Name……………………………….. Chemistry Class……………...

Student Number……………………..

Pre coursework

ATOMIC STRUCTURE



**Topic 1: Atomic Structure and the Periodic Table**

1. know the structure of an atom in terms of electrons, protons and neutrons

2. know the relative mass and relative charge of protons, neutrons and electrons

3. know what is meant by the terms ‘atomic (proton) number’ and ‘mass number’

4. be able to determine the number of each type of sub-atomic particle in an atom, molecule or ion from the atomic (proton) number and mass number

5. understand the term ‘isotopes’

6. be able to define the terms ‘relative isotopic mass’ and ‘relative atomic mass’, based on the 12C scale

7. understand the terms ‘relative molecular mass’ and ‘relative formula mass’, including calculating these values from relative atomic masses *Definitions of these terms will not be expected. The term ‘relative formula mass’ should be used for compounds with giant structures.*

8. be able to analyse and interpret data from mass spectrometry to calculate relative atomic mass from relative abundance of isotopes and vice versa

9. be able to predict the mass spectra, including relative peak heights, for diatomic molecules, including chlorine

10. understand how mass spectrometry can be used to determine the relative molecular mass of a molecule *Limited to the m/z value for the molecular ion, M+, giving the relative molecular mass of the molecule.*

**What to do if you get stuck:**

****

1. **Read pages 12-22 in the textbook –** [there is an online link on GOL](https://online.godalming.ac.uk/course/view.php?id=395)
2. **Watch the crash course chemistry video on atomic structure:**

[https://www.youtube.com/watch?v=rcKilE9CdaA&index=5&list=PL8dPuuaLjXtPHzzYuWy6fYEaX9mQQ8oGr](https://www.youtube.com/watch?v=FSyAehMdpyI&list=PL8dPuuaLjXtPHzzYuWy6fYEaX9mQQ8oG)

1. Look at the Powerpoint on Atoms and Isotopes <http://www.knockhardy.org.uk/ppoints.htm>
2. Drop into Chemistry Clinic – 1pm on Fridays or after college on Tuesdays in room 141

**What to do if you have some of your 5 h over:**

After you have finished the work set by your class teacher and you still have some of the 5 h left you should look at some of the following:

1. Make a revision/ summary page – using the specification statements on the front of the pack as a guide.
2. Read the year 1 textbook, Curtis p12 – 23 <https://www.dawsonera.com/readonline/9781471807473>
3. Read the following on the Chemguide website:

[http://www.chemguide.co.uk/atoms/propsmenu.html#top](https://www.chemguide.co.uk/atoms/properties/gcse.html%22%20%5Cl%20%22top)

1. Complete the Exam Practice Questions 1, 2, 4 & 8 (extension) on p. 35 of Curtis year 1 textbook. Answers can be found at <https://www.hoddereducation.co.uk/edexcelachemistry1>
2. Watch the following video: <http://estream/View.aspx?ID=3223~4k~jEaGVgFQ&from=AuthSuccess>
3. Look at the following [chem factsheets](https://online.godalming.ac.uk/mod/folder/view.php?id=26688) (top left hand corner on GOL):

|  |  |
| --- | --- |
| 01 | Atomic Structure |
| 151 | How to answer AS Exam Questions on Atomic Structure |
| 55 | Organic Analysis II: Mass Spectrometry |

Go to the Atomic structure folder on GOL open the ppt Atomic structure. Complete up to p16 before the lesson

In order to give yourself the best possible start to the course and so maximise your chances of success, work your way through this pack. **There will be a TEST on tasks 1-5 in the first week of term**

**TASK 1 - Learn the symbols of the first 30 elements**

Use a periodic table to complete the following table.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Atomic Number | **Name** | **Symbol** | Atomic Number | **Name** | **Symbol** |
| 1 |  |  | 16 |  |  |
| 2 |  |  | 17 |  |  |
| 3 |  |  | 18 |  |  |
| 4 |  |  | 19 |  |  |
| 5 |  |  | 20 |  |  |
| 6 |  |  | 21 |  |  |
| 7 |  |  | 22 |  |  |
| 8 |  |  | 23 |  |  |
| 9 |  |  | 24 |  |  |
| 10 |  |  | 25 |  |  |
| 11 |  |  | 26 |  |  |
| 12 |  |  | 27 |  |  |
| 13 |  |  | 28 |  |  |
| 14 |  |  | 29 |  |  |
| 15 |  |  | 30 |  |  |

