)
to convert the Mole RR into a corresponding Mass RR.

And that is all that there is to it!

<u>QUESTION 4</u> : One stage in the production of Chromium metal from its ore Chromite [i.e. $Fe(CrO_2)_2$],[4] is as follows

$$4Fe(CrO_2)_2(s) + 8Na_2CO_3(s) + 7O_2(g) \longrightarrow 8Na_2CrO_4(s) + 2Fe_2O_3(s) + 8CO_2(g)$$

If 11.2 t of Chromite are reacted, then

a) what mass of Sodium Chromate (Na_2CrO_4) would be produced, and

b) what mass of Oxygen (g) would be needed to react with 11.2 t of Chromite?

ANSWER 4

For 4(a) all that we need is two ratios viz. the ratio of the Iron Chromite to the Sodium Chromate, and for 4(b) again all that we need is two ratios that of the Chromite to Oxygen.

To simplify the calculation, I am going to do the RFM calculations up-front so that you can then forget about the trifling arithmetic and concentrate on the CHEMISTRY:

1 mole of $Fe(CrO_2)_2$ has a mass of [55.8+2{52.0+(2 x 16.0)}]g	=	223.8g	and
1 mole of Na_2CrO_4 has a mass of [46.0+52.0+64.0]g	=	162.0g	and
1 mole of O_2 has a mass of [2 x 16.0]g	=	32.0g	and

I have deliberately chosen a question that uses a unit other than "grams" because I want to show you that you do not need to multiply by 10^6 to convert "tonnes" into "grams". **MASS Reaction Ratios (RRs) are RATIOS, therefore if a ratio is valid for "grams" then it must also be valid for "tonnes"!**

4a	Mole RR	=	4 moles of $Fe(CrO_2)_2$	:	8 moles of Na_2CrO_4
	(M = N x RAM, or RFM or RMM)				
	Therefore Mass RR	=	4x[223.8]g		8[162]g
		=	895.2g		1296.0g
	Therefore		**11.2t**		**Xt**

Please notice that I have perfectly validly used **tonnes (t)** for the unknown amount of Chromite (as in the question) even though the previous units were **grams (g)**. It is valid to do this because we are dealing with **RATIOS**, therefore any ratio that is valid for one unit (e.g. grams) will also be valid for any other unit e.g. tonnes/kilograms/pounds/ounces/etc. OK, let us now solve for X.

$$X = \frac{1296.0g \times 11.2\mathbf{t}}{895.2g} \approx 16.2\mathbf{t}$$ [Easy isn't it!]

[4] In technical manuals Chromite tends to be written as "$FeCr_2O_4$", and "Fe_2O_3" is sometimes written as $FeO \cdot Fe_2O_3$. It contains both Fe^{2+} and Fe^{3+} ions.

Can you see that even if the examiners want to throw you off balance, they CANNOT do so!!!

4b Mole RR = 4 moles of $Fe(CrO_2)_2$: 7 moles of O_2
(M = N x RAM, or RFM or RMM)
Therefore Mass RR = 4x[55.8+2{52.0+(2 x 16.0)}]g 7[2 x 16.0]g
895.2g 224.0g
Therefore **11.2t** **Xt**

Where X = $\frac{224.0g \times 11.2t}{895.2g} \approx 2.80$**t**

NB The answer should be given to 3 sig figs, therefore the answer is 2.80**t**. The question asked for the **mass** of Oxygen, so please do not give your answer in volume terms.

B) CALCULATIONS FOR LIQUIDS

OK, before we do some calculations for LIQUIDS, let me once more remind you that **everything to do with calculations in Chemistry requires either a formula or a reaction equation or both**; and, from a reaction equation, a MOLE Reaction Ratio can be derived, and then from the MOLE Reaction Ratio a **Mass** RR can be derived (for a solid), or a **Volume** or a **Concentration** can be derived (for a liquid) – but that for gases (and for GASES only), a **MOLE RR** will be numerically identical to a **VOLUME RR**.

Please note how I have used " .... x 10^{-3} " interchangeably with "... ÷ 1,000 ", and please remember that the number of significant figures that you show in your answer must be the same as the **smallest** number of sig. figs. in the question, and also remember that

$$\mathbf{C = \frac{N}{V\ in\ dm^3}}, \qquad \mathbf{V\ in\ dm^3 = \frac{N}{C}} \qquad \text{and} \qquad \mathbf{N = C \times V\ in\ dm^3}$$

Q1 In a titration, 25 cm^3 of 0.100M (i.e. they used the old-fashioned notation for 0.100 mol dm^{-3}) potassium hydroxide was pipetted into a conical flask, and Sulphuric Acid was dripped into the flask from a burette – and 19.8 cm^3 of acid were required to exactly neutralise the alkali. What was the concentration of the Sulphuric Acid?

