Pearson Edexcel

Mark Scheme (Results)

Summer 2022

Pearson Edexcel International Advanced Subsidiary Level
In Chemistry (WCH11)
Paper 01: Structure, Bonding and Introduction to Organic Chemistry

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Summer 2022
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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.

Using the mark scheme

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit. ( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer. ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Section A (Multiple Choice)

Question number	Answer	Mark
1	**The only correct answer is D** (isolated atoms, atoms in molecules and atoms in giant structures) ***A*** *is not correct because elements also exist as isolated atoms and as molecules* ***B*** *is not correct because elements also exist as isolated atoms* ***C*** *is not correct because elements also exist as molecules*	**1**

Question number	Answer	Mark
2	**The only correct answer is C** (0.56 g) ***A*** *is not correct because the* A_r *has been halved instead of doubled to give the* M_r ***B*** *is not correct because the* A_r *has been used instead of the* M_r ***D*** *is not correct because the* A_r *has been doubled twice to give the* M_r	**1**

Question number	Answer	Mark
3	**The only correct answer is B** ($MgO(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(l)$) ***A*** *is not correct because the sulfate spectator ions have not been eliminated* ***C*** *is not correct because the magnesium oxide is involved in the change of state and the sulfate ion is not* ***D*** *is not correct because the magnesium oxide is involved in the change of state*	**1**

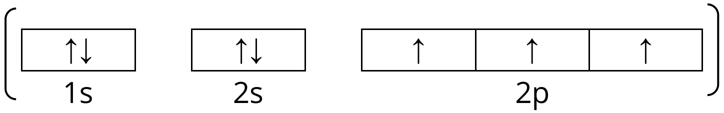
Question number	Answer	Mark
4	**The only correct answer is B** (0.684) ***A*** *is not correct because this is the number of moles of sodium chloride in 250* cm^3 ***C*** *is not correct because this is the mass of sodium chloride in 250* cm^3 ***D*** *is not correct because this is the concentration of sodium chloride in g* dm^{-3}	**1**

Question number	Answer	Mark
5	**The only correct answer is D** ($CrCl_3$) ***A*** *is not correct because this is the same as the ratio of silver ions to chloride ions* ***B*** *is not correct because this is based on the ratio of volume of silver nitrate added to precipitate height* ***C*** *is not correct because this is based on the ratio of precipitate height to volume of silver nitrate added*	**1**

Question number	Answer	Mark
6(a)	**The only correct answer is A** (20) ***B*** *is not correct because this is the number of electrons in a Sc atom* ***C*** *is not correct because this is the number of electrons in a* Sc^- *ion* ***D*** *is not correct because this is calculated by taking* $Z = 45 - 21$ *and then removing an electron.*	**1**

Question number	Answer	Mark
6(b)	**The only correct answer is A** (22.5) ***B*** *is not correct because this is 0.5 x (mass number + atomic number)* ***C*** *is not correct because this is the m/z value for an* Sc^{+} *ion* ***D*** *is not correct because this is mass number x2*	**1**

Question number	Answer	Mark
7	**The only correct answer is D** ($I(g) \rightarrow I^{+}(g) + e^{-}$) ***A*** *is not correct because the iodine is molecular and in the solid state and forms 2 mol of ions* ***B*** *is not correct because the iodine is molecular and forms 2 mol of ions* ***C*** *is not correct because the iodine is molecular and in the solid state*	**1**

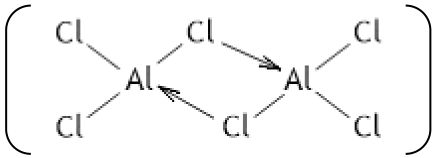
Question number	Answer	Mark
8	**The only correct answer is C**  ***A*** *is not correct because the paired 1s and 2s electrons have parallel spin* ***B*** *is not correct because the paired electrons have parallel spin and the 2p electrons do not have parallel spin* ***D*** *is not correct because the unpaired 2p electrons do not have parallel spin*	**1**

