OCR GCSE GATEWAY CHEMISTRY A · J248

# CHEMISTRY



## MARK SCHEME

### C3.2 ENERGETICS

| SCORE | PERCENTAGE |
| --- | --- |
| /128 | % |

STEMUP

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | a | | **any four from:**<br>reaction is exothermic (1)<br>as reactants have more energy than products (1)<br>**A** is the activation energy (1)<br>activation energy is the amount of energy supplied to get the reaction started (1)<br>**B** is the energy change for the reaction (1)<br>the value of **B** is negative (1) | 4 | |
| | b | i | bonds broken – endothermic (1)<br>bonds made – exothermic (1) | 2 | both required |
| | | ii | energy needed to break bonds = 2736 (kJ) (1)<br><br>energy released when new bonds form = 3466 (kJ) (1)<br><br>energy change for a reaction = 730 (kJ) given out / – 730 (kJ) (1) | 3 | Correct answer scores 3 if no working is shown |
| | c | | energy transferred = 4.2 × 200 × (100 – 15) (1)<br>= 71400 J (1)<br><br>Mass of fuel needed to boil water (g) = energy needed to boil water (J) / energy per gram<br><br>50 kJ = 50000 J (1)<br><br>= 71400 / 50000 (1)<br><br>= 1.43 g (1) | 5 | **ALLOW** 1.428 g instead of 1.43 (1) |
| | | | **Total** | **14** | |
| 2 | | | B | 1 | |
| | | | **Total** | **1** | |
| 3 | | | (1 × 40.1) + [(16.0 + 1.0) × 2]<br><br>Correct use of number of atoms (1)<br>Correct use of $A_r$ (1) | 2 | |
| | | | **Total** | **2** | |

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<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>4</td><td></td><td></td><td>
<table>
<tr><th>Molten electrolyte</th><th>Formula</th><th>Product at negative electrode (cathode)</th><th>Product at positive electrode (anode)</th></tr>
<tr><td>sodium chloride</td><td>NaCl</td><td>sodium (1)</td><td>chlorine</td></tr>
<tr><td>lead bromide</td><td>$PbBr_2$</td><td>lead</td><td>bromine (1)</td></tr>
</table>
</td><td>2</td><td>DO NOT ALLOW bromide</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>2</td><td></td></tr>
<tr><td>5</td><td>a</td><td></td><td>large surface area to volume ratio (2)</td><td>2</td><td>ALLOW large surface area (1)</td></tr>
<tr><td></td><td>b</td><td></td><td>Number of particles = 80.0 mg ÷ (5.0 × $10^{-3}$ mg) (1)<br>= 16 000 particles (1)</td><td>2</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>5</td><td></td></tr>
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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 6 | a | | catalyst / vanadium(V) oxide / $V_2O_5$ (1) | 1 | **allow** vanadium pentoxide<br><br>if a named catalyst is given it must be correct including oxidation number except **allow** vanadium oxide catalyst<br><br>if formula and name given **both** must be correct<br><br>Examiner's Comments<br><br>This question was about the Contact Process.<br><br>The need for a catalyst was well known but many candidates gave the name of the wrong catalyst for example iron or nickel. A small proportion of candidates referred to a high concentration as a condition. |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | b | | **any three from:**<br>catalyst increases rate of reaction (1)<br><br>catalyst does not change position of equilibrium (1)<br><br>increasing temperature - increases rate of reaction / temperature used to have a high rate of reaction (1)<br><br>but increasing temperature position of equilibrium to left / temperature used to not shift the equilibrium to the left (1)<br><br>at low pressure position of equilibrium is already on right (1)<br><br>so expensive high pressures are not needed / at low pressure rate is low so reaction is easier to control (1) | 3 | **allow** ora where appropriate<br><br>**allow** catalyst does not change (percentage) yield<br><br>**allow** increasing temperature decreases (percentage) yield / increasing temperature favours backward reaction (1)<br><br>reference to it is a compromise temperature is **not** sufficient<br><br>**allow** good product (percentage) yield at low pressure<br><br>**not** use low pressure to shift equilibrium to the right<br><br>**Examiner's Comments**<br><br>This question was about the Contact Process.<br><br>There were many different marking points that could be accessed by the candidates. In terms of temperature the idea that the reaction would be fast and was low enough to keep the equilibrium on the right was sufficient – many candidates only mentioned the reference to rate. In terms of the pressure many candidates thought that the low pressure was to force the position of equilibrium to the right. Only the best answers appreciated that even at low pressure the position of equilibrium was on the right. Many candidates appreciated that a higher pressure would be more expensive. Most candidates appreciated that the catalyst increases the rate of reaction but the candidates did not often mention that the position of equilibrium was unaffected. |
| | | | **Total** | **4** | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 7 | | | thermometer (1) | 1 | **allow** temperature probe<br><br>Examiner's Comments<br><br>This question focused on calorimetric investigation involving burning fuels.<br><br>Almost all the candidates were able to identify the thermometer. |
| | | | Total | 1 | |

