C5aD Exothermic and Endothermic Reactions: Exam Drill

Total Marks

AQA 8464 · Calculator allowed · about 90 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Define the terms exothermic and endothermic reaction.

(a) Define exothermic reaction. **(1)**

(b) Define endothermic reaction. **(1)**

(Total for Question 1 is 2 marks)

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2 Give one example of an exothermic chemical reaction and one example of an endothermic chemical reaction. For each, name the reaction and state whether energy is released or absorbed.

(a) Example of an exothermic reaction and energy direction. **(1)**

(b) Example of an endothermic reaction and energy direction. **(1)**

(Total for Question 2 is 2 marks)

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3 Sketches of energy profile diagrams are used to show activation energy and overall energy change.

(a) State which feature on an energy profile diagram represents the activation energy. **(1)**

(b) For an exothermic reaction, state whether the products are higher or lower in energy than the reactants and explain what this means for the overall energy change. **(2)**

(Total for Question 3 is 3 marks)

4 A student uses a simple calorimeter to measure the energy released by burning a sample of a liquid fuel. Details: mass of water heated = 200 g, temperature rise = 12.5 degrees C, amount of fuel burned = 0.0200 mol. Use specific heat capacity of water 4.18 J g-1 degrees C-1. Calculate the molar enthalpy change of combustion in kJ per mol. State the sign of the enthalpy change.

(a) Calculate the heat absorbed by the water, q = m x c x deltaT, and then the molar enthalpy change in kJ per mol. Include the sign. **(3)**

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(Total for Question 4 is 3 marks)

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5 Identify one likely experimental error in the calorimetry experiment above that would make the measured molar enthalpy of combustion less exothermic than the true value, and give one practical improvement to reduce this error.

(a) State one experimental error causing the measured value to be less exothermic and why. **(1)**

(b) Give one practical improvement to reduce this error. **(1)**

(Total for Question 5 is 2 marks)

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6 Use bond energies to calculate the enthalpy change for the reaction: H2(g) + Cl2(g) -> 2 HCl(g). Bond energies: H-H = 436 kJ mol-1, Cl-Cl = 243 kJ mol-1, H-Cl = 431 kJ mol-1. State whether the reaction is exothermic or endothermic.

(a) Calculate the enthalpy change using bond energies and give the sign. **(3)**

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(Total for Question 6 is 3 marks)

7 A neutralisation experiment: 25.0 cm3 of 0.200 M hydrochloric acid at 18.2 degrees C is mixed with 25.0 cm3 of 0.200 M sodium hydroxide at 19.6 degrees C. After mixing the final temperature is 24.8 degrees C. Assume the density and specific heat capacity of the solution are the same as water and no heat loss to the calorimeter except that considered in the calculation below. Calculate the molar enthalpy change for the neutralisation in kJ per mol. Show your working.

(a) Calculate the molar enthalpy change for the neutralisation, including working. **(4)**

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(Total for Question 7 is 4 marks)

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8 Explain why adding a catalyst to a reaction does not change whether the reaction is exothermic or endothermic.

(a) Explain why a catalyst does not change the enthalpy change of a reaction. **(2)**

(Total for Question 8 is 2 marks)

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9 Required practical style question: Describe a method to determine the enthalpy change when magnesium reacts with excess dilute hydrochloric acid to form magnesium chloride and hydrogen gas. Include the main measurements, one control variable, and one safety precaution.

(a) Describe the method, main measurements and calculation. **(2)**

(b) State one control variable and one safety precaution. **(2)**

(Total for Question 9 is 4 marks)

10 Explain how the Maxwell-Boltzmann distribution of molecular energies shows why increasing temperature increases the rate of a chemical reaction. Include the effect of a catalyst in your answer. (Higher tier only)

(a) Explain temperature and catalyst effects using the Maxwell-Boltzmann concept. **(4)**

(Total for Question 10 is 4 marks)

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11 A student measured that 0.0100 mol of a reactant produced 3150 J of heat in a small exothermic reaction. Calculate the enthalpy change in kJ per mol for the reaction, giving the sign.

(a) Calculate the molar enthalpy change and give the sign. **(3)**

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(Total for Question 11 is 3 marks)

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12 Levelled question (6 marks): Explain how bond breaking and bond making determine whether a chemical reaction is exothermic or endothermic. In your answer include a clear definition, a description of energy absorbed and released during bond breaking and formation, and an example reaction to illustrate your explanation.

(Total for Question 12 is 6 marks)

Mark scheme · C5aD Exothermic and Endothermic Reactions: Exam Drill

Question 1

- (a) **B1** reaction that transfers energy to the surroundings (often as heat), oe
- **(a) Answer: A reaction that transfers energy to the surroundings, often as heat.**
- (b) **B1** reaction that takes in energy from the surroundings (often as heat), oe
- **(b) Answer: A reaction that takes in energy from the surroundings, often as heat.**

Question 2

- (a) **B1** combustion of methane (CH4 + 2O2 -> CO2 + 2H2O) with energy released, oe
- **(a) Answer: Combustion of methane, energy released.**
- (b) **B1** thermal decomposition of calcium carbonate (CaCO3 -> CaO + CO2) with energy absorbed, oe
- **(b) Answer: Thermal decomposition of calcium carbonate, energy absorbed.**

