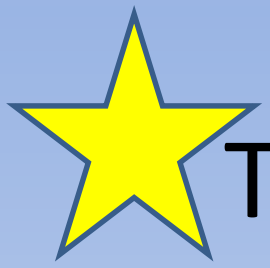
Summer 2018

Chemistry A level

Summer Work



This Summer Work includes…

- Background Reading and questions on Mass Spectrometry
- Revision of GCSE calculations and linking these to A level
- Revision of GCSE bonding and linking this to A level

Please make sure that..

- ALL questions have been completed on paper, clearly showing all your working

- Notes have been made as evidence of your background reading using the links provided

Task 1

Read through the following slides. They give you some information on a process called mass spectrometry and how it is used. You should also read around this topic using online resources (suggestions given at the end of this PowerPoint).

The Mass Spectrometer

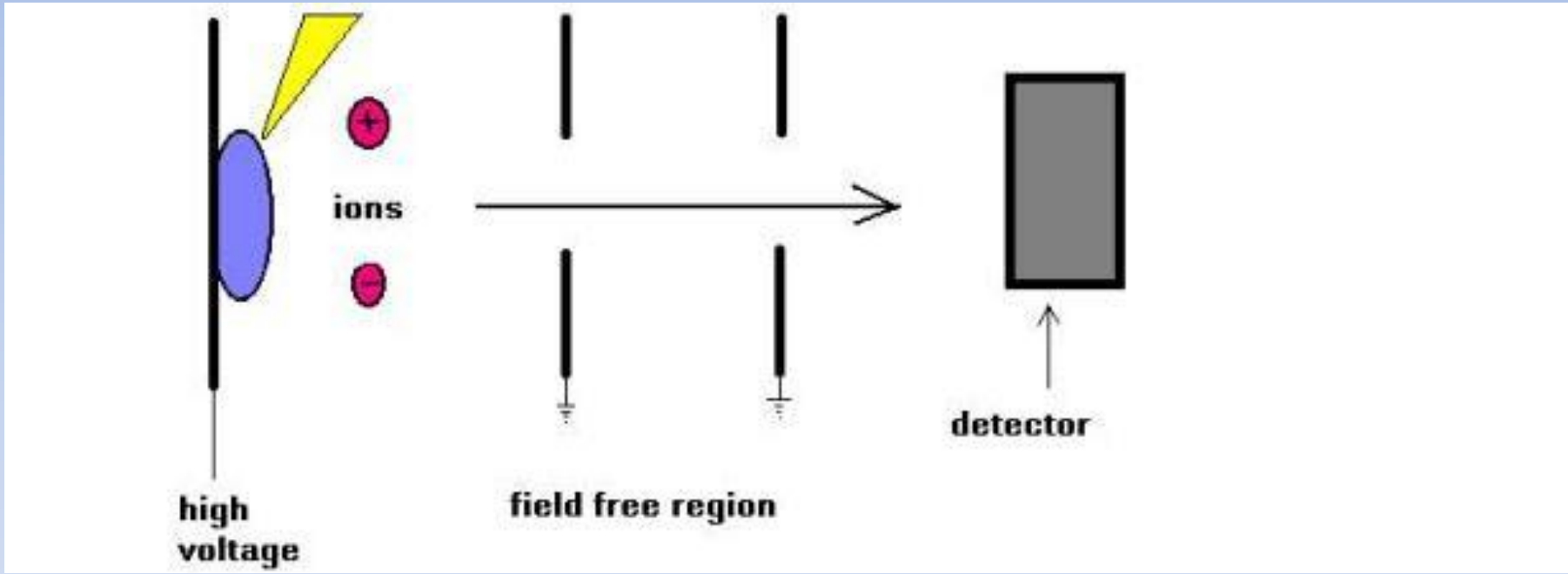
The Mass Spectrometer: Watch the video clip and make notes

- https://www.youtube.com/watch?v=J-wao0O0_qM

- The link below provides lots of information on Mass spectrometry specifically for AQA A level Chemistry and it is definitely worth reading and/or making notes from:

http://filestore.aqa.org.uk/resources/chemistry/AQA-7404-7405-SG-TOFMS.PDF

The Mass Spectrometer: Learn the different parts



1. Ionisation:

- There are several different ways in which a sample can be ionised. The traditional method involves bombardment of a gaseous sample with a beam of high-energy electrons, fired from an electron gun. The atom or molecule is ionised as this knocks one or more electrons off to give a positive ion.
- This technique is still in use with TOF mass spectrometers for obtaining the mass spectra of small molecules and atoms.

