Chapter 1

Topic 1 Summary

1.1 Atomic structure

You should be able to understand what atoms, elements, element symbols, atomic number, mass number and isotopes are. This is all GCSE stuff. The use of the mass spectrometer in determining atomic masses and isotope abundance has been touched on briefly already. The topic of atomic structure is covered in more detail in Topic 3.

You should be able to calculate how many protons and neutrons there are in the nucleus of an atom or ion, and the corresponding number of electrons, given its mass number, atomic number and charge. Satisfy yourself that you can do this by considering a sodium ion, Na^+. You might like to draw a diagram in the space below.

You should understand what molecules, compounds and chemical formulae are.

The first section of work we did focussed on **types of chemical reaction**. The ones we looked at were thermal decomposition and precipitation.

1.2 Thermal decomposition

This is characterised by the use of heat to break down a substance into simpler substances. Examples you should be able to describe are

Metal carbonates (e.g. zinc carbonate)

Any hydrated compound (e.g. cobalt (II) chloride)

Metal sulphates (e.g. iron (II) sulphate)

Metal nitrates (e.g. copper (II) nitrate and sodium nitrate)

Fill in the blanks above with equations and observations for the thermal decomposition of the compounds. Remember that many of them may be hydrated. Thermal decomposition may thus evolve water. If you are asked to write an equation for such species you will be, at the very least, given a clue as to how much water is present. You are expected to know that copper (II) sulphate crystals will be ____________ when they contain water, and that cobalt (II) chloride is ____________ in the presence of water, and ____________ when water is absent.

1.3 Precipitation reactions

The important aspect you should learn about precipitation reactions is that the change is from solutions containing ions which are mobile and independent to one containing some free ions but where a pair of ions combines to produce something insoluble. This means that you must learn the solubility rules on page 4.

- Sodium, potassium and ammonium compounds are always soluble / insoluble in water
- All nitrates are soluble / insoluble in water
- Most chlorides are soluble / insoluble in water. Lead chloride and silver chloride are common exceptions.
- Most sulphates are soluble / insoluble in water. Lead sulphate and barium sulphate are common exceptions.
- Most oxides, hydroxides and carbonates are soluble / insoluble in water. Those of sodium and potassium are soluble / insoluble. Calcium hydroxide is slightly soluble in water.

The solubility rules will help you spot when a precipitate (solid) is formed. You should understand the terms **ionic equation** and **spectator ions**. You should be able to put the correct **state symbols** on species in equations, even if it is an ionic equation. State symbols normally refer to the state of the reactants and products at the beginning and end of a reaction. Thus for the Thermit reaction, although molten iron is produced, you should give it the state symbol for a solid as when the reaction is complete the iron will cool. Remember that ionic equations can demonstrate the chemical change which is actually happening when two ionic solutions are mixed.

Know the colours of the precipitate formed when the following ions react with aqueous sodium hydroxide:

- $Cu^{2+}{}_{(aq)}$
- $Fe^{2+}{}_{(aq)}$
- $Fe^{3+}{}_{(aq)}$

1.4 Colours and colour changes

You should realise that compounds of transition metal elements are often coloured. You should know some of the most common colours already. Aqueous copper (II) compounds often produce ____________ colours, aqueous iron (II) ____________, and aqueous iron (III) ____________. Precipitating the products of reaction of the iron ions with aqueous sodium hydroxide is a useful way of distinguishing between them.

1.5 Redox reactions

Redox reactions involve both oxidation and reduction. You should know that oxidation can be described as either the _________ of oxygen or _________ of electrons, and that reduction can be described as either the _________ of oxygen or _________ of electrons.

You should be able to recognise when a redox reaction has taken place. Bear in mind that in order for a species to be reduced, another one needs to be oxidised! You should take care to be able to spot the gain or loss of electrons, especially as in question 1.6 e from the end of Topic questions, in which the chlorine atoms in Cl_2 molecules are reduced to chloride ions in an iron (III) compound.

The course uses redox reactions in Topic 1 to enhance your use of the mole concept and applying it to chemical problems.

1.6 Salts and crystals

The section on salts aims to apply your knowledge of mole calculations to calculate the theoretical maximum yields of reaction products. This can be done simply by **calculating the ratios of moles** which react and knowing the formula mass of the product, most likely hydrated crystals.

Water of crystallisation is seldom required in equations. This is because the products of the reactions which form the salt actually produce an aqueous product. This then crystallises after further steps, and you should know the procedure for obtaining clean dry crystals. You could even write it below:

If you are asked to calculate the mass of crystals, remember that these will be hydrated, and you will be given the formula for them.

1.7 Formulae and equations

Topic 1 aims to check that everyone is starting from the same place, and provides some simple practise at writing equations. You will find it enormously helpful to know the formulae of many ions, as listed on page 15. These include

lithium ________
sodium ________
potassium ________
magnesium ________
calcium ________
strontium ________
barium ________
aluminium ________
oxide ________
sulphide ________
chloride ________
bromide ________
iodide ________
hydrogen ________
ammonium ________
silver ________
cobalt ________
copper ________
iron ________ ________
sulphate ________
carbonate ________
hydroxide ________
nitrate ________.

To **balance equations** it is essential to start and finish with the same numbers of particles on either side of the arrow. This means the same numbers of atoms and the same numbers of electrons. You can check the latter by ensuring that the charges on either side are equal.

1.8 Moles

You already have a brief review sheet of the mole concept. As a demonstration of how big Avogrado's number is, if you had a mole of 1p pieces and distributed them evenly between everyone on the planet, we would all be trillionaires.

As well as being able to perform simple calculations with reacting masses, you need to know that a mole of any gas occupies 24.0 dm^3, 24000 cm^3 at room temperature and pressure. For instance, a sixth of a mole of hydrogen gas, H_2, occupies ________ dm^3, or _____________ cm^3, and a sixth of a mole of oxygen gas occupies ________ dm^3, or _____________ cm^3.

You can think of this as a result of particle theory. The particles in a gas have a negligible size compared to their average separation. This means that the volume of a certain number of gaseous particles (at the same temperature and pressure) will be equal to the volume of the same number of different gaseous particles.

Percentage yield calculations are simply a ratio of how much you did make to how much you could have made, were you a more talented experimentalist and procedures not so inherently flawed…