Pearson
Edexcel

Mark Scheme (Results)

January 2019

Pearson Edexcel International
Advanced Subsidiary Level
In Chemistry (WCH01)
Paper 01 Core Principles in 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.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

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.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	**The only correct answer is B** ***A*** *is not correct because it is based on 1 m^3 = 10^9 cm^3* ***C*** *is not correct because it is based on 1 m^3 = 10^3 cm^3* ***D*** *is not correct because 0.0209 has just been multiplied by 10^6*	1

Question Number	Correct Answer	Mark
2	**The only correct answer is A** ***B*** *is not correct because the mass in g has been divided by the atomic number of Na* ***C*** *is not correct because the mass in mg has been divided by the molar mass of Na* ***D*** *is not correct because the mass in mg has been divided by the atomic number of Na*	1

Question Number	Correct Answer	Mark
3	**The only correct answer is C** ***A*** *is not correct because displacement is a term sometimes used for a redox reaction and this is not redox* ***B*** *is not correct because the reaction produces hydrochloric acid so no neutralisation occurs* ***D*** *is not correct because this reaction is not redox*	1

Question Number	Correct Answer	Mark
4	**The only correct answer is B** ***A*** *is not correct because it does not take into account that there are four atoms in a molecule of ammonia* ***C*** *is not correct because it uses the formula* NH_4 *for ammonia and hence five atoms per molecule.* ***D*** *is not correct because molar volume =* $24\ dm^3$ *has been used*	1

Question Number	Correct Answer	Mark
5	**The only correct answer is C** ***A*** *is not correct because the moles of silver chloride have been halved not doubled* ***B*** *is not correct because the moles of silver chloride have not been doubled* ***D*** *is not correct because the moles of silver chloride have been doubled twice*	1

Question Number	Correct Answer	Mark
6	**The only correct answer is C** ***A*** *is not correct because the mass of silver has not been doubled* ***B*** *is not correct because this is the mass of copper doubled* ***D*** *is not correct because the amount of Ag has been doubled twice*	1

Question Number	Correct Answer	Mark
7	**The only correct answer is C** ***A*** *is not correct because this is the percentage of phosphorus atoms in the molecule* ***B*** *is not correct because this has been calculated using atomic numbers rather than molar masses* ***D*** *is not correct because this is the percentage by mass of oxygen in the compound*	1

Question Number	Correct Answer	Mark
8	**The only correct answer is D** ***A*** *is not correct because the number of moles of hydrogen formed has been taken as 1 rather than 3* ***B*** *is not correct because the amount of aluminium has been multiplied by 2/3 rather than 3/2* ***C*** *is not correct because a 1:1 reacting ratio has been used*	1

Question Number	Correct Answer	Mark
9	**The only correct answer is D** ***A*** *is not correct because the volume of CO_2 has not been doubled and the excess oxygen has been omitted* ***B*** *is not correct because the excess oxygen has been omitted* ***C*** *is not correct because the volume of CO_2 has not been doubled*	1

Question Number	Correct Answer	Mark
10	**The only correct answer is B** ***A*** *is not correct because this is the difference between the maximum measured temperature and the starting temperature* ***C*** *is not correct because this is the maximum measured temperature* ***D*** *is not correct because this is the extrapolated temperature at 3½ min not the temperature difference*	1

Question Number	Correct Answer	Mark
11	**The only correct answer is B** ***A*** *is not correct because* $\Delta H^{\ominus}$ *has been calculated for the reverse reaction* ***C*** *is not correct because* $\Delta H^{\ominus}$ *has been calculated for the reverse reaction and using only 1 mol of carbon* ***D*** *is not correct because* $\Delta H^{\ominus}$ *has been calculated using only 1 mol of carbon*	1

Question Number	Correct Answer	Mark
12	**The only correct answer is A** ***B*** *is not correct because atomisation is always endothermic* ***C*** *is not correct because melting is always endothermic* ***D*** *is not correct because ionisation is always endothermic*	1

Question Number	Correct Answer	Mark
13	**The only correct answer is A** ***B*** *is not correct because the units of* ΔH *are* $kJ\ mol^{-1}$ ***C*** *is not correct because the units of* ΔH *are* $kJ\ mol^{-1}$ ***D*** *is not correct because the units of* ΔH *are* $kJ\ mol^{-1}$	1