A1 The reaction equation is
H_2SO_4 (aq) + 2KOH (aq) —> K_2SO_4 (aq) + $2H_2O$ (l)
No of mol of KOH = C x V in dm^3 = 0.100 mol dm^{-3} x 0.025 dm^3 = 0.0025 mol (were neutralised)
Reaction Ratio = 2 mol of KOH : 1 mol of H_2SO_4
Therefore 0.0025 mol : **0.00125 mol (were neutralised)**
Therefore C of H_2SO_4 = $\frac{N}{V\ in\ dm^3} = \frac{0.00125\ mol}{(19.8 \times 10^{-3})\ dm^3} \approx 0.063\ mol\ dm^{-3}$

Q2 Excess Calcium Carbonate is added to 20cm^3 of 1.2M (i.e. 1.2 mol dm^{-3}) Nitric Acid. Calculate the volume of Carbon Dioxide formed at RTP. (In the exam, the question will state the conditions e.g. at RTP.)

A2 The reaction equation is

$CaCO_3$ (aq) + $2HNO_3$ (aq) —> $Ca(NO_3)_2$ (aq) + H_2O (l) + CO_2 (g)

No of mol of HNO_3 = C x V in dm^3 = 1.2 mol dm^{-3} x 0.020 dm^3 = 0.024 mol

Reaction Ratio = 2 mol of HNO_3 : 1 mol of CO_2

Therefore 0.024 mol : **0.012 mol**

But, 1 mol of ANY gas occupies 24.0 dm^3 at RTP (20˚C/293K) or 24.5 dm^3 at 25˚C/293K.

Therefore 0.012 mol of CO_2 occupy X dm^3 at RTP

Where $X = \frac{24.0 \text{ dm}^3 \times 0.012 \text{ mol}}{1 \text{ mol}} = 0.288 \text{ dm}^3$

In the exam the data booklet will tell you what volume and temperature they want you to use.

OK, let us now do a couple of examples of calculations involving gases.

C) CALCULATIONS INVOLVING GASES

NB You can do gas calculation using either Simple Proportions or by the Formulae

Vol of ANY gas at **STP** = N x 22.4 dm^3 mol^{-1} , or

Vol of ANY gas at **RTP** = N x 24.0 dm^3 mol^{-1} (at 20˚C/293K) or 24.5 at 25˚C.

Q1 What volume of Oxygen would be needed at RTP to react with 10 dm^3 of Pentane gas when it burns, and what volume of Carbon Dioxide will be formed?

A1a) The reaction equation is

C_5H_{12} (g) + $8O_2$ (g) —> $5CO_2$ (g) + $6H_2O$ (l)

∴ Mole RR = 1 mol of Pentane (g) : 8 mol of O_2 (g)

∴ Volume RR = 1 dm^3 8 dm^3

∴ 10 dm^3 **80 dm^3 of O_2 (g)**

A1b) Mole RR = 1 mol of Pentane (g) : 5 mol of CO_2 (g)

Volume RR = 1 dm^3 5 dm^3 *(Mole RR = Volume RR)*

∴ 10 dm^3 **50 dm^3 of CO_2 (g)**

Please note that because the Mole RR = the Volume RR for Gases and for GASES only, then no complicated calculations are required (as are required in Solids and Liquids). Gases involve very simple calculations!

Q2) 250 cm^3 of SO_2 and 300 cm^3 of H_2S reacted together according to the following equation

SO_2 (g) + $2H_2S$ (g) —> $2H_2O$ (g) + 3S (s).

What volume of gas will be left at the end of the reaction?

A2) 1st Mole RR = 1 mol of SO2 (g) : 2 mol of H_2S (g)

Volume RR = 1 dm^3 : 2 dm^3 *(Mole RR = Volume RR)*

Therefore **0.150 dm^3** : 0.300 dm^3

∴ amount of excess SO_2 (g) = 0.250 dm^3 – **0.150 dm^3** = **0.100 dm^3 of SO_2 (g)**

This is the amount of SO_2(g) left when reaction ended

2nd Mole RR = 2 mol of H_2S (g) : 2 mol of H_2O (g)

Volume RR = 2 dm^3 : 2 dm^3 *(Mole RR = Volume RR)*

Therefore 0.300 dm^3 : **0.300 dm^3 of H_2O (g)**

Therefore the Volume of gas at the end of the reaction is given by

Volume of H_2O (g) = 0.300 dm^3

Volume of unused SO_2 (g) = 0.100 dm^3

0.400 dm^3

NB H_2O here is a GAS (i.e. steam) and not a liquid (i.e. water).

"S (s)" is solid Sulphur, therefore it is **not** a gas, therefore it is ignored in this calculation!

Q3 10 cm^3 of a hydrocarbon of formula C_xH_y were burnt in excess Oxygen. At the end of the reaction, 0.048g of liquid water had been formed and the total volume of gas left was 80 cm^3, of which 30 cm^3 were unburnt Oxygen. Deduce the values of x and y . [All measurements were at STP.]

