Year 10 revision 2006

Atomic structure

Atoms are made up of 3 types of particle. Complete the table below showing the type of particle, its mass and its location within the atom.

Type of particle and charge	Electron -1	Proton +1	Neutron 0
Mass in atomic units	0 or 1/1800 or 'negligible'	1	1
Location within the atom	Orbiting the nucleus in shells	Nucleus	Nucleus

Write the symbol for phosphorus, showing the atomic number and the mass number.

$^{31}_{15}P$

What determines the mass number?

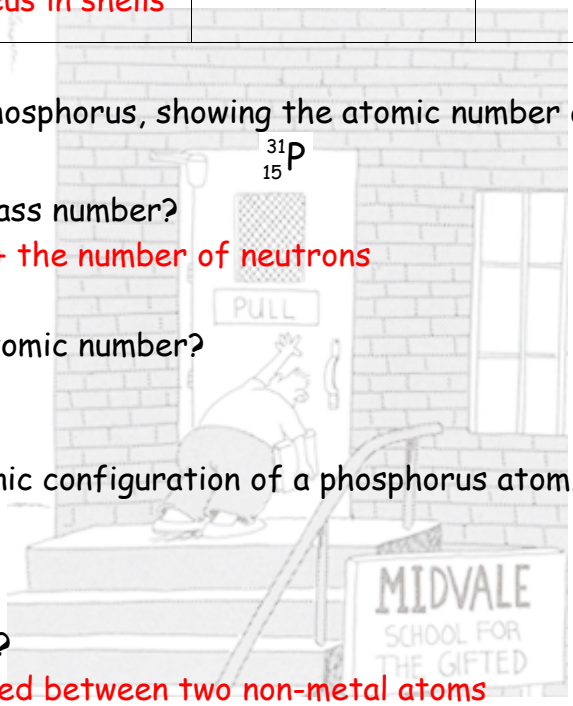
The number of protons + the number of neutrons

What determines the atomic number?

The number of protons

Write down the electronic configuration of a phosphorus atom.

2, 8, 5



Bonding

What is a covalent bond?

A pair of electrons shared between two non-metal atoms

What types of atoms can be joined together by covalent bonds?

Non-metal atoms

What is an ionic bond?

Transfer of electrons between metal and non-metal atoms to produce oppositely-charged ions

What types of atoms can be joined together by ionic bonds?

Metal with non-metal

What is metallic bonding?

An array of positive metal ions in a 'sea' of delocalised electrons

Methane is a compound of one carbon atom and some hydrogen atoms. What sort of bonding would you expect methane to have?

Covalent

Draw a 'dot and cross' diagram of the bonding in methane.

From your diagram write down the formula for methane.

CH_4

Calcium bromide is a compound of calcium and bromine only. What sort of bonding would you expect calcium bromide to have?

Ionic

Draw 'dot and cross' diagrams to show how calcium bromide bonds together (you will need to draw 'before' and 'after' diagrams). Only show outer electrons.

'Before'

'After'

How does the structure of copper metal explain the electrical conductivity of copper?

Structures - pages 21 - 29

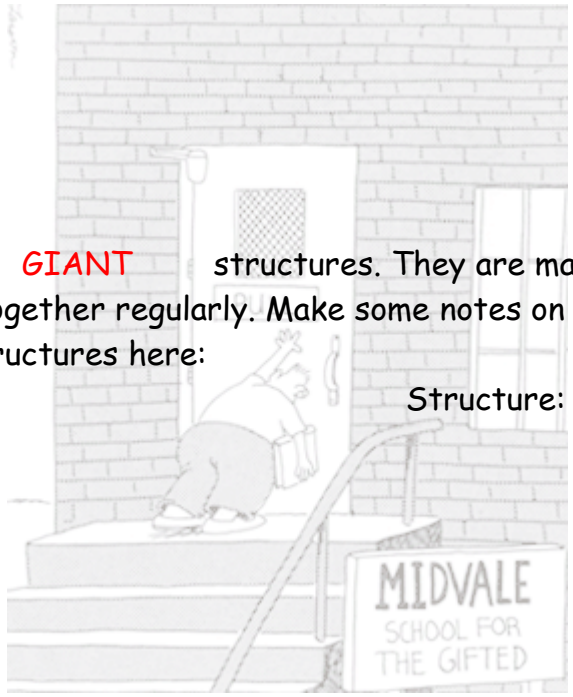
Substances come in two types – those with molecular structures and those with giant structures.

