

# Markscheme

**May 2019**

**Chemistry**

**Standard level**

**Paper 3**

24 pages

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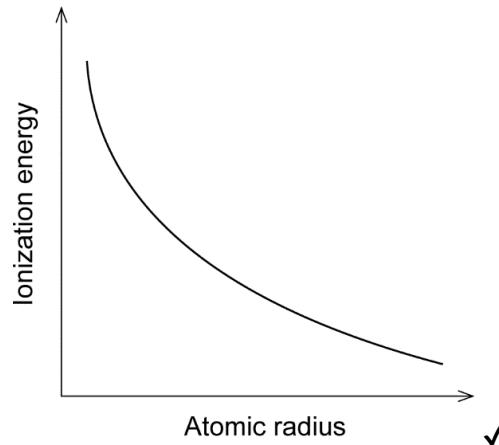
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## Section A

| Question |   |    | Answers   | Notes  | Total |
|----------|---|----|---|--|-------|
| 1.       | a |    | group 18/noble gases ✓<br><br>smallest difference between melting and boiling points<br><b>OR</b><br>weakest intermolecular forces «in that period» ✓   | Accept “group 17/halogens”.  | 2     |
| 1.       | b | i  | density increases «to a maximum in the transition elements» <b>AND</b> then decreases ✓   |  | 1     |
| 1.       | b | ii | actinoids <b>AND</b> density increases down all groups «due to large increase in atomic mass for small increase in atomic volume»<br><b>OR</b><br>actinoids <b>AND</b> «much» greater atomic mass with similar type of bonding<br><b>OR</b><br>actinoids <b>AND</b> density «of actinoids» atomic number 90 to 95 is greater than corresponding lanthanoids ✓ | Accept “actinoids <b>AND</b> on graph actinoids have «much» greater density than lanthanoids”. | 1     |

(continued...)

(Question 1b continued)

| Question |   |     | Answers   | Notes  | Total |
|----------|---|-----|---|--|-------|
| 1.       | b | iii | <p><b>Alternative 1:</b><br/>           «metals with» low densities oxidize easier ✓<br/>           «metals with» low melting points oxidize easier ✓</p> <p><b>Alternative 2:</b><br/>           in s-block «metals with» high densities oxidize easier<br/> <b>OR</b><br/>           in s-block «metals with» low melting points oxidize easier ✓</p> <p>in d-block «metals with» low densities oxidize easier<br/> <b>OR</b><br/>           in d-block «metals with» low melting points oxidize easier ✓</p> | Award <b>[1 max]</b> for “s-block metals more easily oxidized” <b>OR</b> “s-block metals have lower melting points” <b>OR</b> “s-block metals have lower densities”.<br><br>Accept “have greater activity” for “oxidize easier”. | 2     |
| 1.       | b | iv  |   | Accept any negative sloping line.<br>Do <b>not</b> award mark if line touches either axis.   | 1     |

| Question |   |    | Answers   | Notes  | Total |
|----------|---|----|---|--|-------|
| 2.       | a | i  | 100 «s» ✓   | Accept 90 to 100 s.  | 1     |
| 2.       | a | ii | highest recorded temperature<br><b>OR</b><br>when rate of heat production equals rate of heat loss ✓  | Accept “maximum temperature”.<br>Accept “completion/end point of reaction”.                  | 1     |
| 2.       | b | i  | <i>Maximum temperature:</i><br>73 «°C» ✓<br><br><i>Assumption:</i><br>«temperature reached if» reaction instantaneous<br><b>OR</b><br>«temperature reached if reaction occurred» without heat loss ✓  | Accept “rate of heat loss is constant” <b>OR</b> “rate of temperature decrease is constant”. | 2     |
| 2.       | b | ii | <i>Any one of:</i><br>copper(II) sulfate <b>AND</b> mass/amount of zinc is independent variable/being changed.<br><b>OR</b><br>copper(II) sulfate <b>AND</b> with zinc in excess there is no independent variable «as amount of copper(II) sulfate is fixed» ✓<br><br>copper(II) sulfate <b>AND</b> having excess zinc will not yield different results in each trial ✓<br>zinc <b>AND</b> results can be used to see if amount of zinc affects temperature rise «so this can be allowed for» ✓<br><br>zinc <b>AND</b> reduces variables/keeps the amount reacting constant ✓ |  | 1 max |

(continued...)