**TASK 2 – Learn the formulae of common compounds and gases**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ACIDS** | Sulfuric acid | Nitric acid | Hydrochloric acid | Phosphoric acid |
|  | H2SO4 | HNO3 | HCl | H3PO4 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ALKALIS** | Sodium hydroxide | Potassium hydroxide | Calcium hydroxide | Sodium carbonate |
|  | NaOH | KOH | Ca(OH)2 | Na2CO3 |

|  |  |
| --- | --- |
| **GASES** |  |
| Compounds | Ammonia | Methane | Carbon dioxide | Carbon monoxide | Sulfur dioxide | Nitrogen dioxide |
| NH3 | CH4 | CO2 | CO | SO2 | NO2 |
| Elements | Hydrogen | Oxygen | Nitrogen | Chlorine | Fluorine | Argon |
| H2 | O2 | N2 | Cl2 | F2 | Ar |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| H+ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Li+ | Be2+ |  |  |  |  |  |  |  |  |  |  |  |  |  | O2- | F- |  |
| Na+ | Mg2+ |  |  |  |  |  |  |  |  |  |  | Al3+ |  |  | S2- | Cl- |  |
| K+ | Ca2+ |  |  |  |  |  | Fe2+Fe3+ |  |  | Cu+Cu2+ | Zn2+ |  |  |  |  | Br- |  |
| Rb+ | Sr2+ |  |  |  |  |  |  |  |  | Ag+ |  |  |  |  |  | I- |  |
| Cs+ | Ba2+ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Task 3 Formulae of ions: Learn these common ions

Metals form simple ions with positive charges called cations – their names are the same as the element.

 Non-metal simple ions have negative charges and are called anions – their names end in -ide

**Task 4 Ions with different charges and polyatomic ions**

Some metals can form ions with differing charges:-

Copper can form the ions Cu+ or Cu2+, these are named as copper(I) ions or copper(II) ions respectively. For simple ions the roman numerals signify the charge on the ion.

You will study how the roman numeral is derived for polyatomic ions later next term.

Complete the table

|  |  |
| --- | --- |
| **Name of cation** | **formula** |
| Copper(I) | Cu+ |
| Copper(II) | Cu2+ |
| Iron(II) |  |
| Iron(III) |  |
| Manganese(II) |  |
| Chromium(III) |  |

There are also ions composed of more than one element, **polyatomic** ions

**NH4+** (ammonium ion)

**OH-** (hydroxide ion)

**NO3-** (nitrate(V) ion)

**SO42-** (sulfate(VI) ion)

**CO32-** (carbonate ion) and **HCO3-** (hydrogencarbonate ion)

**PO43-** (phosphate(V) ion)

**CrO42-** (chromate (VI) ion) and  **Cr2O72-** (dichromate(VI) ion)

**MnO4-** (manganate(VII) ion)

**THESE NEED TO BE LEARNT**

Note that some ions require a Roman numeral in their name. You will learn more about these later when we study redox and oxidation numbers

**I = 1 II=2 III=3 IV=4 V=5 VI=6 VII=7**

**Now for some practice…..**

|  |  |
| --- | --- |
| **CATIONS** | **ANIONS** |
| **Name** | **Symbol & charge** | **Name** | **Symbol & charge** |
| Calcium |  | Hydroxide |  |
| Sodium |  | Hydrogencarbonate |  |
| Ammonium |  | Chloride |  |
| Hydrogen |  | Nitrate(V) |  |
| Potassium |  | Bromide |  |
| Silver |  | Sulfate(VI) |  |
| Copper(II) |  | Carbonate |  |
| Magnesium |  | Oxide |  |
| Zinc |  | Phosphate(V) |  |
| Barium |  | Iodide |  |
| Iron(II) |  | Fluoride |  |
|  | **Name** |  | **Name** |
| Al3+ |  | NO3- |  |
| Cu2+ |  | SO42- |  |
| Be2+ |  | F- |  |
| Mg2+ |  | Br- |  |
| Sr2+ |  | O2- |  |
| Zn2+ |  | CO32- |  |
| K+ |  | CrO42- |  |
| Cs+ |  | OH- |  |
| Fe3+ |  | Cl- |  |

Did you remember the names of simple anions end in **–ide** ?

