Mark Scheme (Results)

Summer 2019

Pearson International Advanced Subsidiary Level In Chemistry (WCH02)
Paper 01Application of Core Principles of 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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate.

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 <u>meaning</u> 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(a)	The only correct answer is A B is not correct because C=C has a higher bond enthalpy C is not correct because C=C is shorter D is not correct because C=C is shorter and has a higher bond enthalpy	**(1)**

Question Number	Correct Answer	Mark
1(b)	The only correct answer is B A is not correct because carbon 3 has H-C-H 109.5° apart C is not correct because carbon 1 has H-C-H 120° apart D is not correct because carbon 1 has H-C-H 120° and carbon 3 has H-C-H 109.5° apart	**(1)**

Question Number	Correct Answer	Mark
1(c)	The only correct answer is D A is not correct because the shape is trigonal planar B is not correct because the shape is trigonal planar C is not correct because the shape is trigonal planar	**(1)**

Question Number	Correct Answer	Mark
2	The only correct answer is C A is not correct because it contains delocalised electrons B is not correct because it contains delocalised electrons D is not correct because it contains delocalised electrons	**(1)**

Question Number	Correct Answer	Mark
3(a)	The only correct answer is D A is not correct because diiodomethane is polar B is not correct because ethanol is polar C is not correct because propanal is polar	**(1)**

Question Number	Correct Answer	Mark
3(b)	The only correct answer is A B is not correct because ethanol cannot produce halide ions C is not correct because propanal cannot produce halide ions D is not correct because tetrachloromethane would give a white precipitate if it reacted	**(1)**

Question Number	Correct Answer	Mark
4(a)	The only correct answer is A B is not correct because this ignores the 2- charge on the ion C is not correct because this does not divide the negative charge on the ion and the oxygen by 2 D is not correct because the 2- is added to the 6- of the oxygen and is not divided by two	**(1)**

Question Number	Correct Answer	Mark
4(b)	The only correct answer is A B is not correct because this ignores the 2- charge on the ion C is not correct because the 12- for the oxygen and the 2- for the charge are added then divided by 4 D is not correct because the 12- for the oxygen and the 2- for the charge are added then divided by 2	**(1)**

Question Number	Correct Answer	Mark
5	The only correct answer is B A is not correct because 0.148 g of Mg would give 2.5×10^{-3} mol of gas C is not correct because 0.212 g of Sr would give 2.5×10^{-3} mol of gas D is not correct because 0.261 g of Ba would give 2.5×10^{-3} mol of gas	**(1)**

Question Number	Correct Answer	Mark
6(a)	The only correct answer is C A is not correct because activation energy is not changed by temperature B is not correct because activation energy is not changed by temperature D is not correct because this does cause an increase in rate but is less significant	**(1)**

Question Number	Correct Answer	Mark
6(b)	The only correct answer is B A is not correct because this refers to the lower temperature C is not correct because this refers to all the molecules with enough energy to react at the lower temperature D is not correct because this refers to all the molecules with enough energy to react at the higher temperature	**(1)**

Question Number	Correct Answer	Mark
7	The only correct answer is D A is not correct because Mn (VI) disproportionates B is not correct because Cu (I) disproportionates C is not correct because I (I) disproportionates	**(1)**

Question Number	Correct Answer	Mark
8a	The only correct answer is B A is not correct because the equilibrium shifts to the left C is not correct because the equilibrium shifts to the left D is not correct because the equilibrium shifts to the left	**(1)**

Question Number	Correct Answer	Mark
8b	The only correct answer is C A is not correct because the equilibrium shifts to the right but some NO_2 remains B is not correct because the equilibrium shifts to the right D is not correct because the equilibrium shifts to the right	**(1)**

Question Number	Correct Answer	Mark
9	The only correct answer is A B is not correct because this is a tertiary halogenoalkane C is not correct because this is primary D is not correct because this is primary and a dihalogenoalkane	**(1)**

Question Number	Correct Answer	Mark
10	The only correct answer is D A is not correct because the reaction is nucleophilic substitution B is not correct because the reaction is substitution C is not correct because the reaction is nucleophilic	**(1)**

Question Number	Correct Answer	Mark
11	The only correct answer is B A is not correct because this is a free radical mechanism C is not correct because this is a free radical mechanism D is not correct because this is a free radical mechanism	**(1)**