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<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>8</td><td>a</td><td></td><td>fair test / easier to compare results (1)</td><td>1</td><td>ignore to make the results reliable<br><br><u>Examiner's Comments</u><br><br>This question focused on calorimetric investigation involving burning fuels.<br><br>Candidates often referred to a fair test although some candidates stated that the experiments would be more reliable which was not given any credit.</td></tr>
<tr><td></td><td>b</td><td></td><td><table><tr><th>Fuel</th><th>Temperature change of water in °C</th></tr><tr><td>A</td><td>23</td></tr><tr><td>B</td><td>26</td></tr><tr><td>C</td><td>27</td></tr><tr><td>D</td><td>40</td></tr></table><br>Correct temperature changes (1)<br><br>Fuel D (1)</td><td>2</td><td>allow ecf from incorrect temperature changes<br><br><u>Examiner's Comments</u><br><br>This question focused on calorimetric investigation involving burning fuels.<br><br>Candidates were able to interpret the experimental results and deduce that fuel D released the most energy.</td></tr>
<tr><td></td><td>c</td><td></td><td>exothermic (1)</td><td>1</td><td><u>Examiner's Comments</u><br><br>This question focused on calorimetric investigation involving burning fuels.<br><br>The term exothermic was well known by many candidates although some candidates did give the opposite term i.e. endothermic.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>4</td><td></td></tr>
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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 9 | | | **any three from:**<br><br>amount of pollution / type of pollution (1)<br><br>cost (1)<br><br>availability (1)<br><br>toxicity / is it safe / is it harmful / is it dangerous (1)<br><br>ease of use (1)<br><br>storage (1)<br><br>flammability (1)<br><br>is it finite source / is it a fossil fuel (1) | 3 | **ignore** colour of flame<br><br>**allow** the gases produced (during combustion) eco-friendly is not sufficient<br><br>Examiner's Comments<br><br>This question used the context of the London Olympic flame to assess aspects of combustion.<br><br>Candidates often gave one or two factors that needed to be considered but rarely gave three acceptable factors. Typically these were related to cost and pollution. Candidates often gave imprecise and vague answers rather than giving the specific factors that affect the choice of a fuel. |
| | | | **Total** | 3 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 10 | a | | 32 000 (1) | 1 | **unit not needed**<br><br>Examiner's Comments<br><br>This question tested ideas about energy transfers.<br><br>The most common incorrect answer here was 8000J indicating a misunderstanding of what the units J/g mean. |
| | b | | LOOK FOR ANSWER FIRST OF ALL<br>IF ?T = 76.2 AWARD 3 MARKS<br><br>Correct substitution into equation i.e.<br>32 000 = 100 × 4.2 × ?T (1)<br><br>Correct rearrangement of equation i.e.<br>$\Delta T = \frac{32000}{100 \times 4.2}$ /<br>$\Delta T = \frac{\text{energy}}{\text{mass x } 4.2}$ (1)<br><br>?T = 76.2 (1) | 3 | **allow** 76 / 76.19<br>**unit not needed**<br><br>**allow** ecf from (a)<br><br>**allow** max 2 marks for correct rearrangement of equation using mass of 2g, or incorrect energy other than ecf,<br><br>ie $\Delta T = \frac{32000}{2 \times 4.2}$ / 3809.5<br><br>**or** $\frac{16000}{100 \times 4.2}$ / 38.1<br><br>**allow** max 1 mark for correct rearrangement of equation using incorrect mass and energy<br><br>Examiner's Comments<br><br>This question tested ideas about energy transfers.<br><br>Many candidates correctly substituted values into the equation and then rearranged it to calculate the rise in temperature. Candidates who substituted the mass of the fuel, rather than the mass of water, gained partial credit. Examiners allowed error carried forward from part (a). |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | c | | bond breaking absorbs energy /<br>bond breaking is endothermic (1)<br><br>bond making releases energy /<br>bond making is exothermic (1)<br><br>more energy released than absorbed (1) | 3 | **allow** bond breaking needs energy (1)<br><br>**not** bond making needs energy<br><br>**allow** heat instead of energy<br>**ignore** references to more bonds<br><br>Examiner's Comments<br><br>This question tested ideas about energy transfers.<br><br>Candidates found this question very challenging. Good responses described that bond breaking is endothermic, bond making is exothermic, and that more energy is given out during bond making than is taken in during bond breaking. When candidates did not score marks it was usually because they simply stated that bond breaking is exothermic or gave an answer in terms of the number of bonds broken or made. Many candidates still refer to bond breading as exothermic and bond making as endothermic. A significant proportion of candidates contradicted themselves within their answers thus negating marks that they could have scored. |
| | | | Total | 7 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 11 | a | | energy = 100 × 4.2 × 9 (1)<br><br>energy = 3780 (J) (1) | 2 | **allow** full marks for correct answer with no working out<br><br>**Examiner's Comments**<br><br>This question involved the interpretation of data obtained by calorimetry.<br><br>Many candidates were able to gain two marks for calculating the energy released. A common misconception was to substitute the mass of the fuel burned, rather than the mass of water. |
| | b | | no<br><br>energy released calculated for other value(s) / idea that temperature increase relates to the energy released (1)<br><br>because the one with most atoms or pentanol the temperature increase is not the highest / with most atoms does not release the most energy (1) | 2 | **allow** yes<br><br>with energy calculated for the other value(s) / idea that the temperature increase is related to the energy released (1)<br><br>and the last result is an anomaly (1)<br><br>**allow** energy calculations based on using the mass of fuel (1.0g)<br><br>**Examiner's Comments**<br><br>Candidates found very challenging. Some candidates were about to identify the anomalous result. Others identified that there was a link between energy released and the temperature change. |
| | | | **Total** | **4** | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 12 | | | bond breaking is endothermic / bond breaking takes in energy / bond breaking absorbs energy (1)<br><br>bond making is exothermic / bond making gives out energy / bond making releases energy (1)<br><br>more energy taken in than is released / more energy absorbed than given out (1) | 3 | **allow** heat instead of energy<br><br>**ignore** more bonds are broken than are made<br><br>**Examiner's Comments**<br><br>This question focused on the reaction between nitrogen and oxygen.<br><br>Was very challenging. A significant proportion of candidates referred to endothermic reactions as giving out energy. Other misconceptions included that both bond making and bond breaking were endothermic processes requiring energy, and that the reaction involved bond making or bond breaking, rather than both.<br><br>Many candidates gave detailed answers. |
| | | | Total | 3 | |