**Task 5 Forming compounds from ions**

When a compound is formed between ions, the number of positive charges must equal the number of negative charges so that the compound is neutral.

E.g. Sodium chloride is made up of Na+ and Cl- ions. A sodium ion has a single positive charge and a chloride ion has a single negative charge so the formula of sodium chloride is NaCl.

 E.g. Sodium sulfate(VI) is made up of Na+ and SO42- ions. A sodium ion has a single positive charge and a sulfate ion has a double negative charge so twice as many sodium ions as sulfate ions must be present in order to have equal positive and negative charge. Thus the formula of sodium sulfate is Na2SO4.

Go to <http://www.docbrown.info/page01/ElCpdMix/formula1wf.htm>

To test yourself further complete the following table:

|  |  |  |  |
| --- | --- | --- | --- |
| **Compound** | **Ions Present** | Ratio of ions | **Formula** |
| **Positive** | **Negative** | **Positive** | **Negative** |
| Sodium chloride | Na+ | Cl- | 1 | 1 | NaCl |
| Sodium sulfate(VI) | Na+ | SO42- | 2 | 1 | Na2SO4. |
| Iron(II) hydroxide | Fe2+ | OH- | 1 | 2 | Fe(OH)2 |
| Silver nitrate(V) |  |  |  |  |  |
| Magnesium chloride |  |  |  |  |  |
| Copper(II) oxide |  |  |  |  |  |
| Ammonium chloride |  |  |  |  |  |
| Copper(II) sulfate |  |  |  |  |  |
| Iron(III) hydroxide |  |  |  |  |  |
| Sodium hydroxide |  |  |  |  |  |
| Hydrochloric acid |  |  |  |  |  |
| Sulfuric acid |  |  |  |  |  |
| Nitric acid |  |  |  |  |  |

From now on you must be careful to use the **correct technical term**.

(give the right name to the right thing).

An ammonium ion is not the same as an ammonia molecule.

A chloride ion is not the same as a chlorine atom or a chlorine molecule.

Hydrogen chloride (HCl(g)) and hydrochloric acid (HCl(aq)) are different.

If you are careless not only will you lose marks in the exam but as they have different chemical reactions…….Almost the same is not good enough!

**Introduction to Atoms and Elements**.

Everything we see around us, benches, computers and you! are made of atoms. At one time these atoms were part of something else. Some may have been in the soil, the air or even part of someone else. In other words one of the atoms that make up you could have been in your neighbour’s great grandad. There are 92 naturally occurring types of atoms, we call these Elements.

Define:-

**ELEMENT** ……………………………………..………………………………………………..

……………………………………………………………………………………………………..

You will need to be familiar with the symbols for the first 36 elements. For the moment check that you know symbols for the first 30.

The simplest model of the **atom** is shown in the diagram below:



Atoms have a tiny central NUCLEUS containing:- PROTONS (positively charged)

and NEUTRONS (neutral)

The nucleus is surrounded by a cloud of ELECTRONS (negatively charged)

These are arranged in shells having different energy levels

The diagram above is of a Lithium atom. How do we know this?

................................................................................................................................................................................................................................................................................................................................

It is the number of protons in the nucleus which determines which element we are looking at. An atom with 6 protons would be the element carbon; the number of protons determines the element. This number is called the ATOMIC NUMBER of the element, the number of protons also determines its position in the Periodic Table

Changing the number of neutrons, or electrons does not change the element.

Find the element:-

|  |  |
| --- | --- |
| No of Protons  | Name  |
| 77 |  |
| 53 |  |
| 47 |  |
| 6 |  |
| 10 |  |
| 92 |  |

If the number of electrons surrounding the nucleus is equal to the number of protons inside it, the atom is neutral. If the number of **electrons does not equal the number of protons** it is no longer an atom it is now an ion

Define:-

**ION** ……………………………………..………………………………………………………...

……………………………………………………………………………………………………..

Identify the following ions or atoms, giving the correct symbol

|  |  |  |
| --- | --- | --- |
| No protons | No electrons | Symbol |
| 17 | 18 | Cl- |
| 55 | 54 |  |
| 13 | 10 |  |
| 23 | 21 |  |
| 7 | 10 |  |
| 7 | 4 |  |
| 35 | 36 |  |
| 9 | 9 |  |
| 29 | 28 |  |
| 25 | 23 |  |

Almost all the **mass** of an atom is in the nucleus. Almost all the **volume** is in the electron cloud.

