5.1 Exothermic and endothermic reactions

Name: _____ Class: _____ Date: _____ **Total: 42 marks**

KEY WORDS exothermic • endothermic • activation energy

Objective

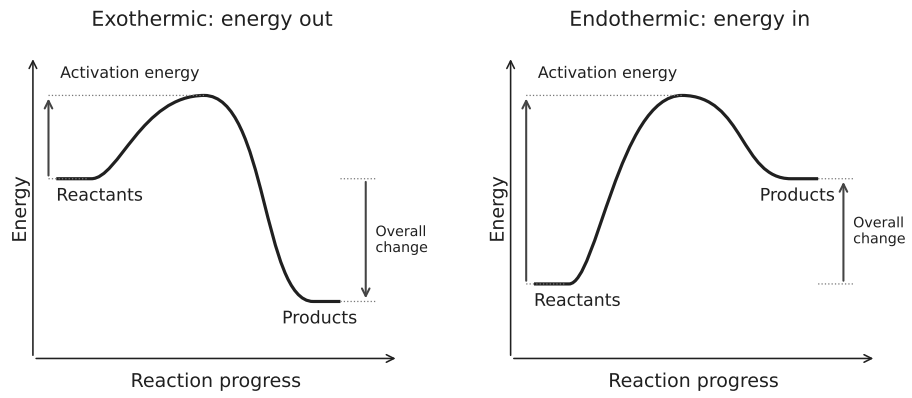
Classify reactions from temperature change, read reaction profiles and (HT) use bond energies. Original questions for spec statements 4.5.1.1–4.5.1.3.

1 Key knowledge and worked examples

- **Exothermic** – energy transferred to the surroundings; temperature **rises**. Combustion, oxidation, neutralisation. Uses: hand warmers, self-heating cans.
- **Endothermic** – energy taken in; temperature **falls**. Thermal decomposition, citric acid + sodium hydrogencarbonate. Uses: sports injury packs.
- **Reaction profile**: label **reactants**, **products**, the **activation energy** (minimum energy to react) from the reactants' level, and the **overall energy change**. Exothermic – products below reactants; endothermic – above.
- **(HT) Bond energies**: breaking bonds **costs** energy; forming bonds **releases** it. Exothermic – forming releases more than breaking costs; endothermic – the reverse. Overall change = Σ(bonds broken) − Σ(bonds formed).

Worked example (3 marks, HT). Why is a reaction exothermic in terms of bonds?

Energy is supplied to break the bonds in the reactants; energy is released when the new bonds in the products form; the reaction is exothermic because more energy is released forming product bonds than was needed to break reactant bonds.



2 Practice

2.1 A thermometer in a reaction mixture falls from 21 °C to 15 °C. Classify the reaction. [1]

2.2 Name the minimum energy particles need to react. [1]

2.3 Name one everyday use of an exothermic reaction. [1]

2.4 Give one named example of an exothermic reaction and one named example of an endothermic reaction. A beaker cools during dissolving: does cooling alone prove a chemical reaction? Explain. [4]

3 Exam-style questions

3.1 Sketch the reaction profile for an endothermic reaction, labelling the reactants, products, activation energy and overall energy change. [4]

3.2 *(HT)* In a reaction, 1000 kJ/mol is needed to break bonds and 850 kJ/mol is released forming bonds. Calculate the overall energy change and classify the reaction. [3]

3.3 A single-use iron hand warmer heats for 30 minutes before its reactants run out. An instant cold pack cools for 15 minutes and cannot be reused. Explain the energy transfer in each and evaluate these limits for a 45-minute activity. [5]

3.4 *(HT)* For $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$, use C–H = 413, O=O = 498, C=O = 805 and O–H = 464 kJ/mol. List and count the bonds broken and formed, calculate the overall energy change and explain its sign. [6]

3.5 Plan an RP4 investigation of how alkali volume affects the temperature when it is added to a fixed acid volume. Include apparatus, measurements, three controlled factors, repeats and one practical precaution. State why insulation matters. [6]

3.6 In an RP4 trial, total alkali volumes 10, 15, 20, 25 and 30 cm^3 give peak temperatures 25.0, 27.5, 30.0, 28.5 and 27.0 °C. All starting solutions were 20.0 °C. At 20 cm^3, two further trials give 29.6 and 29.8 °C. Calculate the mean peak and mean temperature rise at 20 cm^3. Explain how the whole graph can estimate a maximum between readings, and why the highest reading alone is not an exact endpoint. [5]

3.7 A profile shows reactants 30, peak 95 and products 55 in relative units. Find the activation energy and overall change; classify the reaction. Explain the catalyst effect and name the horizontal-axis quantity. [6]