2.4 Energy Changes: 1-hour Pack

AQA 8462 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Self-heating cans of coffee use an exothermic reaction (e.g. between calcium oxide and water) to warm the drink. Instant cold packs used to treat sports injuries use an endothermic reaction (e.g. ammonium nitrate dissolving in water).

(a) Explain, in terms of energy transfer, how the reaction in a self-heating can warms the drink. **(2)**

(b) Explain, in terms of energy transfer, why the cold pack feels cold when it is activated. **(2)**

(Total for Question 1 is 4 marks)

2 A student investigates how the concentration of hydrochloric acid affects the temperature change when it reacts with an excess of sodium hydroxide solution (a neutralisation reaction).

(a) Identify the independent variable in this investigation. **(1)**

(b) Identify the dependent variable in this investigation. **(1)**

(c) State two variables that should be controlled to make this a fair test. **(2)**

(Total for Question 2 is 4 marks)

© Revision Library | revisionlibrary.co.uk

3 The table shows a student's results for the temperature change when hydrochloric acid reacts with sodium hydroxide solution.

Repeat	Temperature change / °C
1	6.2
2	6.4
3	11.9

(a) Identify the anomalous result. **(1)**

(b) Suggest one possible reason for this anomalous result. **(1)**

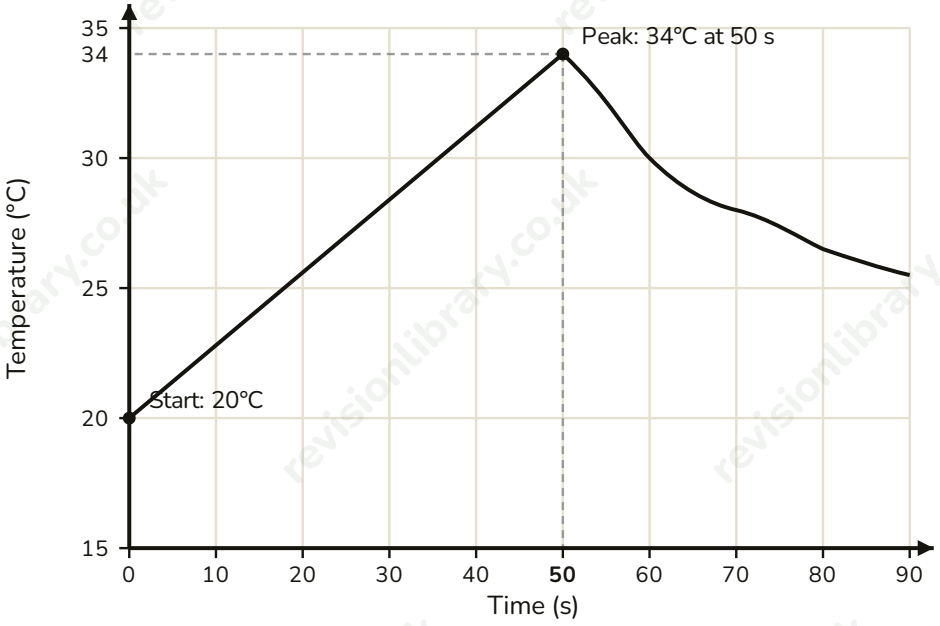
(c) Calculate the mean temperature change, excluding the anomalous result. **(2)**

(d) Suggest one improvement to the method that would reduce heat loss to the surroundings. **(1)**

(Total for Question 3 is 5 marks)

© Revision Library | revisionlibrary.co.uk

4 A student plots a graph of temperature (y-axis) against time (x-axis) for a reaction between magnesium and dilute sulfuric acid. The temperature starts at 20 C, rises steadily and reaches a peak of 34 C at 50 seconds, then gradually falls as the mixture cools.



(a) State the maximum temperature reached during the reaction. **(1)**

(b) Calculate the temperature change during the reaction. **(1)**

.....

(c) Explain why the temperature decreases after the peak at 50 seconds. **(1)**

.....