The mass of one proton approximately equals the mass of one neutron i.e. 1 u (atomic mass unit), but an electron is much lighter. ( ~ 1/2000 u).

Complete the following table:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Proton | Neutron | Electron |
| Approximate mass /u |  |  |  |
| Charge |  |  |  |

Refer to; Curtis textbook 1 p16 - 17.



Refer to **slide 6** of the PPT

**MASS NUMBER** **(A) of an isotope** is the number of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ plus

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of an atom

**ATOMIC NUMBER** (proton number) **(Z)** is the number of \_\_\_\_\_\_\_\_\_\_\_ in the \_\_\_\_\_\_\_\_\_\_\_

of an atom

…………………………………………………………………………………………………….

This information is expressed:

##### Li

Mass Number

Atomic number

7

3

Elements are arranged on the periodic table according to:

* + - Increasing atomic number
		- The arrangement of electrons in shells.

Complete the following table:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Atom | Atomicnumber | Massnumber | Number ofprotons | Number of neutrons | Number of electrons |
| 12C6 | 6 | 12 | 6 | 6 | 6 |
| 23Na11 |  |  |  |  |  |
|  | 9 | 19 |  |  |  |
|  |  | 40 | 18 |  |  |
|  |  |  | 19 | 20 |  |
|  |  |  |  | 14 | 13 |
| 197Au79 |  |  |  |  |  |
|  | 35 |  |  | 44 |  |
|  |  | 238 |  |  | 92 |

For more practice go to:-

![MCj04247820000[1]]()Curtis year 1 textbook p17 Test yourself Q8 - 10

Go to <http://www.softschools.com/chemistry/atomic_theory/>

and try the Atomic Number Quiz.

# ISOTOPES refer to slide 7 of the PPT



Reference: Curtis year 1 textbook p19 - 21

It is the proton number that determines the element, not the number of electrons OR the number of neutrons. Atoms which have the same number of protons but a different number of neutrons are called ISOTOPES. You need the LEARN these definitions carefully word for word.

Define:-

**ISOTOPES** are atoms of the same \_\_\_\_\_\_\_\_\_\_\_ which have the same number

of \_\_\_\_\_\_\_\_\_\_\_\_ in the \_\_\_\_\_\_\_\_\_\_\_\_ but different number of \_\_\_\_\_\_\_\_\_\_\_\_\_ .

They will have the same atomic number but a different mass number.

In Chemistry we are interested in the electrons and their arrangement, as this is what determines
the reactions they undergo. This means that all isotopes react in exactly the same way. The key difference between isotopes is their MASS.

**RELATIVE ISOTOPIC MASS**: is the mass of one \_\_\_\_\_\_\_\_\_\_ of an \_\_\_\_\_\_\_\_\_\_ relative to \_\_\_\_\_ of the mass of an atom of the \_\_\_\_\_\_\_\_\_\_ carbon-12.

Compare this definition with that of mass number on page 3.

These are numerically almost identical for a given isotope, however, never mix them up.

Although relative isotopic masses are close to whole numbers, by definition, Mass Number must be exactly a whole number (integer).

Complete the following table:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Cl1735 | Cl1737 | Ne1020 | Ne1022 |
| Number of protons |  |  |  |  |
| Number of electrons |  |  |  |  |
| Atomic number |  |  |  |  |
| Number of neutrons |  |  |  |  |



#### Class videoVideos:

[Atom](http://estream/View.aspx?ID=3223) (e-stream 3223) 11.30 – 23.02 The structure of the atom

[Discovery of the atom](http://estream/View.aspx?ID=306) (e-stream 306) 26 min

[Bohr’s model of the atom](http://estream/View.aspx?ID=2880) (e-stream 2880) 1.00 – 7.36

**THE RELATIVE ATOMIC MASS**

Refer to **slide 8** of the PPT

Reference: Curtis p19 - 20

Atoms are very small, very, very small - so small in fact that there are more atoms in this full stop ‘.’ than there are people on the planet.

Weighing them is therefore difficult. To get round this problem scientist use a concept called relative atomic mass. This is the mass of the atom relative (i.e. compared to) something else. Originally they were compared to Hydrogen; however, it was difficult to produce pure samples of hydrogen without any isotopes.

