Bonding, Polarity & Intermolecular Forces

Mark Scheme 2

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Application of Core Principles of Chemistry
Sub Topic	Bonding, Polarity & Intermolecular Forces
Booklet	Mark Scheme 2

Time Allowed: **80 minutes**

Score: **/66**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

Question Number	Acceptable Answers	Reject	Mark
1 (a)(i)	FIRST, CHECK THE FINAL ANSWER IF answer IO_3^- + 6 H^+ + 5 I^- → 3 I_2 + 3 H_2O (ALLOW multiples) then award **(2)** marks, with or without any working OTHERWISE **First mark:** Any evidence of correctly multiplying the half-equations in order to cancel electrons (e.g. second equation x 5 OR first equation x 2 and second equation x 10) **(1)** **Second mark:** For correctly balanced equation overall IO_3^- + 6 H^+ + 5 I^- → 3 I_2 + 3 H_2O OR 2 IO_3^- + 12 H^+ + 10 I^- → 6 I_2 + 6 H_2O **(1)** IGNORE State symbols, even if incorrect	NO **2nd mark** if e^- un-cancelled on LHS and RHS in balanced eqtn	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (a)(ii)	IO_3^- / $NaIO_3$ **and** **gains electrons** (from the iodide ions) ALLOW 'electron gain' (singular) IGNORE References to iodate**(V)** or sodium iodate NOTE: IGNORE **Just** correct changes in oxidation number, as answer requires reference to **gain of electrons**		**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(i)	Iodine / I_2	**Just** 'I'	**1**

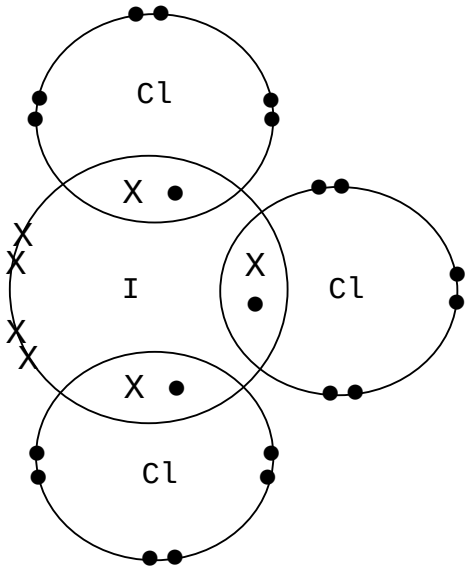
Question Number	Acceptable Answers	Reject	Mark
1 (b)(ii)	$H_2SO_4 + 6H^+ + 6e^- \rightarrow S + 4H_2O$ **OR** $SO_4^{2-} + 8H^+ + 6e^- \rightarrow S + 4H_2O$ **OR** $8SO_4^{2-} + 64H^+ + 48e^- \rightarrow S_8 + 32H_2O$ **(2)** IGNORE State symbols, even if incorrect **First mark – M1:** All species correct **(1)** **Second mark – M2:** Balancing M2 can only be awarded if the correct species mark (M1) has been awarded **(1)** ACCEPT Multiples	S_2 or S_4 for sulfur e^- on wrong side (no M1)	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(iii)	**M1** - (Identity of **X**) H_2S / hydrogen sulfide / hydrogen sulphide **(1)** **M2** - **(this is a stand-alone mark)** - (Oxidation number of S in sulfuric acid) **+** ALLOW 6 or "6+" **(1)** **M3** - (Oxidation number of S in **X**) −2 ALLOW 2− No TE on incorrect **X** **(1)**	 **+4**	**3**