Question Number	Correct Answer	Mark
14	**The only correct answer is D** ***A*** *is not correct because all three species have the electronic structure* $1s^2\ 2s^2\ 2p^6$ ***B*** *is not correct because all three species have the electronic structure* $1s^2\ 2s^2\ 2p^6$ ***C*** *is not correct because all three species have the electronic structure* $1s^2\ 2s^2\ 2p^6$	1

Question Number	Correct Answer	Mark
15	**The only correct answer is D** ***A*** *is not correct because alkali metals have the lowest ionisation energy in each period* ***B*** *is not correct because alkaline earth metals never have the highest ionisation energy in a period* ***C*** *is not correct because halogens always have a lower ionisation energy than the noble gas in the same period.*	1

Question Number	Correct Answer	Mark
16	**The only correct answer is B** ***A*** *is not correct because electrons repel electrons, nuclei repel nuclei and nuclei attract electrons* ***C*** *is not correct because electrons repel electrons* ***D*** *is not correct because nuclei repel nuclei*	1

Question Number	Correct Answer	Mark
17	**The only correct answer is C** ***A*** *is not correct because the longest carbon chain has four carbon atoms so it is a butane* ***B*** *is not correct because the longest carbon chain has four carbon atoms so it is a butane. (Also the numbering of the methyl groups would be incorrect.)* ***D*** *is not correct because there is not an extra carbon atom between the chlorine and the carbon chain*	1

Question Number	Correct Answer	Mark
18	**The only correct answer is C** ***A*** *is not correct because methane is a greenhouse gas* ***B*** *is not correct because methane is a fossil fuel* ***D*** *is not correct because while true, this is also the case for other fossil fuels*	1

Question Number	Correct Answer	Mark
19	**The only correct answer is D** ***A*** *is not correct because this is the number of carbon-carbon single bonds.* ***B*** *is not correct because this is the number of carbon-carbon bonds.* ***C*** *is not correct because this omits the carbon-carbon σ bond in the double bond*	1

Question Number	Correct Answer	Mark
20	**The only correct answer is D** ***A, B*** *and* ***C*** *are not correct because the double bond is oxidised and therefore the OH groups bond to C2 and C3*	1

Section B

Question Number	Acceptable Answer	Reject	Mark
21(a)(i)	The (gaseous) atom is struck by a **high energy** electron (removing an electron and forming a positive ion) ALLOW Nickel / vapour is bombarded / struck by **high energy** / **high speed** electron(s) (1) IGNORE Just 'electron gun /beam' $Ni + e^{-} \rightarrow Ni^{+} + 2e^{-}$ ALLOW Any symbol in place of Ni (1) IGNORE State symbols even if incorrect	molecule $Ni \rightarrow Ni^{+} + e^{-}$	2

Question Number	Acceptable Answer	Reject	Mark
21(a)(ii)	**S**: Acceleration **and** by an electric field ALLOW Focusing / collimating the ion stream **and** by a series of slits (1) IGNORE Charged plates Reference to velocity of ions **T**: Deflection **and** by a magnetic field ALLOW magnet / electromagnet (1) If no other mark is scored acceleration **and** deflection score (1) OR electric field and magnetic field / magnet / electromagnet score (1) IGNORE use of incorrect or general symbols for the ion	Electron /electronic field Electric charge Potential difference	2

Question Number	Acceptable Answer	Reject	Mark
21(a)(iii)	Neutral atoms / molecules are not affected by electric and magnetic fields OR Only charged particles are affected by electric and magnetic fields ALLOW So that it can be accelerated / deflected OR So that it is affected by the electric / magnetic field Only ions register on the detector OR A neutral particle would not register on the detector		1

Question Number	Acceptable Answer	Reject	Mark
21(b)(i)	**MP1** (Expression for A_r) $\frac{58 \text{ x } 100 \ + \ 60 \text{ x } 39.8}{100 + 39.8} = A_r$ (1) **MP2** (evaluation to 1 dp) = 58.569 = 58.6 TE on $\frac{58 \text{ x } 60.2 \ + \ 60 \text{ x } 39.8}{100} = A_r$ = 58.8 (1) Correct answer to 1 dp with no working scores (2) IGNORE Units	58.7 81.9	2