Question number	Answer	Mark
9	**The only correct answer is B** (8, 12, 5) ***A*** *is not correct because the 4s electrons have been placed in the 3d subshell* ***C*** *is not correct because the 4p subshell has been filled and 1 electron placed in 3d and 0 electron in 4s* ***D*** *is not correct because the 4p subshell has been occupied before the 3d*	**1**

Question number	Answer	Mark
10	**The only correct answer is D** (attractive forces between oppositely charged ions, repulsive forces between like charged ions and some covalent bonding forces) ***A*** *is not correct because the ions with the same charge will repel and there will be some covalency with* Li^+ *and* I^- ***B*** *is not correct because there will be some covalency with* Li^+ *and* I^- *ions* ***C*** *is not correct because the ions with the same charge will repel*	**1**

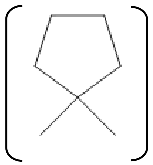
Question number	Answer	Mark
11(a)	**The only correct answer is C** (M and N only) ***A*** *is not correct because M is also a metal* ***B*** *is not correct because L cannot be a metal because it is a poor conductor in the solid state* ***D*** *is not correct because L cannot be a metal because it is a poor conductor in the solid state*	**1**

Question number	Answer	Mark
11(b)	**The only correct answer is D** (Q) ***A*** *is not correct because L conducts in the liquid state* ***B*** *is not correct because M conducts in the solid and liquid states* ***C*** *is not correct because P does not dissolve in water*	**1**

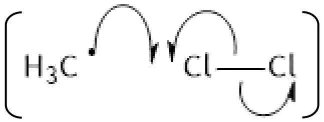
Question number	Answer	Mark
12	**The only correct answer is C**  ***A*** *is not correct because* Al_2Cl_6 *is not ionic* ***B*** *is not correct because the structure does not have a covalent bond between the aluminium atoms* ***D*** *is not correct because the aluminium atoms have no lone pairs to donate in a dative bond*	**1**

Question number	Answer	Mark
13	**The only correct answer is A** (the hazard is fixed but the risk varies) ***B*** *is not correct because the hazard is fixed and the risk varies* ***C*** *is not correct because the risk varies* ***D*** *is not correct because the hazard is fixed*	**1**

Question number	Answer	Mark
14	**The only correct answer is B** (ions only) ***A*** *is not correct because heterolytic fission only produces ions* ***C*** *is not correct because heterolytic fission only produces ions* ***D*** *is not correct because heterolytic fission only produces ions*	**1**

Question number	Answer	Mark
15	**The only correct answer is D**  ***A*** *is not correct because this compound has a molar mass of 100 g mol*$^{-1}$ ***B*** *is not correct because this compound has a molar mass of 114 g mol*$^{-1}$ ***C*** *is not correct because this compound would decolourise bromine water*	**1**

Question number	Answer	Mark
16	**The only correct answer is A** (ammonia) ***B*** *is not correct because oxides of nitrogen are emitted in the combustion of alkane fuels* ***C*** *is not correct because oxides of sulfur are emitted in the combustion of alkane fuels* ***D*** *is not correct because unburnt hydrocarbons are emitted in the combustion of alkane fuels*	**1**

Question number	Answer	Mark
17	**The only correct answer is B**  ***A*** *is not correct because two radicals reacting occurs in termination* ***C*** *is not correct because a methyl radical reacting with methane would re-form the reactants* ***D*** *is not correct because two molecules reacting together directly does not occur*	**1**

Question number	Answer	Mark
18	**The only correct answer is C** (*E*-2-chlorobut-2-ene) ***A*** *is not correct because cis-trans is not the IUPAC systematic name but is correct non-IUPAC name* ***B*** *is not correct because cis-trans is not the IUPAC systematic name and is an incorrect non-IUPAC name* ***D*** *is not correct because Cl is the priority group on the right-hand carbon and is on the opposite side of the double bond to the* CH_3 *on the left-hand carbon*	**1**