(d) Suggest one way the student could get a more accurate value for the maximum temperature change. **(1)**

.....

.....

.....

.....

.....

.....

.....

(Total for Question 4 is 4 marks)

© Revision Library | revisionlibrary.co.uk

5 Explain, in terms of energy transfers, why breaking bonds is endothermic and forming new bonds is exothermic, and how these two energy transfers determine whether a reaction is exothermic or endothermic overall.

(Total for Question 5 is 3 marks)

6 Calculate the energy absorbed by the water and give the answer in kilojoules to 2 significant figures. Show substitution.

(Total for Question 6 is 4 marks)

7 Bond breaking and bond forming determine whether a chemical reaction is exothermic or endothermic. Use this idea to explain why forming bonds releases energy while breaking bonds absorbs energy. You may refer to energy changes and to examples. (6 marks)

(Total for Question 7 is 6 marks)

8 Calculate the energy absorbed by the water. Show substitution in an equation and give the final answer with units.

(Total for Question 8 is 3 marks)

© Revision Library | revisionlibrary.co.uk

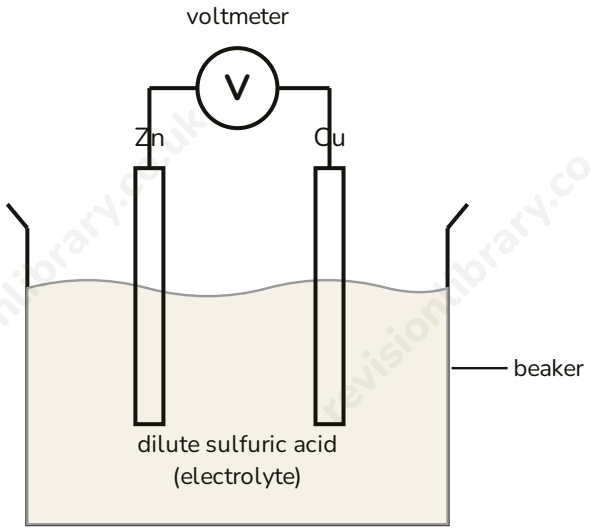
9 Explain one reason why the experimentally determined molar enthalpy change for a neutralisation is often less exothermic than the accepted literature value.

(a) Explain one experimental cause for a lower magnitude of measured enthalpy change compared to literature value, and explain one change to the procedure that would reduce the error. **(4)**

(Total for Question 9 is 4 marks)

---

10 A simple chemical cell can be made by placing a zinc electrode and a copper electrode into an electrolyte (e.g. dilute sulfuric acid) and connecting them with wires and a voltmeter.



(a) Explain how this cell produces a voltage (potential difference). **(2)**

(b) Predict, giving a reason, how the voltage would change if the zinc electrode were replaced with a magnesium electrode. **(2)**

(Total for Question 10 is 4 marks)

© Revision Library | revisionlibrary.co.uk

11 Batteries contain chemical cells connected together. Some batteries are non-rechargeable and some are rechargeable.

(a) State one difference between how a non-rechargeable battery and a rechargeable battery behave once fully discharged. **(2)**

(b) Give one advantage and one disadvantage of using rechargeable batteries instead of non-rechargeable batteries. **(2)**

(Total for Question 11 is 4 marks)

12 In a hydrogen fuel cell, hydrogen is oxidised at the negative electrode.

(a) Write the half equation for the reaction that occurs at the negative electrode of a hydrogen fuel cell. **(2)**

(b) State whether this half equation represents oxidation or reduction, giving a reason. **(1)**

(Total for Question 12 is 3 marks)

© Revision Library | revisionlibrary.co.uk

Mark scheme · 2.4 Energy Changes: 1-hour Pack

Question 1

(a) the reaction is exothermic oe **M1**

(a) energy is transferred to the surroundings (the drink), increasing its temperature oe **A1**

(a) Answer: The reaction is exothermic, so it transfers energy to the surroundings (the drink), causing its temperature to increase.