Molecules, such as carbon dioxide (formula: CO_2), water (formula: H_2O) and ammonia (formula: NH_3) have definite numbers of atoms in them.

Giant structures do not have definite numbers of atoms in them – they have many millions of each of the constituent particles in them, arranged in a particular way and in definite proportions.

Metals have GIANT structures. Mixing two types of metal makes an alloy, which changes the physical properties of the original metal. Make some notes on the properties of metals and their structure here:

Properties: Structure:



Ionic substances have GIANT structures. They are made of huge lattices of ions which are packed together regularly. Make some notes on the properties of ionic substances and their structures here:

Properties: Structure:

Diamond, graphite and silicon dioxide have GIANT structures, even though they are held together by COVALENT bonds. Describe the physical properties of diamond and graphite. Use their structures to explain these physical properties

Properties: Structure:

Simple molecular structures contain DEFINITE numbers of atoms. These are joined together by covalent bonds which are strong / weak. The forces between the molecules are weak, and so molecular compounds generally have low melting points.

Common Ions

You should, by now, have an idea what atoms form what ions. Most of the ones you meet will be dictated by their position in the periodic table – metals and non-metals will try to get a full outer shell of electrons.

Metals form POSITIVE ions because they LOSE electrons.

Non-metals form NEGATIVE ions because they GAIN electrons.

Complete this table:

Group (column) of periodic table	Charge on ion
1	+1
2	+2
3	+3
6	-2
7	-1

Some compounds will tell you the charge on the ion in the name of the compound. For instance, what ions do copper (II) oxide and iron (III) chloride contain?

Cu^{2+}, O^{2-}, Fe^{3+}, Cl^{-}

Some ions need to be learnt. You will not get a data sheet with common ions on, so be prepared to learn and use these now.

Positive ions	zinc	Zn^{2+}
	silver	Ag^{+}
	hydrogen	H^{+}
	ammonium	NH_4^{+}
Negative ions	nitrate	NO_3^{-}
	hydroxide	OH^{-}
	hydrogencarbonate	HCO_3^{-}
	carbonate	CO_3^{2-}
	sulphate	SO_4^{2-}

Methane reacts with oxygen to form carbon dioxide and water. Write a balanced symbol equation for this reaction.

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$$

If we burn 16g of methane, can we work out how much oxygen is needed for the combustion? Yes…
The relative formula mass of methane is 12 + (4 x 1) = 16
This means that one mole of methane weighs 16g
We are therefore starting with one mole of methane
Our equation shows us that two moles of oxygen, O_2, are required for each mole of methane (there is a 1:2 ratio)
Each mole of oxygen, O_2, weighs 2 x 16 = 32g
We need two lots of O_2, and this will weigh 2 x 32 = 64g

If we burn 8g of methane, how much oxygen is needed for the combustion?
Each mole of methane weighs 16g
8g of methane is how many moles of methane? 8/16 = 0.5 moles

The equation tells us that two moles of oxygen react with one of methane. When we have 8g of methane how many moles of oxygen do we need? 1 mole

How much does a mole of oxygen, O_2 weigh? (16 + 16) = 32g

How much do our moles of oxygen, O_2, weigh? 32g

Sodium can react with chlorine gas, Cl_2, to make sodium chloride. Write an equation for this reaction.

$$2\ Na + Cl_2 \rightarrow 2\ NaCl$$

If we start with 23g of sodium, what mass of sodium chloride can we make at the end?
Use 'reacting masses'

(2 x 23g) = 46g Na : 2 x (23+35.5) = 117g NaCl
46/46 = 1g Na : 117/46 = 2.54g NaCl
23 x 1 = 23g Na : 2.54 x 23 = 58.5g NaCl

Reactivity series

The reactivity series is worth learning! It will not be in the exam. Use p 53 of the text book to complete this list:

potassium
sodium
calcium
magnesium
aluminium
zinc
iron
tin
(hydrogen)
copper
silver
gold
platinum

Label the most reactive metal and the least reactive metal on the list.

The thermit reaction involves the reaction of aluminium powder with iron (III) oxide powder. Iron and aluminium oxide are the products. It is useful because the iron produced is in molten form. Write a balanced symbol equation for the reaction between aluminium and iron (III) oxide.

$$2\ Al + Fe_2O_3 \rightarrow Al_2O_3 + 2\ Fe$$

Why does the aluminium displace the iron from the iron (III) oxide?