Question Number	Acceptable Answers	Reject	Mark
1 (c)(i)	FIRST CHECK THE ANSWER ON ANSWER LINE, IF answer = 183 (µg), **N.B. must be 3 sf**, then award **(2)** marks, with or without any working OTHERWISE look for: **1st mark – M1** EITHER (Moles of I^-) = 140 x 10^{-6} ÷ 126.9 OR (Moles of I^-) = 140 x 10^{-6} ÷ 127 OR (Moles of I^-) = 1.1(0) x 10^{-6} (mol) ALSO ALLOW 140 ÷ 126.9 OR 140 ÷ 127 for M1 **(1)** **2nd mark – M2** (Mass of KI) = mol of I^- x 166 ÷ 10^{-6} **and 3 s.f.** [NOTE: Expected answer: [(1.1(0) x 10^{-6} /10^{-6}) x 166] = 183(µg) **to 3 sf** 2nd mark is CQ on moles of I^- calculated ALLOW 140 x 166 ÷ 126.9 for M2 OR 140 x 166 ÷ 127 for M2 ALLOW M_r for KI as 166 or 166.1 or 165.9 **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
1 (c)(ii)	Any ONE of: (Morally) wrong to put additives in food supplies; People should be able to choose if I^- is added to their food; Food / tap water already has sufficient I^- (from other sources); Other foodstuffs contain I^-; **Excess** K^+ (ions) harmful; **Excess** I^-(ions) harmful; Any reference to radioactivity; Allergies/intolerance (to I^-); Raises blood pressure; Any reference to thyroid issues NOTE ALLOW 'dangerous' for 'harmful' IGNORE Any references to cost	KI/I^- 'toxic' or 'poisonous'; References to just "K" or "I" or "I_2"; "KI reacts with (stomach) acid"; (KI) difficult to obtain; (KI) difficult to prepare; (KI) difficult to store; (KI) not readily available; (KI) strong reducing agent; (KI) bad taste	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (d)(i)	**First mark (M1)** ICl has permanent dipole (-permanent dipole) forces OR ICl has dipole-dipole forces IGNORE **Just** I−Cl bond is polar or **just** ICl is a polar molecule **(1)** **Second mark (M2)** Cl_2 has London forces / Cl_2 has van der Waals' forces / Cl_2 has dispersion forces / Cl_2 has INDUCED-dipole forces/ temporary dipole forces **(1)** **Third mark (M3)** Any suggestion that the intermolecular forces / any named intermolecular forces / any 'interactions' between molecules are **stronger in ICl** (than in Cl_2) / need more (heat) energy to overcome forces in ICl **OR** Mentions that ICl has BOTH London AND permanent dipole forces **(1)** **Fourth mark (M4)** **EITHER** ICl has strong**er** London forces / strong**er** van der Waals' forces / strong**er** dispersion forces (than Cl_2) **OR** ICl has more electrons (per molecule than Cl_2) / ICl larger molecule (than Cl_2) **(1)**	Reference to ionic bonds (no M3) Reference to/implication of the breaking of ionic bonds or covalent bonds or hydrogen bonds or ambiguity as to what interactions are being broken (no M3)	**4**

Question Number	Acceptable Answers	Reject	Mark
1 (d)(ii)	2 lone pairs on the iodine **(1)** Rest of molecule correct (i.e. 3 I-Cl bond pairs **and** 3 lone pairs on each Cl atom) **(1)**  IGNORE Inner-shell electrons Circles are not required NOTE Must use the dot and cross convention to distinguish the electrons ALLOW Lone pair electrons shown separately rather than in pairs (totals of the non-bonding electrons **must** be correct)		**2**

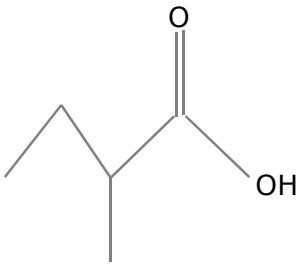
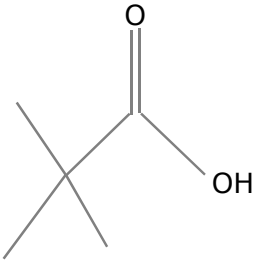
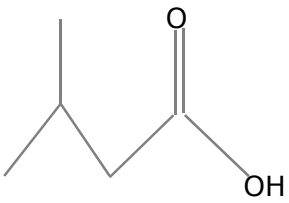
Question Number	Acceptable Answers	Reject	Mark
1 (e)(i)	$Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$ ALLOW multiples IGNORE State symbols, even if incorrect Full equation **also** given	If K^+ ions are left in the equation	**1**

Question Number	Acceptable Answers	Reject	Mark
***1 (e)(ii)**	(So from 0.66 mol NaI) **0.33** mol I_2 formed **(1)** (So) **0.17** mol Br_2 formed **(1)** **NOTE:** **0.33** mol I_2 scores **(1)**, with or without working **0.17** mol Br_2 scores **(1)**, with or without working **M3** - [Justification] **Stand alone** EITHER I^- has greater reducing power (than Br^-) OR NaI has greater reducing power (than NaBr) OR Reducing power (of the halide ions) increases down the group OR I^- more easily oxidised (than Br^-) **(1)**	TE on incorrect moles of I_2 or incorrect moles of Br_2 Iodine/I_2 has greater reducing power than bromine/Br_2	**3**