(Question 2b continued)

| Question                                   |  |     | Answers   | Notes   | Total      |                       |  |  |  |  |   |
|--|--|-----|---|---|------------|-----------------------|--|--|--|--|---|
| 2.   | b  | iii | <table border="1"> <thead> <tr> <th>Value</th> <th>Assumption</th> </tr> </thead> <tbody> <tr> <td><math>m = 25.00 \text{ g}</math></td> <td>           density of solution is <math>1.000 \text{ g cm}^{-3}</math>/same as water<br/> <b>OR</b><br/> <math>25.00 \text{ cm}^3</math> solution has a mass of <math>25.00 \text{ g}</math><br/> <b>OR</b><br/>           mass of zinc/reactant is negligible<br/> <b>OR</b><br/>           mass of contents was <math>25.00 \text{ g}</math> ✓         </td></tr> <tr> <td><math>c = 4.18 \text{ J g}^{-1} \text{ K}^{-1}</math></td> <td>           specific heat of solution is <math>4.18 \text{ J g}^{-1} \text{ K}^{-1}</math>/same as water<br/> <b>OR</b><br/>           zinc/calorimeter/beaker/thermometer absorbs no heat ✓         </td></tr> </tbody> </table> | Value   | Assumption | $m = 25.00 \text{ g}$ | density of solution is $1.000 \text{ g cm}^{-3}$ /same as water<br><b>OR</b><br>$25.00 \text{ cm}^3$ solution has a mass of $25.00 \text{ g}$<br><b>OR</b><br>mass of zinc/reactant is negligible<br><b>OR</b><br>mass of contents was $25.00 \text{ g}$ ✓ | $c = 4.18 \text{ J g}^{-1} \text{ K}^{-1}$ | specific heat of solution is $4.18 \text{ J g}^{-1} \text{ K}^{-1}$ /same as water<br><b>OR</b><br>zinc/calorimeter/beaker/thermometer absorbs no heat ✓ | Accept “copper(II) sulfate/zinc sulfate” for “solution”. | 2 |
| Value                                      | Assumption   |     |   |   |            |                       |  |  |  |  |   |
| $m = 25.00 \text{ g}$                      | density of solution is $1.000 \text{ g cm}^{-3}$ /same as water<br><b>OR</b><br>$25.00 \text{ cm}^3$ solution has a mass of $25.00 \text{ g}$<br><b>OR</b><br>mass of zinc/reactant is negligible<br><b>OR</b><br>mass of contents was $25.00 \text{ g}$ ✓ |     |   |   |            |                       |  |  |  |  |   |
| $c = 4.18 \text{ J g}^{-1} \text{ K}^{-1}$ | specific heat of solution is $4.18 \text{ J g}^{-1} \text{ K}^{-1}$ /same as water<br><b>OR</b><br>zinc/calorimeter/beaker/thermometer absorbs no heat ✓   |     |   |   |            |                       |  |  |  |  |   |
| 2.   | b  | iv  | lower/less exothermic/less negative <b>AND</b> heat loss/some heat not accounted for<br><b>OR</b><br>lower/less exothermic/less negative <b>AND</b> mass of reaction mixture greater than $25.00 \text{ g}$<br><b>OR</b><br>greater/more exothermic /more negative <b>AND</b> specific heat of solution less than water ✓   | Accept “temperature is lower” instead of “heat loss”.<br>Accept “similar to theoretical value <b>AND</b> heat losses have been compensated for”.<br>Accept “greater/more exothermic/more negative <b>AND</b> linear extrapolation overestimates heat loss”. | 1          |                       |  |  |  |  |   |

