4.5 Energy changes

Energy changes are an important part of chemical reactions. The interaction of particles often involves transfers of energy due to the breaking and formation of bonds. Reactions in which energy is released to the surroundings are exothermic reactions, while those that take in thermal energy are endothermic. These interactions between particles can produce heating or cooling effects that are used in a range of everyday applications. Some interactions between ions in an electrolyte result in the production of electricity. Cells and batteries use these chemical reactions to provide electricity. Electricity can also be used to decompose ionic substances and is a useful means of producing elements that are too expensive to extract any other way.

4.5.1 Exothermic and endothermic reactions

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Energy is conserved in chemical reactions. The amount of energy in the universe at the end of a chemical reaction is the same as before the reaction takes place. If a reaction transfers energy to the surroundings the product molecules must have less energy than the reactants, by the amount transferred.

An exothermic reaction is one that transfers energy to the surroundings so the temperature of the surroundings increases.

Exothermic reactions include combustion, many oxidation reactions and neutralisation.

Everyday uses of exothermic reactions include self-heating cans and hand warmers.

An endothermic reaction is one that takes in energy from the surroundings so the temperature of the surroundings decreases.

Endothermic reactions include thermal decompositions and the reaction of citric acid and sodium hydrogencarbonate. Some sports injury packs are based on endothermic reactions.

Students should be able to:

• distinguish between exothermic and endothermic reactions on the basis of the temperature change of the surroundings

• evaluate uses and applications of exothermic and endothermic reactions given appropriate information.

Limited to measurement of temperature change. Calculation of energy changes or ΔH is not required.

Required practical activity 10: investigate the variables that affect temperature changes in reacting solutions such as, eg acid plus metals, acid plus carbonates, neutralisations, displacement of metals.

4.5.1.2 Reaction profiles

Chemical reactions can occur only when reacting particles collide with each other and with sufficient energy. The minimum amount of energy that particles must have to react is called the activation energy.

Reaction profiles can be used to show the relative energies of reactants and products, the activation energy and the overall energy change of a reaction.

Students should be able to:

• draw simple reaction profiles (energy level diagrams) for exothermic and endothermic reactions showing the relative energies of reactants and products, the activation energy and the overall energy change, with a curved line to show the energy as the reaction proceeds

• use reaction profiles to identify reactions as exothermic or endothermic

• explain that the activation energy is the energy needed for a reaction to occur

4.5.1.3 The energy change of reactions (HT only)

During a chemical reaction:

• energy must be supplied to break bonds in the reactants

• energy is released when bonds in the products are formed.

The energy needed to break bonds and the energy released when bonds are formed can be calculated from bond energies.

The difference between the sum of the energy needed to break bonds in the reactants and the sum of the energy released when bonds in the products are formed is the overall energy change of the reaction.

In an exothermic reaction, the energy released from forming new bonds is greater than the energy needed to break existing bonds.

In an endothermic reaction, the energy needed to break existing bonds is greater than the energy released from forming new bonds.

Students should be able to calculate the energy transferred in chemical reactions using bond energies supplied.

4.5.2 Chemical cells and fuel cells (chemistry only)

4.5.2.1 Cells and batteries

Cells contain chemicals which react to produce electricity.

The voltage produced by a cell is dependent upon a number of factors including the type of electrode and electrolyte.

A simple cell can be made by connecting two different metals in contact with an electrolyte.

Batteries consist of two or more cells connected together in series to provide a greater voltage.

In non-rechargeable cells and batteries the chemical reactions stop when one of the reactants has been used up. Alkaline batteries are non-rechargeable.

Rechargeable cells and batteries can be recharged because the chemical reactions are reversed when an external electrical current is supplied.

Students should be able to interpret data for relative reactivity of different metals and evaluate the use of cells.

Students do not need to know details of cells and batteries other than those specified.

4.5.2.2 Fuel cells

Fuel cells are supplied by an external source of fuel (eg hydrogen) and oxygen or air. The fuel is oxidised electrochemically within the fuel cell to produce a potential difference.

The overall reaction in a hydrogen fuel cell involves the oxidation of hydrogen to produce water.

Hydrogen fuel cells offer a potential alternative to rechargeable cells and batteries.

Students should be able to:

• evaluate the use of hydrogen fuel cells in comparison with rechargeable cells and batteries

• (HT only) write the half equations for the electrode reactions in the hydrogen fuel cell.