Question Number	Correct Answer	Mark
12	The only correct answer is D A is not correct because they will be different B is not correct as they both have a C=O bond C is not correct because they will be different	**(1)**

Question Number	Correct Answer	Mark
13	The only correct answer is B A is not correct because $[CH_3]^+$ present in both C is not correct because this is $[C_2H_5O]^+$ present in both D is not correct because this is the molecular ion peak, which is the same for both	**(1)**

Question Number	Correct Answer	Mark
14	The only correct answer is D A is not correct because it does not absorb IR B is not correct because it does not absorb IR C is not correct because it does not absorb IR	**(1)**

(Total for Section A = 20 marks)

Section B

Question Number	Acceptable Answers	Reject	Mark
15(a)	Thermal stability increases down the group / (Group 2 carbonates are) more stable down the group **(1)** Ionic radius / size / radius of the **cation / metal ion** increases down the group (and the charge on the ion remains the same) ALLOW Charge density of the **cation / metal ion** decreases **(1)** Resulting in a less polarisation / distortion of the carbonate / anion (electron clouds) / C–O bond **(1)** Resulting in less weakening of the **C–O** / **C=O** bond / more energy needed to break the **C–O** / **C=O** bond ALLOW Bond between **C and O** is stronger / needs more energy to break **(1)** OR reverse argument up the group	Use of metal / atoms / atomic radius Just 'Charge density decreases' Just '…the bond …'	**(4)**

Question Number	Acceptable Answers	Reject	Mark
15(b)(i)	Indicator EITHER Methyl orange **(1)** (red to) Orange / peach ALLOW Yellow-orange **(1)** OR Phenolphthalein **(1)** (colourless to)(pale) pink **(1)** Colour dependent on indicator mark being scored or near miss, e.g. phenylphthalein or pht, only award correct colour for indicator given. ALLOW Other suitable indicators and colours	Yellow Red with anything Phenyl… Red / purple Universal Indicator / Litmus	**(2)**

Question Number	Acceptable Answers	Reject	Mark
15(b)(ii)	$\frac{\underline{18.5}}{1000} \times 0.100 = 0.00185 / 1.85 \times 10^{-3} / 1.9 \times 10^{-3}$ (mol) Ignore SF except for 1SF	1.8×10^{-3} / 2×10^{-3} / 2.0×10^{-3}	**(1)**

Question Number	Acceptable Answers	Reject	Mark
15(b)(iii)	Mol of HCl added = $\frac{50.0}{1000} \times 0.200 =$ 0.0100 / 1.00×10^{-2} / 0.01 / 1×10^{-2} (mol) **(1)** Moles of HCl reacted = Mol of HCl added **–** mol reacted with NaOH = 0.0100 **–** 0.00185 = 0.00815 / 8.15×10^{-3} (mol) **(1)** ALLOW TE on incorrect moles of HCl and (b)(ii) Ignore SF except 1 SF in the final answer Ignore units, even if incorrect Correct answer with no working scores 2		**(2)**

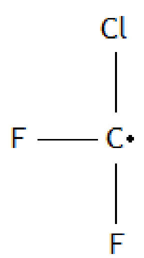
Question Number	Acceptable Answers	Reject	Mark
15(b)(iv)	Mol MgO = $\frac{\text{mol of HCl}}{2}$ = 0.004075 / 4.075 x 10^{-3} (mol) **(1)** Mass of MgO = mol MgO x M_r mol x M_r = 0.004075 x 40.3 = 0.16422 / 1.6422 x 10^{-1} (g) ALLOW 0.163 if M_r = 40 used **(1)** TE on incorrect mol of HCl If mol of HCl is not divided by 2 to give mol of MgO do not award M1 but M2 can be awarded for 0.32844 / 3.2844 x 10^{-1} IGNORE SF except 1SF Correct answer with no working or alternative working scores 2		**(2)**

Question Number	Acceptable Answers	Reject	Mark
15(b)(v)	Mass of water = mass of mixture – **ans (b)(iv)** = 0.180 – 0.16422 = 0.01578 (g) **(1)** Mol H_2O = Mol $Mg(OH)_2$ = $\frac{0.01578}{18}$ = 0.00087667 / 8.7667 x 10^{-4} (mol) **(1)** Mass of $Mg(OH)_2$ = 0.00087667 x 58.3 = 0.051110 / 5.1110 x 10^{-2} (g) ALLOW 0.050847 / 5.0847 x 10^{-2} (g) if 58 is used 0.054777 / 5.4777 x 10^{-2} if 40 used in (iv) and 58 is used **(1)** Ignore SF except 1 SF TE throughout Use of 0.32844 – 0.180 = 0.14844 does not score M1 but 0.18444/18 = 0.0082467 / 8.2467 x 10^{-3} (1) 0.0082467 x 58.3 = 0.48078 (g) (1) Correct answer with no working or alternative working scores 3		**(3)**