Question Number	Acceptable Answer	Reject	Mark
21(b)(ii)	The mass numbers do not need to be linked to the percentages but if they are used they must be correct **Algebraic method** $^{58}Ni + {}^{60}Ni = 100$ $^{60}Ni/^{58}Ni = 39.8/100 = 0.398$ (1) $^{60}Ni = 0.398 \times {}^{58}Ni$ $1.398\ {}^{58}Ni = 100;\ {}^{58}Ni = 71.53$ $^{58}Ni = 71.53(\%)$ $^{60}Ni = 28.47(\%)$ (1) **Simple method** 139.8 is 100% So $39.8\ is\ \frac{39.8 \times 100}{139.8} = 28.47\%$ (1) $^{58}Ni = 71.53(\%)$ $^{60}Ni = 28.47(\%)$ (1) Correct answers with no working scores(2) ALLOW Just the correct percentages without identifying the isotopes IGNORE SF except 1 SF Use of A_r (instead of peak heights) $$A_r = \left\lfloor \frac{58x + 60(100 - x)}{100} \right\rfloor$$ e.g. A_r = 58.5694 gives 71.53 & 28.47 (2) = 58.569 gives 71.55 & 28.45 (2) = 58.6 gives 70 & 30 (1) = 58.8 gives 60 & 40 (1)		2

Question Number	Acceptable Answer	Reject	Mark
21(b)(iii)	$^{58}Ni^{2+}$ (1) $^{(58)}Ni^{+} + e(^{-}) \rightarrow {}^{(58)}Ni^{2+} + 2e(^{-})$ ALLOW $^{(58)}Ni^{+} \rightarrow {}^{(58)}Ni^{2+} + e(^{-})$ OR $^{(58)}Ni \rightarrow {}^{(58)}Ni^{2+} + 2e(^{-})$ OR $^{(58)}Ni^{+} - e(^{-}) \rightarrow {}^{(58)}Ni^{2+}$ OR $^{(58)}Ni - 2e(^{-}) \rightarrow {}^{(58)}Ni^{2+}$ (1) Any of these equations **including** the mass number on the RHS scores (2) IGNORE state symbols even if incorrect		2

Question Number	Acceptable Answer	Reject	Mark
21(c)	In sport to detect the (illegal) use of drugs To measure blood alcohol levels In the pharmaceutical industry to EITHER establish whether a desired compound has been formed OR Test the purity of a sample ALLOW Any valid application of the **identification** of chemical compounds IGNORE Just 'to identify chemical compounds' Generalisations e.g. 'space research' Drug testing	measurement of isotope concentrations radio isotope dating pharmacists	1

(Total for Question 21 = 12 marks)

Question Number	Acceptable Answer	Reject	Mark
22(a)	This is (the enthalpy / heat / energy change / produced / released) when 1 mol of a substance is burned / combusted ALLOW 'compound / reactant / element' for 'substance' (1) completely / in **excess** oxygen **and** under standard conditions OR 1 atm / 1.0 x 10^5 Pa and a stated temperature / 298 K / 25°C ALLOW 'air' for 'oxygen' (1) IGNORE r.t.p / s.t.p.	Required atom	2

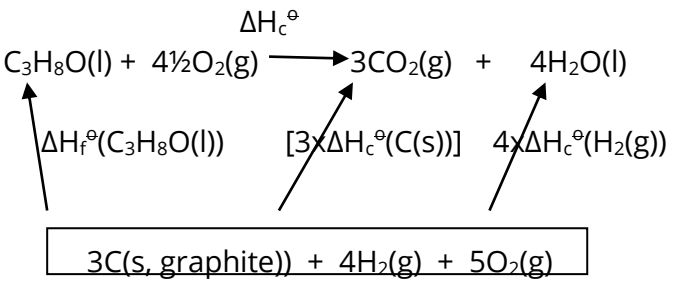
Question Number	Acceptable Answer	Reject	Mark
22(b)(i)	ΔE = 250 x 4.18 x 9.5 = 9927.5 (J) / 9.9275 **kJ** ALLOW ΔE = 250 x 4.2 x 9.5 = 9975 (J) / 9.975 **kJ** IGNORE SF except 1 SF IGNORE signs	J mol^{-1} / kJ mol^{-1}	1