## Section B

### Option A — Materials

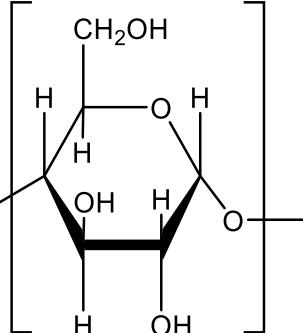
| Question |   |    | Answers   | Notes  | Total |
|----------|---|----|---|--|-------|
| 3.       | a | i  | ionic ✓   |  | 1     |
| 3.       | a | ii | lithium has an unpaired electron ✓<br><br>all electrons in lithium hydride are paired ✓   | Award [1 max] for correct electron configurations of Li AND Li <sup>+</sup> AND H without discussion of pairing. | 2     |
| 3.       | b | i  | emission spectra of both « <sup>6</sup> Li and natural Li» give same colour/produce same «range of» wavelengths<br><b>OR</b><br>they have same electron transitions/same nuclear charge ✓ | Accept “the spectra are almost identical”.   | 1     |
| 3.       | b | ii | ICP-MS ✓  | Accept “MS/mass spectrometry”.   | 1     |
| 3.       | c |    | $n = \frac{m}{M_r} = \frac{0.694}{6.94} = 0.100 \text{ mol}$ ✓<br>$t = \frac{0.100 \text{ mol} \times 96\,500 \text{ C mol}^{-1}}{2.00 \text{ C s}^{-1}} = 4820 \text{ s}$<br>4830 «s» ✓  | Accept “4820” OR “4825 «s»”.<br>Award [2] for correct final answer.  | 2     |

| Question |   |    | Answers  | Notes  | Total |
|----------|---|----|--|--|-------|
| 4.       | a |    | <p>Any two of:</p> <p>heterogeneous catalyst is in different phase than reactants <b>AND</b> homogeneous catalyst in same phase ✓</p> <p>homogeneous catalysts chemically change/react and are reformed at end of reaction</p> <p><b>OR</b></p> <p>reactants adsorb onto heterogenous catalyst and products desorb ✓</p> <p>heterogeneous catalysts are more easily removed than homogenous catalysts ✓</p> <p>heterogeneous catalysts can function at higher temperatures ✓</p> <p>homogeneous catalysts are «generally» more selective ✓</p> <p>homogeneous catalysts offer a broader range of reactions ✓</p> | <p>Accept “state” for “phase”.</p> <p>Accept “heterogeneous catalyst provides a surface to activate reaction”.</p> | 2 max |
| 4.       | b |    | <p>elastomers bend under force «and return to original form when force is released»</p> <p><b>OR</b></p> <p>elastomers make tyre more flexible ✓</p> <p>allows greater contact with road ✓</p>   |  | 2     |
| 4.       | c | i  | <p>does not contain heterocyclic ring with 2 oxygen atoms</p> <p><b>OR</b></p> <p>middle ring has only 1 oxygen atom ✓</p> <p>produces similar toxic effects to dioxins ✓</p>  | <p>Accept “does not contain dioxin ring” for M1.</p>   | 2     |
| 4.       | c | ii | <p>taken up by plants, which are eaten by animals «and then further dispersed»</p> <p><b>OR</b></p> <p>passed on in food chain ✓</p>   | <p>Accept “do not break down and can be remobilised as dust”.</p>  | 1     |

| Question |   |  | Answers   | Notes   | Total |
|----------|---|--|---|---|-------|
| 5.       | a |  | nitrile ✓   | Accept "cyano".   | 1     |
| 5.       | b |  | <p><i>Low temperature:</i><br/>intermolecular forces prevent molecules moving <b>AND</b> solid/«normal» crystal formation ✓</p> <p><i>High temperature:</i><br/>«above a critical temperature» disrupts alignment of molecules <b>AND</b> behaves as fluid/liquid ✓</p> | Accept "weak intermolecular forces break <b>AND</b> behaves as fluid/liquid". | 2     |

