Chemical Changes

Heat changes in chemical reactions

Exothermic reactions

- Reactions that give out energy to the surroundings
- Example: burning of magnesium in air
- The energy taken in to break the bonds in the reactants is more than the energy given out when new bonds are made
- $\Delta H = -ve$

Endothermic reactions

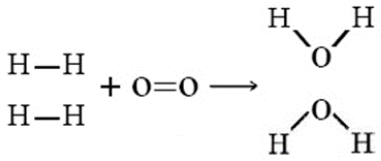
- Reactions that take in heat from the surroundings
- Example: photosynthesis
- The energy taken in to break the bonds in the reactants is less than the energy given out when new bonds are made
- $\Delta H = +ve$

$$\Delta H = heat\ energy\ of\ products - heat\ energy\ of\ reactanats$$

Energy profiling diagrams

Bond Energy Calculations

Example: Calculate the energy change when water is formed from H_2 and O_2.



STEP 1 Bonds Broken

2 x (H-H) = 2 x 436 = 872

1 x (O=O) = 498

Total = 866 + 498 = 1370

Bond	Bond Energy
H-H	436
H-O	464
O=O	498

STEP 2 Bonds Made

4 x (O-H) = 4 x 464 = 1856

STEP 3

Energy change = bonds broken – bonds made

= 1370 – 1856 = -486

Fuels and energy production

The variety of fuels

- A fuel is a substance that can be burnt to release energy
- Fuels are used for heating, lighting, cooking, transportation and electricity
- We can use a calorimeter and thermometer to compare the energy released when different fuels are burnt

Fossil Fuels

Coals

- Formed by the decay of plants in swampy areas in the absence of oxygen. Over millions of years, plants remnants changed to coal. Coal is polluting, causes acid rain and contributes to global warming.

Petroleum

- A complex of mixture of compounds containing carbon and hydrogen. Formed when bodies of tiny animals and plants sank to the sea bed millions of years ago. Pressure from rocks formed above changed the ting organisms into petroleum. Petroleum is less polluting than coal but still contributes to global warming

$$C_8H_{18} + 12\frac{1}{2}O_2 \longrightarrow 8CO_2 + 9H_2O$$

Petrol – 48kJ/g energy given out

Natural Gas

- Largely methane. Found underground trapped in layers of ice or near areas rich in petroleum. Natural gas is less polluting than coal but still contribute to global warming.

$$CH_4 + 2H_2O \longrightarrow CO_2 + 2H_2O$$

Natural gas- 55kJ/g energy given out

Energy from reactivity

- Many nuclear power stations use an radioisotope of uranium-235
- Made into fuel rods and lowered into the reactor in nuclear power station
- Uranium-235 is bombarded with high speed neutrons
- Collisions cause nucleus of uranium-235 to split
- Large amounts of energy released
- More neutrons produced of lower mass (thorium and radium)
- New neutrons collide with uranium-235 and split them
- If not stopped, chain reactions can cause an explosion
- Control rods are pushed into nuclear reactor to absorb excess neutrons
- Energy given out in this reaction used as a heat up gas
- Hot gas heats up water to form steam, steam used in generator to produce electricity
- Produce more energy per gram than ordinary fuels and are not as polluting

- They are difficult to dispose of and many people can be exposed to radiation if reactor has a leak

Energy from electrochemical cells

Simple electrochemical cells

- Consists of two metals of different reactivity dipping into an electrolyte
- The electrolyte can be an acid or an alkali or a solution of a salt
- In commercial cells, the electrolyte is made into a paste so that the electrolyte does not leak

How a simple electrochemical cell works

- The more reactive metal in an electrochemical cell is better at releasing electrons
- The more reactive metal becomes the negative electrode or negative pole of the cell
- The electrons flow through the wire of the external circuit to the less reactive metal electrode
- At the positive pole, or positive electrode, these electrons are released to combine with the ions to form atoms
- The difference in the ability of the different metal ions to release electrons causes a voltage to be produced
- This results in a flow of electrons from the negative electrode of the cell to the positive
- The electrical circuit is completed by the movement of ions in the electrolyte

Getting the best voltage

- The further apart the metals are in the reactivity series, the greater the voltage
- This is because the more reactive metal is better at releasing electrons to form ions
- The more reactive metal in the cell is always the negative electrode

Fuel Cells

- Simple electrochemical cells lose their power after a time
- This happens because one of the reactants is bulky
- Electrical cells in car batteries are bulky-they take up a lot of space
- Some electrochemical cells have to be recharged from time to time
- Many substances found in electrochemical cells are harmful and difficult to dispose of safely
- Hydrogen is a non-polluting fuel
- When burning in oxygen only water is formed
- We can use this reaction to supply electrical energy continuously
- We do this by reacting hydrogen and oxygen in a fuel cell

How does a fuel cell work?

- A fuel cells consists of two platinum electrodes and an electrolyte
- Platinum is coated onto a porous material that allows gases to pass through it
- Hydrogen gas and oxygen gas are bubbled through the porous electrodes where the reactions take place
- Hydrogen gas is bubbled through the negative electrode and oxygen is bubbled through the positive electrode

Acidic electrolyte

At the negative electrode the hydrogen loses electrons and forms hydrogen ions in the electrolyte:

$$2H_2 \rightarrow 4H^+ + 4e^-$$

The electrons released move around the external circuit to the positive electrode. At the positive electrode oxygen gains electrons and reacts with hydrogen ions from the acid electrolyte.

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

The hydrogen ions removed at the positive electrode are replaced by those produced at the negative electrode. So the concentration of the electrolyte remains constant, the overall reaction is:

$$2H_2 + O_2 \rightarrow 2H_2O$$

Water is removed

Alkaline electrolyte

At the negative electrode the hydrogen reacts with the hydroxide ions in the electrolyte and forms water:

$$2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$$

At the positive electrode oxygen gains electrons and reacts with water to form hydroxide ions:

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

The hydroxide ions removed at the negative electrode are replaced by those produced at the positive electrode. So again the concentration of the electrolyser remains constant. The overall reaction is the same as for the acidic electrolyte

Advantages of fuel cells

- Hydrogen fuel cells are used to provide electrical power in spacecraft
- Water produced can be used for drinking
- Fuel cell are increasingly used instead of petrol to power cars
- Water is the only product made-no pollutants formed
- They produce more energy per gram of fuel than other fuels
- They are lightweight
- They don't need recharging like batteries
- Operate with high efficiency
- Hydrogen and oxygen needed for fuel cells to operate are usually produced using fossil fuels present