Question Number	Acceptable Answer	Reject	Mark
22(b)(ii)	ALLOW Any value for Δ*E* Molar mass of ethanol = 46 (1) Amount of ethanol = 0.55/46 = 0.011957 mol (1) $\text{Enthalpy of combustion} = -\frac{9927.5}{0.011957}$ = −830300 J mol^{-1} / −830.3 kJ mol^{-1} (1) IGNORE SF except 1 SF Correct answer including sign & units without working scores (3) (+)830300 / (+)830.3 scores (2) **COMMENT** Do not penalise premature correct rounding (e.g. 0.012 for 0.011957 which gives −827 kJ mol^{-1}) Here and throughout the paper allow kJ mol^{-} for kJ mol^{-1}		3

Question Number	Acceptable Answer	Reject	Mark
22(c)(i)	$\text{Percentage error} = \frac{100 \text{ x } (1367 - 840)}{1367}$ = 38.552 (%) IGNORE SF except 1 SF		1

Question Number	Acceptable Answer	Reject	Mark
***22(c)(ii)**	Uncertainties in measurement result in random variations above and below the expected value ALLOW Just 'uncertainties are random' (1) (Almost) all the values obtained by the students must have been below the Data Book value indicating a systematic error ALLOW Just 'the error is systematic' (1) If no other mark is scored 'Uncertainties are too small to account for the difference' scores (1)		2

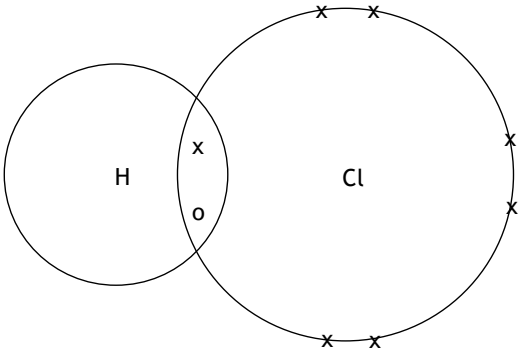
Question Number	Acceptable Answer	Reject	Mark
***22(c)(iii)**	Any of these pairs Heat loss (to the surroundings) (from any part of the apparatus) (1) This energy does not heat up the water (1) OR Incomplete combustion (of ethanol) (1) The ethanol produces less energy (1) OR Evaporation of ethanol (1) The ethanol (apparently) produces less energy (per g) (1) OR The calculation does not take into account heating of the container / apparatus (1) This energy does not heat up the water (1) IGNORE So the measured energy / temperature change is too low Explanations of cause, eg, 'no insulation', 'lack of stirring'		2

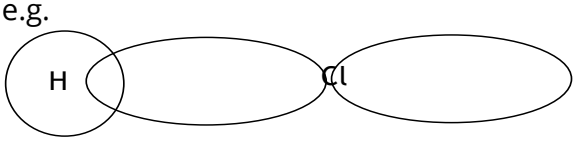
Question Number	Acceptable Answer	Reject	Mark
22(d)(i)	 All three substances in box ALLOW C(s) (1) All three states **and** coefficients in box (1) Enthalpy changes with arrows (species & states **not** required but if given must be correct) ALLOW ΔH_f^{o} ($H_2O(l)$) for $\Delta H_c^{o}(H_2(g))$ (1) IGNORE $\Delta H^{\ominus}$ coefficients even if incorrect omission of second arrow on RHS	Omission of standard symbol	3

