



Mark Scheme (Results)

January 2021

Pearson Edexcel International Advanced
Subsidiary Level

In Chemistry (WCH11)

Paper 1: Structure, Bonding and Introduction to
Organic Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Section A

Question number	Answer	Mark
1	<p>The only correct answer is B (C_3H_8)</p> <p><i>A is incorrect because the empirical formula is CH_2</i></p> <p><i>C is incorrect because the empirical formula is C_2H_5</i></p> <p><i>D is incorrect because the empirical formula is CH_2</i></p>	1

Question number	Answer	Mark
2	<p>The only correct answer is C (BH_3)</p> <p><i>A is incorrect because there are 1.51×10^{23} atoms</i></p> <p><i>B is incorrect because there are 4.52×10^{23} atoms</i></p> <p><i>D is incorrect because there are 7.53×10^{23} atoms</i></p>	1

Question number	Answer	Mark
3	<p>The only correct answer is A ($0.1 \text{ g dm}^{-3} \text{ HCl}$)</p> <p><i>B is incorrect because HCl has a higher concentration of chloride ions</i></p> <p><i>C is incorrect because HCl has a higher concentration of chloride ions</i></p> <p><i>D is incorrect because HCl has a higher concentration of chloride ions</i></p>	1

Question number	Answer	Mark
4	<p>The only correct answer is D ($\text{CaCO}_3 + 2\text{NaCl} \rightarrow \text{CaCl}_2 + \text{Na}_2\text{CO}_3$)</p> <p>A is incorrect because there are no waste products</p> <p>B is incorrect because H_2 has a lower M_r than Na_2CO_3</p> <p>C is incorrect because the combined M_r of H_2O and CO_2 is lower than Na_2CO_3</p>	1

Question number	Answer	Mark
5	<p>The only correct answer is B ($^{124}_{50}\text{Sn}$)</p> <p>A is incorrect because $^{115}_{49}\text{In}$ has 66 neutrons</p> <p>C is incorrect because $^{123}_{51}\text{Sb}$ has 72 neutrons</p> <p>D is incorrect because $^{124}_{52}\text{Te}$ has 72 neutrons</p>	1

Question number	Answer	Mark
6	<p>The only correct answer is B ($1s^2 2s^2 2p^6 3s^2 3p^6$)</p> <p>A is incorrect because this is the electronic configuration of an s-block element</p> <p>C is incorrect because this could not be the electronic configuration of the ion of a p-block element</p> <p>D is incorrect because this could not be the electronic configuration of the ion of a Period 3 element</p>	1

Question number	Answer	Mark
7	<p>The only correct answer is C (carbon)</p> <p><i>A is incorrect because Al is in Period 3</i></p> <p><i>B is incorrect because the element with the highest melting temperature is in Group 4</i></p> <p><i>D is incorrect because Si is in Period 3</i></p>	1

Question number	Answer	Mark
8	<p>The only correct answer is C (Hg(l))</p> <p><i>A is incorrect because simple molecules do not conduct electricity</i></p> <p><i>B is incorrect because simple molecules do not conduct electricity</i></p> <p><i>D is incorrect because ionic compounds do not conduct electricity as solids</i></p>	1

Question number	Answer	Mark
9	<p>The only correct answer is A (N^{3-})</p> <p><i>B is incorrect because F^- has more protons than N^{3-} so greater nuclear attraction on the outer electrons</i></p> <p><i>C is incorrect because Na^+ has more protons than N^{3-} so greater nuclear attraction on the outer electrons</i></p> <p><i>D is incorrect because Al^{3+} has more protons than N^{3-} so greater nuclear attraction on the outer electrons</i></p>	1

Question number	Answer	Mark
10	<p>The only correct answer is D (Ca^{2+})</p> <p><i>A is incorrect because anions do not polarise cations</i></p> <p><i>B is incorrect because anions do not polarise cations</i></p> <p><i>C is incorrect because K^+ has a smaller charge and a greater ionic radius</i></p>	1

Question number	Answer	Mark
11	<p>The only correct answer is A (C_{60} fullerene)</p> <p><i>B is incorrect because the structure of diamond is formed by a giant lattice of carbon atoms</i></p> <p><i>C is incorrect because the structure of graphene is formed by a giant lattice of carbon atoms</i></p> <p><i>D is incorrect because the structure of graphite is formed by a giant lattice of carbon atoms</i></p>	1

Question number	Answer	Mark
12	<p>The only correct answer is A (HF)</p> <p><i>B is incorrect because there is a relatively small difference in electronegativity between oxygen and fluorine</i></p> <p><i>C is incorrect because BF_3 is a non-polar molecule</i></p> <p><i>D is incorrect because CF_4 is a non-polar molecule</i></p>	1