(b) the dissolving process is endothermic oe **M1**

(b) energy is transferred from the surroundings (skin/injury) to the chemicals, decreasing the surroundings' temperature oe **A1**

(b) Answer: The dissolving process is endothermic, so it takes in energy from the surroundings (the skin and injury), lowering their temperature and making the pack feel cold.

Question 2

(a) concentration of the hydrochloric acid **B1**

(a) Answer: The concentration of the hydrochloric acid.

(b) the (maximum) temperature change of the reaction mixture **B1**

(b) Answer: The temperature change (temperature rise) of the reaction mixture.

(c) volume of sodium hydroxide solution used oe **B1**

(c) starting temperature of the solutions / same insulated equipment used / same concentration of sodium hydroxide oe (any second valid control variable) **B1**

(c) Answer: For example: the volume of sodium hydroxide solution used, and the starting temperature of both solutions (also accept: same insulated container, same concentration of sodium hydroxide).

Question 3

(a) 11.9 C (repeat 3) cao **B1**

(a) Answer: 11.9 C (Repeat 3)

(b) e.g. thermometer misread, spillage, contamination, measuring error oe (any sensible practical error) **B1**

(b) Answer: For example, the thermometer may have been misread, or the solutions may not have mixed/reacted fully before the temperature was recorded.

(c) (6.2 + 6.4) / 2, excluding 11.9 oe **M1**

(c) 6.3 C cao **A1**

(c) Answer: 6.3 C

(d) use a lid on the insulated container / use a polystyrene cup with a lid oe **B1**

(d) Answer: Use an insulated container with a lid (e.g. a polystyrene cup with a lid and a hole for the thermometer).

Question 4

(a) 34 C cao **B1**

(a) Answer: 34 C

(b) 14 C (34 - 20) cao **B1**

(b) Answer: 14 C

(c) the reaction has finished (no more energy is being released) and the mixture loses energy (heat) to the cooler surroundings oe **B1**

(c) Answer: The reaction has finished, so no more energy is being released; the warm mixture then loses energy (heat) to the cooler surroundings, so it cools down.

(d) extrapolate the cooling part of the graph back to the time the reactants were mixed oe; or use a data logger for continuous, more frequent readings **B1**

(d) Answer: Extrapolate the falling (cooling) part of the graph back to the time the reactants were first mixed, to estimate the true peak temperature (correcting for heat already lost before 50 s).

Question 5

breaking bonds requires energy to be supplied/taken in from the surroundings, so it is endothermic oe **B1**

forming (making) new bonds releases/transfers energy to the surroundings, so it is exothermic oe **B1**

whether the overall reaction is exothermic or endothermic depends on the balance/difference between the energy needed to break bonds and the energy released forming bonds oe **B1**

Answer: Breaking bonds takes in energy from the surroundings (endothermic); forming new bonds releases energy to the surroundings (exothermic). The overall reaction is exothermic if more energy is released forming bonds than is needed to break them, and endothermic if more energy is needed to break bonds than is released forming them.

Question 6

substitutes into q = m x c x deltaT, e.g. q = 100.0 x 4.2 x 5.0 **M1**

evaluates multiplication to 2100 J **M1**

converts to kJ correctly: 2.10 kJ **M1**

gives final answer 2.1 kJ cao (to 2 s.f.) **A1**

Answer: 2.1 kJ

© Revision Library | revisionlibrary.co.uk

Question 7

Level 3 Detailed explanation. Candidate explains that bond breaking requires energy input because chemical bonds must be overcome, and bond forming releases energy as new bonds form. Links these ideas to overall reaction enthalpy and gives an example or uses energy profile language to show how more energy released in bond formation than absorbed in bond breaking gives an exothermic reaction (or the reverse for endothermic). **5-6**

Level 2 Partial explanation. Candidate states that breaking bonds absorbs energy and forming bonds releases energy and makes a simple link to overall energy change, but explanation may lack depth or example. **3-4**

Level 1 Basic statements. Candidate recalls that breaking bonds needs energy or forming bonds releases energy but does not link these to overall reaction energy or provide an example. **1-2**