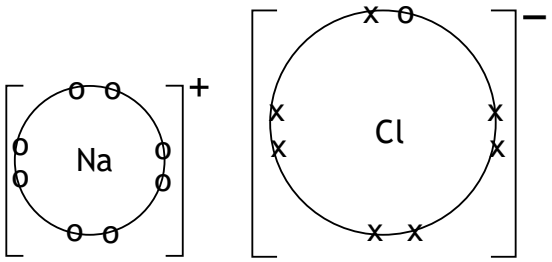
Question Number	Acceptable Answer	Reject	Mark
22(d)(ii)	$\Delta H_f^{\ominus}(C_3H_8O(l))$ $= 3x\Delta H_c^{\ominus}(C(s)) + 4x\Delta H_c^{\ominus}(H_2(g)) - \Delta H_c^{o}(C_3H_8O(l))$ $= 3x{-}394 + 4x{-}286 - (-2021)$ (1) $= -305$ (kJ mol^{-1}) (1) (+)305 scores (1) Omission of coefficient (3x and 4x) gives (+)1341 scores (1) IGNORE SF except 1 SF Correct answer with no working scores (2) COMMENT Omission of any one term from the calculation scores (0)	Incorrect units	2

(Total for Question 22 = 16 marks)

Question Number	Acceptable Answer	Reject	Mark
23(a)(i)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$ OR $1s^2\ \ 2s^2\ 2p_x^2\ 2p_y^2\ 2p_z^2\ \ 3p_x^2\ 3p_y^2\ 3p_z^1$ ALLOW 1s2 2s2 2p6 3s2 3p5	$[Ne]\ 3s^2\ 3p^5$	1

Question Number	Acceptable Answer	Reject	Mark
23(a)(ii)	 ALLOW Any symbols for electrons Bond pair side by side Omission of circles Inclusion of a horizontal line for the bond Non-bonding electrons unpaired IGNORE Inner shell electrons even if incorrect		1

Question Number	Acceptable Answer	Reject	Mark
23(a)(iii)	Any three from four: **MP1** The (half-filled) 1s orbital of hydrogen (1) **MP2** and a (half-filled) 3p orbital of chlorine (1) In **MP1** and **MP2** penalise the omission of principal quantum number (1/3) once only Penalise the use of subshell for orbital once only **MP3** overlap of the orbitals along the axis between the atoms ALLOW Head-on overlap OR Bond formed is a σ bond OR A diagram e.g.  ALLOW Diagram with one 3p lobe (1) **MP4** Producing a region of high electron density (between the two nuclei) (1)		3

Question Number	Acceptable Answer	Reject	Mark
23(b)(i)	 ALLOW Any symbols for electrons Na^+ with no electrons Brackets omitted Any relative size for ions IGNORE Inner shell electrons even if incorrect		1

Question Number	Correct Answer	Reject	Mark
***23(b)(ii)**	Sodium chloride is (almost) 100% ionic (1) Silver chloride is partly / significantly covalent (1) EXPLANATION 1 silver ion / Ag^+ is polarising ALLOW has a high(er) charge density OR chloride ion / Cl^- is polarised / distorted (by Ag^+) IGNORE Just 'polarisation occurs' OR there is orbital overlap between silver and chloride ions EXPLANATION 2 large electronegativity difference between Na and Cl **and** small(er) electronegativity difference between Ag and Cl (1) ALLOW Reverse arguments IGNORE Reference to radius of Ag^+	silver / Ag polarising silver ion has a high(er) charge Ag^{2+} / Ag^{3+} Chlorine / Cl polarised Reference to electronegativity differences between **ions**	3

(Total for Question 23 = 9 marks)

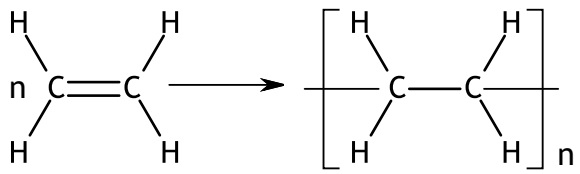
Question Number	Acceptable Answer	Reject	Mark
24(a)	**A** is fractional distillation or fractionation (1) IGNORE Just 'distillation' **B** is cracking OR catalytic cracking OR thermal cracking (1) **C** is reforming OR reformation OR catalytic reforming OR catalytic reformation (1) **D** is polymerisation OR addition polymerisation OR Polymerising (1)	forming / formation/ deforming / dehydrogenation/ elimination	4

Question Number	Acceptable Answer	Reject	Mark
24(b)	The compounds evaporate / boil **and** condense OR evaporation / boiling and condensation ALLOW Liquefy for condensation (1) The separation/process depends on (differences in) boiling temperature / boiling point / boiling temperature range OR All the compounds in the naphtha fraction boil at similar temperatures / over a narrow range of temperature (1)	melting temperature / melting point density	2