| Question |   | Answers  | Notes  | Total |
|----------|---|--|--|-------|
| 6.       | a | <p><i>Structure:</i><br/>giant covalent/network covalent ✓</p> <p><i>Bonding:</i><br/>each carbon covalently bonded to 3 other carbons<br/><b>OR</b><br/>each bond has order of 1.5</p>  | Accept “cylindrical/tube shaped”.<br><br>Accept “has delocalized electrons” <b>OR</b><br>“has $sp^2$ hybridization”. | 2     |
| 6.       | b | Any one of:<br>3D electrodes ✓<br>catalysts ✓<br>biosensors ✓<br>molecular stents ✓<br>body armour ✓<br>synthetic muscles ✓<br>micro transistors/circuitry/capacitors/electrodes ✓<br>reinforcing phase in a matrix/composite material «such as concrete» ✓<br>micro antenna ✓<br>stealth technology ✓<br>water/air filtration ✓<br>solar cells ✓<br>tennis racquets ✓<br>microelectronic circuits ✓ | <i>Do not accept just general answers such as “medicine” or “defence”.</i>   | 1 max |

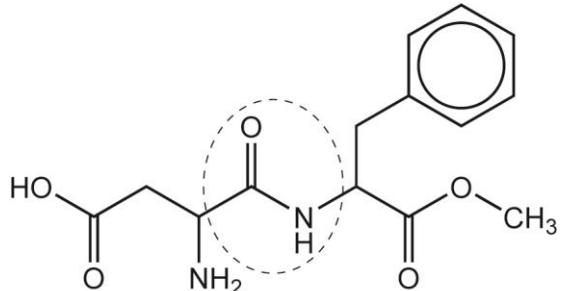
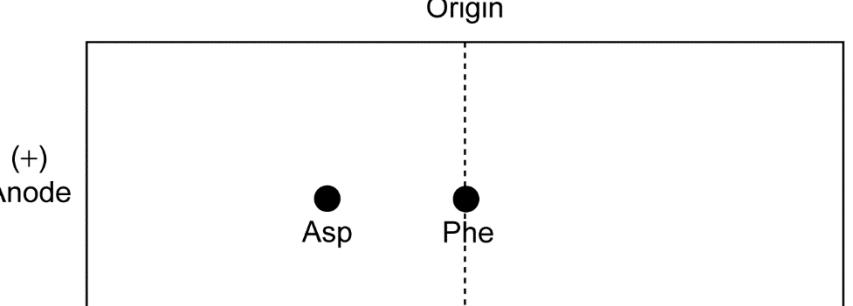
## Option B — Biochemistry

| Question |   | Answers  | Notes   | Total |
|----------|---|--|---|-------|
| 7.       | a |  <p>continuation bonds <b>AND</b> -O- attached to just one end <b>AND</b> both H-atoms on end carbons must be on the same side ✓</p> <p>Type of linkage:<br/>glycosidic ✓</p> | <p>Square brackets not required.<br/>Ignore "n" if given.<br/>Mark may be awarded if a polymer is shown but with the repeating unit clearly identified.</p> | 2     |
| 7.       | b | $(C_6H_{10}O_5)_n(s) + nH_2O(l) \rightarrow nC_6H_{12}O_6(aq)$ ✓   | <p>Accept "(n-1)H<sub>2</sub>O".<br/>Do <b>not</b> award mark if "n" not included.</p>  | 1     |
| 7.       | c | $q = mc\Delta T = 975 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ K}^{-1} \times 15.0 \text{ K} = 61100 \text{ J} / 61.1 \text{ kJ}$ ✓<br>$\text{heat per gram} = \frac{61.1 \text{ kJ}}{3.49 \text{ g}} = 17.5 \text{ kJ g}^{-1}$ ✓                         | Award [2] for correct final answer.   | 2     |

(continued...)