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<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>13</td><td>a</td><td></td><td>
<table>
<tr><th>fuel</th><th>molecular formula</th><th>number of atoms in a molecule</th><th>temperature increase in °C</th></tr>
<tr><td>methanol</td><td>$CH_4O$</td><td>6</td><td>9</td></tr>
<tr><td>ethanol</td><td>$C_2H_6O$</td><td>9</td><td>12</td></tr>
<tr><td>propanol</td><td>$C_3H_8O$</td><td>12</td><td>14</td></tr>
<tr><td>butanol</td><td>$C_4H_{10}O$</td><td>15</td><td>16</td></tr>
<tr><td>pentanol</td><td>$C_5H_{12}O$</td><td>18</td><td>15</td></tr>
</table>
Correct number of atoms (1)<br><br>Correct temperature increases (1)</td><td>2</td><td>Examiner's Comments<br><br>Most candidates gained both marks for correctly completing the table. A number of weaker candidates stated that methanol had 5 atoms in its molecule and lost that mark.</td></tr>
<tr><td></td><td>b</td><td></td><td>identification of pentanol as odd result (1)<br><br>explanation with a correct reason for yes or no (1)</td><td>2</td><td>e.g. the rest of the temperature increases go up with the number of atoms (1)<br>e.g. pentanol has less of a temperature rise than butanol (2)<br>e.g. pentanol is an anomaly (1)<br><br>allow ecf from table but apply same principles<br><br>Examiner's Comments<br><br>This question assessed Assessment Objective 3 (analyse and evaluate evidence, make reasoned judgements and draw conclusions based on evidence). Candidates needed to identify that pentanol was the odd result for the first mark and then give a correct explanation concerning the conclusion for the second mark.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>4</td><td></td></tr>
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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 14 | | | reaction which absorbs energy /<br>reaction which gains energy /<br>reaction which takes in energy (1) | 1 | **allow** heat or enthalpy for energy<br>**allow** a reaction in which surroundings get colder (1)<br><br>Examiner's Comments<br><br>About a quarter of all candidates understood that an endothermic reaction takes in energy. A number confused endothermic with exothermic and a number thought that endothermic meant that the reaction was heated. |
| | | | Total | 1 | |