Total for Section A = 20 marks

Section B

Question number	Answer	Additional guidance	Mark
19(a)(i)	• calculation of mass of iron and use of A_r(Fe) (1) • evaluation of moles of iron (1)	Example of calculation: $\text{mol} = \frac{6.17 - 3.38}{55.8} = \frac{2.79}{55.8}$ mol iron = 5×10^{-2} / 0.05 (mol) Allow A_r of Fe = 56 when mol Fe =0.0498 Ignore SF Correct answer with some working scores 2 Use of incorrect mass for 1 mark TE e.g. 6.17g gives 0.11(057) 3.38g gives 0.06(0057) Dividing 2.79g by an incorrect A_r gets 1 mark	**2**

Question number	Answer	Additional guidance	Mark
19(a)(ii)	• expression for concentration and substitute values (1) • evaluation of moles of iron(III) chloride (1)	Example of calculation: $\text{concentration} = \frac{\text{mol}}{\text{vol in dm}^3}$ $0.500 = \frac{\text{mol}}{200/1000}$ mol = 0.500 × 200/1000 = 0.1 (mol) Correct answer with some working scores 2 Ignore SF	2

Question number	Answer	Additional guidance	Mark
19(a)(iii)	• calculation of whole number ratio (1) • ionic equation (1) • all three states correct (1)	Example of calculation: 0.1 mol Fe^{3+} (or $FeCl_3$) reacts with 0.05 mol Fe so 2 mol Fe^{3+} (or $FeCl_3$) reacts with 1 mol Fe (0.1 ÷ 0.05 or 1 : 0.5 is enough for M1, not 2:1 alone) TE on incorrect i & ii e.g. 1:1 $Fe(s) + 2Fe^{3+}(aq) \rightarrow 3Fe^{2+}(aq)$ Allow multiples Allow correct states on species in the reaction Allow correct states on compounds, Cl^- must be (aq) M2 and M3 standalone marks Comment: If no working shown max 2 marks	3

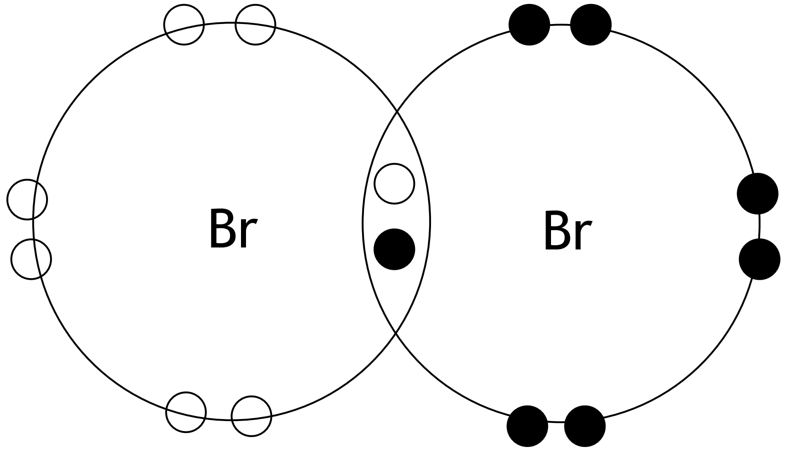
Question number	Answer	Additional guidance	Mark
19(b)	• calculation of relative formula mass of $FeCl_2.xH_2O$ (1) • calculation of relative formula mass of $FeCl_2$ (1) • calculation of moles of H_2O in crystals (1) • calculation of moles of H_2O per mole of $FeCl_2$ (1)	Example of calculation: RFM(1) = $\frac{55.8}{28.1} \times 100$ = 198.58 RFM(2) = 55.8 + 2 × 35.5 = 126.8 RFM(1) − RFM(2) = 71.777 71.777 / 18 = 3.988 = 4 so x = 4 M4 is only awarded for final answer of 4 Allow A_r of Fe = 56 Correct answer with some appropriate working scores 4 Ignore SF <u>Alternative:</u> M1 mol Fe (in 100g hydrated salt) = 28.1/55.8 = 0.50358 M2 mass of Cl (in 100g hydrated salt) = 0.50384 × 2 × 35.5 = 35.75(448)g M3 mass of H_2O (in 100g hydrated salt) = 100 – 28.1 – 35.75 = 36.15g moles H_2O = 36.15/18 = 2.008 M4 Ratio $FeCl_2$: H_2O = 0.5(0384):2(.008) = 1:4, so x = 4 (55.8)/(55.8 + 71 + 18x) = 0.281 is another valid way of getting to x = 4	**4**