- New methods of ionisation have been developed that are particularly suited to large organic molecules because they overcome the destructive effects of an electron gun that could lead to complete fragmentation of a molecule and therefore no molecular ion. One of these new 'soft' methods of ionisation is electrospray ionisation. More detail on electrospray ionisation can be found on the next slide →

More about Electrospray Ionisation:

- The sample is dissolved in a polar, volatile solvent such as water or methanol.
- The solvent acts as a source of protons to facilitate the ionisation process. $M + H^+ \rightarrow MH^+$
- The solution is pumped through a hypodermic capillary needle, where the sample is converted into a fine mist.
- A very high voltage e.g. 4,000 volts is applied to the tip of the capillary and the sample emerges dispersed in an aerosol of highly charged droplets.
- The solvent evaporates (desolvation) and we are only interested in the singly charged MH+ (g) ions produced.

Find more detail on this here:
http://filestore.aqa.org.uk/resources/chemistry/AQA-7404-7405_SG_TOFMS.PDF

2. Acceleration:

- The ions are accelerated by an electric field so that they all have the same kinetic energy.

3. Ion Drift

- The ions enter a region with no electric field, so they just *drift* through it.
- Lighter ions will drift through faster than heavier ions.

4. Detection

- As the lighter ions travel faster than heavier ions, they reach the detector in less time.
- When the ions reach the detector, they gain an electron and this causes a current to flow.
- The size of the current is proportional to the abundance of the ion.

Answer these Questions after your notes:

1) What happens during electron impact ionisation?
2) What type of molecules is this method used with?
3) Research and write a brief description of the new method of forming ions: Electrospray Ionisation
4) What type of molecules is this new method suited for use with and why?
5) Why is electrospray ionisation considered a soft technique?

Working out Time of Flight (TOF)

Firstly, you can use the method below to work out the velocity of the particles:

The positive ions are accelerated using an electric field so that they all have the same kinetic energy.

$KE = \frac{1}{2}mv^2$

(students would be given this equation if expected to use it in an exam)

KE = kinetic energy of particle (J)

m = mass of the particle (kg)

v = velocity of the particle (m s^{-1})

Therefore, the velocity of each particle is given by: $v = \sqrt{\frac{2KE}{m}}$

Given that all the particles have the same kinetic energy, the velocity of each particle depends on its mass. Lighter particles have a faster velocity, and heavier particles have a slower velocity.

Working out Time of Flight (TOF)

Secondly, you use your calculated velocity to work out the time taken for that particle to move through the flight tube:

The positive ions travel through a hole in the negatively charged plate into a tube. The time of flight of each particle through this flight tube depends on its velocity which in turn depends on its mass

$$t = \frac{d}{v}$$

$$t = d\sqrt{\frac{m}{2KE}}$$

(students would be given this equation if expected to use it in an exam)

t = time of flight (s)

d = length of flight tube (m)

v = velocity of the particle (m s^{-1})

m = mass of the particle (kg)

KE = kinetic energy of particle (J)

Now try the exam Questions:

(b) Describe how ions are formed in a time of flight (TOF) mass spectrometer.

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(2)

(c) A TOF mass spectrometer can be used to determine the relative molecular mass of molecular substances.

Explain why it is necessary to ionise molecules when measuring their mass in a TOF mass spectrometer.

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(a) Explain how ions are accelerated, detected and have their abundance determined in a time of flight (TOF) mass spectrometer.

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(3)

Calculations Consolidation

Now you need to spend some time revising the following GCSE calculations before trying the next A level exam questions:

- ***RFM***
- ***Calculating moles in solids from mass***
- ***Calculating percentage by mass***
- ***The Avogadro Constant***

The information on the following slides may help you, but you should be reading through your GCSE work too and trying to find out answers that you may not already know.