(Question 7 continued)

| Question |   | Answers   | Notes   | Total        |
|----------|---|---|---|--------------|
| 7.       | d | <p>Any two of:</p> <p>carbohydrate grains swell/break plastic into smaller pieces ✓</p> <p>inclusion of carbohydrate makes the plastic more hydrophilic/water soluble ✓</p> <p>carbohydrates are broken down/hydrolysed/digested by bacteria/micro-organisms ✓</p> <p>plastic becomes more accessible to bacteria as holes/channels are created in it ✓</p> <p>«presence of» carbohydrate weakens intermolecular/London/dispersion forces between polymer chains in the plastic ✓</p> | <p>Accept “starch” for “carbohydrate” throughout.</p> <p><i>Do not accept carbohydrates are broken down/hydrolyzed.</i></p> | <b>2 max</b> |

| Question |   | Answers  | Notes                          | Total |
|----------|---|--|--------------------------------|-------|
| 8.       | a |  <p>Name:<br/>amide/amido/carboxamide ✓</p>   | Accept “peptide bond/linkage”. | 2     |
| 8.       | b | <p>Origin</p>  <p>Phe: must be on the origin ✓<br/>Asp: any position on the left/anode/+ side ✓</p> |                                | 2     |

| Question |   | Answers  | Notes  | Total |
|----------|---|--|--|-------|
| 9.       | a | <p>coconut oil has higher content of lauric/short-chain «saturated» fatty acids<br/> <b>OR</b><br/>         cocoa butter has higher content of stearic/palmitic/longer chain «saturated» fatty acids ✓<br/> <br/>         longer chain fatty acids have greater surface area/larger electron cloud ✓<br/> <br/>         stronger London/dispersion/instantaneous dipole-induced dipole forces «between triglycerides of longer chain saturated fatty acids» ✓</p>  | <p><i>Do not accept arguments that relate to the melting points of saturated and unsaturated fats.</i></p> | 3     |
| 9.       | b | $  \begin{array}{c}  \text{H}_2\text{C} \text{---} \text{O} \text{---} \overset{\text{O}}{\underset{  }{\text{C}}} \text{---} (\text{CH}_2)_{10}\text{CH}_3 \\    \\  \text{HC} \text{---} \text{O} \text{---} \overset{\text{O}}{\underset{  }{\text{C}}} \text{---} (\text{CH}_2)_{16}\text{CH}_3 + 3\text{H}_2\text{O} \\    \\  \text{H}_2\text{C} \text{---} \text{O} \text{---} \overset{\text{O}}{\underset{  }{\text{C}}} \text{---} (\text{CH}_2)_{16}\text{CH}_3  \end{array}  $<br>$  \xrightarrow{\text{H}^+/\text{heat}}  \text{CH}_3(\text{CH}_2)_{10}\text{COOH} + 2\text{CH}_3(\text{CH}_2)_{16}\text{COOH} +   \begin{array}{c}  \text{H} \\    \\  \text{H} \text{---} \overset{\text{H}}{\underset{\text{C}}{\text{---}}} \text{OH} \\    \\  \text{H} \text{---} \overset{\text{H}}{\underset{\text{C}}{\text{---}}} \text{OH} \\    \\  \text{H} \text{---} \overset{\text{H}}{\underset{\text{C}}{\text{---}}} \text{OH}  \end{array}  $ <p>correct products ✓<br/>         correctly balanced ✓</p> |  | 2     |

(continued...)

(Question 9 continued)

| Question |   | Answers  | Notes | Total |
|----------|---|--|-------|-------|
| 9.       | c | <p><i>Any two of:</i></p> <p>«increased risk of» coronary/heart disease ✓</p> <p>«increased risk of» stroke ✓</p> <p>«increased risk of» atherosclerosis ✓</p> <p>«increased risk of type-2» diabetes ✓</p> <p>increase in LDL cholesterol ✓</p> <p>decrease in HDL cholesterol ✓</p> <p>«increased risk of» obesity ✓</p> |       | 2 max |

| Question |  | Answers   | Notes   | Total |
|----------|--|---|---|-------|
| 10.      |  | <p><i>ascorbic acid</i>: many hydroxyl/OH groups <b>AND</b> <i>retinol</i>: few/one hydroxyl/OH group<br/> <b>OR</b></p> <p><i>ascorbic acid</i>: many hydroxyl/OH groups <b>AND</b> <i>retinol</i>: long hydrocarbon chain ✓</p> <p><i>ascorbic acid</i>: «many» H-bond with water<br/> <b>OR</b></p> <p><i>retinol</i>: cannot «sufficiently» H-bond with water ✓</p> | <p><i>Do not accept "OH<sup>-</sup>/hydroxide".</i></p> | 2     |