A3 When a hydrocarbon is burnt in **excess** Oxygen, then nothing but CO_2 (g) and H_2O (g) are formed. The quantity of each atom on the RHS and on the LHS of the equation must be the same, therefore the relevant reaction equation is given by

Reaction Equation = C_xH_y (s/l/g) + zO_2 (g) —> xCO_2 (g) + $\frac{y}{2}$ H_2O (l)

NB There must be "**y divided by 2**" H_2Os on the RHS of the equation, because there are 2H atoms in each H_2O.

Substances involved	**C_xH_y**	**CO_2**	**H_2O**
RR Given	10 cm^3	(80-30 =) 50 cm^3	0.048g

N of H_2O (l) = N of H_2O (g) = $\frac{M}{RMM}$ = $\frac{0.048g}{(2 + 16)\ g\ mol^{-1}}$ = 0.00267 mol

NB N = Amount or Number of Moles, and the N of a given amount of H_2O must be exactly the same whether it is in solid form, liquid form, or gaseous form!

However, V of ANY gas = N x 22.4 dm^3 mol^{-1} at STP

Therefore V of H_2O (l) = 0.00267 mol x 22.4 dm^3 mol^{-1} at STP ≈ 0.06 dm^3

= 60 cm^3

Therefore for the RE = C_xH_y (s/l/g) + zO_2 (g) —> xCO_2 (g) + $\frac{y}{2}$ H_2O (l)

Volume RR = 10 cm^3 50 cm^3 60 cm^3

Therefore MOLE RR = 1 5 6

(because for GASES and for Gases only, the MOLE RR is exactly the same as the Volume RR)

Therefore x = 5, and (y ÷ 2) = 6

Therefore C_xH_y = C_5H_{12}.

NB Please do lots, and lots and LOTS more calculations for yourselves from ILPAC and Jim Clark, and practice these calculations until you are very familiar with them! Doing the Maths in Chemistry is very much like learning to drive a car. If you PRACTICE and PRACTICE and PRACTICE doing the stuff, then eventually you will be able to do it all superbly well and with consummate ease, but you must PRACTICE and PRACTICE and PRACTICE doing the calculations till you can do them in your sleep!

Just in case you have to do an entrance examination for somewhere special, I will include a more difficult calculation for the Mass of something. I put it here also for those of you who have now fallen in love with your brains and want to start using them. However, in reality, you will see that this calculation is not more *difficult* than any of the others. It is merely more *complicated*.

Q3 17.16g of hydrated Sodium Carbonate ($Na_2CO_3.xH_2O$) were dissolved in distilled water and made up to exactly 250 cm^3 in a standard flask. 25 cm^3 of this solution were then pipetted into a conical flask and titrated with 0.78M (0.78 mol dm^{-3}) Hydrochloric acid. 15.4 cm^3 of acid were required to react with the Sodium Carbonate. Calculate the value of "x".

A3 The reaction equation is

$Na_2CO_3.xH_2O$ (aq) + 2HCl (q) ⟶ 2NaCl (aq) + CO_2 (g) + (x+1)H_2O (l)

No of mol of HCl = C x V in dm^3 = 0.78 mol dm^{-3} x 0.0154 dm^3 = 0.012 mol

Reaction Ratio = 1 mol of $Na_2CO_3.xH_2O$: 2 mol of HCl

Therefore **0.006 mol** : 0.012 mol

But, No of mol of $Na_2CO_3.xH_2O$ also $= \frac{M}{RFM}$, where M = 17.16g

and RFM of $Na_2CO_3.xH_2O$ = [(2 x 23.0) + 12 + (3 x 16.0) + X{(2 x 1.0) + 16.0}] g mol^{-1}

= [46.0 + 12.0 + 48.0 + 18.0X] g mol^{-1}

= (106.0 + 18.0X) g mol^{-1}

Therefore No of mol of $Na_2CO_3.xH_2O$ $= \frac{M}{RFM} = \frac{17.16g}{(106.0 + 18.0X)\ g\ mol^{-1}}$,

But this is the number of moles in 250 cm^3

Therefore no of moles in 25 cm^3 $= \mathbf{\frac{1.716g}{(106.0 + 18.0X)\ g\ mol^{-1}} = \frac{1.716\ mol}{(106.0 + 18.0\ X)}}$

and (from the Reaction Ratio) this must equal 0.006 mol

Therefore $\frac{1.716\ mol}{(106.0 + 18.0X)} = 0.006\ mol$

Therefore $\frac{1.716}{0.006} = 106.0 + 18.0X$

Therefore 286 = 106.0 + 18.0X

Therefore 180 = 18X

Therefore X = 10

(X is normally an integer, but it could equally well be a fraction e.g. $\frac{1}{2}$ H_2O)

NB This is quite a difficult question to answer – but you will **NOT** be given a question as difficult as this to answer in your First Year exams.