(Total for Question 19 = 11 marks)

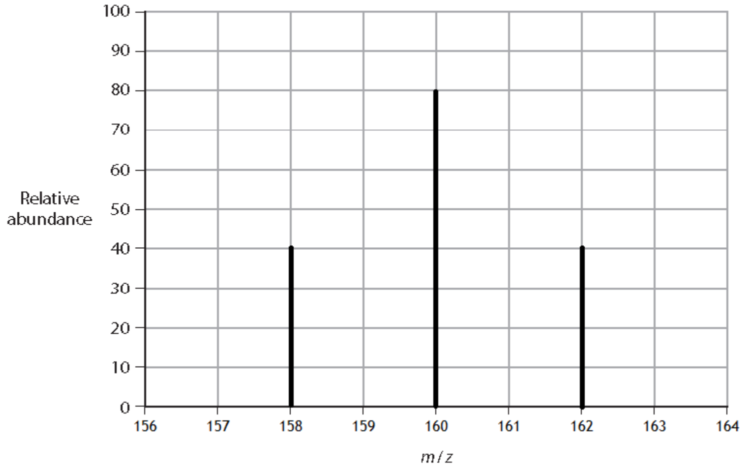
Question number	Answer	Additional guidance	Mark
20(a)	An answer that makes reference to • (atoms with the) same atomic number and different mass numbers	Accept proton number for atomic number or same number of protons but different numbers of neutrons Allow bromine-79 has 35 protons & 44 neutrons **and** bromine-81 has 35 protons & 46 neutrons Allow “an atom” or “element” Do not award molecule Ignore same number of electrons	**1**

Question number	Answer	Additional guidance	Mark
20(b)	An answer that makes reference to: • all subatomic particles correct for bromine-79 (1) • all subatomic particles correct for bromine-81 (1)	Protons / Neutrons / Electrons: 35 / 44 / 35 35 / 46 / 35 Any four correct scores 1	**2**

Protons	Neutrons	Electrons
35	44	35
35	46	35

Question number	Answer	Additional guidance	Mark
20(c)(i)	A diagram showing: • one shared pair of electrons (1) • six non-bonding electrons on **both** atoms in the molecule (1)	Example of diagram:  Accept shared electrons on circles between the atoms Accept omission of circles or chemical symbols Allow any symbols for the electrons or elements (even if incorrect) Allow non-bonding electrons to be unpaired Allow horizontal sharing of bond pair Ignore horizontal line representing the bond	**2**

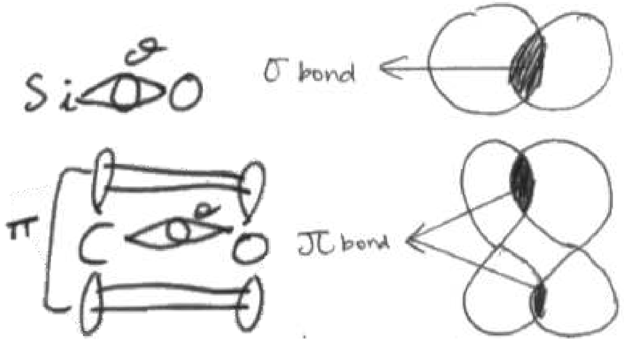
Question number	Answer	Additional guidance	Mark
20(c)(ii)	An answer that makes reference to: • (a beam of) high energy electrons striking the (gaseous) bromine (molecule) (1) • equation for the formation of the molecular ion (1)	Both marks may be scored with a correct equation and any indication the **bombarding** electrons are high energy Allow 'high speed electrons' Allow electron gun Allow "fast moving" Allow bromine atoms $Br_2 + e^{(-)} \rightarrow Br_2^{+} + 2e^{(-)}$ Allow $Br_2 \rightarrow Br_2^{+} + e^{(-)}$ $Br_2 - e^{(-)} \rightarrow Br_2^{+}$ Allow $^{81}Br^{81}Br$ (etc) instead of Br_2 on either side of the equation Ignore state symbols even if incorrect Do not award $Br_2 \rightarrow 2Br^{+} + 2e^{(-)}$ or $\frac{1}{2}Br_2 \rightarrow Br^{+} + e^{(-)}$	**2**