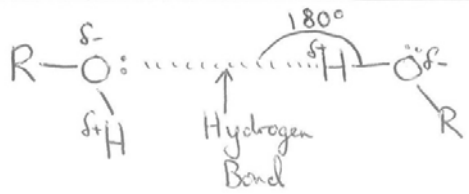
(Total for Question 1 = 22 marks)

Question Number	Acceptable Answers	Reject	Mark
2(a)	(-)methylbutanoic acid ALLOW **3**(-)methylbutyric acid	**2-**methylbutanoic acid	1

Question Number	Acceptable Answers	Reject	Mark
2(b)	$C_5H_{10}O_2$ ALLOW atoms in any order if numbers are correct for each atom eg $H_{10}O_2C_5$/ $C_5O_2H_{10}$/ $H_{10}O_2C_5$/ $O_2C_5H_{10}$ ALLOW Additional formulae as well as correct answer	Just 'C_4H_9COOH'	1

Question Number	Acceptable Answers	Reject	Mark
2(c)	 (1) Bonds may go in other directions eg methyl group upwards  (1)	 	2

Question Number	Acceptable Answers	Reject	Mark
2*(d)	Equal/specified volumes/masses/amounts of solvent (1) **MP2** Equal volumes of valeric acid **and** shake/stir/ mix (and allow to stand) OR Add valeric acid a drop at a time/from a burette to the solvents (1) **MP3** (Two) layers with water **and** a (single) layer with ethanol OR Immiscible with water mixes with ethanol OR Cloudy with water **and** clear with ethanol OR Measure depth of mixture/smaller rise for ethanol (1)	precipitate	3

Question Number	Acceptable Answers	Reject	Mark
2(e)	Drawing of hydrogen bond between correct atoms and in a straight line Ignore extra molecules Ignore dipoles and omission of lone pair of electrons Ignore R-OH bond angle ALLOW Any alcohol (1)  Bond angle 180° around the correct H atom and consequential on MP1 (1) NOTE If two water molecules/R-OH and a water molecule are correctly drawn with a linear hydrogen bond and 180° correctly labelled then award (1)		2

Question Number	Acceptable Answers	Reject	Mark
2(f)*(i)	Instantaneous dipole OR temporary asymmetric electron distribution (1) Induced dipole/charge in adjacent/another molecule/atom/particle (1)		2

Question Number	Acceptable Answers	Reject	Mark
2(f)(ii)	**MP1** (Boiling temperature will be) lower/ **straight chain** is higher (1) Remaining marks are dependent on **MP1** **MP2 and MP3** Branching reduces/ less(ens)/weakens the London/dispersion/ Van der Waals'/vdW forces (1) (because it has) less surface area (in contact)/ molecules can't align/molecules can't get as close (1) OR Straight chain stronger/ more/ increases London/etc forces (1) (because it has) greater surface area (in contact) /molecules can align better/molecules can get as closer/pack more closely (1) IGNORE References to energy		3

Question Number	Acceptable Answers	Reject	Mark
2(g)(i)	(The alcohol) can **only** be oxidized to the ketone OR cannot be further oxidized OR cannot be oxidized to a carboxylic acid OR Further oxidation would have to break a C-C bond IGNORE It's a secondary alcohol/It's not a primary alcohol/ Same product formed		1

Question Number	Acceptable Answers	Reject	Mark
2(g)(ii)	Alkene/carbon-carbon double bond ALLOW C=C (1) (Type of molecule) (1,2-) diol ALLOW (1,2-) dialcohol (1)	Just 'double bond' Alcohol	2

Question Number	Acceptable Answers	Reject	Mark
2(h)	**Up to 2 marks for IR points** **Penalise the omission of bonds once only** **IR MP1** 3300-2500 (cm^{-1}) O—H/OH (stretch in a carboxylic acid) (1) **IR MP2** 1725-1700 (cm^{-1}) C=O (stretch in a carboxylic acid) (1) **Ignore** 2962 – 2853 (cm^{-1}) C-H (stretch in an alkane) **Up to 3 marks for Mass Spec points** Only penalise negative charges or lack of positive charge once Molecular ion/parent ion peak /$C_5H_{10}O_2^+$ at 102 (1) $C_5H_9O_2^+$ at 101 (1) $COOH^+$ at 45 (1) $C_4H_9^+$/$CH_3CH(CH_3)CH_2^+$ at 57 (1) $C_4H_7O_2^+$/$CH_3CHCH_2CO_2H^+$ at 87 (1) OH^+ at 17 (1) CH_3^+ at 15 (1)	3095-3010 3750-3200 1700-1680	4