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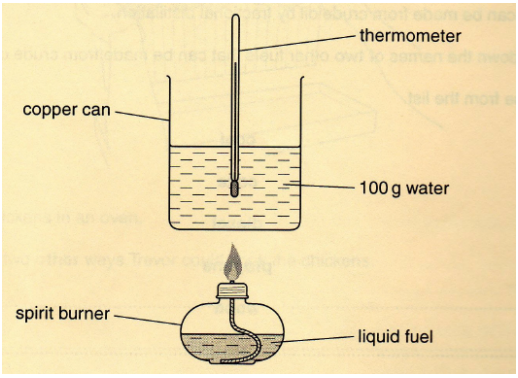
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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 15 | a | | horizontal line on the LHS is above the horizontal line on RHS (1)<br><br>reactants i.e. hydrogen and oxygen and products i.e. water correctly labelled (1)<br><br>(2)$H_2$ + $O_2$<br><br>(2)$H_2O$ | 2 | **ignore** any labelling on the lines<br><br>**ignore** any lines linking the reactants and products<br><br>**ignore** transition states or free atoms in the middle of the diagram – focus on reactants and products only<br><br>**this mark is independent of the first marking point**<br><br>**allow** words instead of formulae / reactant and product<br><br>**allow** H—H and O–O<br><br>?Examiner's Comments??<br><br>Candidates found this question about an energy level diagram very demanding. Many candidates had no idea what an energy level diagram looks like and drew straight lines from the origin. To get full marks candidates had to have the two energy levels correctly positioned and then have the energy levels correctly labelled as reactant and product. Some candidates gave excellent answers with more information than was required in the mark scheme. For example they gave the displayed formulae of the reactant and products and showed an activation energy with atomic oxygen and hydrogen. |
| | b | | provides water that astronauts can use / light / lightweight / low density / compact / no moving parts (1) | 1 | **allow** idea that makes a usable product i.e. water (for astronauts) / can be used as drinking water<br>**ignore** efficient / reliable<br><br>?Examiner's Comments??<br><br>A very large proportion of the candidates referred to the fuel cell forming drinking water. Only a very small number of candidates referred to no pollutants being formed and this was not sufficient to be awarded a mark. |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | Total | 3 | |
| 16 | | | **any four from:**<br><br>correct use of a **spirit burner** (1)<br><br>container of water above (spirit) burner (1)<br><br>measures the change in temperature of the water (1)<br><br>idea of measuring the mass of paraffin in the correct context (1)<br><br>idea of repeating appropriate experiment (1) | 4 | **if experiment is unsafe, or incorrect experiment, max 1**<br><br>**allow** paraffin burner<br><br>**not** Bunsen burner<br><br>**allow** reference to ?T or change in temperature in equation (1)<br>**allow** measure the temperature of the water at the start and at the end (1)<br><br>**allow** marks from a **labelled** diagram<br><br><br><br><br>**Examiner's Comments**<br><br>This experiment was obviously familiar to most candidates who were able to describe using the paraffin to measuring the temperature rise when heating water in a suitable container. Most candidates chose to draw a diagram to illustrate their answer and many would have scored more marks if their diagram had been correctly *labelled*. |
| | | | Total | 4 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 17 | a | | bond making is exothermic / bond making gives out energy / bond making releases energy (1)<br><br>more energy taken in than is released / more energy absorbed than given out (1)<br><br>**but**<br>it takes more energy to break the bonds than the energy released in making new bonds scores (2) | 2 | **allow** heat instead of energy<br><br>**ignore** more bonds are broken than are made<br><br>**Examiner's Comments**<br><br>Candidates found this question very challenging. Good responses described that bond formation is exothermic and that more energy is given out during bond formation than is taken in during bond breaking. When candidates did not get marks, it was usually because they simply stated that the reaction in the cold pack is endothermic because endothermic reactions take in heat (which was given in the stem of the question) or gave an answer in terms of the number of bonds broken or made. |
| | b | i | energy = 100 × 4.2 × 20 (1)<br><br>**but**<br><br>energy = 8400 (J) (2) | 2 | **allow** full marks for correct answer with no working out<br><br>**allow** 2.2 × 4.2 × 20 or 184.8 (J) (1)<br><br>**allow** 8.4 kJ (2)<br><br>**Examiner's Comments**<br><br>Many candidates were able to gain two marks for calculating the energy released. A common misconception was to substitute the mass of the fuel burned, rather than the mass of water. |

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|---|---|---|---|---|---|
| | | ii | highest temperature **change** (1)<br><br>for least amount of fuel burnt (1) | 2 | **allow** calculation of energy change for each fuel showing that paraffin releases most energy (2)<br><br>**allow** ecf from (i) for energy calculations based on using the mass of fuel (instead of the mass of water) (2)<br><br>**Examiner's Comments**<br><br>Good responses analysed and evaluated the evidence to conclude that paraffin gives out the most energy per gram because it gives the highest temperature change for the least amount of fuel burnt. When candidates did not gain both marks. It was often because they stated that paraffin had the highest temperature at the end. |
| | | | **Total** | **6** | |
| 18 | a | | **A** (1) | 1 | **Examiner's Comments**<br><br>Well answered. |
| | b | i | methylated spirits (1) | 1 | **Examiner's Comments**<br><br>Well answered. |
| | | ii | correct mass (100g) and temperature change (20°C) substituted in equation (1)<br><br>**but** correct answer of 8400 (J) (2) | 2 | **allow** 84 (J) for one mark<br><br>mark answer on answer line 8400 (J) (2)<br><br>**Examiner's Comments**<br><br>Well answered, in the energy calculation many candidates only scored a mark because they used the mass of the fuel not the water. |
| | | | **Total** | **4** | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 19 | a | | LOOK FOR ANSWER FIRST OF ALL<br>IF final temperature = 37.2 AWARD 3 MARKS<br>IF final temperature = 37. 23809523809524 / 37 / or any value correctly rounded up to 2 or more decimal places AWARD 2 MARKS<br>$\Delta T = \frac{1600}{25 \times 4.2}$ (1)<br>? T = 15.23809523809524 (1)<br>Final temperature = 37.2 (1) | 3 | **allow** $\Delta T = \frac{q}{c \times m}$ (1)<br>$q$ = energy transferred<br>$c$ = specific heat capacity<br>$m$ = mass<br>**allow** any answer correctly rounded up<br>only **allow** this mark if quoted to one decimal place<br>**allow** ecf from wrong temperature rise calculated<br>Examiner's Comments<br>Many candidates correctly calculated the final temperature of the acid as 37.2°C. The majority of candidates scored at least 2 marks for calculating the temperature change as 15.2°C, but some then subtracted this from the initial temperature of 22.0°C. Using the mass of magnesium (0.5g) instead of the mass of acid (25.0g) in the calculation was also a common error. A significant number of candidates were penalised for not expressing their answer to one decimal place. |

