2.22 Exothermic and Endothermic Reactions: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 For each of the following changes, state whether it is exothermic or endothermic.

(a) Methane burning in a Bunsen burner: $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ **(1)**

(b) Calcium carbonate breaking down when heated strongly in a lime kiln: $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ **(1)**

(c) Dilute hydrochloric acid neutralising sodium hydroxide solution: $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$ **(1)**

(d) Solid ammonium nitrate dissolving in water. **(1)**

(Total for Question 1 is 4 marks)

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2 Reactions need a minimum amount of energy before they can happen.

(a) State what is meant by 'activation energy'. **(1)**

(b) State the effect that a catalyst has on the activation energy needed for a reaction. **(1)**

(Total for Question 2 is 2 marks)

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3 When investigating temperature changes in reacting solutions, other than the mass of a solid reactant, state two other independent variables that could be changed.

(Total for Question 3 is 2 marks)

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4 Higher tier only. A scientist is designing a reusable hand warmer that contains a supersaturated solution of sodium ethanoate (sodium acetate). When a small metal disc inside the pack is clicked, the solution rapidly turns into solid crystals, and the pack becomes warm. The pack can be made ready to use again by placing it in boiling water, which turns the crystals back into a solution, ready to be clicked again.

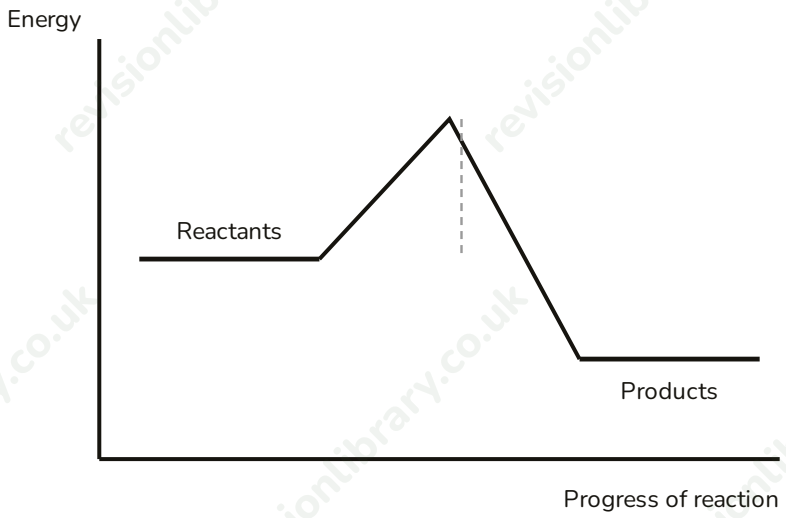
(a) State whether the crystallisation (solidifying) of the sodium ethanoate solution is exothermic or endothermic. Use information from the question to justify your answer. **(2)**

(b) Explain, in terms of energy transfer, why reheating the pack in boiling water is needed to make it reusable. **(2)**

(Total for Question 4 is 4 marks)

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5 The diagram shows a reaction profile for a general reaction.



(a) State whether this reaction profile represents an exothermic or an endothermic reaction. **(1)**

(b) State what is represented by the peak on the diagram. **(1)**

(c) Give one everyday device that makes use of an exothermic reaction like this one to produce warmth. **(1)**

(Total for Question 5 is 3 marks)

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6 In a different investigation, a student adds increasing masses of magnesium ribbon to a fixed volume of dilute hydrochloric acid, which is always in excess: $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$.

(a) Predict what would happen to the temperature change as the mass of magnesium added is increased (while the acid remains in excess). **(1)**

(b) Explain your answer to part (a). **(2)**

(Total for Question 6 is 3 marks)

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7 A hand warmer contains 75 g of iron powder. The iron reacts slowly with oxygen in the air: $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$ (exothermic). Each gram of iron that fully reacts releases approximately 1.6 kJ of energy as heat.

(a) Calculate the total energy released when all 75 g of iron in the hand warmer has fully reacted. **(2)**

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(b) The hand warmer transfers this energy over 6 hours of use. Calculate the mean rate of energy transfer, in kJ per hour. **(1)**

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(Total for Question 7 is 3 marks)

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8 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°C, amount of fuel burned = 0.0200 mol. Use specific heat capacity of water 4.18 J g-1°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 8 is 3 marks)

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9 State three factors, other than the identity of the reactants, that should be kept the same for this to be a fair comparison.