Question number	Answer	Mark
13	<p>The only correct answer is B (corrosive)</p> <p><i>A is incorrect because this is a precaution and not a hazard</i></p> <p><i>C is incorrect because this is a precaution and not a hazard</i></p> <p><i>D is incorrect because this is not the symbol for oxidising</i></p>	1

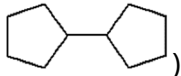
Question number	Answer	Mark
14	<p>The only correct answer is C (3,4,6-trimethyloctane)</p> <p><i>A is incorrect because the longest chain of carbon atoms is not seven</i></p> <p><i>B is incorrect because the longest chain of carbon atoms is not seven</i></p> <p><i>D is incorrect because the sum of the locant numbers is not the lowest</i></p>	1

Question number	Answer	Mark
15	<p>The only correct answer is A (burn to produce greenhouse gases)</p> <p><i>B is incorrect because they are not all carbon neutral</i></p> <p><i>C is incorrect because they are not all sustainable</i></p> <p><i>D is incorrect because they do not all biodegrade rapidly</i></p>	1

Question number	Answer	Mark
16(a)	<p>The only correct answer is D ($C_5H_{10} + Br_2 \rightarrow C_5H_9Br + HBr$)</p> <p>A is incorrect because C_5H_8 is the formula of cyclopentene and the reaction is not addition</p> <p>B is incorrect because the reaction is not addition and this product is not formed</p> <p>C is incorrect because these products are not formed</p>	1

Question number	Answer	Mark
16(b)	<p>The only correct answer is A (only the initiation step involves homolytic bond fission)</p> <p>B is incorrect because not all of the bromine is converted to radicals in the initiation step</p> <p>C is incorrect because many more propagation than termination reactions occur</p> <p>D is incorrect because additional substitution products are likely to form</p>	1

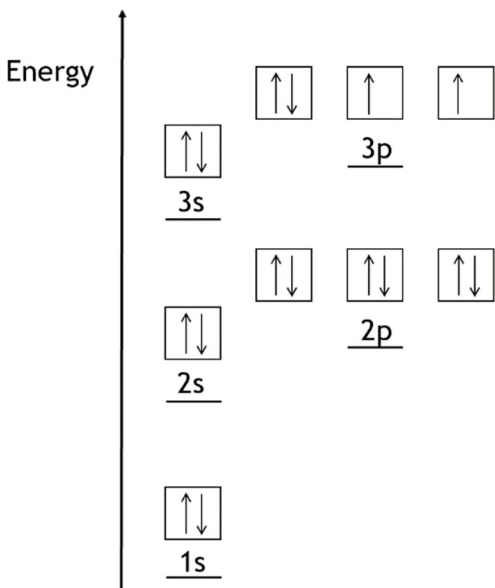
Question number	Answer	Mark
16(c)	<p>The only correct answer is D (H^\bullet)</p> <p>A is incorrect because $C_5H_9^\bullet$ radicals form in propagation reactions</p> <p>B is incorrect because Br^\bullet radicals form in propagation reactions</p> <p>C is incorrect because $C_5H_8Br^\bullet$ radicals may form in secondary propagation reactions</p>	1

Question number	Answer	Mark
16(d)	<p>The only correct answer is C ()</p> <p><i>A is incorrect because the molecule does not contain 10 carbon atoms</i></p> <p><i>B is incorrect because the molecule does not contain 10 carbon atoms</i></p> <p><i>D is incorrect because the molecule does not contain 18 hydrogen atoms</i></p>	1

Question number	Answer	Mark
17	<p>The only correct answer is B (exporting polymer waste)</p> <p><i>A is incorrect because biodegradable polymers are broken down by microorganisms</i></p> <p><i>C is incorrect because this removes harmful pollution</i></p> <p><i>D is incorrect because this saves energy and conserves non-renewable resources</i></p>	1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Answer	Additional guidance	Mark
18(a)	<p>A completed diagram showing:</p> <ul style="list-style-type: none"> • correctly labelled subshells (1) • correctly filled boxes/orbitals (1) 	<p>Allow p subshell labelled as orbitals eg $2p_x$, $2p_y$, $2p_z$ Ignore specified number of electrons, even if incorrect eg $3p^5$</p> <p>Allow paired 3p electrons in any 3p orbital Allow unpaired 3p electrons as spin down Allow half-headed arrows Do not award vertical lines for arrows Do not award paired electrons with parallel spin</p> <p><u>Example of completed diagram:</u></p> 	2