Question Number	Acceptable Answer	Reject	Mark
24(c)	$C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$ OR Displayed / skeletal / structural formulae or any combination LHS (1) RHS (1) Correct equations with an alkane reactant with more than 10 carbons but forming octane **and** more than one molecule of ethene score (1) e.g. $C_{12}H_{26} \rightarrow C_8H_{18} + 2C_2H_4$ Balanced correct equations with an alkane reactant with more than 10 carbons **and** a product other than octane score (0) e.g. $C_{12}H_{26} \rightarrow C_{10}H_{22} + C_2H_4$ IGNORE State symbols even if incorrect		2

Question Number	Acceptable Answer	Reject	Mark
24(d)(i)	$C_8H_{18} \rightarrow C_8H_{16} + H_2$ OR Displayed / skeletal / structural formulae or any combination IGNORE State symbols even if incorrect		1

Question Number	Acceptable Answer	Reject	Mark
24(d)(ii)	(because) it has a high(er) octane rating / number (than octane) OR to increase the octane rating / number (of petrol) ALLOW RON (Research Octane Number) for octane number (1) (this gives) smoother / more efficient combustion (of the petrol) OR reduces engine knocking OR prevents pre-ignition (1) IGNORE So petrol burns more easily / faster prevents auto-ignition Any reference to energy produced		2

Question Number	Acceptable Answer	Reject	Mark
24(e)	 Repeat unit of poly(ethene), ie, brackets and n omitted (1) Everything else (1)	Repeat unit with C>2 suffix 'n' on LHS of equation	2

(Total for Question 24 = 13 marks)

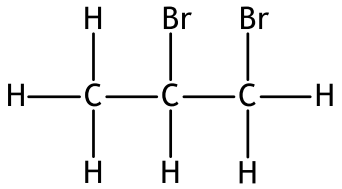
Question Number	Acceptable Answer	Reject	Mark
25(a)(i)	Ultraviolet / UV radiation ALLOW Ultraviolet / UV light Ultraviolet / UV rays Ultraviolet / UV Sunlight light	 sun	1

Question Number	Acceptable Answer	Reject	Mark
25(a)(ii)	a single / one / an electron (1) IGNORE unpaired electron transferring / moving from the bond to one of the (chlorine) atoms joined by the bond ALLOW transferring / moving from a bond to an atom (1) IGNORE Reference to / description of homolytic / heterolytic bond fission	 to each chlorine atom	2

Question Number	Acceptable Answer	Reject	Mark
25(a)(iii)	$CH_4 + Cl^{\cdot} \rightarrow CH_3^{\cdot} + HCl$ (1) $CH_3^{\cdot} + Cl_2 \rightarrow CH_3Cl + Cl^{\cdot}$ (1) ALLOW Equations in either order Penalise omission of the unpaired electron or extra unpaired electron once only Penalise use of Br once only		2

Question Number	Acceptable Answer	Reject	Mark
25(a)(iv)	**MP1** In propagation one (chlorine) radical produces one molecule of chloromethane and a new radical in each sequence ALLOW In propagation free radical(s) are regenerated (1) **MP2** So the propagation stage keeps repeating (until radicals are removed in the termination stage) (1) IGNORE Just 'chain reaction occurs' **MP3** In termination two radicals / a methyl radical and a chlorine radical form one molecule of chloromethane and no other product ALLOW In termination two radicals form one product (1) If no other mark is scored, 'the termination forming chloromethane is one of three possible terminations' scores (1) IGNORE Just 'termination removes free radicals' Reference to other terminations Equations		3

Question Number	Acceptable Answer	Reject	Mark
25(b)(i)	Electrophilic addition (reaction) OR Heterolytic electrophilic addition ALLOW Electrophile addition		1

Question Number	Acceptable Answer	Reject	Mark
25(b)(ii)	 ALLOW Any correct formula that clearly shows the Br atoms on C1 and C2 IGNORE Names even if incorrect Reaction equations Mechanisms	any bromoalcohol	1

(Total for Question 25 = 10 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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