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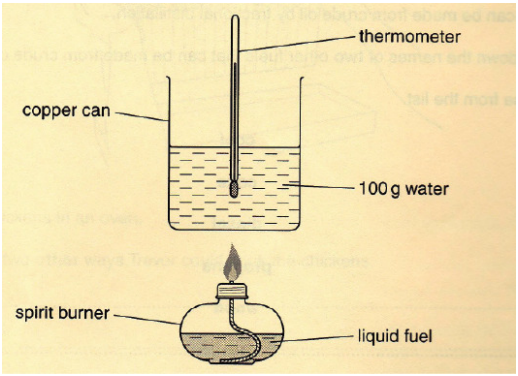
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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | b | | bond breaking absorbs or takes in energy **AND** bond making releases or gives out energy (1)<br><br>idea that energy released is greater than energy absorbed (1) | 2 | Second marking point is dependent on the first<br><br>**allow** bond breaking is endothermic **AND** bond making is exothermic (1)<br><br>**allow** more energy associated with bond making than with bond breaking (1)<br>**BUT** more energy released on forming bonds than absorbed in breaking bonds (2)<br><br>Examiner's Comments<br><br>Candidates found this question very challenging. Good responses described that bond breaking is endothermic, bond making is exothermic, and that more energy is given out during bond making than is taken in during bond breaking. When candidates did not score marks, it was usually because they simply stated that bond breaking is exothermic or gave an answer in terms of the number of bonds broken or made. |
| | | | Total | 5 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 20 | a | | exothermic (1) | 1 | **allow** any other indication of the correct answer e.g. tick, or circle providing answer line is blank<br><br>**Examiner's Comments**<br><br>Many candidates recognised the description for an exothermic reaction. |
| | b | i | suitable container of water (1)<br><br>**but** container of water above spirit burner (2)<br><br>thermometer in water (1) | 3 | **allow** any suitable container e.g. beaker / can / metal can<br><br><br><br><br>**Examiner's Comments**<br><br>Candidates found this a demanding question and even if they drew a diagram were not awarded any marks. Centres should advise candidates to ensure that the pieces of apparatus and the substances they contain should be labelled. A common misconception was to use a Bunsen burner to heat a container of paraffin; often the thermometer was used to measure the change in temperature of the paraffin.<br>Other candidates did have a spirit burner below a container of liquid but did not label the liquid so it was not possible to tell if the liquid was water.<br>Some candidates used gas syringes to collect some of the gases produced.<br>A significant proportion of the candidates did not attempt this question. |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | ii | points plotted correctly to within a half a square (1)<br><br>mass of paraffin is 2.5 g (1) | 2 | **ignore** any line drawn<br><br>unit **not** needed<br><br>**allow** any value between 2.4 to 2.6<br><br>**allow** 2 marks for correct answer<br><br>**allow** ecf from any incorrect line drawn<br><br>**Examiner's Comments**<br><br>Many candidates obtained an answer between 2.4 and 2.6 (g) and were awarded full marks. Candidates were often able to correctly plot the points and draw a line of best fit. |
| | | | Total | 6 | |