Indicative content:

- Breaking bonds requires energy input to overcome attractions between atoms; energy is taken in from the surroundings.
- Forming bonds releases energy because atoms move to lower energy arrangements and the excess energy is given out to the surroundings.
- Overall reaction enthalpy depends on balance: if energy released from forming new bonds is greater than energy absorbed breaking old bonds, the reaction is exothermic.
- If energy absorbed breaking bonds is greater than energy released forming new bonds, the reaction is endothermic.
- Example: combustion of methane is exothermic because strong C-H and O-H bonds formed release more energy than that needed to break C-H and O=O bonds.
- Reference to energy profile language is creditworthy: reactants to products energy difference, activation energy as hump, and overall release or absorption shown by vertical difference.

Question 8

substitutes into q = m x c x deltaT, e.g. q = 50.0 x 4.2 x 10.0 **M1**

correct multiplication leading to 2100 **M1**

2100 J cao **A1**

Answer: 2100 J

Question 9

(a) identifies a plausible source of heat loss or systematic error (eg heat lost to the surroundings, incomplete mixing, not using polystyrene cup lid) **M1**

(a) states how this reduces measured temperature change (eg some energy escapes, so deltaT is smaller) **A1**

(a) identifies a linked procedural factor that could be changed to reduce the error (eg use insulating lid, minimise transfer time) **M1**

(a) explains why the change would increase measured deltaT (eg reduces heat loss so recorded temperature rises closer to true value) **A1**

(a) Answer: Heat is lost to the surroundings during the reaction (for example through the cup walls or during transfer), so the recorded temperature rise is smaller. Using better insulation and reducing transfer time reduces heat loss so the measured deltaT is larger and the calculated enthalpy is closer to the literature value.

Question 10

(a) chemical reactions occur at the two different metal electrodes oe **M1**

(a) this produces a difference in electrical potential between the electrodes, driving electrons through the external circuit oe **A1**

(a) Answer: Chemical reactions take place at each electrode; because the two metals are different, they react to different extents, producing a difference in electrical potential between them, which drives electrons through the external circuit (wire) - a voltage.

(b) voltage increases oe **M1**

(b) because magnesium is more reactive than zinc (further from copper in the reactivity series), giving a bigger difference in reactivity between the two metals oe **A1**

(b) Answer: The voltage would increase, because magnesium is more reactive than zinc, so it is further away from copper in the reactivity series; a bigger difference in reactivity between the two electrodes produces a bigger voltage.

Question 11

(a) a non-rechargeable battery cannot be reused because its chemical reaction cannot easily be reversed oe **M1**

(a) a rechargeable battery's chemical reaction can be reversed by supplying electrical energy (charging), so it can be reused many times oe **A1**

(a) Answer: A non-rechargeable battery's chemical reaction cannot be reversed, so once discharged it must be thrown away/replaced. A rechargeable battery's reaction can be reversed by supplying electrical energy (charging), so it can be reused many times.

(b) advantage, e.g. cheaper in the long term / less waste produced / fewer batteries need to be manufactured oe **B1**

(b) disadvantage, e.g. takes time to recharge / more expensive to buy initially / voltage falls as it discharges / limited number of charge cycles oe **B1**

(b) Answer: Advantage: cheaper overall and less waste, since the battery can be reused many times instead of being thrown away. Disadvantage: it takes time to recharge (and may be more expensive to buy initially).

Question 12

(a) correct species shown: H_2, H^+, e- oe **M1**

(a) correctly balanced: $2H_2 \rightarrow 4H^+ + 4e^-$ cao (accept $H_2 \rightarrow 2H^+ + 2e^-$) **A1**

(a) Answer: $2H_2 \rightarrow 4H^+ + 4e^-$ (or the simplest form $H_2 \rightarrow 2H^+ + 2e^-$)

(b) oxidation, because electrons are lost oe **B1**

(b) Answer: Oxidation, because hydrogen atoms lose electrons to form H^+ ions.

© Revision Library | revisionlibrary.co.uk