**Option C — Energy**

| Question |   |    | Answers  | Notes  | Total |
|----------|---|----|--|--|-------|
| 11.      | a |    | « $\frac{891\text{kJmol}^{-1}}{16.05\text{gmol}^{-1}} = 55.5 \text{ kJ g}^{-1} \Rightarrow 55.5 \text{ «MJ kg}^{-1}» \checkmark$   |  | 1     |
| 11.      | b | i  | « $55.5 \text{ MJ} \times 58 \% =\Rightarrow 32.2 \text{ «MJ} \checkmark$  |  | 1     |
| 11.      | b | ii | <p><i>Reason for higher efficiency:</i><br/>           no heat/energy loss in producing steam<br/> <b>OR</b><br/>           no need to convert chemical energy of the fuel into heat and then heat into mechanical energy<br/> <b>OR</b><br/>           direct conversion of «gravitational» potential energy to mechanical energy ✓</p> <p><i>Reason for decreased use:</i><br/>           limited supply of available hydroelectric sites<br/> <b>OR</b><br/>           rapid growth of electrical supply in countries with little hydroelectric potential<br/> <b>OR</b><br/>           not building «new hydroelectric» dams because of environmental concerns ✓</p> | Accept “less energy lost as heat” but do <b>not</b> accept “no energy lost”.<br><br>Accept “new/alternative/solar/wind power sources «have taken over some of the demand»”.<br>Accept “lower output from existing stations due to limited water supplies”. | 2     |

(continued...)

(Question 11 continued)

| Question |   |    | Answers   | Notes  | Total |
|----------|---|----|---|--|-------|
| 11.      | c | i  | <p>The diagram illustrates a fractional distillation process. On the left, a 'Crude oil' drum is connected via a U-shaped coil to a 'Furnace' containing a flame. The furnace heats the crude oil. The heated oil enters the bottom of a tall 'Fractionating tower'. The tower is filled with a packing material (represented by a grid). Several horizontal lines descend from different heights within the tower, each labeled with a temperature range:     <ul style="list-style-type: none"> <li>Less than 40 °C</li> <li>40 °C–200 °C</li> <li>200 °C–300 °C</li> <li>250 °C–350 °C</li> <li>300 °C–370 °C</li> <li>Greater than 370 °C</li> </ul>     Arrows point from these lines to external collection vessels or outlets at the top of the tower. A checkmark (✓) is located at the bottom right of the tower's base.</p> |  | 1     |
| 11.      | c | ii | gasoline > diesel > lubricating motor oil > asphalt ✓   | <i>Accept products written in this order whether separated by &gt;, comma, or nothing.</i> | 1     |

(continued...)

(Question 11 continued)

| Question |   |    | Answers  | Notes | Total |
|----------|---|----|--|-------|-------|
| 11.      | d | i  | <p>methane is tetrahedral<br/> <b>OR</b><br/>         methane has zero dipole moment/is non-polar/bond polarities cancel ✓</p> <p><i>Any two of:</i></p> <p>IR absorption can result in increased vibrations/bending/stretching ✓</p> <p>only modes that cause change in dipole absorb IR ✓</p> <p>for methane this is asymmetric bending/stretching ✓</p> |       | 3 max |
| 11.      | d | ii | methane is less abundant <b>AND</b> has a greater effect «per mol» ✓   |       | 1     |