Question number	Answer	Additional guidance	Mark
20(c)(iii)	An answer on the grid showing: • three peaks: at m/z = 158, m/z = 160 and m/z = 162 (1) • peak heights in the ratio 1:2:1 (for 158: 160: 162) (1)	Example of grid:  Allow bars or "X" at the top of any lines Allow bars shown around the m/z values Do not award if a line is drawn from peak to peak Do not award if more than three peaks Allow any abundance values No TE on incorrect m/z values	**2**

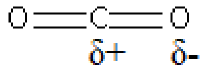
Question number	Answer	Additional guidance	Mark
20(d)	• weighted mean mass expression (1) • evaluation of relative atomic mass for Br (1) • calculation of relative molecular mass for Br_2 corrected to 2 d.p. (1)	Example of calculation: $A_r = \frac{79 \times 56.38 + 81 \times 43.62}{100}$ = 79.87 2 x 79.87 = 159.74 = 159.74 Allow TE to M2 for values between 79 and 81 Allow TE for M3 of double M2 value Ignore units even if incorrect Penalise rounding errors once only Correct answer to 2 d.p. scores (3) A **final** answer of 79.9 or 79.872 only scores 1 mark	**3**

(Total for Question 20 = 12 marks)

Question number	Answer	Additional guidance	Mark
21(a)(i)	An answer that makes reference to the following points: • the (strong electrostatic) **attraction** between the **shared** pair of **electrons** of the covalent bond (1) • and the nuclei (of the silicon atom and the oxygen atom) (1)	Allow attraction between 2 shared electrons Ignore plurals Ignore bonding pair of electrons Allow “silicone” in place of silicon Allow references to protons instead of nuclei Do not award M2 for carbon atoms Ignore numbers of bonds Ignore references to giant/simple, double bonds, polar bonds, sigma bonds or orbital overlap Both marks may be scored by a clearly labelled diagram	**2**

Question number	Answer	Additional guidance	Mark
21(a)(ii)	An answer that makes reference to the following points: Similarities: • both molecules contain a σ-bond (1) • description of end-on overlap (1) Difference: • carbon dioxide (also) contains sideways overlap of orbitals / π–bond (with the oxygen atom) (1)	All marks may be scored by clearly labelled diagrams e.g.  Allow any indication that the σ overlap is between the atoms and the π overlap is above and below the plane of the atoms e.g. “end-on”, “horizontal”, “head on” for axial “sideways” or “parallel” for lateral	**3**

Question number	Answer	Additional guidance	Mark
21(b)(i)	An explanation that makes reference to the following points: • there are two sets of bonding electrons (and no lone pairs) about the carbon atom (1) • which arrange to minimise repulsion (1) • resulting in a linear shape / bond angle of 180° (1)	Any indication of two regions of electrons (this includes a correct diagram) e.g. O=C=O Allow two double bonds Do not award MP1 for just "two bonding pairs" or just "4 bonding pairs" Allow maximum separation / to be as far apart as possible Do not award repulsion between atoms Accept bond angle labelled on a diagram Do not award linear with any angle other than 180° Ignore references to symmetry Ignore references to lone pairs on oxygen All marks are independent No TE for any mark	**3**

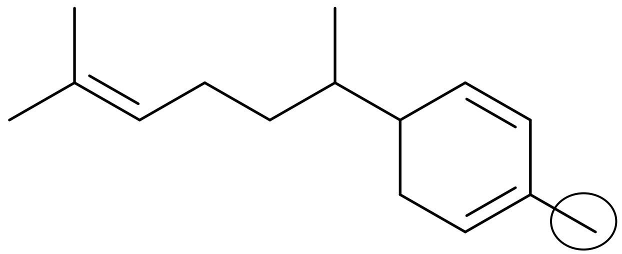
Question number	Answer	Additional guidance	Mark
21(b)(ii)	An explanation that makes reference to the following points: • the carbon atom is slightly positive / δ+ **and** the oxygen atom slightly negative / δ− (1) • because oxygen is more electronegative than carbon (1)	Accept shown on a diagram e.g.  Allow single C—O bond with dipole Allow use of dipole symbol  Do not award full charges Accept reverse argument Ignore “they have different electronegativities”	**2**

