Unit 3: Acids, Bases and Metals

Section 3.1 Acids and bases

The pH scale

- The pH scale is a continuous range from below 0 to above 14.
- Acids have a pH of less than 7; alkalis have a pH of more than 7; pure water and neutral solutions have a pH equal to 7.
- Non-metal oxides which dissolve in water produce acid solutions.
- Metal oxides and hydroxides which dissolve in water produce alkaline solutions.
- Ammonia dissolves in water to produce an alkali.
- Acids and alkalis are in common use in both the laboratory and the home.
- In water and neutral solutions, the concentration of hydrogen ions is equal to the concentration of hydroxide ions.
- An acidic solution contains more hydrogen ions than hydroxide ions.
- An alkaline solution contains more hydroxide ions than hydrogen ions.
- The effect of dilution on the pH of an acid or alkali is explained in terms of the decreasing concentration of hydrogen and hydroxide ions.
- In water and aqueous solutions there is an equilibrium between hydrogen and hydroxide ions and water molecules.
- When a reversible reaction is in equilibrium, the concentrations of reactants and products remain constant although not necessarily equal.

Concentration

- The concentration of a solution is expressed in mol dm^{-3}.
- The number of moles of solute, volume and concentration of solution can be calculated from the other two variables.

Strong and weak acids and bases

- In aqueous solution, strong acids are completely dissociated into ions but weak acids are only partially dissociated.

- Hydrochloric acid, sulphuric acid and nitric acid are strong acids.
- Ethanoic acid is a weak acid.
- Equimolar solutions of strong and weak acids differ in pH, conductivity and rate of reaction.
- In aqueous solution, strong bases are completely ionised but weak bases are only partially ionised.
- Solutions of metal hydroxides are strong bases.
- Ammonia solution is a weak base.
- Equimolar solutions of strong and weak bases differ in pH, conductivity and rate of reaction.

Section 3.2 Salt preparation

Reactions of acids

- Neutralisation is the reaction of acids with bases.
- Metal oxides, metal hydroxides and metal carbonates are examples of bases.
- Neutralisation moves the pH of an acid up towards 7.
- Neutralisation moves the pH of an alkali down towards 7.
- In the reaction of an acid with an alkali the hydrogen ions and hydroxide ions form water.
- In the reaction of an acid with a metal oxide the hydrogen ions and the oxide ions form water.
- In the reaction of an acid with a metal carbonate the hydrogen ions and carbonate ions form water and carbon dioxide.
- Bases which dissolve in water form alkalis.
- Everyday examples of neutralisation include the treatment of acid indigestion and using lime to reduce acidity in soil and lochs.
- An acid reacts with some metals to give off hydrogen gas.
- In the reaction, hydrogen ions form hydrogen molecules.
- The test for hydrogen is that it burns with a pop.
- Sulphur dioxide, produced by the burning of fossil fuels, and nitrogen dioxide, produced by the sparking of air in car engines, dissolve in water in the atmosphere to produce acid rain.

- Acid rain has damaging effects on buildings made from carbonate rock, structures made of iron and steel, soils and plant and animal life.

Volumetric titrations

- The concentration of acids/alkalis can be calculated from the results of volumetric titrations.

Naming salts

- A salt is a compound in which the hydrogen ions of an acid have been replaced by metal ions (or ammonium ions).
- Salts are formed in the reaction of acids with bases or metals.
- Hydrochloric acid forms chloride salts, sulphuric acid forms sulphate salts and nitric acid form nitrate salts.
- Some nitrogen salts, including ammonium nitrate, ammonium sulphate and potassium nitrate are made by neutralisation reactions for use as fertilisers; these salts are soluble in water.
- In the preparation of a soluble salt, it is often easier to use an insoluble metal carbonate or metal oxide as the base.

Precipitation

- Precipitation is the reaction of two solutions to form an insoluble product called a precipitate.
- Insoluble salts can be formed by precipitation.

Ionic equations

- Spectator ions can be identified in neutralisation and precipitation reactions and the equations can be rewritten omitting these ions.

Section 3.3 Metals

The electrochemical series

- Electricity can be produced by connecting different metals together, with an electrolyte, to form a simple cell.
- The voltage between different pairs of metals varies and this leads to the electrochemical series.
- Displacement reactions occur when a metal is added to a solution containing ions of a metal lower in the electrochemical series.
- The reaction of metals with acids can establish the position of hydrogen in the electrochemical series.

- Electricity can be produced in a cell by connecting two different metals in solutions of their metal ions.
- Electricity can be produced in a cell when at least one of the half-cells does not involve metal atoms.
- Electrons flow in the external circuit from the species higher in the electrochemical series to the one lower in the electrochemical series.
- The purpose of the 'ion bridge' (salt bridge) is to allow the movement of ions to complete the circuit.

Redox reactions

- Oxidation is a loss of electrons by a reactant in any reaction.
- A metal element reacting to form a compound is an example of oxidation.
- Reduction is a gain of electrons by a reactant in any reaction.
- A compound reacting to form a metal is an example of reduction.
- In a redox reaction, reduction and oxidation go on together.
- Ion-electron equations can be written for oxidation and reduction reactions.
- Ion-electron equations can be combined to produce redox equations.
- During electrolysis, oxidation occurs at the positive electrode and reduction occurs at the negative electrode.

Reactions of metals

- Metals react with oxygen, water and dilute acid.
- Differences in the reaction rates give an indication of the reactivity of the metal.

Metal ores

- Ores are naturally occurring compounds of metals.
- The less reactive metals, including gold, silver and copper, are found uncombined in the Earth's crust and the more reactive metals have to be extracted from their ores.
- Some metals can be obtained from metal oxides by heat alone; some metal oxides need to be heated with other substances, e.g.

carbon or carbon monoxide; other metals cannot be obtained by these methods.

- Iron is produced from iron ore in the Blast Furnace.
- The production of carbon monoxide and the reduction of iron oxide are the two key reactions which take place in the Blast Furnace.
- The more reactive metals, including aluminium, are obtained by electrolysis.

Corrosion

- Corrosion is a chemical reaction which involves the surface of a metal changing from an element to a compound.
- Different metals corrode at different rates.
- The term rusting is applied to the corrosion of iron.
- Both water and oxygen, from the air, are required for rusting.
- When iron rusts, initially the iron atom loses two electrons to form iron(II) ions which can be oxidised further to give iron(III) ions.
- Electrons lost by the iron during rusting are accepted by the water and oxygen to form hydroxide ions.
- Ferroxyl indicator can be used to detect the presence of iron(II) ions and hydroxide ions.
- Acid rain increases the rate of corrosion.
- Salt spread on roads increases the rate of corrosion on car bodywork.
- When attached to metals higher in the electrochemical series, electrons flow to the iron, and when attached to metals lower down in the series, electrons flow from the iron.
- Iron does not rust when attached to the negative terminal of a battery.
- Electrons flowing to the iron prevents rusting.
- Anti-corrosion methods are used in everyday situations.
- Painting, greasing, electroplating, galvanising, tin-plating and coating with plastic give a surface barrier to air and water which can provide physical protection against corrosion.
- Galvanising and the use of scrap magnesium result in electrons flowing to the iron giving sacrificial protection.

- Scratching tinplate increases the rate of rusting of iron.