Aluminium is more reactive that iron, so can displace iron from the iron compound

Rewrite the equation in terms of the ions involved – leave out any ions which are not taking place in the reaction. Oxide ions are not involved:

$$Al + Fe^{3+} \rightarrow Al^{3+} + Fe$$

What are ions which do not take part in the reaction called?

Spectator ions

This is a redox reaction. Identify the species which has been reduced.

Fe^{3+} has gained electrons, it has been reduced.

Identify the species which has been oxidised.

Al has lost electrons, it has been oxidised.

You should also make yourself familiar with the reaction between copper (II) oxide and magnesium metal. This is in your notes.

Displacement reactions can also happen in **solution**. If a copper wire is dipped in silver nitrate solution, silver metal is seen to form around the copper wire.

Write an equation for the reaction between copper and silver nitrate solution (silver forms an Ag^+ ion and nitrate is NO_3^-).

$$Cu + 2\ AgNO_3 \rightarrow Cu(NO_3)_2 + 2\ Ag$$

Why does copper displace silver from a solution of its ions?

Copper is more reactive than silver and so displaces it from its compound

What type of reaction is this?

Redox or reduction / oxidation or displacement (the last is not a great answer)

The equation for the formation of copper ions from copper metal is

$$Cu \rightarrow Cu^{2+} + 2e^-$$

Write a similar equation for the formation of silver from silver ions

$$Ag^+ + e^- \rightarrow Ag$$

How would you describe the nitrate ions in this reaction?

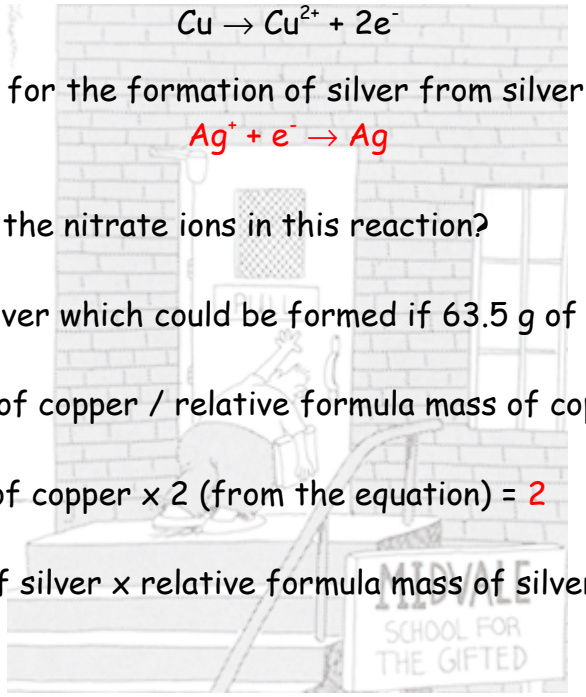
Spectator ions

Calculate the mass of silver which could be formed if 63.5 g of copper were used.

Moles of copper = mass of copper / relative formula mass of copper = 63.5/63.5 = 1

Moles of silver = moles of copper x 2 (from the equation) = 2

Mass of silver = moles of silver x relative formula mass of silver = 2 x 108 = 216g



Acids

Complete the table

Name of acid	Formula
Sulphuric acid	H_2SO_4
Hydrochloric acid	HCl
Nitric acid	HNO_3

What do all these acids have in common?

They all contain hydrogen ions

How could you tell that these substances were acidic?

Any test for acidity – pH with either litmus or universal indicator and what you would see.

Complete (and balance if necessary) the following

Metal + Acid → Salt + Hydrogen

e.g. $Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4 + H_2$

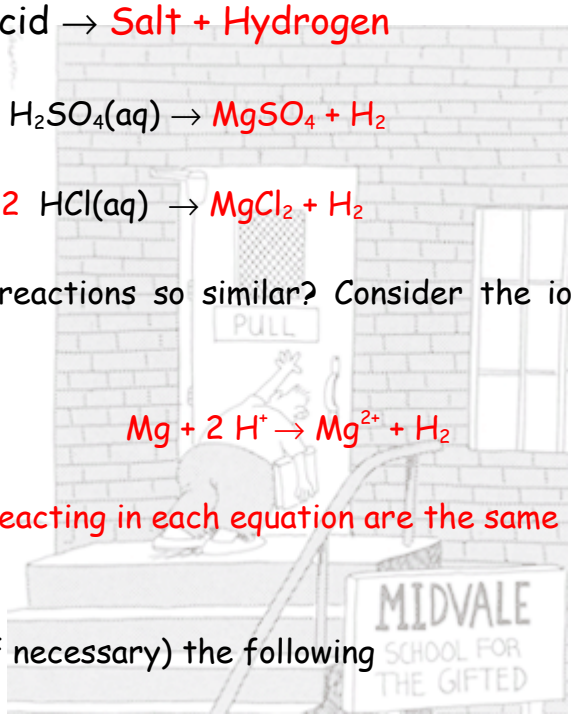
or $Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2 + H_2$

Why are the last two reactions so similar? Consider the ionic equations for these reactions.