Question number	Answer	Additional guidance	Mark
21(b)(iii)	An answer that makes reference to the following point: • the carbon dioxide molecule is not polar **and** because (it is a linear molecule) the dipoles cancel	(No TE on (b)(i)) Allow the polar bonds cancel Allow dipoles balance Allow symmetrical molecule Do not award “the charges cancel”	**1**

Question number	Answer	Additional guidance	Mark
21(c)(i)	An answer that makes reference to the following: • each silicon atom has four silicon atoms in a **tetrahedral** arrangement as nearest silicon atom neighbours or each silicon is bonded to four oxygen atoms in a **tetrahedral** arrangement or each carbon is bonded to 4 carbon atoms in a **tetrahedral** arrangement (in diamond)	Allow "giant tetrahedral structure(s)" Do not award each silicon is tetrahedrally bonded to four other silicon atoms Ignore just "the silicon atoms are in a diamond structure" Do not award (simple) molecule(s) anywhere in the response	**1**

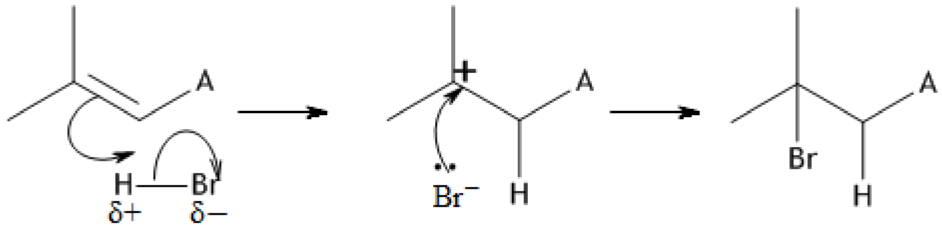
Question number	Answer	Additional guidance	Mark
21(c)(ii)	An answer that makes reference to the following point: • There are fewer bonds (per atom) in the structure of silicon dioxide	Allow reverse argument Allow oxygen only forms two bonds Allow bond strength is an average Allow oxygen has lone pairs of electrons Ignore silicon-oxygen bond is polar Ignore references to sizes of atoms Do not award reference to intermolecular forces	**1**

(Total for Question 21 = 13 marks)

Question number	Answer	Additional guidance	Mark
22(a)	An answer that shows the following: • any indication of the methyl group on the right-hand side of the structure being selected	Example of diagram:  Allow inclusion of the "2" carbon within the circle Do not award more than one group circled or selected	**1**

Question number	Answer	Additional guidance	Mark
22(b)	An answer that makes reference to the following: • C_{15} (1) • H_{24} (1)	Allow $H_{24}C_{15}$ / C15H24 No TE on incorrect number of carbon atoms	**2**

Question number	Answer	Additional guidance	Mark
22(c)(i)	An answer that makes reference to the following: • electrophilic addition	Ignore 'heterolytic' Do not award 'free radical' Do not award substitution	**1**

Question number	Answer	Additional guidance	Mark
22(c)(ii)	An answer that makes reference to the following: • curly arrow from H—Br bond to Br atom or just beyond **and** dipole on H−Br (1) • curly arrow from C=C to H or close by (1) • structure of tertiary carbocation intermediate (1) • curly arrow from **lone pair** on Br^- to positively charged carbon atom (1)	Example of mechanism shown below  Addition of Br−Br loses M1 only Allow secondary carbocation (should be based on structure from paper) Do not award $Br^{\delta-}$ Do not penalise an incorrect product Allow structural formulae etc. Ignore omission of added hydrogen Ignore omission of A or substitution of A at any stage Ignore connectivity of CH_3 groups Ignore other lone pairs	**4**

