2.22 Exothermic and Endothermic Reactions: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A reaction profile diagram is used to show the energy changes during a reaction.

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

(b) State what is meant by a 'product'. **(1)**

(c) State what a reaction profile diagram is used to show. **(1)**

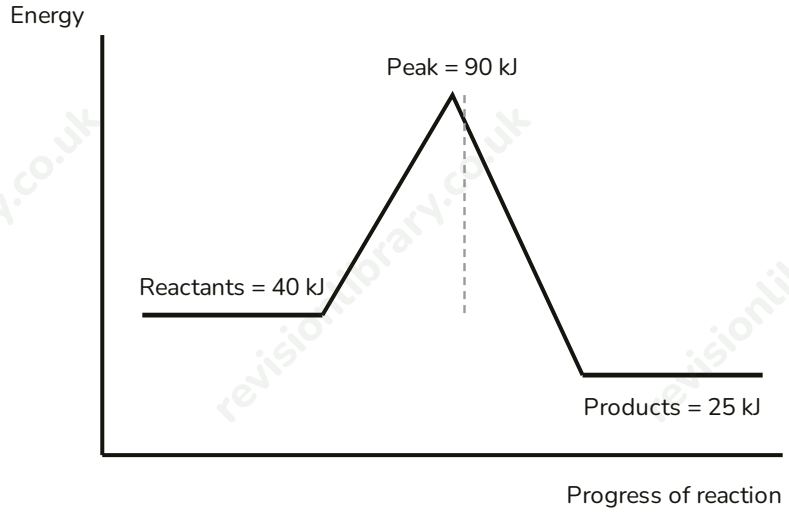
(Total for Question 1 is 3 marks)

2 State three safety precautions the student should take during this investigation.

(Total for Question 2 is 3 marks)

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3 Hydrogen peroxide decomposes in the presence of a manganese dioxide catalyst: $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$. The reaction profile for this reaction has these energy values:
Energy of reactants = 40 kJ
Energy of the peak (transition state) = 90 kJ
Energy of products = 25 kJ



(a) Calculate the activation energy of the reaction. **(1)**

.....

(b) Calculate the overall energy change for the reaction, and state whether energy is released or absorbed overall. **(2)**

.....

(c) Use the values given to explain why this reaction is exothermic. **(2)**

.....

.....

(d) A different catalyst is used that lowers the activation energy of this reaction. Describe the effect this would have on the shape of the reaction profile, and explain why a catalyst has this effect. **(2)**

.....

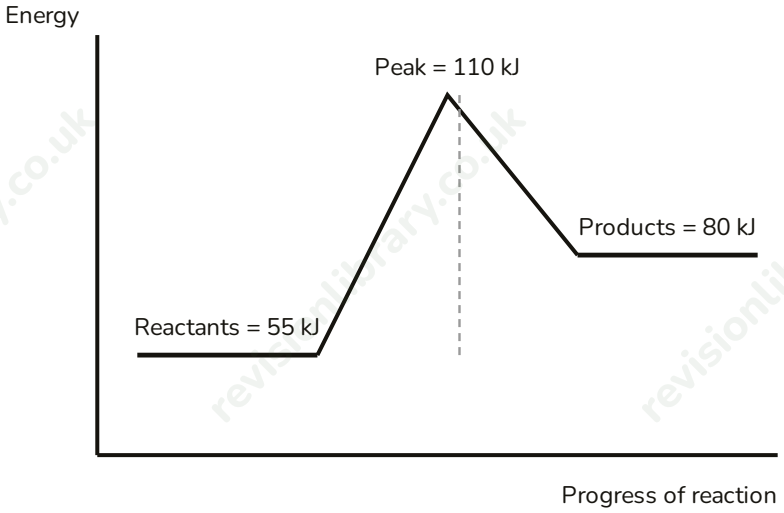
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(Total for Question 3 is 7 marks)

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4 Copper carbonate decomposes when heated: $CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$. This is an endothermic reaction. The reaction profile for this reaction has these energy values:
Energy of reactants = 55 kJ
Energy of the peak (transition state) = 110 kJ
Energy of products = 80 kJ



(a) Calculate the activation energy of the reaction. **(1)**

.....

(b) Calculate the overall energy change for the reaction. **(1)**

.....

(c) State how the reaction profile diagram shows that this reaction is endothermic. **(1)**

(d) A different decomposition reaction has a lower activation energy than this one, but the same overall energy change. State how this would be shown differently on a reaction profile diagram. **(1)**

(Total for Question 4 is 4 marks)

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5 A student added a small piece of magnesium ribbon to excess dilute hydrochloric acid in a polystyrene cup, and measured the temperature every 10 seconds. The temperature rose from 19.0°C to 34.0°C over the first 40 seconds, then stayed constant.

(a) Calculate the overall temperature change during the first 40 seconds. **(1)**

.....

(b) Calculate the mean rate of temperature increase, in °C per second, during the first 40 seconds. **(2)**

.....

(Total for Question 5 is 3 marks)

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6 Compare the two reactions and evaluate which would be more suitable for use in a hand warmer that needs to stay warm for several hours. You should refer to energy transfer and to practical/safety considerations in your answer.