To avoid this problem the standard in use since 1961 consists of a single isotope:

What is it? ...........................................................................................................................

**RELATIVE ATOMIC MASS (Ar)** is the \_\_\_\_\_\_\_\_\_\_\_ mass of an \_\_\_\_\_\_\_\_\_\_ of an \_\_\_\_\_\_\_\_\_\_\_\_ relative to \_\_\_\_\_\_\_\_ the mass of an \_\_\_\_\_\_\_\_ of the isotope \_\_\_\_\_\_\_\_\_\_\_.

Try: Curtis p21 Test yourself Q12 – 15.

### RELATIVE MOLECULAR MASS

This is the mass for substances which exist as **molecules,** a molecule is something which exists as a fixed number of atoms with covalent bonds. To find the RMM it is all of the atomic masses of a molecule added together

E.g.: RMM of CH3Cl = 1C +3H +1Cl = 12 + 3x1 + 1x35.5 = 50.5

|  |  |  |
| --- | --- | --- |
| **Formula** | **Working** | **RMM** |
| C6H12 |  |  |
| CH2F2 |  |  |
| H2SO4 |  |  |

### RELATIVE FORMULA MASS

Curtis p21

### This is very similar to the RMM, however it is for substances which form giant structures, e.g. ionic solids, where the cations and anions arrangement continues indefinitely.

### For example for NaCl, there is not one sodium ion and one chloride ion in a lattice – there are far far more!

### However to find the RFM we simply add up the masses in the formula given:

e.g. K2SO4 = 2K + S + 4O = 2x39.1 + 32.1 + 4x16 = 174.3

|  |  |  |
| --- | --- | --- |
| Formula | Working | RMM |
| Ca(OH)2 |  |  |
| MgCl2 |  |  |
| NaNO3 |  |  |



Curtis p22 Test yourself Q16 and 17.

### MASS SPECTROMETER

Refer to **slide 9** of the PPT

Video: [Mass spectrometer](http://estream/View.aspx?ID=303) (e-stream 303) 19.34 – 23.50 Modern Chemical Techniques

(Video: [Atom 2](http://estream/View.aspx?ID=3224) (e-stream 3224) 07.35 -18.53. 1st mass spec, discovery of the proton and neutron.)

The existence of isotopes was suspected for quite a long time due to the fact that some relative atomic masses e.g. chlorine, were so far off being whole numbers.

The first absolute proof that isotopes existed was given by an instrument called a MASS SPECTROMETER.

There are now several different types of mass spectrometer that are used to investigate different aspects of atoms and molecules.

For our syllabus we only need to know the basic points of the original design of mass spectrometer, and not in elaborate detail.

Refer to: Curtis p17-18 and Test yourself Q11

Mass Spectrometer[1] RSC Power-point

Give an equation to show ionisation of an element E to form a 1+ positive ion by bombardment of a fast moving electron in the mass spectrometer:

……………………………………………………………………………………………………….

Label the clear simplified diagram of a mass spectrometer to illustrate a written summary of the 5 / 6 stages in the identification of the relative atomic masses of atoms (or molecules).



### Mass spectra of elements

Refer to **slide 10** of the PPT <http://estream.godalming.ac.uk/View.aspx?id=15736~5j~BZGUS7vzwq>

* Mass spectra of elements usually show more than one ion present (more than one peak)
* ![MCj04247820000[1]]()Elements for which this occurs contain **isotopes**.
* The **heights of the peaks** show the **abundances** of these isotopes.
* From this information the **relative atomic mass** of the element can be calculated.

**The mass spectrum of boron** is given below.



Scaled so most abundant peak is 100%

mass/charge

For our purposes only ions of +1 charge are considered

Looking at the mass spectra above:

1. How many isotopes does boron have? ………..
2. What are their mass numbers? ...................................................
3. What is the ratio of abundance of these? …………………
4. The relative atomic mass of boron = 23 x 10 100 x 11

 123 + 123

$$Relative atomic mass:$$

$$=\frac{\left(abundance of peak1×mass of peak1\right)+ \left(abundance of peak2×mass of peak2\right)+…}{total abundance}$$

**Predicting the mass spectra of bromine, Br2:**

Refer to **slide 11** of the PPT <http://estream.godalming.ac.uk/View.aspx?id=15735~5i~adrjgVkd8o>

|  |  |
| --- | --- |
| **Isotope** | **Abundance** |
| 79Br | 50.7% |
| 81Br | 49.3% |

|  |  |  |
| --- | --- | --- |
| RATIO: | 79Br | 81Br |
| 79Br |  |  |
| 81Br |  |  |

Draw and label the peaks in the mass spectrum below.