Question Number	Answer	Additional guidance	Mark
18(b)	<ul style="list-style-type: none"> <li data-bbox="387 451 734 483">• species and balancing <li data-bbox="387 675 734 707">• correct state symbols 	<p data-bbox="1055 220 1346 252">Example of equation:</p> <p data-bbox="1055 300 1272 331">$S(g) \rightarrow S^+(g) + e^{(-)}$</p> <p data-bbox="1055 347 1088 379">or</p> <p data-bbox="1055 387 1272 419">$S(g) - e^{(-)} \rightarrow S^+(g)$</p> <p data-bbox="1055 459 1373 491">(1) Do not award multiples</p> <p data-bbox="1055 547 1910 611">M2 dependent on S/S₈ on one side of equation and charged S⁺/S₈⁺/S⁻/S₈⁻ on the other (does not need to be balanced)</p> <p data-bbox="1055 667 1529 699">(1) Ignore (g) state symbol on electron</p> <p data-bbox="1055 738 1507 770">$S(g) + e^{(-)} \rightarrow S^+(g) + 2e^{(-)}$ scores (1)</p>	2

Question Number	Answer	Additional guidance	Mark
18(c)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li data-bbox="389 316 1189 384">• outermost electrons in same subshell / (quantum) shell (1) <li data-bbox="389 580 1189 655">• Cl contains the greatest number of protons / more protons than S (1) <li data-bbox="389 1114 1189 1189">• repulsion between (paired) electrons in (3)p orbital in S (1) 	<p>Accept similar/same (electron) shielding Allow same number of shells Allow correct reference to full or partial electronic configurations for two/three elements Do not award incorrect electronic configurations</p> <p>Accept Cl has the greatest nuclear charge Ignore Cl has the greatest nuclear attraction Ignore Cl has the greatest atomic number Do not award just Cl has the greatest charge Do not award S has the smallest nuclear charge Allow Cl has the smallest atomic radius / smaller atomic radius than S Do not award S had the greatest atomic radius Do not award same/similar atomic radius Do not award outer electron same/similar distance from nucleus Do not award ionic/molecular radius</p> <p>There must be a mention of p (orbital) Allow subshell for orbital Do not award shell for orbital Allow spin-spin repulsion in p orbital/subshell Allow correct reference to stable half-full p subshell: eg stable half-full p subshell in P eg removing electron from S gives stable half-full p subshell Do not award reference to bonding electrons</p>	3

Question Number	Answer	Additional guidance	Mark
18(d)(i)	<ul style="list-style-type: none"> (atoms with the) same number of protons (1) (and) different number of neutrons (1) 	Penalise use of species/particles/molecules for atoms once only Allow same atomic number Allow amount for number Ignore atoms of the same element Ignore electrons Ignore different mass number Do not award different number of electrons	2

Question Number	Answer	Additional guidance	Mark
18(d)(ii)	<ul style="list-style-type: none"> Expression for relative atomic mass (1) Calculation and answer to two decimal places (1) 	Example of calculation: $(A_r =) \frac{32 \times 94.88 + 33 \times 0.83 + 34 \times 4.27 + 36 \times 0.02}{100}$ $(A_r =) 32.09$ TE on transcription errors only (ie no TE on incorrect expression) Ignore units of amu / g / g mol ⁻¹ Do not award any other unit 32.09 scores (2) provided there is evidence of all four isotopes having been used in the calculation 32.09 with no working scores (1) 32.10 with no working scores (0) 33.75 scores (0)	2

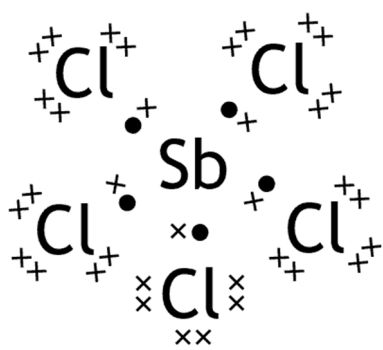
Question Number	Answer	Additional guidance	Mark
18(e)(i)	<ul style="list-style-type: none"> $\frac{256}{32} = 8$ (atoms) 	Allow working shown on mass spectrum Ignore calculations involving the Avogadro constant, even if incorrect Do not award just 8 (with no working)	1

Question Number	Answer	Additional guidance	Mark
18(e)(ii)	An answer that makes reference to the following points: <ul style="list-style-type: none"> (species containing) two sulfur atoms (1) (ion with) 1+ charge (1) 	Penalise isotopes other than ^{32}S once only eg S_2 / S—S Allow SS / S,S Ignore incorrect charge, including negative charge M2 dependent on an ion containing sulfur only S_2^+ / $[\text{S—S}]^+$ / SS^+ / S,S^+ scores (2) S_4^{2+} / $[\text{S}_2\text{—S}_2]^{2+}$ / $\text{S}_2\text{S}_2^{2+}$ / S_2^+S_2^+ / $\text{S}_2^+,\text{S}_2^+$ scores (1)	2