(Total for Question 6 is 6 marks)

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Mark scheme · 2.22 Exothermic and Endothermic Reactions: 30-minute Pack

Question 1

(a) a starting substance in a chemical reaction, before it has reacted (oe) **B1**

(a) Answer: A starting substance in a chemical reaction, before it has reacted.

(b) a substance formed as a result of a chemical reaction (oe) **B1**

(b) Answer: A substance that is formed as a result of a chemical reaction.

(c) how the energy of the reactants and products (and the energy needed to start the reaction) changes as a reaction takes place (oe) **B1**

(c) Answer: How the energy of the substances involved changes as the reaction proceeds, from reactants to products.

Question 2

any one valid precaution, e.g. wear eye protection/safety goggles, a lab coat or gloves, or tie back long hair **B1**

a second, different valid precaution, e.g. take care handling the dilute acid, avoiding skin or eye contact and washing off any spills **B1**

any one from: stand up during the practical rather than sitting; do not put the thermometer down on the desk/use it to stir; work in a well-ventilated area, as carbon dioxide gas is produced (any one, oe; credit any three different valid precautions) **B1**

Answer: Any three from: wearing eye protection; handling the dilute acid carefully and washing off spills; standing up during the practical; not using the thermometer to stir; working in a well-ventilated area.

Question 3

(a) 50 kJ (cao) [90 - 40] **B1**

(a) Answer: 50 kJ

(b) correctly subtracts to find 40 - 25 (= 15) **M1**

(b) 15 kJ released overall (exothermic) (allow -15 kJ) (cao) **A1**

(b) Answer: 15 kJ released overall (the reaction is exothermic).

(c) the products (25 kJ) have less energy than the reactants (40 kJ) (oe) **M1**

(c) so overall energy is transferred (released) to the surroundings (oe) **A1**

(c) Answer: The products (25 kJ) have less energy than the reactants (40 kJ), so overall energy (15 kJ) is released to the surroundings.

(d) the peak (transition state) would be drawn lower, closer to the reactants line; the reactants and products lines stay in the same place (oe) **M1**

(d) because a catalyst provides an alternative reaction pathway that needs less energy for the reaction to happen (oe) **A1**

(d) Answer: The peak of the profile would be lower (a smaller hump), because the catalyst provides an alternative reaction pathway with a lower activation energy; the reactants and products energy levels stay the same.

Question 4

(a) 55 kJ (cao) [110 - 55] **B1**

(a) Answer: 55 kJ

(b) 25 kJ absorbed (allow +25 kJ) (cao) [80 - 55] **B1**

(b) Answer: 25 kJ absorbed (endothermic).

(c) the products line is drawn above (higher than) the reactants line (oe) **B1**

(c) Answer: The products line is drawn above (higher than) the reactants line.

(d) the peak (transition state) would be drawn lower, closer to the reactants line, with the reactants and products lines the same distance apart (oe) **B1**

(d) Answer: The peak (transition state) would be lower, nearer the reactants line, while the reactants and products lines stay the same distance apart.

Question 5

(a) 15.0°C increase (cao) [34.0 - 19.0] **B1**

(a) Answer: 15.0°C increase.

(b) correctly divides the temperature change by the time taken: 15.0 / 40 (ecf from candidate's answer to (a)) **M1**

(b) 0.375°C per second (allow awrt 0.38°C/s, or 0.4°C/s to 1 sf) (cao, ecf) **A1**

(b) Answer: 0.375°C per second (accept awrt 0.38°C/s).

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Question 6

Level 3 A detailed, logical comparison of both reactions is given, referring to the rate/duration of energy release and to safety/practicality, leading to a fully justified conclusion about which reaction is more suitable for a long-lasting hand warmer.	**5-6**
Level 2 Some relevant comparison is made between the two reactions, using ideas about the rate of energy release and/or safety or practicality, but the judgement on suitability is only partly justified.	**3-4**
Level 1 Simple statements are made about the reactions, e.g. identifying that both are exothermic, with little or no comparison or reasoned judgement.	**1-2**
Level 0 No relevant content.	**0**

Indicative content:

- Both reactions are exothermic and transfer energy to the surroundings, raising the temperature.
- The iron and oxygen reaction is relatively slow, releasing energy gradually over a long period, giving sustained warmth over several hours.
- The magnesium and hydrochloric acid reaction is fast and vigorous, releasing energy quickly and then stopping, giving only a short burst of warmth rather than several hours of warmth.
- The iron/oxygen reaction produces only a solid product (iron oxide), so it is safe to seal in a packet with no gas build-up.
- The magnesium/acid reaction produces hydrogen gas, which is flammable and would need to escape from the packaging, and also involves handling a corrosive liquid acid, both of which are safety and practicality concerns.
- Iron-based hand warmers can be designed to start reacting only when air reaches the iron powder, for example when the packet is opened, which is a practical, controllable trigger.
- A reasoned conclusion is required: the iron and oxygen reaction is more suitable for a hand warmer that must stay warm for several hours, because it releases energy slowly and safely over a long period, whereas the magnesium and acid reaction is too fast, less safe, and impractical to carry as a liquid.

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