GCSE Chemistry Module 22 Revision Guide

Chemistry in Action

Why is sulphuric acid a useful material? How is it made?

Because sulphuric acid has so many uses the industrial development of a country is sometimes measured by the amount of sulphuric acid that is used each year. Sulphuric acid is made starting from the element sulphur which is found in the Earth's crust.

Sulphuric acid is used as car battery acid and to make fertilisers and detergents. It is manufactured from the raw materials sulphur, air and water:

1. Sulphur is burned in air to form sulphur dioxide.
2. The sulphur dioxide is then mixed with air and the mixture passed over a catalyst of vanadium oxide, V_2O_5, at a high temperature (about 450°C) and a pressure of between one and two atmospheres. This reaction forms sulphur trioxide.
3. The sulphur trioxide is dissolved in concentrated sulphuric acid to form fuming sulphuric acid (oleum).
4. Water is then carefully added to the oleum to produce concentrated sulphuric acid (98%). If the sulphur trioxide is added directly to water an acid mist forms which is difficult to contain.

You should be able to explain the details of the steps in the manufacture of sulphuric acid in terms of chemical principles from the specification including:

- energy transfers during the reaction;
- rate of reactions;
- oxidation;
- use of catalysts;
- equilibrium conditions in reversible reactions.

Concentrated sulphuric acid can be used in the laboratory as a dehydrating agent. Dehydration is the removal of water or the elements of water from a compound. When added to some organic compounds containing hydrogen and oxygen, e.g. sugar, concentrated sulphuric acid removes the elements of water from the compound leaving carbon. When added to copper sulphate crystals concentrated sulphuric acid removes the water of crystallisation leaving anhydrous copper sulphate.

How can metals be made more useful?

Aluminium can be made more resistant to corrosion by a process called anodising. Iron can be made more useful by mixing it with other substances to make various types of steel. Many metals can be given a coating of a different metal to protect them or to improve their appearance.

Aluminium is a reactive metal but it is resistant to corrosion. This is because it reacts to form a layer of aluminium oxide which then protects the metal below from further attack. For some uses of aluminium it is desirable to increase artificially the thickness of the protective oxide layer. This involves removing the oxide layer by adding sodium hydroxide solution. The aluminium is then placed in dilute sulphuric acid and is the positive electrode used in the electrolysis of the acid. Oxygen forms on the surface of the aluminium and reacts with the metal to form a thicker oxide layer.

The properties of **iron** can be altered by adding small quantities of other metals or carbon to make steel. **Steels** are alloys since they are mixtures of iron with other metals or with carbon. Molten iron from the blast furnace is mixed with recycled scrap iron and pure oxygen is passed into the mixture. The non-metal impurities are converted into acidic oxides. Calcium carbonate is then added to remove the acidic impurities. These reactions produce pure iron. Calculated quantities of carbon and/or other elements are then added to make a wide range of steels with particular properties.

High carbon steel is strong but brittle. Low carbon steel is soft and is easily shaped. Mild steel is easily pressed into shape. Stainless steel which contains chromium and nickel is hard and resistant to corrosion.

Steel (and most metals) can be **electro-plated**. The steel object is made the negative electrode and placed in a solution containing ions of the plating metal. The positive electrode is made of the pure plating metal. Nickel, silver and gold are examples of plating metals.

<u>You should be able to</u> explain the details of the processes in the manufacture of steel in terms of the chemical principles from the specification including redox and acid-base reactions.

What is titanium and how is it produced?

Titanium is a very important metal for various specialised uses. It is more difficult to extract from its ore than other, more common metals.

Titanium is a transition metal and is strong and resistant to corrosion. It is used in aeroplanes, in nuclear reactors and for replacement hip joints.

Titanium is extracted from its ores by reaction with a more reactive metal. The raw material is the ore **rutile** which contains titanium dioxide. The oxide is converted into titanium chloride $TiCl_4$ [no details required]. The titanium chloride is then reacted with sodium or magnesium to form titanium metal and sodium chloride or magnesium chloride; this reaction is carried out in an atmosphere of argon (which is an inert gas so the metal cannot react with it).

You should be able to explain the details of the processes in the extraction of titanium in terms of the chemical principles from the specification including the reactivity series, noble gases, and reduction.

How can chemical elements and compounds be detected?

We can use a range of standard laboratory tests to detect the presence of various elements and compounds in e.g. air, water or soil.

Lithium, sodium, potassium, calcium and barium compounds can be detected by their distinctive colours in flame tests.

Carbonates react with dilute acids to form carbon dioxide. Copper carbonate and zinc carbonate can be identified by their distinctive colour changes during thermal decomposition.

Aluminium, calcium and magnesium ions form white precipitates with sodium hydroxide solution but only the aluminium hydroxide precipitate dissolves in excess sodium hydroxide solution. Copper (II), iron(II) and iron(III) ions form coloured precipitates with sodium hydroxide solution.

Sulphate ions in solution produce a white precipitate with barium chloride solution in the presence of dilute hydrochloric acid.

The ammonium ion reacts with sodium hydroxide solution to form ammonia. Ammonia gas turns damp litmus paper blue.

The nitrate ion is reduced by aluminium powder in the presence of sodium

hydroxide solution to form ammonium ions.

Chloride ions in solution produce a white precipitate with silver nitrate solution in the presence of dilute nitric acid.
Bromide and iodide ions in solution form coloured precipitates with silver nitrate solution in the presence of dilute nitric acid.

You should be able to describe the practical details of the chemical tests and interpret information based on these tests.

Why are instrumental methods of detection so useful?

Instead of testing for chemicals using standard laboratory equipment such as test tubes etc., special instruments have been developed to carry out such testing. These are quick, accurate and can be used on very small samples.

Elements and compounds can also be detected and identified using a variety of instrumental methods. Some instrumental methods are suited to identify elements while other instrumental methods are suited to the identification of compounds. Instrumental methods are accurate, sensitive and rapid. These methods are particularly useful when the amount of a sample is very small.

You should be able to:

- name two instrumental methods – one for the identification of elements and one for the identification of compounds;
- understand the advantages and disadvantages of the two methods chosen.

Industry requires rapid and accurate methods for the analysis of its products. There have also been increasing demands from society for safe and reliable monitoring of our health and environment. The development of modern instrumental methods has been aided by the rapid progress in technologies such as electronics and computing.

You should be able to:

- describe the practical details of the chemical tests and interpret information based on these tests;
- describe the factors that influence the development of instrumental methods and to give examples of where these methods are used to solve particular problems.