TOTAL FOR SECTION C (QUESTION 2) = 21 MARKS

Question Number	Acceptable Answers	Reject	Mark
3(a)	$C_6H_8O_3$ Allow elements in any order.	Any other answers	**1**

Question Number	Acceptable Answers	Reject	Mark
3(b)	(Secondary) alcohol/Hydroxyl OR Alkene/Carbon-Carbon double bond OR Enol/ether	C-OH/ Just 'OH Group' Primary alcohol C=C Just 'double bond' Ester	**1**

Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	$ROH + Na \rightarrow RO^{(-)}Na^{(+)} + \frac{1}{2}H_2$ **(1)** Allow multiples Ignore state symbols even if incorrect Effervescence/Fizzing/Bubbles OR Sodium dissolves/disappears/ decreases in size OR White solid forms **(1)** Stand alone marks	RNaO White ppt	**2**

Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	$ROH + PCl_5 \rightarrow RCl + POCl_3 + HCl$ **(1)** Ignore state symbols even if incorrect Steamy /misty / white **and** fumes/gas **(1)** Stand alone marks Allow PCl_3O	White smoke	**2**

Question Number	Acceptable Answers	Reject	Mark
3(c)(iii)	(HCl poses the greater risk – No credit but must be stated for the second mark) (because it is)toxic/corrosive/poisonous/ reference damage to skin **(1)** Not enough hydrogen produced/ hydrogen produced only slowly (so won't catch fire) **(1)**	Harmful/ ozone depletion/ Flammable Just 'acidic' Just 'dangerous'	**2**

Question Number	Acceptable Answers	Reject	Mark
3(d)(i)	Agent: sodium dichromate((VI)) / $Na_2Cr_2O_7$/ potassium dichromate((VI))/ $K_2Cr_2O_7$ **(1)** sulfuric acid/H_2SO_4 **(1)** If name and formula are given, both must be correct. Conditions: Distillation **(1)** Allow 'Fractional distillation' Acidified dichromate/ H^+ and $Cr_2O_7^{2-}$ scores 1 mark Allow the acid as a reagent or as a condition. Acid can be conc. or dilute	$KMnO_4$ Any other acids Reflux/ Just 'heat'	**3**

Question Number	Acceptable Answers	Reject	Mark
***3(d)(ii)**	(infrared radiation causes) stretching/ bending/changes in bond polarity/bond vibration **(1)** different bonds absorb different IR (frequencies/wavelength/wavenumber)/ different peaks for different groups **(1)** compare absorption with database / data booklet **(1)**	Molecular vibration Bonds broken	**3**

Question Number	Acceptable Answers	Reject	Mark
***3(e)**	Point 1: (Alkanes) London Forces/ Dispersion forces/van der Waals' forces **(1)** Point 2: (Arises) – instantaneous dipole/momentary imbalance in electron density **(1)** Point 3: which **induces** dipole in adjacent molecule (and results in attraction) / description of **induction** **(1)** Ignore reference to atoms/molecules --- Point 4: (Alcohols) Hydrogen bonds **(1)** Point 5: (Arises) – oxygen's higher electronegativity creates dipole/large difference in electronegativity **(1)** Point 6: Bond is attraction between (lone pair of electrons on) O of one molecule and H of **another** molecule **(1)** --- Point 7: London forces are weaker than hydrogen bonds **(1)** Allow "alkanes intermolecular force weaker (than that of alcohols)" for point 7	Just 'Id-Id' Any other forces in combination Any reference to permanent dipoles loses points 2 & 3 London Forces	**7**

Question Number	Acceptable Answers	Reject	Mark
3(f)	Unique fragmentation/ different fragmentation/ different peak pattern	Just 'different masses'	**1**

Question Number	Acceptable Answers	Reject	Mark
3(g)	Polymers have low volatility/ do not bind to receptors in nose/ Polymers do not have an aroma/ Polymer formation does not involve the 'aroma' molecules/ The chemicals causing the aroma are not affected (by the enzyme)		**1**

TOTAL FOR Question 3 = 23 MARKS