Remember to include the **charge** on the peaks.

% abundance

Mass/charge (m/e)

A mass spectrometer was used to analyse a sample of bromine Br2, with only the 79Br and 81Br isotope present.

Explain why a very small peak occurs at m/z = 80

…………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

**Mass spectra of molecules**

Chlorine has two isotopes 35Cl and 37Cl in the ratio of 3:1. You might, therefore expect the mass spectrum would look like:



However, Chlorine **atoms** form diatomic (two-atom) **molecules**, Cl2 , (or Cl ─ Cl where ─ represents a covalent bond). These molecules will have an electron knocked off in the ionisation chamber of the mass spectrometer to form a **molecular ion.**

Give an equation to show how chlorine molecules ionise in a mass spectrometer:

……………………………………………………………………………………………………….

Given that the ratio of chlorine atoms, = 75% 35Cl : 25 % 37Cl

= 3 : 1

It is possible to work out the % abundances of each of the chlorine molecules by filling in the relative molecular masses of the chlorine molecules in the table below.

(The relative molecular mass of a compound is the sum of the relative atomic masses)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| RATIO 3:1 | 35Cl | 35Cl | 35Cl | 37Cl |
| 35Cl | 35 + 35 = 70 |  |  |  |
| 35Cl |  |  |  |  |
| 35Cl |  |  |  |  |
| 37Cl |  |  |  |  |

The emerging species will be :- 35Cl ─ 35Cl+ : 35Cl ─ 37Cl+ : 37Cl ─ 37Cl+

And the ratio is therefore: ..……….. : …………… : ..…………

**The mass spectrum of chlorine molecules, Cl2**

From the ratio you have calculated construct a mass spectrum for the molecular ions of the possible chlorine atoms and molecules on the axes given below:-

* The heights of the peaks must represent the abundances.
* Calculate the % abundance of each to give the height of each peak as shown below:

|  |  |  |  |
| --- | --- | --- | --- |
|  | 35Cl ─ 35Cl+ | 35Cl ─ 37Cl+ | 37Cl ─ 37Cl+ |
| Ratio | 9 | 6 | 1 |
| % abundance | 9/16 x 100 = |  |  |

Add an appropriate scale to each axis and draw in the mass spectrum peaks and label them.

% abundance

Mass/charge (m/e)

**Note:** The Cl2 molecules can break up into atoms in the mass spectrometer so there are also peaks due to these at m/e values 35 and 37. You will learn more about this fragmentation of molecules in the mass spectrometer later in the course.

The species detected in a mass spectrometer have a **positive charge.**

**Finding the relative molecular mass of a molecule**

The relative molecular mass of a molecule is easily found as it is the peak with the highest mass. The peak represents the molecular ion- the whole molecule with an electron missing so it will have a positive charge (M+).

Circle the peak which represents the molecular ion in the following spectra and write the formula of the molecular ion in the table:

|  |  |  |
| --- | --- | --- |
| **Mass spectra example** | **Mass of molecular ion peak** | **Molecular ion** |
| http://panomics.pnnl.gov/images/waterspectrum.jpg |  |  |
| http://www.chemguide.co.uk/analysis/masspec/p3onemspec.GIF |  |  |
| http://www.chemguide.co.uk/analysis/masspec/pentanemspec.GIF |  |  |

**Revision Notes**

Use the specification on the front page and include:

* Definition of:
	+ Atomic/proton number
	+ Mass number
	+ Isotope
	+ Relative isotopic mass
	+ Relative atomic mass
* How to predict mass spectra
* How to calculate relative atomic mass from a mass spectra
* How to find the relative molecular mass of a molecule from a mass spectra

**Questions**

**Q1.**

This question is about the structure of the atom and isotopes.

The following excerpt is taken from the book *Inorganic Chemistry* by Bailey and Snellgrove, fourth impression 1938.