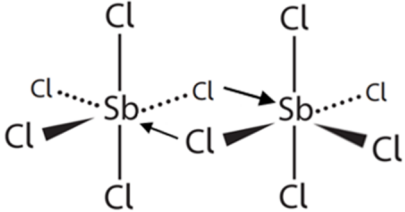
(Total for Question 18 = 14 marks)

Question Number	Answer	Additional guidance	Mark								
19(a)	A completed table showing: <ul style="list-style-type: none"> • correct number of bond pairs and lone pairs (1) • correct Cl–N–Cl bond angle (1) • correct name of shape (1) 	Mark all points independently <table border="1" data-bbox="1158 301 1984 799" style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td data-bbox="1158 301 1608 379">Number of bond pairs around N atom</td> <td data-bbox="1608 301 1984 379" style="text-align: center;"><u>3</u></td> </tr> <tr> <td data-bbox="1158 379 1608 458">Number of lone pairs around N atom</td> <td data-bbox="1608 379 1984 458" style="text-align: center;"><u>1</u></td> </tr> <tr> <td data-bbox="1158 458 1608 596">Cl–N–Cl bond angle</td> <td data-bbox="1608 458 1984 596" style="text-align: center;"> <u>107^(o)</u> Allow 106^(o) – 108^(o) </td> </tr> <tr> <td data-bbox="1158 596 1608 799">Name of shape of molecule</td> <td data-bbox="1608 596 1984 799"> (Trigonal) <u>pyramidal</u> Allow pyramid Ignore tetrahedral Do not award bipyramidal </td> </tr> </tbody> </table>	Number of bond pairs around N atom	<u>3</u>	Number of lone pairs around N atom	<u>1</u>	Cl–N–Cl bond angle	<u>107^(o)</u> Allow 106 ^(o) – 108 ^(o)	Name of shape of molecule	(Trigonal) <u>pyramidal</u> Allow pyramid Ignore tetrahedral Do not award bipyramidal	3
Number of bond pairs around N atom	<u>3</u>										
Number of lone pairs around N atom	<u>1</u>										
Cl–N–Cl bond angle	<u>107^(o)</u> Allow 106 ^(o) – 108 ^(o)										
Name of shape of molecule	(Trigonal) <u>pyramidal</u> Allow pyramid Ignore tetrahedral Do not award bipyramidal										

Question Number	Answer	Additional guidance	Mark
19(b)(i)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li data-bbox="369 359 1296 391">• strong(er) (electrostatic) attraction between ions (in PCl_5) (1) <li data-bbox="369 766 1296 798">• (than) weak intermolecular forces (in SbCl_5) (1) 	<p>Mark M1 and M2 independently Ignore reference to solid/liquid</p> <p>Allow strong ionic bonds / strong ionic lattice Allow strong attraction between positive and negative charges Allow strong attraction between cations and anions / PCl_4^+ and PCl_6^- Ignore just PCl_5 is (giant) ionic Do not award reference to PCl_5 molecules/ intermolecular forces Do not award reference to breaking of covalent bonds</p> <p>Accept just London/van der Waals/dispersion/ temporary-induced dipole/instantaneous-induced dipole forces Ignore just SbCl_5 is (simple) molecular Do not award reference to breaking of covalent/ionic bonds</p> <p>Ionic bonding is stronger than intermolecular forces scores (2)</p>	2

Question Number	Answer	Additional guidance	Mark
19(b)(ii)	<p>Dot-and-cross diagram showing the following:</p> <ul style="list-style-type: none"> • central Sb with five bond pairs and no lone pairs (1) • five Cl atoms each with one bond pair and three lone pairs (1) 	<p>Mark M1 and M2 independently</p> <p>Example of dot-and-cross diagram:</p>  <p>TE on M1 for three or four Cl atoms</p> <p>Allow any combination of crosses and dots</p> <p>Allow circles to indicate outer shells Ignore inner shells Ignore lines showing the covalent bonds</p>	2

Question Number	Answer	Additional guidance	Mark
19(c)(i)	<ul style="list-style-type: none"> suitable description of a dative covalent bond 	<p>For credit to be awarded, it must be clear that:</p> <ul style="list-style-type: none"> i) a pair of / two electrons are involved ii) these electrons are shared/bonding iii) these electrons come from the same atom <p>eg shared electrons in which both electrons come from the same atom</p> <p>eg lone pair/full orbital from one atom overlaps with empty orbital of another</p> <p>Allow element for atom</p> <p>Allow just both electrons in the bond come from the same element</p> <p>Allow one element donates/gives/shares both electrons to the bond</p> <p>Allow one atom shares both electrons</p> <p>Do not award just one atom donates/gives both electrons (or any reference to ions being formed)</p> <p>Do not award ion/molecule/species for atom</p>	1