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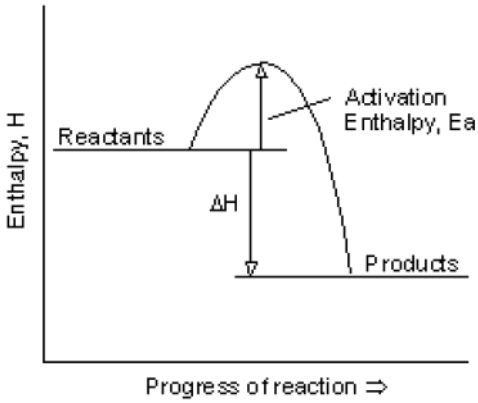
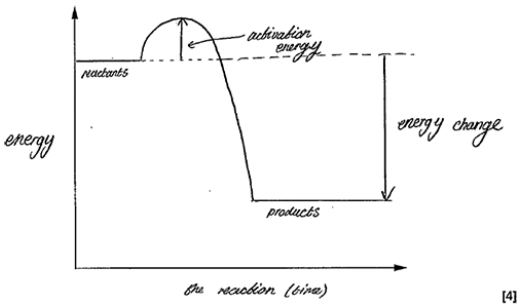
| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 21 | a | | More energy is given out during bond making than is taking in during bond breaking / AW ✓ | 1(AO1.1) | DO NOT ALLOW ideas about more bonds<br><br>IGNORE idea that more energy is **used** during bond making than is taken in during bond breaking<br>IGNORE idea that it takes more energy to make bonds than to break bonds<br><br>Examiner's Comments<br><br>Good responses to this question described that more energy is given out during bond making than is taken in during bond breaking. When candidates did not gain the mark, it was usually because they gave an answer in terms of the number of bonds broken or made. Many candidates still refer to bond breaking as exothermic and bond making as endothermic. A significant proportion of candidates contradicted themselves within their answers and therefore did not gain credit. |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | b | i | FIRST CHECK THE ANSWER ON ANSWER LINE<br>**If answer = (+)3057 (kJ / mol) award 2 marks**<br><br>(413 × 3) + (358) + (464) + (2 × 498) ✓<br>= 3057 (kJ / mol) ✓ | 2(AO2.2) | IGNORE + or - sign<br><br><u>Examiner's Comments</u><br><br>If candidates did not obtain the correct answers to parts (i) and / or (ii), examiners looked to award 'error carried forward' in part (iii). A common error was for candidates to subtract the smaller of their answers in parts (i) and (ii) from the larger, rather than appreciating that the energy change is calculated by 'energy transferred breaking bonds - energy transferred making bonds'.<br><br>In part (i) the most common error was to omit the C-O bond energy from the calculation.<br><br>In part (ii) the most common error was to use 2 × 358 (i.e. twice the C-O bond energy) rather than 2 × 805 (i.e. twice the C=O bond energy). |
| | | ii | FIRST CHECK THE ANSWER ON ANSWER LINE<br>**If answer = (-)3466 (kJ / mol) award 2 marks**<br><br>(805 × 2) + (464 × 4) ✓<br>= 3466 (kJ / mol) ✓ | 2(AO2.2) | IGNORE + or - sign |
| | | iii | 3057 – 3466 = -409 (kJ / mol) ✓ | 1(AO2.2) | ALLOW ecf from parts (i) and (ii)<br>DO NOT ALLOW +409 |
| | | | Total | 6 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 22 | | i |  | 4 | |
| | | | | (AO1.2) | ALLOW ‘energy’ for ‘enthalpy’ and ‘time’ for ‘progress of reaction’ |
| | | | | (AO2.2) | Reactants and products **must** be labelled (**ALLOW** formulae or names) |
| | | | Correctly labelled axes ✓ | (AO2.2) | **DO NOT ALLOW** double headed arrow |
| | | | Products shown below reactants ✓ | (AO2.2) | **DO NOT ALLOW** double headed arrow |
| | | | Activation energy correctly labelled ✓ | | <u>Examiner’s Comments</u> |
| | | | Energy change or ΔH correctly labelled ✓ | | Many candidates correctly labelled the reactants and products, with the products shown below the reactants. They also drew the correctly shaped curve. Candidates who did not gain full marks usually omitted the labels on the axes. Fewer candidates than on a similar question 2018 lost marks by indicating the energy change and the activation energy with either a double headed arrow or a line without any arrow. |
| | | | | | **Exemplar 4** |
| | | | | |  [4] |
| | | | | | This response illustrates a correctly drawn and labelled reaction profile. The candidate’s response illustrates the comment that examiners only gave credit for correctly drawn single headed arrows, as is the correct convention for reaction profile diagrams. |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | ii | Carbon donates or gives or loses electrons (to the lead ions) /<br><br>electrons are transferred from carbon (to lead ions) ✓ | 1(AO1.1) | IGNORE carbon is oxidised<br>IGNORE reference to lead oxide<br><br>DO NOT ALLOW idea of transfer of electrons to oxygen / oxide ion<br><br>Examiner's Comments<br><br>Good responses to this question described that carbon donates / gives / loses electrons. Lower ability candidates gave a response in terms of carbon removing oxygen, which did not address the question. |
| | | | **Total** | **5** | |
| 23 | | | D | 1<br>(AO 1.1) | Examiner's Comments<br><br>A and C were popular incorrect responses. |
| | | | **Total** | **1** | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 24 | a | i | Exothermic ✓ | 1<br>(AO1.1) | Examiner's Comments<br><br>Exothermic was quite well known. Common incorrect responses included: endothermic, chemical, combustion, melting and redox |
| | | ii | $Mg + 2HCl \rightarrow MgCl_2 + H_2$<br><br>Formulae ✓<br>Balancing ✓ | 2<br><br>(AO2.1)<br>(AO2.2) | **ALLOW** any correct multiple, including fractions<br>**ALLOW** = / ⇌ instead of →<br>**NOT** and / & instead of +<br><br>balancing mark is dependent on the correct formulae but<br>**ALLOW** 1 mark (M2) for a balanced equation with a minor error in subscripts / formulae<br>eg $MG + 2HCl \rightarrow MgCl_2 + H_2$<br><br>Examiner's Comments<br><br>Candidates found this very difficult with few gaining marks. Most gave H or 2H as the formula for hydrogen. |
| | | iii | Aluminium chloride ✓ | 1<br>(AO2.2) | **ALLOW** correct formula $AlCl_3$<br><br>Examiner's Comments<br><br>Candidates found naming the salt difficult and a significant number omitted the question. Common incorrect responses included: aluminium hydroxide, aluminium oxide, aluminium hydrochloride, salt, and magnesium chloride. |
| | b | i | 7.6✓ | 1<br>(AO3.2b) | |