Question Number	Acceptable Answers	Reject	Mark
15(c)	Magnesium (ions) give no flame colour ALLOW Energy emitted outside of the visible region	White flame	**(1)**

(Total for Question 15 = 15 marks)

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	Dichlorodifluoromethane ALLOW Difluorodichloromethane IGNORE Punctuation	2-chloro-2-fluoro instead of di	**(1)**

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	 / $CF_2Cl^{\bullet}$ ALLOW Radical dot anywhere on structure or outside of bracket around structure IGNORE curly arrows / bond lengths / bond angles		**(1)**

Question Number	Acceptable Answers	Reject	Mark
16(a)(iii)	An unpaired electron ALLOW An electron $e^{(-)}$ IGNORE Free radical Discussion of homolytic bond breaking	Free electron	**(1)**

Question Number	Acceptable Answers	Reject	Mark
16(a)(iv)	$Cl^{\bullet} + O_3 \rightarrow ClO^{\bullet} + O_2$ **(1)** $ClO^{\bullet} + O_3 \rightarrow Cl^{\bullet} + 2O_2$ **(1)** ALLOW Equation in either order Answers anywhere in the response IGNORE Position of dot Penalise missing radical dot once only IGNORE state symbols and curly arrows, even if incorrect Equation showing formation of chlorine radical		**(2)**

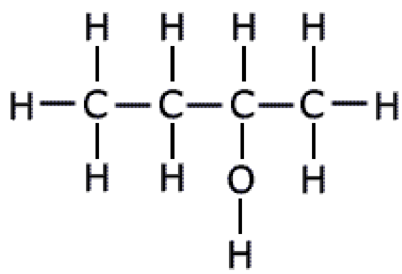
Question Number	Acceptable Answers	Reject	Mark
16(b)	Pentane contains no carbon to chlorine bonds (which may break giving radicals) OR Pentane cannot form **chlorine** radicals ALLOW Pentane contains no chlorine	Less chlorine	**(1)**

(Total for Question 16 = 6 marks)

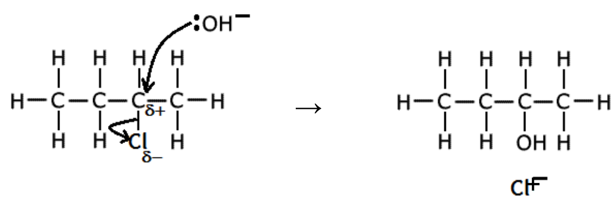
Question Number	Acceptable Answers	Reject	Mark
17(a)(i)	EITHER (At the temperature of the experiment) A, B and C are gases, while D is a liquid OR A, B and C cannot be condensed by the condenser, while D can be condensed ALLOW D has a (much) higher boiling temperature (than A, B and C) IGNORE References to volatility	Just 'D has a high boiling point' without comparison	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(a)(ii)	A, B and C all contain a C=C / carbon to carbon double bond / carbon to carbon multiple bond / are alkenes (and D does not) ALLOW A, B and C contain a double bond / are unsaturated	Just 'it contains a C=C'	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(b)	For **A**, **B** and **C** allow name, structural, displayed or skeletal formulae. If name and formula or two formulae are given they must both be correct **A** is but-1-ene / $CH_2{=}CHCH_2CH_3$ Allow 1-butene **(1)** **B** and **C** are *cis*-but-2-ene / *cis*-$CH_3CH{=}CHCH_3$ / *Z*-but-2-ene / *Z*-$CH_3CH{=}CHCH_3$ **(1)** *trans*-but-2-ene / *trans*-$CH_3CH{=}CHCH_3$ / *E*-but-2-ene / *E*-$CH_3CH{=}CHCH_3$ **(1)** Allow *E*-2-butene / *trans*-2-butene *Z*-2-butene / *cis*-2-butene **B** and **C** can be in either order Allow but-2-ene as either **B** or **C** for 1 mark if **B** and **C** are not scored **X** is 2-bromobutane **(1)** **Y** is 1-bromobutane **(1)** ALLOW For 1 mark **X** is 1-bromobutane and **Y** is 2-bromobutane For 1 mark **X** is a 2-bromo and **Y** is a 1-bromo compound which is a near miss e.g. 2-bromobut**e**ne or 2-bromopentane	Molecular formula	**(5)**