| Question |   |    | Answers  | Notes  | Total |
|----------|---|----|--|--|-------|
| 12.      | a | i  | $^{235}\text{U} + ^1\text{n} \rightarrow ^{144}\text{Ba} + ^{89}\text{Kr} + 3 ^1\text{n}$ ✓  |  | 1     |
| 12.      | a | ii | greater binding energy per nucleon in products than reactant ✓   | Accept “mass of products less than reactants” <b>OR</b> “mass converted to energy/ $E = mc^2$ ”. | 1     |
| 12.      | b |    | <p>mass/amount/quantity required so that «on average» each fission/reaction results in a further fission/reaction ✓</p> <p>at least one of the «3» neutrons produced must cause another reaction ✓</p> | Accept “minimum mass of fuel needed for the reaction to be self-sustaining”.                     | 2     |
| 12.      | c |    | «6.25 % = 4 half-lives, so $4 \times 3.15 \Rightarrow 12.6$ «min» ✓  |  | 1     |

| Question |   | Answers  | Notes | Total |
|----------|---|--|-------|-------|
| 13.      | a | increased <b>AND</b> fuels can be compressed more «before ignition» ✓<br><br>Accept “engines can be designed with higher compression ratio” <b>OR</b> “less chance of pre-ignition/auto-ignition/knocking occurring”.  |       | 1     |
| 13.      | b | <p><b>Alternative 1</b></p> <p><math>\text{C}_2\text{H}_5\text{OH}(\text{l}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})</math> / 1 mol ethanol produces 2 mol <math>\text{CO}_2</math></p> <p><b>OR</b></p> <p><math>\text{C}_8\text{H}_{18}(\text{l}) + 12.5\text{O}_2(\text{g}) \rightarrow 8\text{CO}_2(\text{g}) + 9\text{H}_2\text{O}(\text{l})</math> / 1 mol octane produces 8 mol <math>\text{CO}_2</math> ✓</p> <p>For 1 g of fuel:</p> <p>« <math>\frac{1\text{g}}{46\text{ g mol}^{-1}} \times 2\text{ mol CO}_2(\text{g}) = \gg 0.04\text{ «mol CO}_2(\text{g})»</math> from ethanol ✓</p> <p>« <math>\frac{1\text{g}}{114\text{ g mol}^{-1}} \times 8\text{ mol CO}_2(\text{g}) = \gg 0.07\text{ «mol CO}_2(\text{g})»</math> from octane ✓</p> <p><b>Alternative 2</b></p> <p>ratio of C in ethanol:octane is 2:8, so ratio in carbon dioxide produced per mole will be 1:4 ✓</p> <p>ratio amount of fuel in 1 g = <math>\frac{1}{46} : \frac{1}{114} = 2.5:1</math> ✓</p> <p>4 &gt; 2.5 so octane produces more carbon dioxide</p> <p><b>OR</b></p> <p>ratio of amount of carbon dioxide = 2.5:4 = 1:1.61 so octane produces more «for combustion of same mass» ✓</p> |       | 3     |

(continued...)

(Question 13 continued)

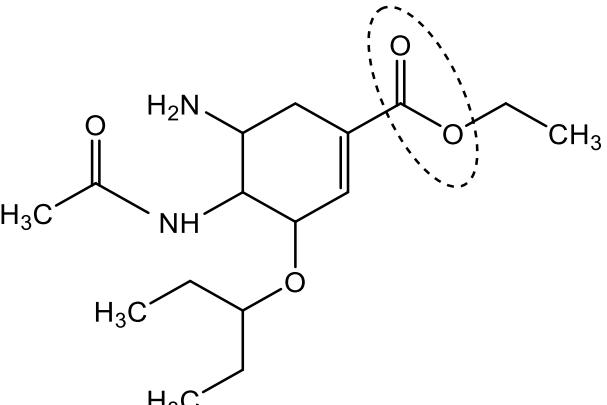
| Question |   | Answers  | Notes                                | Total |
|----------|---|--|--------------------------------------|-------|
| 13.      | c | <p>use of «farm» land «for production»<br/><b>OR</b><br/>deforestation «for crop production for fuel»<br/><b>OR</b><br/>can release more NO<sub>x</sub> «than normal fuel on combustion» ✓</p> | <i>Ignore any reference to cost.</i> | 1     |