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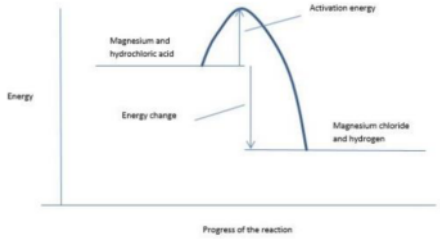
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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | ii | error taking the temperature (at start or at end) ✓ | 1<br>(AO3.2a) | ALLOW used more/less metal / used more/less acid<br>ALLOW reaction did not finish<br>IGNORE faulty thermometer<br><br>Examiner's Comments<br><br>Most candidates explained what an anomalous result is rather than explain what might have caused the anomalous result. |
| | | iii | FIRST CHECK THE ANSWER ON ANSWER LINE<br>If answer = 10.3 (°C) award 2 marks<br><br>(10.3 + 10.5 + 10.2) ÷ 3 = 10.3333…. (°C) ✓<br>= 10.3 (°C) (1 decimal place) ✓ | 2<br>(AO2.2) | Examiner's Comments<br><br>Most candidates calculated the mean correctly but some truncated their answer rather than rounding it. |
| | c | i | Improvement<br>Any one from:<br>Put a lid on the polystyrene cup /<br>Put insulating material around the polystyrene cup /<br>Use a digital thermometer ✓<br>Use a data logger ✓<br><br>AND<br>Reason<br>Any one from:<br>Stops/reduces heat loss (through evaporation) /<br>Prevents/reduces heat loss (from the polystyrene cup) /<br>(Digital thermometer) is easier to read /<br>(Digital thermometer) gives more accurate/precise readings ✓<br>(data logger) gives continuous data so can get max T | 2<br><br>(AO3.3b)<br><br><br><br><br><br>(AO2.2) | Reason must be linked to the Improvement to be awarded the second mark<br><br>ALLOW add same amount of metal / acid/measure mass metal / measure volume acid<br><br>..... so can compare results<br><br>ALLOW more metal / acid<br><br>..... gives larger T change / errors are less significant<br><br>Examiner's Comments<br><br>Candidates found this very difficult. Repetition was the most common improvement with accuracy for the reason. Some thought glass to be a better insulator than polystyrene. Most able candidates discussed either heat loss or digital devices. |

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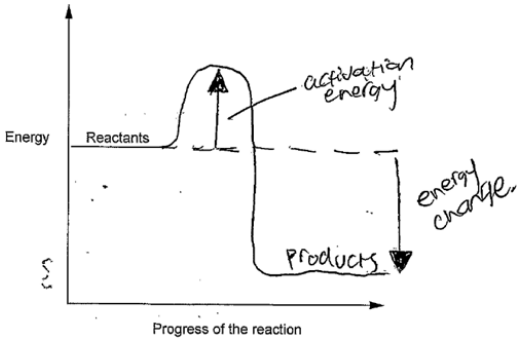
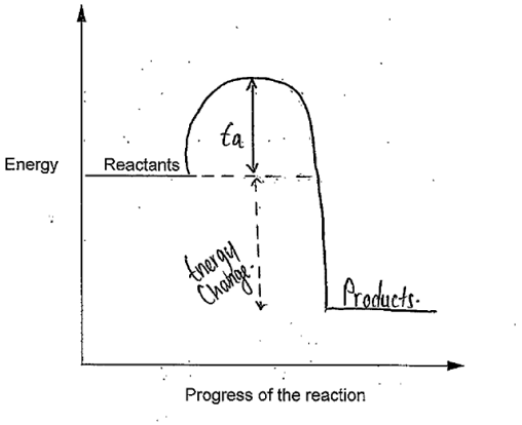
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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | ii | **Any two from:**<br>Use different types of acids ✓<br>Use a wider range of metals ✓<br>Change the mass of metal used ✓<br>Change the volume of acid used ✓ | 2<br>(AO3.3a) | **ALLOW** more reactive/less reactive metals<br><br>**IGNORE** concentration<br><br>Examiner's Comments<br><br>Candidates found this difficult with a significant number omitting the question. Those that answered the question usually only gave one further test. Using a wider range of metals was the most common response. |
| | d | | <br><br><br>Reactants above and to the left of products and both labelled in words or formulae ✓<br><br>Energy change downward arrow and labelled ✓<br><br>Activation energy upward arrow and labelled ✓ | 3<br><br>(AO1.2)<br><br>(AO2.2 ×2) | **ALLOW ECF** if endothermic is given as answer in **(a)(i)**<br><br>**ALLOW** label as just 'products'<br><br>**ALLOW** double headed labelled -ΔH<br><br>**DO NOT ALLOW** activation energy with a double headed arrow<br>**DO NOT ALLOW** activation energy arrow pointing downwards<br><br>Examiner's Comments<br><br>Candidates found this difficult with a significant number omitting the question. Many candidates placed and labelled the products correctly but few gained any further credit. The labels for energy change and activation energy were frequently written on the curve or in space. The arrows were often in the wrong place on the curve. The lines which were in the correct place were almost always double headed. |