Question Number	Acceptable Answers	Reject	Mark
17(c)(i)	 ALLOW -OH IGNORE position attachment to OH if the bond is vertical	Butan-1-ol C-HO if horizontal bond	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(c)(ii)	Change solvent from ethanol / alcohol to aqueous ethanol / ethanol and water ALLOW Change solvent from ethanol / alcohol to water / aqueous Use aqueous (KOH) solution IGNORE Ratios of alcohol : water		**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(c)(iii)	dipole on 2-chlorobutane and Cl^- shown as a product and correct organic product **(1)** Curly arrow from the lone pair on OH^- including charge **(1)** Curly arrow from C-Cl bond to Cl or just beyond **(1)** ALLOW S_N1 or S_N2 mechanism with correct arrows. 	Use of Br instead of Cl only in M1 Ignore K^+ Lone pair on H	**(3)**

(Total for Question 17 = 12 marks)

Question Number	Acceptable Answers	Reject	Mark
18(a)(i)	Potassium dichromate((Vi)) and sulfuric acid / $K_2Cr_2O_7$ and H_2SO_4 ALLOW Acidified dichromate $Cr_2O_7^{2-}$ / H^+ Na for K **(1)** IGNORE Concentration of acid Distillation **(1)** IGNORE Amount of oxidising agent Mark independently	$KMnO_4$ instead of $K_2Cr_2O_7$ Hydrochloric acid Fractional distillation Reflux	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	Propanal has (permanent) dipole-dipole and London forces **(1)** Propan-1-ol has (permanent) dipole-dipole and London forces and hydrogen bonds **(1)** If M1 and M2 are not scored ALLOW Both have London forces / (permanent) dipole-dipole scores (1) Hydrogen bonds are stronger / strongest / require more energy to break (so propan-1-ol has the higher boiling temperature) **(1)** ALLOW Use of alternatives names for London forces e.g. temporary induced dipole-dipole forces, van der Waal's forces, dispersion forces	Just 'hydrogen bonds so higher boiling temperature'	**(3)**

Question Number	Acceptable Answers	Reject	Mark
18(b)	Correct test and correct result not linked to propan-1-ol or propanal or linked to the wrong substance scores (1) Allow correct result given for a near miss of the test e.g. fruity smell if no acid catalyst added Test for propan-1-ol EITHER Add phosphorus(V) chloride / PCl_5 / phosphorus pentachloride **(1)** Misty/steamy fumes / white smoke with NH_3 gas **(1)** OR Add sodium / Na **(1)** Bubbles / fizzing / effervescence **(1)** OR Addition of a suitable carboxylic acid **and** acid catalyst **(1)** Fruity smell **(1)** Test for propanal EITHER Fehling's / Benedict's solution **(1)** (Blue to) **red and precipitate / solid** **(1)** OR Tollens' Reagent **(1)** Silver mirror **(1)** OR 2,4 dinitrophenylhydrazine (solution) / Brady's Reagent **(1)** Yellow/Orange/Red Precipitate **(1)**	$K_2Cr_2O_7$ / H^+ $KMnO_4$ /H^+	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(c)	$CH_3CH_2CH_2OH + 2[O] \rightarrow CH_3CH_2COOH + H_2O$		**(1)**

(Total for Question 18 = 8 marks)

(Total for Section B = 41 marks)