(Total for Question 9 is 3 marks)

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10 A neutralisation experiment: 25.0 cm^3 of 0.200 M hydrochloric acid at 18.2°C is mixed with 25.0 cm^3 of 0.200 M sodium hydroxide at 19.6°C. After mixing the final temperature is 24.8°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)**

(Total for Question 10 is 4 marks)

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11 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 11 is 6 marks)

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Mark scheme · 2.22 Exothermic and Endothermic Reactions: 1-hour Pack

Question 1

(a) exothermic (cao) **B1**

(a) Answer: Exothermic.

(b) endothermic (cao) **B1**

(b) Answer: Endothermic.

(c) exothermic (cao) **B1**

(c) Answer: Exothermic.

(d) endothermic (cao) **B1**

(d) Answer: Endothermic.

Question 2

(a) the minimum amount of energy that particles must have when they collide for a reaction to occur (oe) **B1**

(a) Answer: The minimum amount of energy that particles need when they collide for a reaction to happen.

(b) a catalyst lowers the activation energy needed, by providing an alternative reaction pathway (oe) **B1**

(b) Answer: A catalyst lowers the activation energy needed for the reaction, by providing an alternative reaction pathway.

Question 3

any one from: the concentration of a solution used; the volume of solution used; the identity/type of reactant used (e.g. which metal or acid); the starting temperature of the solution (oe) **B1**

any second, different variable from the same list (oe) **B1**

Answer: Any two from: the concentration of a solution used; the volume of solution used; which reactant (e.g. metal or acid) is used; the starting temperature of the solution.

Question 4

(a) exothermic **M1**

(a) because the pack becomes warm as the solution crystallises, showing that energy is released to the surroundings (oe) **A1**

(a) Answer: Exothermic; the pack becomes warm as it crystallises, showing that energy is released to the surroundings.

(b) heating the solid crystals in boiling water melts/redissolves them, an endothermic change that takes in (absorbs) energy from the water (oe) **M1**

(b) this reverses the crystallisation, resetting the pack so the same amount of energy can be released again the next time it is clicked (oe) **A1**

(b) Answer: Heating redissolves the crystals in an endothermic process that absorbs energy from the boiling water; this reverses the crystallisation and resets the pack so it can release that same energy again next time it is used.

Question 5

(a) exothermic, because the products line is drawn lower than the reactants line (cao) **B1**

(a) Answer: Exothermic (the products line is lower than the reactants line).

(b) the transition state, the highest-energy state along the reaction pathway (oe) **B1**

(b) Answer: The transition state, the highest-energy state along the reaction pathway.

(c) any valid example, e.g. a hand warmer, a self-heating can (oe, any one) **B1**

(c) Answer: A hand warmer (or a self-heating drinks can).

Question 6

(a) the temperature change would increase (oe) **B1**

(a) Answer: The temperature change would increase.

(b) a greater mass of magnesium means more reactant particles take part in the exothermic reaction (oe) **M1**

(b) so more energy in total is transferred to the surroundings (the fixed volume of acid), giving a bigger temperature rise (oe) **A1**

(b) Answer: A greater mass of magnesium means more reactant reacts, releasing more energy in total to the fixed volume of acid, so a bigger temperature rise is measured (until the acid is no longer in excess).

Question 7

(a) 75 x 1.6 **M1**

(a) 120 kJ (cao) **A1**

(a) Answer: 120 kJ.

(b) 20 kJ per hour (allow ft from candidate's answer to (a) divided by 6) **B1**

(b) Answer: 20 kJ per hour.

Question 8

(a) substitutes into q = m x c x deltaT: q = 200 x 4.18 x 12.5 **M1**

(a) calculates molar value: q per mol = 10450 J / 0.0200 mol **M1**

(a) -523 kJ per mol cao **A1**

(a) Answer: -523 kJ per mol

Question 9

any one from: the mass/amount of reactant used **B1**

any one from: the volume (and starting temperature) of the water or solution used **B1**

any one from: the concentration of any solutions used; the type of container/level of insulation used (any one, oe; any three different factors from this list) **B1**

Answer: Any three from: the mass/amount of reactant used; the volume and starting temperature of the water or solution used; the concentration of any solutions used; the type of container/level of insulation used.

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Question 10

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

(a) Answer: -247 kJ per mol

Question 11

Level 3 Detailed explanation linking bond breaking and forming to overall enthalpy change, with a correct example and clear use of energy terms.	**5-6**
Level 2 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.	**3-4**
Level 1 Simple statements about bond breaking or bond making without linking to overall energy change, or a superficial example.	**1-2**

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.

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