Question Number	Answer	Additional guidance	Mark
19(c)(ii)	<ul style="list-style-type: none"> two correct dative covalent bonds shown as arrows 	 <p>Ignore lone pairs shown on Cl Do not award dative bonds from any other Cl atoms</p>	1

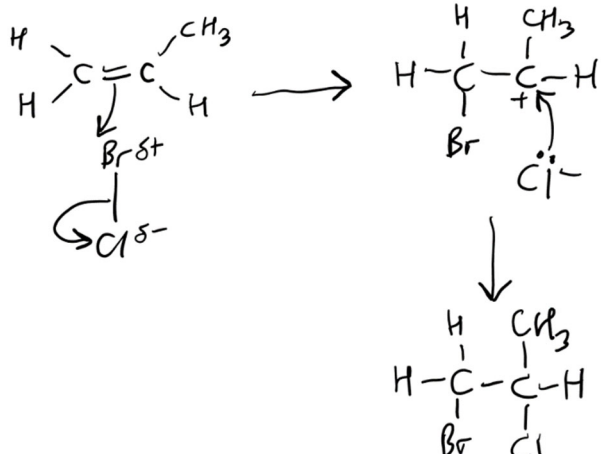
Question Number	Answer	Additional guidance	Mark
19(d)	<p>An answer that makes reference to one of the following points:</p> <ul style="list-style-type: none"> no 2d orbitals or (nitrogen) cannot expand its octet or (nitrogen is) too small (to bond to 5 atoms) or repulsion between electron pairs would be too great 	<p>Accept reverse arguments</p> <p>Allow no d orbitals as only two (quantum) shells Allow no d orbitals (accessible) Allow (nitrogen) cannot have more than eight electrons in its outer shell Ignore just cannot expand its outer/valence shell Ignore just nitrogen obeys the octet rule</p> <p>Ignore just (nitrogen has a) very small/smallest atomic radius Ignore Cl atoms too large Ignore nitrogen has fewest/only two shells</p> <p>Ignore just repulsion between electron pairs Ignore repulsion between Cl atoms Ignore not enough room for 5 electron pairs</p>	1

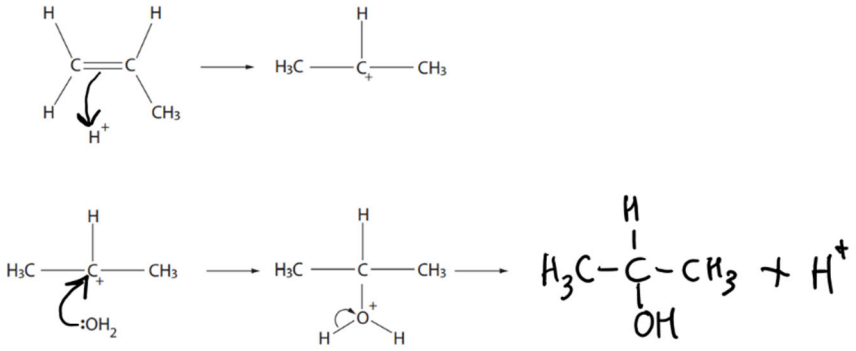
(Total for Question 19 = 10 marks)

Question Number	Answer	Additional guidance	Mark
20(a)	<ul style="list-style-type: none"> • balanced equation with 1 mol C₃H₆ and correct products (1) • state symbols (1) 	<p>Example of equation:</p> $\text{C}_3\text{H}_6(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{CO}(\text{g}) + \text{C}(\text{s}) + 3\text{H}_2\text{O}(\text{l})$ <p>Allow structural, displayed or skeletal formulae</p> <p>Allow H₂O(g) Do not award H₂O(aq)</p> <p>M2 dependent on correct species for the incomplete combustion of any C_nH_{2n} / C_nH_{2n+2} hydrocarbon forming CO₂(g), CO(g), C(s) and H₂O(l)/(g)</p> <p>If no other mark awarded, a correctly balanced equation, with correct state symbols, for the incomplete combustion of propene scores (1) eg C₃H₆(g) + 3O₂(g) → 3CO(g) + 3H₂O(l)/(g) eg 2C₃H₆(g) + 7O₂(g) → 2CO₂(g) + 4CO(g) + 6H₂O(l)/(g)</p>	2