Ionic equations:

$$Mg + 2\ H^+ \rightarrow Mg^{2+} + H_2$$

i.e. The things actually reacting in each equation are the same



Complete (and balance if necessary) the following

Metal oxide + Acid → Salt + Water

e.g. $CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4 + H_2O$

What ions are important in the above reaction? Re-write the equation as an ionic equation.

Split ionic substances into ions:

$$Cu^{2+} + O^{2-} + 2\ H^+ + SO_4^{2-} \rightarrow Cu^{2+} + SO_4^{2-} + H_2O$$

Rewrite without the spectator ions:

$$O^{2-} + 2\ H^+ + \rightarrow H_2O$$

Complete (and balance if necessary) the following

Metal hydroxide + Acid → Salt + Water

e.g. $NaOH(aq) + HCl(aq) \rightarrow NaCl + H_2O$

or $Ca(OH)_2(aq) + H_2SO_4(aq) \rightarrow CaSO_4 + 2\ H_2O$

Rewrite the equations between sodium hydroxide and hydrochloric acid, and calcium hydroxide and sulphuric acid, as ionic equations.

$$OH^- + H^+ \rightarrow H_2O$$
$$2\ OH^- + 2\ H^+ \rightarrow 2\ H_2O$$

What is the similarity between these reactions?
The ions which are actually reacting are the same.

Complete (and balance if necessary) the following

Metal carbonate + Acid → Salt + Carbon dioxide + Water

e.g. $CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + CO_2 + H_2O$

Rewrite the equation as an ionic equation.

$$CO_3^{2-} + 2\ H^+ \rightarrow CO_2 + H_2O$$

Salts

You should learn the solubility rules – these can be summarised as:

All sodium, potassium and ammonium salts are soluble
Most of the others are soluble apart from carbonates and hydroxides

- Soluble salts can be made by reacting excess metal or metal compound with acid. The resulting mixture is then filtered and the salt crystallised. An example of this is preparation of copper (II) sulphate by reaction between copper (II) oxide and sulphuric acid.

- Sodium, potassium and ammonium salts should be prepared by titration.

- Insoluble salts are prepared by precipitation reactions – two solutions are mixed to produce a solid.

- Direct combination involves directly combining the components of a salt – sodium chloride can be made by reaction between sodium and chlorine.

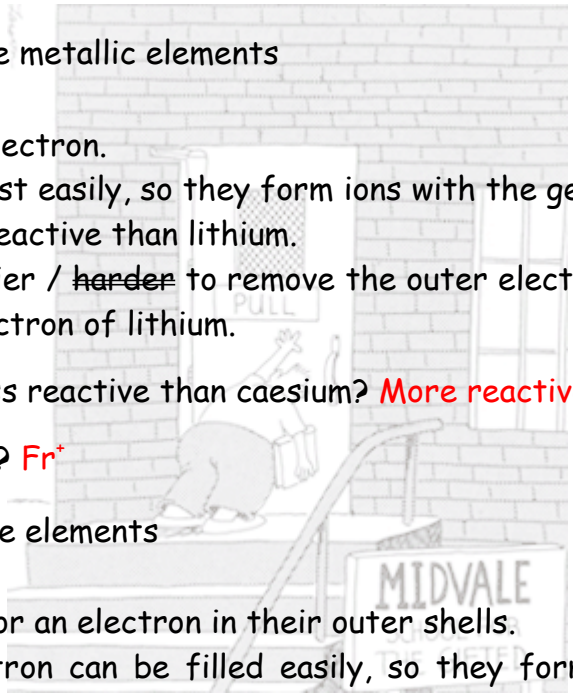
Periodic table

The periodic table is made up of groups and periods.

Groups run vertically / ~~horizontally~~ (delete one)
Periods run ~~vertically~~ / horizontally (delete one)

- Group 0 contains the elements He, Ne, Ar, Kr , Xe, Rn. These are called the noble gases.