Question number	Answer	Additional guidance	Mark
22(c)(iii)	An explanation that makes reference to the following points: • I is formed via a tertiary carbocation **and** II is formed via a secondary carbocation (1) • tertiary (carbocations) are more stable (than secondary) (1)	Assume "it" is I Must have carbocation at least once for M1 "It is a tertiary carbocation" does not score M1 Allow secondary are more stable than primary for M2 Allow tertiary is the most stable Allow reverse argument Marks are independent Ignore "tertiary cations have more alkyl groups' Allow "I is formed via a more stable intermediate" for M2 only	**2**

Question number	Answer	Additional guidance	Mark
22(d)(i)	An answer that makes reference to the following: • nickel / Ni	Accept platinum / Pt / palladium / Pd	**1**

Question number	Answer	Additional guidance	Mark
22(d)(ii)	• rearrangement of ideal gas equation to make volume the subject (1) • changing kPa to Pa **and** °C to K (1) • substitution of values into IGE (including 2 x 3 mol of H_2) (1) • calculation of volume of hydrogen with units (1)	Example of calculation $V = n \times R \times T \div p$ $p = 120 \times 1000 = 1.2 \times 10^5$ (Pa) **and** $T = 150 + 273 = 423$ (K) $V = 6 \times 8.31 \times 423 \div 1.2 \times 10^5 =$ = 0.17576 m^3 Accept 175.76 dm^3 / 175760 cm^3 TE at each stage Ignore SF except 1 SF Correct answer **and** units with some working scores (4) Penalise incorrect rounding once only	**4**

(Total for Question 22 = 15 marks)

Question number	Answer	Additional guidance	Mark
23(a)(i)	An answer that makes reference to one of the following: • biodegradation / putrefaction / decomposition • fermentation • anaerobic respiration	Ignore decay Allow any indication of a biological process e.g. 'bacterial action' Do not award "**thermal** decomposition"	**1**

Question number	Answer	Additional guidance	Mark
23(a)(ii)	An answer that makes reference to the following points: • climate change / global temperature (1) • methane / CH_4 **and** carbon dioxide / CO_2 (1)	Allow global warming Ignore greenhouse effect / increase in temperature Do not award ozone depletion / acid rain Do not award ammonia/NO_x/SO_x/H_2S	**2**

Question number	Answer	Additional guidance	Mark
23(a)(iii)	• calculation of annual volume of carbon dioxide (1) • calculation of moles of carbon dioxide (1) • calculation of mass of carbon dioxide (1)	Example of calculation = (45 ÷ 100) × 365 × 90000 × 12.5 = = 1.8478×10^8 (dm^3) = $1.8478 \times 10^8 \div 24(.0) = 7.6992 \times 10^6$ (mol) = $7.6992 \times 10^6 \times 44 = 3.3877 \times 10^8$ (g) / 3.3877×10^2 tonnes / 338.77 tonnes Answers not in grams must have units for M3 TE at each stage Allow 365.25 / 366 days Ignore SF except 1 SF Correct answer with some working scores (3)	3

Question number	Answer	Additional guidance	Mark
23(b)	An answer that makes reference to any **two** of the following points: • decreases quantity of waste / less space is needed (1) • can be used (more easily) to generate electricity / produce heat (energy) (1) • pollutants can be trapped more easily (1) • transport costs lower (because sites can be sited near urban centres) (1) • prevents release of **methane** into the atmosphere (1) • high temperatures eliminate harmful bacteria / fungi (1) • residue can be used in construction products (1) • can deal with polymers/plastics/wastes that do not biodegrade (1) • reduced risk of water / soil pollution (by leaching) (1)	Allow less land needed Allow no land needed **for waste** Ignore no waste products Do not award generate energy Allow is a source of power Do not award incineration is less polluting / produces less CO_2 without referring to capture Allow residue can be used as fertiliser Ignore "reduces pollution" Ignore cost, appearance, time and contaminants	2

Question number	Answer	Additional guidance	Mark
23(c)	An answer that makes reference to **one** of the following points: • resources conserved (by recycling) (1) • less energy is used (in recycling) (1)	Allow reverse arguments Allow produces **less** toxic or greenhouse gases Do not award answers relating to cost Ignore renewable / sustainable	1

(Total for Question 23 = 9 marks)

Total for Section B = 60 marks

Total for paper = 80 marks

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