Question Number	Answer	Additional guidance	Mark
20(b)	<ul style="list-style-type: none"> <li data-bbox="371 453 1012 485">• both solutions decolourise / turn colourless <li data-bbox="371 549 1012 715">• from purple with (potassium) manganate(VII)/$\text{KMnO}_4/\text{MnO}_4^-$ and from orange with (aqueous) bromine/Br_2 	<p data-bbox="1261 225 1957 411">Ignore any reference to breaking of the C=C bond / type of reaction Ignore any reference to layers / effervescence Ignore any reference to reaction products / formation of solids</p> <p data-bbox="1189 456 1709 496">(1) Ignore turn clear / change colour</p> <p data-bbox="1261 544 1856 616">Allow pink for purple or any combination of purple/pink</p> <p data-bbox="1189 663 1924 775">(1) Allow yellow or brown for orange or any combination of orange/yellow/brown Do not award any mention of red (eg red-brown)</p> <p data-bbox="1261 823 1856 1056">If neither M1 nor M2 awarded, either of the following scores (1): (potassium) manganate(VII)/$\text{KMnO}_4/\text{MnO}_4^-$ decolourises from purple/pink or bromine decolourises from orange/yellow/brown</p>	2

Question Number	Answer	Additional guidance	Mark
20(c)	<ul style="list-style-type: none"> poly(propene) structure containing two repeat units with extension bonds 	<p>Example of diagram:</p> $ \begin{array}{cccc} \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 \\ & & & \\ \text{---C} & \text{---C} & \text{---C} & \text{---C---} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ <p>Accept CH₃ groups on same or opposite sides</p> <p>Allow head-to-head and tail-to-tail configurations eg</p> $ \begin{array}{cccc} \text{CH}_3 & \text{H} & \text{H} & \text{CH}_3 \\ & & & \\ \text{---C} & \text{---C} & \text{---C} & \text{---C---} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ <p>Allow displayed, structural, skeletal formulae or any combination of these</p> <p>Ignore connectivity of vertical C-CH₃ bond</p> <p>Ignore brackets and 'n'</p>	1

Question Number	Answer	Additional guidance	Mark
20(d)(ii)	<p>A mechanism showing:</p> <ul style="list-style-type: none"> • curly arrow from C=C bond to ($\delta+$)halogen and curly arrow from Br–Cl bond to ($\delta-$)halogen or just beyond (1) • secondary carbocation (1) • curly arrow from lone pair on halide ion to C⁽⁺⁾ and correct product (1) 	<p>Example of mechanism:</p>  <p>Allow displayed, structural, skeletal formulae or any combination of these</p> <p>Penalise incorrect propene structure once only</p> <p>Penalise half-headed curly arrows once only</p> <p>Allow primary carbocation for mechanism involving ethene only</p> <p>Allow curly arrow from lone pair to positive charge</p> <p>Do not award $\delta-$ on halide ion</p>	3

Question Number	Answer	Additional guidance	Mark
20(e)	<p>A mechanism showing:</p> <ul style="list-style-type: none"> • curly arrow from C=C bond to H⁺ (1) • curly arrow from lone pair on water to C⁺ (1) • correct structure for propan-2-ol and H⁺ (catalyst regenerated) (1) 	<p>Example of correct mechanism:</p>  <p>Do not award any additional curly arrows from/to/on propene/H⁺</p> <p>Allow curly arrow from lone pair to positive charge Do not award any additional curly arrows shown in this step</p> <p>Allow any combination of displayed/structural/skeletal formulae Ignore atom connectivity except displayed C-H-O Ignore any additional curly arrows added to the central intermediate</p>	3

(Total for Question 20 = 12 marks)

Question Number	Answer	Additional guidance	Mark
21(a)	<p>Any two from the following:</p> <ul style="list-style-type: none"> • chemically stable / inert / does not (easily) oxidise (1) • colourless (1) • odourless (1) • non-toxic / non-irritant (1) • hydrophobic / immiscible with water (1) • hypoallergenic (1) 	<p>Ignore any reference to: carbon chain length intermolecular forces melting/boiling temperature flammability/volatility liquid/moisturising/softening/lubricating/hydrating spreads easily/absorbed easily natural/in human skin cheap</p> <p>Allow unreactive / not very reactive / long shelf life / durable / does not breakdown (easily) Ignore just stable</p> <p>Ignore transparent/clear</p> <p>Allow not harmful / non-hazardous / non-corrosive Ignore safe</p> <p>Allow insoluble Ignore oily</p>	2

Question Number	Answer	Additional guidance	Mark
21(b)	<ul style="list-style-type: none"> $C_{30}H_{62}$ 	Accept $H_{62}C_{30}$	1

Question Number	Answer	Additional guidance	Mark
21(c)(i)	<ul style="list-style-type: none"> nickel 	Accept palladium or platinum Allow correct symbol	1

Question Number	Answer	Additional guidance	Mark
21(c)(ii)	<ul style="list-style-type: none"> $0.00001 / (1 \times 10^{-5}) \text{ (g)}$ 	<p>Example of calculation:</p> $\text{mass} = \frac{50}{10^6} \times 0.2 = 0.00001 \text{ (g)}$ <p>Do not award incorrect unit</p> <p>Accept $10 \mu\text{g}$ / 0.01 mg</p> <p>Allow answer as fraction eg $\frac{1}{10^5}$ (g)</p> <p>Ignore SF Correct answer with no working scores (1)</p>	1