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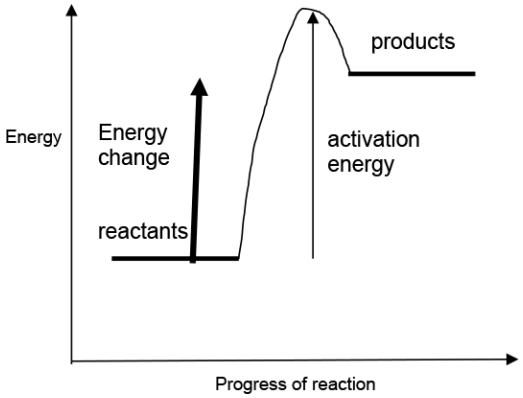
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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | | | **Exemplar 6**<br><br><br>The candidate has the product line in the correct place and labelled. Both energies are labelled and correct. Scores all 3 marks.<br><br>**Exemplar 7**<br><br><br>The candidate has the product line in the correct place and labelled. Both energies are labelled and the arrows are in the correct places but the use of double headed arrows means that they cannot score. This response scores marking point 1 only. |
| | | | Total | 15 | |

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<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>25</td><td>a</td><td>i</td><td>
<table>
<tr><th>Reaction mixture</th><th>Start temperature (°C)</th><th>End temperature (°C)</th><th>Temperature change (°C)</th></tr>
<tr><td>X</td><td>20.0</td><td>25.5</td><td>(+) 5.5</td></tr>
<tr><td>Y</td><td>19.0</td><td>8.0</td><td>–11</td></tr>
<tr><td>Z</td><td>20.0</td><td>20.0</td><td>0</td></tr>
</table>
</td><td>1<br>(AO1.2)</td><td></td></tr>
<tr><td></td><td></td><td>ii</td><td>Y ✓<br><br>the temperature went down / decreased / energy is taken in ✓</td><td>2<br>(AO3.2b<br><br>1.1)</td><td></td></tr>
<tr><td></td><td></td><td>iii</td><td>

<br><br>Activation energy ✓<br>Energy change ✓<br>Reactants ✓</td><td>3<br>(AO1.1)</td><td>ALLOW max 1 mark for correct shape if labels are missing / incorrect</td></tr>
<tr><td></td><td>b</td><td></td><td>Any two from:<br>Change the glass beaker for a metal container ✓<br><br>Move the spirit burner closer to the container / glass beaker / metal container ✓<br><br>Use a draught shield ✓<br><br>Add a lid (to the beaker) ✓</td><td>2<br>(AO3.3b<br>×2)</td><td>IGNORE put all thermometer (bulb) in water</td></tr>
</table>

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | Total | 8 | |
| 26 | a | i | $Zn + 2HCl \rightarrow ZnCl_2 + H_2$<br><br>Reactants ✓<br>Balancing ✓ | 2<br>(AO2.2) | **ALLOW** any correct multiple, including fractions<br>**ALLOW** = **OR** ⇌ instead of →<br>**DO NOT ALLOW** and / & instead of '+'<br><br>balancing mark is dependent on the correct formulae but<br>**ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae eg $Zn + 2HCL \rightarrow ZNCl_2 + H_2$ |
| | | ii | Exothermic ✓ | 1<br>(AO1.1) | |
| | b | | Energy required to start the reaction / energy required for a successful collision to occur / AW ✓ | 1<br>(AO1.1) | **IGNORE** energy needed to activate the reaction / amount of energy for the reaction to take place |
| | c | i | Bond breaking is endothermic / takes in energy ✓<br><br>Bond making is exothermic / gives out energy ✓<br><br>More energy is given out (during bond making) than is taken in (during bond breaking) ✓ | 3<br>(AO2 × 1.1)<br>(AO2.1) | **DO NOT ALLOW** ideas about more bonds<br><br>**IGNORE** idea that more energy is **used** during bond making than is taken in during bond breaking<br>**IGNORE** idea that it takes more energy to make bonds than to break bonds |
| | | ii | C–H: 4 × 413 = 1652 **AND** O=O: 2 × 498 = 996<br><br>Total energy = 1652 + 996 = 2648 (kJ / mol) ✓ | 1<br>(AO1.2) | |
| | | iii | C=O: 2 × 805 = 1610 **AND** O–H: 4 × 464 = 1856<br><br>Total energy = 1610 + 1856 = 3466 (kJ / mol) ✓ | 1<br>(AO1.2) | |
| | | iv | Energy change = 2648 – 3466 = –818 (kJ / mol) ✓ | 1<br>(AO1.2) | Answer MUST show – sign for mark<br>**ALLOW** ECF from parts (ii) & (iii) |
| | | | Total | 10 | |

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