Section C

Question Number	Acceptable Answers	Reject	Mark
19(a)	Outermost / valence electron is in a (5)p-orbital / (5)p-subshell OR (During build-up of its atoms) last electron added is in a (5)p-orbital / (5)p-subshell ALLOW Outermost / valence electrons are in (5)p-orbitals / the (5)p-subshell	p-shell sub orbital numbers other than 5	**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(b)	Mass in 1 tonne = 0.46 g **(1)** Mol in 1 tonne = $\frac{0.46}{126.9}$ = 0.0036249 / 3.6249×10^{-3} **(1)** Use of 127 gives 0.0036220 / 3.6220×10^{-3} ALLOW any mass ÷ 126.9 / 127 IGNORE SF except 1 SF		**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	$2I^- \rightarrow I_2 + 2e^{(-)}$ / $2I^- - 2e^{(-)} \rightarrow I_2$ ALLOW multiples IGNORE state symbols, even if incorrect		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	$H_2O_2 + 2H^+ + 2e^{(-)} \rightarrow 2H_2O$ ALLOW multiples IGNORE state symbols, even if incorrect		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(iii)	$H_2O_2 + 2H^+ + 2I^- \rightarrow 2H_2O + I_2$ ALLOW Multiples 2HI for $2H^+ + 2I^-$ Correct equation even if half-equations are incorrect TE on half equations which include $I^- \rightarrow I_2$ + electron(s) And H_2O_2 + electron(s) $\rightarrow 2H_2O$ but ignore incorrect balancing resulting from errors in (c)(i) and (c)(ii). e.g. $H_2O_2 + 2e^{(-)} \rightarrow 2H_2O + O^{2-}$ in (ii) Would give $H_2O_2 + 2I- \rightarrow 2H_2O + I_2 + O^{2-}$ IGNORE state symbols, even if incorrect	Uncancelled electrons	**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(iv)	(Colourless solution turns) brown / yellow ALLOW Liquid goes brown / brown liquid formed ALLOW Colours for any equation in (c)(iii) for iodide going to iodine even if equation is incorrect ALLOW	Brown gas / vapour Any colour to start other than colourless grey solid / purple vapour / brown precipitate	**(1)**

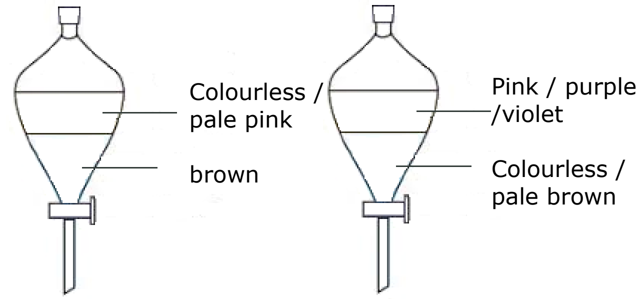
	Brown (solution / liquid) to colourless if $I_2 \rightarrow I^-$ in (c)(iii)		

Question Number	Acceptable Answers	Reject	Mark
19(c)(v)	Oxidising agent **(1)** Oxidation number of oxygen changes from -1 to -2 / causes oxidation number of iodide to change from -1 to 0 **(1)** Mark independently If both changes are given both must be correct	Just 'H_2O_2 is reduced'	**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(vi)	EITHER Iodide ion is a better reducing agent (than bromide or chloride) / is more easily oxidised **(1)** So reacts preferentially with the hydrogen peroxide ALLOW So reacts before chloride or bromide **(1)** OR Chlorine / bromine is a better oxidising agent than iodine **(1)** So any chlorine / bromine formed reacts with iodide ion (to produce iodine) **(1)**	Just 'is more reactive than'	**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(d)(i)	Iodide ions are hydrated by / surrounded by water molecules May be shown on a diagram of I^- and more than one water **(1)** As negative iodide ions interact with $\delta+$ hydrogen in water molecule ALLOW An ion-dipole interaction between I^- and $H^{\delta+}$ Just ion-dipole interactions occur May be shown on a diagram with the H of at least one water molecule, labelled $\delta+$, pointing toward an I^- **(1)**	Iodine H^+ interacts with I^- Dipole-dipole inter-actions	**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(d)(ii)	(Iodine is a non-polar molecule so) forms instantaneous-induced dipole attractions / van der Waals' / London / dispersion forces with cyclohexane **(1)** Interaction of iodine with water does not provide enough energy to break the hydrogen bonds between water molecules OR iodine does not form hydrogen bonds with water **(1)** If M1 and M2 are not scored Iodine and cyclohexane have stronger intermolecular forces than iodine and water scores 1 OR Iodine and cyclohexane are non-polar but water is polar scores 1		**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(e)	 Either both colours in one funnel OR both colours for one layer **(1)** Other two colours ALLOW Yellow for brown **(1)** All four colours correct but layers reversed scores **(1)**	Any colour other than pale pink top left	**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(f)	Iodine will sublime if heated **(1)** Cyclohexane is harmful / flammable **(1)**		**(2)**

(Total for Question 19 = 19 marks)

(Total for Section C = 19 marks)

Total for Paper = 80 marks

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