The Avogadro Constant

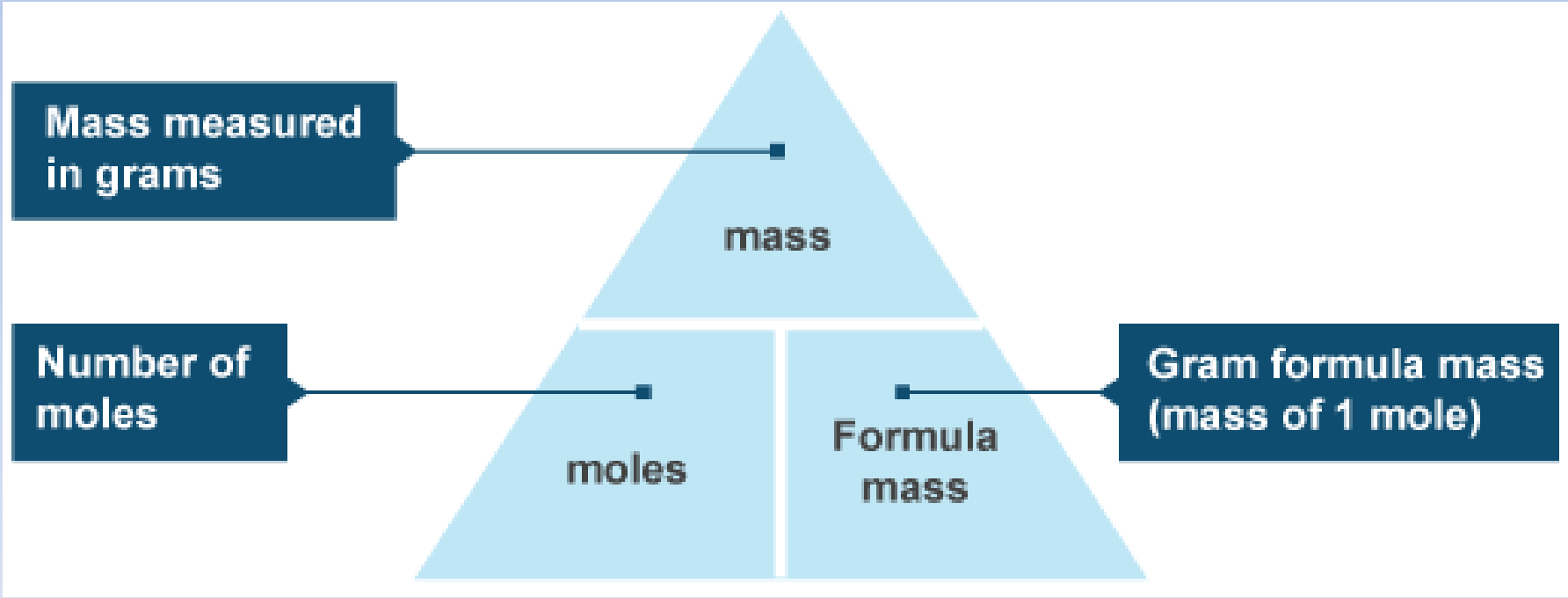
- One mole of a substance is its **gram formula mass (GFM)** e.g. one mole of carbon will weigh 12g (as stated on the Periodic Table)
- One mole of a substance contains 6.02 x 10^{23} particles
- This number is known as the **Avogadro constant**.

Therefore, the mass of one carbon atom would be:

$12/6.02 \times 10^{23}$

Calculating Moles:

- To calculate the number of moles in a solid, you need to use the following formula:



Question | Mark Scheme | Examiner's Report | Notes | Resource

What is the number of atoms in 0.0100 mol of NH_3?
(The Avogadro constant L = $6.022 \times 10^{23} mol^{-1}$)

A 6.02×10^{25} ⬭

B 1.20×10^{23} ⬭

C 1.81×10^{22} ⬭

D 2.41×10^{22} ⬭

(Total 1 mark)

(a) One isotope of sodium has a relative mass of 23.

(i) Define, in terms of the fundamental particles present, the meaning of the term *isotopes*.

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(ii) Explain why isotopes of the same element have the same chemical properties.

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(iii) Calculate the mass, in grams, of a single atom of this isotope of sodium.
(The Avogadro constant, L, is 6.023×10^{23} mol^{-1})

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(5)

Question | Mark Scheme | Examiner's Report | Notes | Resource

When heated, iron(III) nitrate (M_r = 241.8) is converted into iron(III) oxide, nitrogen dioxide and oxygen.

$$4Fe(NO_3)_3(s) \longrightarrow 2Fe_2O_3(s) + 12NO_2(g) + 3O_2(g)$$

A 2.16 g sample of iron(III) nitrate was completely converted into the products shown.

(a) (i) Calculate the amount, in moles, of iron(III) nitrate in the 2.16 g sample.
Give your answer to 3 significant figures.

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(1)

(ii) Calculate the amount, in moles, of oxygen gas produced in this reaction.

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(1)

TOF Mass Spec Calculation

Hint! First, you need to work out the mass of the ion by dividing the Ram (52) by the Avogadro constant. You then need to make sure that this mass is converted into Kg from grams before using it in the equation →

(1)

as

(m = mass/kg and v = velocity/ms^{-1})

(2)

Useful websites to use to help with this work and for background reading on these topics:

General:

https://www.chemguide.co.uk/

Mass Spec

https://www.chemguide.co.uk/analysis/masspec/howitworks.html

Moles:

http://alevelchem.com/aqa_a_level_chemistry/unit3.1/sub312/02.htm

https://alevelchemistry.co.uk/notes/mole-avogadro-constant/

http://www.bbc.co.uk/bitesize/higher/chemistry/calculations_1/mole/revision/1/