Question 3

- (a) **B1** the height of the peak above the reactants (the energy barrier), oe
- **(a) Answer: The activation energy is the height of the peak above the reactants, representing the energy barrier.**
- (b) **M1** states products are lower in energy than reactants
- (b) **A1** states overall energy change is negative and energy is released to the surroundings, oe
- **(b) Answer: Products are lower in energy than reactants, so the overall energy change is negative and energy is released to the surroundings.**

Question 4

- (a) **M1** substitutes into q = m x c x deltaT: q = 200 x 4.18 x 12.5
- (a) **M1** calculates molar value: q per mol = 10450 J / 0.0200 mol
- (a) **A1** -523 kJ per mol cao
- **(a) Answer: -523 kJ per mol**

Question 5

- (a) **B1** heat lost to the surroundings (not all heat goes into the water), leading to smaller measured temperature rise
- **(a) Answer: Heat lost to the surroundings, so not all combustion heat is transferred to the water.**
- (b) **B1** insulate the calorimeter (use a lid and foam insulation) or use a bomb calorimeter to reduce heat loss, oe
- **(b) Answer: Insulate the calorimeter, for example use a lid and foam jacket or use a proper bomb calorimeter.**

Question 6

- (a) **M1** calculates total energy for bonds broken: 436 + 243 = 679 kJ mol-1
- (a) **M1** calculates total energy for bonds formed: 2 x 431 = 862 kJ mol-1
- (a) **A1** -183 kJ mol-1 cao
- **(a) Answer: -183 kJ per mol**

Question 7

- (a) **M1** calculates initial mixture temperature: (25.0 x 18.2 + 25.0 x 19.6) / 50.0 = 18.9 degrees C or states deltaT = 24.8 - 18.9 = 5.9 degrees C
- (a) **M1** calculates heat: q = m x c x deltaT = 50.0 x 4.18 x 5.9 = 1233 J (allow 1230 to 1240 J), oe
- (a) **M1** calculates moles of HCl neutralised: 0.200 x 0.0250 = 0.00500 mol
- (a) **A1** -247 kJ per mol cao
- **(a) Answer: -247 kJ per mol**

Question 8

- (a) **M1** states catalyst provides an alternative pathway with lower activation energy
- (a) **A1** states enthalpy change depends only on energy difference between reactants and products so it is unchanged by a catalyst, oe
- **(a) Answer: A catalyst provides an alternative pathway with lower activation energy but the enthalpy change depends only on the energy difference between reactants and products, so it does not change**

Question 9

- (a) **M1** measure mass or volume and initial temperature of acid, add excess magnesium ribbon, stir and record maximum temperature reached
- (a) **A1** use q = m x c x deltaT and moles of magnesium reacted to calculate enthalpy change per mole, oe
- **(a) Answer: Measure volume and initial temperature of dilute HCl, add excess magnesium, stir and record maximum temperature. Calculate q = m x c x deltaT for the solution and divide by moles of Mg reacted to get enthalpy per mole.**
- (b) **B1** control variable: concentration or volume of acid (or mass of water), oe
- (b) **B1** safety: wear safety goggles and handle acid with care, oe
- **(b) Answer: Control variable: concentration of acid (keep it the same). Safety precaution: wear safety goggles and use gloves when handling acid.**

Question 10

- (a) **M1** states increasing temperature shifts distribution so more particles have energy greater than activation energy
- (a) **M1** states this increases the frequency of successful collisions hence rate increases
- (a) **M1** states a catalyst provides an alternative pathway with lower activation energy so a larger fraction of particles exceed the lower threshold
- (a) **A1** links both points to show why rate increases with temperature and with a catalyst, oe
- **(a) Answer: Higher temperature shifts the Maxwell-Boltzmann distribution so a greater fraction of molecules have energy above the activation energy, increasing successful collisions and reaction rate. A catalyst lowers the activation energy, so an even larger fraction of molecules can react, increasing the rate further.**

Question 11

- (a) **M1** calculates per mole: 3150 J / 0.0100 mol
- (a) **M1** converts to kJ: 315000 J mol-1 = 315 kJ mol-1
- (a) **A1** -315 kJ per mol cao
- **(a) Answer: -315 kJ per mol**

Question 12

- **Level 3** (5-6): Detailed explanation linking bond breaking and forming to overall enthalpy change, with a correct example and clear use of energy terms.
- **Level 2** (3-4): Partial explanation: some correct statements about energy needed to break bonds and energy released when forming bonds, may lack full linkage or a clear example.
- **Level 1** (1-2): Simple statements about bond breaking or bond making without linking to overall energy change, or a superficial example.
- **Indicative content:**
  - Definition: bond breaking requires energy (endothermic) and bond formation releases energy (exothermic).
  - Overall enthalpy change = total energy to break bonds - total energy released forming bonds.
  - If more energy is released forming bonds than absorbed breaking bonds, reaction is exothermic; if more energy is absorbed, reaction is endothermic.
  - Use example: combustion of methane where breaking C-H and O=O bonds and forming C=O and O-H bonds releases more energy than absorbed, so net exothermic (quote approximate energies or state qualitatively).
  - Explain that bond energy data can be added to calculate a numeric enthalpy and relate to observed temperature change.