(a)  Identify and correct **two** errors in the excerpt.

**(2)**

 .............................................................................................................................................

 .............................................................................................................................................

 .............................................................................................................................................

 .............................................................................................................................................

(b)   What is the structure of a 1+ ion of the carbon-13 isotope?

**(1)**

   **A**    six protons, six neutrons and five electrons

   **B**    six protons, seven neutrons and six electrons

   **C**    six protons, seven neutrons and five electrons

   **D**    seven protons, six neutrons and six electrons

 **(Total for question = 3 marks)**

**Q2.** This question is about magnesium.

The relative atomic mass of a sample of magnesium was found to be 24.3. The percentage composition for two of the three isotopes is given in the table. Use these data to calculate the percentage composition of the third isotope and hence its relative isotopic mass. Give your answer to an appropriate number of significant figures. You **must** show your working.



**(4)**

**(Total for question = 4 marks)**

 **Q3.**

Which of the following species contains the same number of electrons as neutrons?



**(Total for question = 1 mark)**

**Q4.**

(i)   State what is meant by the term **relative atomic mass**.

**(2)**

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(ii)  A 5.000 g sample of lithium, containing the two isotopes lithium-6 and lithium-7, was found to contain 0.460 g of the isotope lithium-6.

Calculate the relative atomic mass of lithium for this sample. Give your answer to an appropriate number of significant figures.



**(3)**

**(Total for question = 5 marks)**

**Q5.** This question is about the use of mass spectrometers.

(a)  Complete the mass spectrum below for a sample of bromine **gas** that contains approximately half 79Br isotope and half 81Br isotope.

**(4)**



(b)  Calculate the relative atomic mass of bromine for a sample which was found to contain 47.0% 79Br and 53.0% 81Br.

Give your answer to **three** significant figures.

**(2)**

(c)  What would be the effect, if any, on the *m*/*e* value of the peak if the ion detected had lost two electrons rather than one electron?

**(1)**

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**Q6.**

An isotope of an element, atomic number z, has mass number 2z + 4. How many neutrons are in the nucleus of the element?

   **A**     z + 4

   **B**     z + 2

   **C**     z

   **D**     4

**(Total for question = 1 mark)**

**Q7.**Bromine has two isotopes with relative isotopic masses 79 and 81. Which of the following values for mass/charge ratio could correspond to a peak in the mass spectrum of bromine, Br2? You should assume the ions detected have a single positive charge.

   **A**    79.9

   **B**    80

   **C**    159

   **D**    160

**(Total for Question = 1 mark)**

**Q8.**The radioactive isotope iodine-131,  I, is formed in nuclear reactors providing nuclear power. Naturally occurring iodine contains only the isotope,  I.

(a)  Complete the table to show the number of protons and neutrons in these two isotopes.

**(2)**



(b)  When iodine-131 decays, one of its neutrons emits an electron and forms a proton. Identify the new element formed by name or symbol.

**(1)**

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(c)  The problem with radioactive iodine is that it accumulates in humans in the thyroid gland. Its absorption can be reduced by taking an appropriate daily dose of a soluble iodine compound.

Suggest a suitable iodine compound which could be used.

**(1)**

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(d)  Nuclear power stations are often proposed as suitable alternatives to those burning coal, gas or oil.

Suggest a country where, because of its location, the dangers of nuclear power may outweigh the advantages. Justify your answer.

**(1)**

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**(Total for Question = 5 marks)**

**Q9.**

Naturally occurring samples of potassium contain three isotopes, 39K, 40K and 41K.

(a)  The isotopes can be separated in a mass spectrometer.

(i)  A sample of potassium has the following composition.



Calculate the relative atomic mass of this sample of potassium, giving your answer to **two** decimal places.

**(2)**

(ii)  Complete the table below to show the numbers of sub-atomic particles in an atom of each of the isotopes 39K and 41K.

**(1)**



**2019**

NAME ...........................……... HOMEWORK DEADLINE .....................

Student Number ………… Chemistry Class ………

Student targets

ATOMIC STRUCTURE

|  |  |
| --- | --- |
| **Task** | Mark |
| Notes | /10 |
| Revision Notes | /10 |
| Exam questions  | / |
| Overall Grade for this work | A B C D E U |

Student comments

Tutor comments

Tutor signature Date

Student targets for **next pack**

Student targets for **next pack**