**Option D — Medicinal chemistry**

| Question |  | Answers   | Notes   | Total |
|----------|--|---|---|-------|
| 14.      |  | <p>Name:<br/>hydroxyl ✓</p> <p>Absorption band:<br/>3200–3600 «cm<sup>-1</sup>» ✓</p> | Accept “phenol” <b>OR</b> “alcohol” but <b>not</b> “hydroxide”. | 2     |

| Question |   | Answers  | Notes   | Total |
|----------|---|--|---|-------|
| 15.      | a | «four-membered» beta-lactam ring ✓                           | Accept a diagram showing a structural representation of the beta-lactam ring. | 1     |
| 15.      | b | i produce penicillinase/enzyme that deactivates penicillin ✓ |   | 1     |
| 15.      | b | ii side-chain changed «preserving beta-lactam ring» ✓        | Accept “R group changed”.   | 1     |

| Question |   |    | Answers  | Notes  | Total |
|----------|---|----|--|--|-------|
| 16.      | a | i  | $\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \checkmark$  | <i>Accept balanced ionic equations involving "H<sup>+</sup>" or "H<sub>3</sub>O<sup>+</sup>".<br/>Do not accept "H<sub>2</sub>CO<sub>3</sub>".</i> | 1     |
| 16.      | a | ii | $n \text{ CaCO}_3 = \frac{1.00 \text{ g}}{100.09 \text{ g mol}^{-1}} = 0.00999 \text{ mol} \checkmark$<br>$\text{volume CO}_2 = 0.00999 \text{ mol} \times 22.7 \text{ dm}^3 \text{ mol}^{-1} = 0.227 \text{ dm}^3 \checkmark$   | <i>Accept 0.224 «dm<sup>3</sup>» if 22.4 dm<sup>3</sup> mol<sup>-1</sup> is used as molar volume.<br/>Award [2] for correct answer.</i>            | 2     |
| 16.      | b |    | <i>Omeprazole:</i><br>inhibits enzyme/«gastric» proton pump «which secretes H <sup>+</sup> ions into gastric juice»<br><b>OR</b><br>inhibits the H <sup>+</sup> /K <sup>+</sup> -ATPase system $\checkmark$<br><br><i>Ranitidine:</i><br>inhibits/blocks H <sub>2</sub> /histamine receptors «in cells of stomach lining»<br><b>OR</b><br>prevents histamine binding to H <sub>2</sub> /histamine receptors «and triggering acid secretion» $\checkmark$ | <i>Accept "H<sub>2</sub>-receptor antagonist" for M2.</i>  | 2     |

| Question |   |    | Answers   | Notes   | Total |
|----------|---|----|---|---|-------|
| 17.      | a | i  | <br><span style="font-size: 2em;">✓</span>     | Accept circles that include the alkyl side chain.                   | 1     |
| 17.      | a | ii | more soluble «in water» ✓   |   | 1     |
| 17.      | b |    | viruses undergo «rapid» mutation ✓<br>mutation causes a change in viral protein<br><b>OR</b><br>drug no longer binds to virus ✓ | Accept “rapid reproduction «allows resistant viruses to multiply»”. | 2     |

| Question |   |  | Answers  | Notes  | Total |
|----------|---|--|--|--|-------|
| 18.      | a |  | «temporarily» bond/bind to «opioid» receptors in the brain/CNS ✓<br>block the transmission of pain impulses ✓  |  | 2     |
| 18.      | b |  | «codeine crosses blood–brain barrier more easily»<br>morphine has more hydroxyl/OH «groups than codeine» ✓<br><br>codeine/ether group is less polar<br><b>OR</b><br>hydroxyl/OH «groups in morphine» H-bond to water ✓ | Award [1 max] if no statement or an incorrect statement about the blood–brain barrier. | 2     |

| Question |   |  | Answers   | Notes   | Total |
|----------|---|--|---|---|-------|
| 19.      | a |  | small/low amounts of radiation <b>AND</b> for a short time ✓            | Accept “weakly ionizing radiation” instead of “small amounts of radiation”.<br>Accept “short half-lives” instead of “for a short time”. | 1     |
| 19.      | b |  | stored in shielded containers until radiation drops «to a safe level» ✓ |   | 1     |