They have electronic structures in which the outer shell is complete.
This makes them very ~~reactive~~ / unreactive.
Helium is used in balloons
Neon is used in lights for signs



- Group 1 contains the metallic elements

These all have 1 outer electron.
This outer electron is lost easily, so they form ions with the general formula M^+.
Caesium is more / ~~less~~ reactive than lithium.
This is because it is easier / ~~harder~~ to remove the outer electron of caesium than it is to remove the outer electron of lithium.

Would Fr be more or less reactive than caesium? More reactive

What ion would Fr form? Fr^+

- Group 7 contains the elements

These all have 1 space for an electron in their outer shells.
This space for an electron can be filled easily, so they form ions with the general formula X^-.
They form homonuclear diatomics, with the general formula X_2.

Fluoride compounds are found in toothpastes

Chlorine is used in bleach

- The transition metals are found

They are useful as catalysts

Their compounds are often coloured

Electrolysis

Electricity is the flow of electrons. Metals contain positive metal ions in a 'sea' of delocalised electrons. The electrons are free to move, so the metal will conduct electricity.

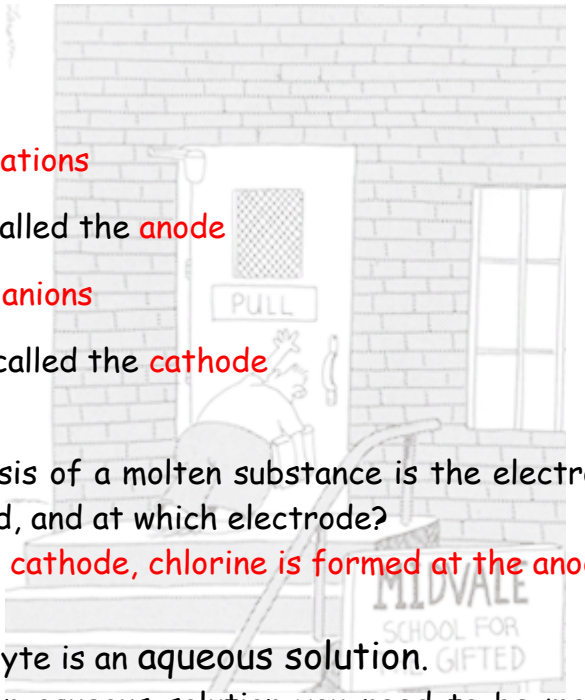
Graphite also contains delocalised electrons. These are between sheets of carbon atoms. The electrons between the layers of carbon allow graphite to conduct electricity.

Ionic solids do not contain free electrons.

They do not conduct electricity because the ions which contain the electrons are held in a rigid lattice.

If the solid is melted the ions become free to move, and the molten ionic substance will conduct electricity – it is called an electrolyte.

Write a definition of electrolysis here (see p119)



Positive ions are called cations

A positive electrode is called the anode

Negative ions are called anions

A negative electrode is called the cathode

An example of electrolysis of a molten substance is the electrolysis of molten sodium chloride. What is formed, and at which electrode?

Sodium is formed at the cathode, chlorine is formed at the anode

Another sort of electrolyte is an aqueous solution.

In the electrolysis of an aqueous solution you need to be more careful than with a molten substance – there are other possible products.

- If the metal is highly reactive (above H in the reactivity series) what is produced?
  Hydrogen is produced at the cathode
- If the metal is below hydrogen in the reactivity series what is produced?
  The metal is produced at the cathode
- If the solution is a concentrated halide (chloride, bromide or iodide) what is produced?
  Chlorine, bromine or iodine is formed at the anode
- What is produced with other common negative ions such as sulphate or nitrate?
  Oxygen is formed at the anode

Purification of copper

Copper purification involves the electrolysis of copper (II) sulphate.
The anode is made of ~~pure~~ / impure copper
The cathode is made of pure / ~~impure~~ copper

Copper ions from the impure anode go into solution. Write a half equation for the reaction, showing how copper ions are formed from copper metal.