Question Number	Answer	Additional guidance	Mark
21(c)(iii)	<ul style="list-style-type: none"> • conversion of temperature to K • rearrangement of ideal gas equation • evaluation to give moles of hydrogen • evaluation of mole ratio <p>and</p> <p>number of C=C bonds per molecule of squalene</p>	<p>Example of calculation:</p> <p>(1) $T = 200 + 273 (= 473 \text{ K})$</p> <p>(1) $n = \frac{pV}{RT}$</p> <p>or</p> $n = \frac{4.0 \times 10^5 \times 500}{8.31 \times 473}$ <p>(1) $n(\text{H}_2) = 50882.429$ Ignore SF except 1 SF TE on temperature M3 dependent on correct use of ideal gas equation</p> $n(\text{H}_2) : n(\text{squalene})$ $50882 : 8500$ $6 : 1$ <p>(1) 6 (× C=C bonds per molecule) TE on $n(\text{H}_2)$ provided $n(\text{H}_2) >$ than 8500 and answer is rounded to nearest integer</p> <p>6 (× C=C bonds per molecule) with no working scores (1)</p> <p>2 (× C=C bonds per molecule) from use of $24 \text{ dm}^3 \text{ mol}^{-1}$ as molar gas volume scores (2)</p>	4

<p>21(c)(iii) cont</p>	<p>Alternative route to M2, M3 and M4</p> <ul style="list-style-type: none"> rearrangement of ideal gas equation (1) evaluation to give volume of squalene (1) evaluation of volume ratio <p>and</p> <p>number of C=C bonds per molecule of squalene (1)</p>	<p><u>Example of calculation:</u></p> $V = \frac{nRT}{p}$ <p>or</p> $V = \frac{8500 \times 8.31 \times 473}{4.0 \times 10^5}$ <p>$V(\text{squalene}) = 83.52589 \text{ (m}^3\text{)}$ Ignore SF except 1 SF TE on temperature M3 dependent on correct use of ideal gas equation</p> <p>$V(\text{H}_2) : V(\text{squalene})$ 500 : 83.52589 6 : 1</p> <p>6 (× C=C bonds per molecule) TE on $V(\text{squalene})$ provided $V(\text{squalene}) < 500 \text{ (m}^3\text{)}$ and answer is rounded to nearest integer</p>	
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Question Number	Answer	Additional guidance	Mark
21(c)(iv)	<ul style="list-style-type: none"> $C_{30}H_{50} + 6H_2 \rightarrow C_{30}H_{62}$ 	<p>Ignore state symbols</p> <p>TE on (c)(iii) for any C_nH_{2n+2} product formula where $24 \leq n \leq 30$</p> <p>If the number of C=C bonds is not stated in (c)(iii) then award (1) for an equation of the form: $C_nH_{2n-2y+2} + yH_2 \rightarrow C_nH_{2n+2}$ Where $24 \leq n \leq 30$ and $1 \leq y \leq 14$</p>	1

Question Number	Answer	Additional guidance	Mark
21(d)(i)	<ul style="list-style-type: none"> (fractional) distillation 	<p>Ignore solvent extraction</p> <p>Ignore filtration as part of the separation process</p> <p>Do not award just filtration</p> <p>Do not award chromatography</p>	1

Question Number	Answer	Additional guidance	Mark
21(d)(ii)	<ul style="list-style-type: none"> <li data-bbox="387 312 1111 432">• calculation of mass of squalene in 2.8 million dm³ or calculation of volume of squalene per shark (1) <li data-bbox="387 539 992 571">• calculation of number of sharks required (1) 	<p data-bbox="1223 225 1541 252">Example of calculation:</p> <p data-bbox="1223 300 1756 336">mass = $2.8 \times 10^9 \times 0.86 = 2.408 \times 10^9$ (g)</p> <p data-bbox="1223 347 1256 368">or</p> <p data-bbox="1223 384 1637 453">volume = $\frac{300}{0.86} = 348.8372$ (cm³)</p> <p data-bbox="1223 544 1921 612">$\frac{2.408 \times 10^9}{300} = 8.0267 \times 10^6 = 8026666.667 / 8.0 \times 10^6$</p> <p data-bbox="1223 624 1379 651">TE on mass</p> <p data-bbox="1223 667 1256 687">or</p> <p data-bbox="1223 703 1890 772">$\frac{2.8 \times 10^9}{348.8372} = 8.0267 \times 10^6 = 8026666.667 / 8.0 \times 10^6$</p> <p data-bbox="1223 783 1406 810">TE on volume</p> <p data-bbox="1223 863 1352 890">Ignore SF</p> <p data-bbox="1223 906 1738 933">Penalise incorrect rounding once only</p> <p data-bbox="1223 949 1794 976">Correct answer with no working scores (2)</p>	2

