# QUANTITATIVE CHEMISTRY: ENERGY CHANGES

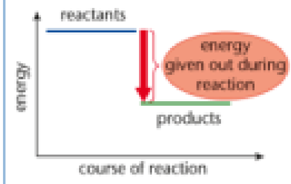
### EXOTHERMIC AND ENDOTHERMIC

- 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.

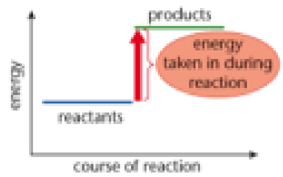
| | EXOTHERMIC | ENDOTHERMIC |
|---|---|---|
| **WHAT HAPPENS?** | Transfers energy to the surroundings → Temperature of surroundings INCREASES | Takes in energy from the surroundings → Temperature of the surroundings DECREASES |
| **WHY?** | Energy released from forming new bonds > energy needed to break existing bonds | Energy needed to break existing bonds > Energy released from forming new bonds |
| **EXAMPLES** | Combustion, many oxidation reactions, neutralisation, reactions in hand warmers | Thermal decompositions, reaction of citric acid and sodium hydrogencarbonate, reactions in sports injury packs |

### REACTION PROFILES

- Chemical reactions can occur only when reacting particles collide with each other and with sufficient energy.
- **ACTIVATION ENERGY:** The minimum amount of energy that particles must have to react.
- **REACTION PROFILES:** Show the relative energies of reactants and products, the activation energy and the overall energy change of a reaction.




**Reaction profile: EXOTHERMIC REACTION**




**Reaction profile: ENDOTHERMIC REACTION**

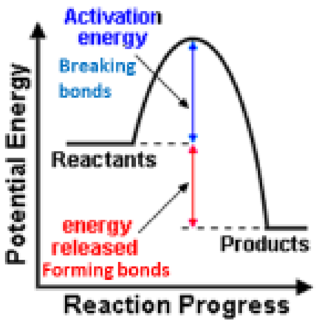
### REQUIRED PRACTICAL: TEMPERATURE CHANGE (REFER TO PRACTICAL SHEET FOR FURTHER DETAIL)

- Investigation of the variables that affect **temperature changes** in reacting solutions, e.g. acid+metals, acid+carbonates, neutralisations, displacement of metals.
- **E.G. Investigation of the temperature changes which take place when an acid is neutralised by an alkali.**

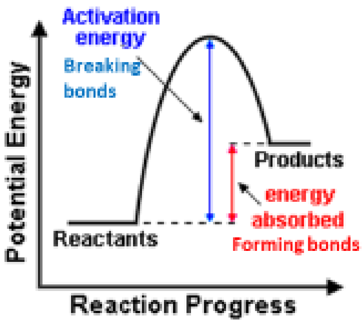
- In this investigation the temperature rise (DEPENDENT VARIABLE) is monitored as small volumes of NaOH solution are added to dilute HCl (INDEPENDENT VARIABLE) in an insulated cup.
- A line graph plotted → to work out how much sodium hydroxide (NaOH) was needed to fully react with the hydrochloric acid (HCl).

# QUANTITATIVE CHEMISTRY: ENERGY CHANGES [HIGHER]

### REACTION PROFILES – MORE DETAIL [HIGHER]




Exothermic reaction
Forming bonds > Breaking bonds




Endothermic reaction
Breaking bonds > Forming bonds

- Energy must be **supplied** to **BREAK BONDS** in the **REACTANTS**
- Energy is **released** when bonds in the **PRODUCTS** are **FORMED**

### CALCULATING BOND ENERGIES [HIGHER]

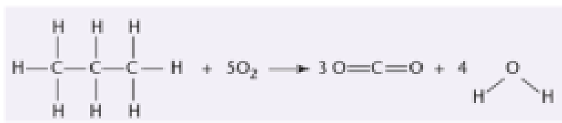
- Energy change in a reaction can be calculated using **bond energies**.
- **BOND ENERGY**: The amount of energy needed to break a **mole** of a particular bond.

**Energy change (ΔH) = Σ[breaking bonds in REACTANTS] – Σ[forming bonds in PRODUCTS]**

- **Exothermic reactions:** **ΔH is NEGATIVE**
- **Endothermic reactions:** **ΔH is POSITIVE**

### CALCULATING BOND ENERGIES [HIGHER]

E.G. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$



| BOND | Bond energy (kJ/mol) |
|---|---|
| C – H | 412 |
| C – C | 368 |
| C – O | 352 |
| C = O | 532 |
| O = O | 498 |
| H - O | 465 |

| Bond energies: REACTANTS (kJ/mol) | Bond energies: PRODUCTS (kJ/mol) |
|---|---|
| 2 x C – C = 2 x 368 = 736<br>8 x C – H = 8 x 412 = 3296<br>5 x O=O = 5 x 498 = 2490 | 3 (2 x C=O) = 3 (2 x 532) = 3192<br>4 (2 x H – O) = 4 (2 x 465) = 3720 |
| **Σ(REACTANTS) = 6522** | **Σ(PRODUCTS) = 6912** |

**ΔH = Σ(REACTANTS) - Σ(PRODUCTS)**

**ΔH = 6522 – 6912 = - 390 kJ/mol**

**More energy released than taken in (ΔH is negative), so reaction is EXOTHERMIC**