$$Cu \rightarrow Cu^{2+} + 2\ e^-$$

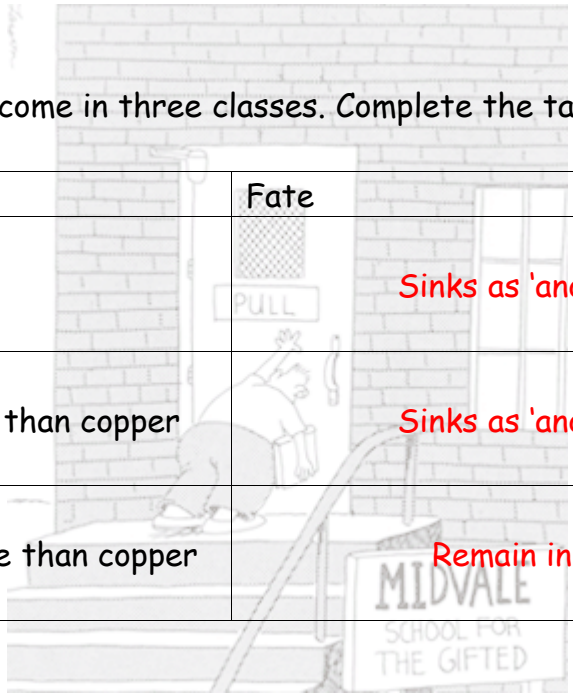
Copper ions from the solution deposit on the cathode. Write a half equation for the formation of copper metal from copper ions in solution.

$$Cu^{2+} + 2\ e^- \rightarrow Cu$$

(When you did this experiment you measured a drop in mass of the anode and a rise in mass of the cathode.)

Impurities in the anode come in three classes. Complete the table.

Impurity	Fate
Unreactive material	Sinks as 'anode sludge'
Metals less reactive than copper	Sinks as 'anode sludge'
Metals more reactive than copper	Remain in solution



Calculations from equations

Sometimes chemists want to know how much product they can get from a certain amount of starting material.

When calcium carbonate is heated, carbon dioxide and calcium oxide are produced. Below we work out how to calculate the mass of calcium oxide produced when 25g of calcium carbonate are heated.
You will need the equation:

$$CaCO_3 \rightarrow CaO + CO_2$$

This means that 1 particle of calcium carbonate produces 1 particle of calcium oxide.
The relative atomic masses are Ca = 40, C = 12, O = 16

The relative formula mass of calcium carbonate is 40 + 12 + (16 x 3) = 100g
The relative formula mass of calcium oxide is 40 + 16 = 56g

So from the equation we can see that 100g of $CaCO_3$ will make 56g of CaO.

If we have 25g of $CaCO_3$ then we will make $\frac{25}{100} \times 40$ g of CaO.

This is 14g of calcium oxide

How much carbon dioxide would be made from 25g of limestone (calcium carbonate)?
From the reacting masses: 100g $CaCO_3$: (12+ 16x2) = 44g CO_2

Divide both sides by 100 1 g $CaCO_3$: 44/100 g CO_2

Multiply both sides by 25 25g $CaCO_3$: (44/100) x 25 g CO_2

= 11g CO_2

You should try to answer the questions on p279, nos 1 – 6.
Answers:

1. 1.92 tonnes
2. 8.61 g
3. a) 0.56 tonnes b) 0.18 tonnes c) 0.74 tonnes
4. 12.50 g
5. a) 0.35 tonnes b) 0.68 tonnes
6. a) 2/3 tonne b) 0.53 tonnes

Empirical formulae

An empirical formula for a compound gives the simplest ratios of the atoms in it. For example, the empirical formula of butane (C_4H_{10}) is C_2H_5.

What are the empirical formulae of:

- Hydrazine, N_2H_4 — NH_2
- Hydrogen peroxide, H_2O_2 — HO
- Diborane, B_2H_6 — BH_3

A compound of carbon hydrogen and oxygen has the following make-up: 52% carbon, 13% hydrogen, 35% oxygen. What is its empirical formula?

	C	H	O
Convert % to g	52g	13g	35g
Divide by the RAMs of the atoms	52/12 = 4.33	13/1 = 13	35/16 = 2.19
Simplify the ratios (÷ smallest no.)	2	6	1
Empirical formula is	C_2H_6O		

A compound is found to consist of 92.3% carbon and 7.7% hydrogen. What is its empirical formula?

	C	H
	92.3g	7.7g
Divide by RAMs	92.3/12 = 7.7	7.7/1
Ratios	1 :	1
Empirical formula is	CH	

This compound actually has a relative formula mass of 78. What is the formula of the molecule?

Mass of 'CH' = 12 + 1 = 13

Number of 'CH' units in molecule with mass of 78 is 78 / 13 = 6

Therefore there are 6 carbons and 6 hydrogens, formula C_6H_6