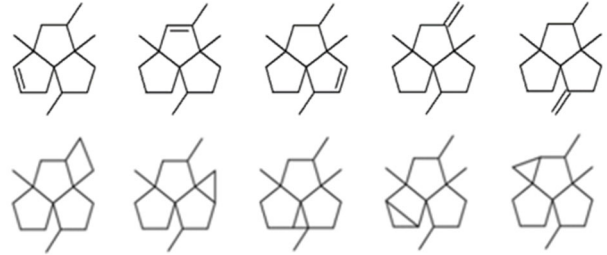
Question Number	Answer	Additional guidance	Mark
21(d)(iii)	<p>Method 1</p> <ul style="list-style-type: none"> • calculation of mass of corn starch required (1) • calculation of required land area in hectares (1) • conversion of land area from hectares to km² (1) <p>Method 2</p> <ul style="list-style-type: none"> • conversion of land area from hectares to km² (1) • calculation of required land area in km² to produce 2500 tonnes of corn starch (1) • calculation of required land area in km² to produce 2500 tonnes of squalene (1) 	<p>Ignore SF and do not penalise correct premature rounding</p> <p>Penalise incorrect rounding once only</p> <p>Penalise incorrect units in final answer only</p> <p>mass = $\frac{2500}{23} \times 100 = 10869.57$ (tonnes)</p> <p>Allow conversion of mass of corn starch to kg / g</p> <p>land area = $10869.57 \times 0.093 = 1010.87$ (hectares)</p> <p>land area = $1010.87 \times 0.01 = 10.1087 = 10$ (km²)</p> <p>$0.093 \times 0.01 = 0.00093 / 9.3 \times 10^{-4}$ (km²)</p> <p>land area = $0.00093 \times 2500 = 2.325$ km²</p> <p>Allow conversion of mass of corn starch to kg / g</p> <p>land area = $\frac{2.325}{23} \times 100 = 10.1087 = 10$ (km²)</p>	3

21(d)(iii) cont	Method 3 <ul style="list-style-type: none"> • calculation of required land area in hectares to produce 2500 tonnes of corn starch (1) • calculation of required land area in hectares to produce 2500 tonnes of squalene (1) • conversion of land area from hectares to km² (1) 	<p>land area = $2500 \times 0.093 = 232.5$ (hectares) Allow conversion of mass of corn starch to kg / g</p> <p>land area = $\frac{232.5}{23} \times 100 = 1010.87$ (hectares)</p> <p>land area = $1010.87 \times 0.01 = 10.1087 = 10$ (km²)</p> <p>If no other mark awarded, 1 tonne corn starch yields 230 kg squalane scores (1)</p>	
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Question Number	Answer	Additional guidance	Mark
21(e)(i)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li data-bbox="427 316 1263 347">• restricted rotation about/around C=C (1) <li data-bbox="427 635 1263 699">• (only) central C=C has two different groups attached to each carbon of the C=C (1) 	<p>Mark M1 and M2 independently</p> <p>Accept pi-bond for C=C Allow just double bond for C=C Allow limited/no rotation about/around C=C Allow C=C restricts rotation Allow C=C cannot rotate Ignore just restricted rotation Do not award molecule cannot rotate</p> <p>Accept C=C from 6th carbon/6-ene for central C=C Allow (only) central C=C has four different groups Allow indication of central C=C on diagram Do not award if any other C=C bond identified as <i>E/Z</i></p>	2

Question Number	Answer	Additional guidance	Mark
21(f)(i)	<ul style="list-style-type: none"> (compounds with the) same molecular formula (1) different structural formula (1) 	<p>Mark M1 and M2 independently</p> <p>Ignore just same formula Ignore compounds with the same atoms Do not award same molecule Do not award same general formula</p> <p>Allow just different structure Allow different position of the C=C/double bonds Allow different displayed/skeletal formulae Ignore different arrangement of atoms (in space)</p>	2

Question Number	Answer	Additional guidance	Mark
21(f)(ii)	<ul style="list-style-type: none"> four / 4 	Ignore <i>E/Z</i>	1

Question Number	Answer	Additional guidance	Mark
21(f)(iii)	<ul style="list-style-type: none"> valid structure containing one C=C bond <p>or</p> <ul style="list-style-type: none"> valid structure containing one bridging carbon-carbon bond 	<p>Examples of valid structure:</p>  <p>Ignore bond lengths and bond angles</p>	1

(Total for Question 21 = 24 marks)
TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

