Mark Scheme (Results)

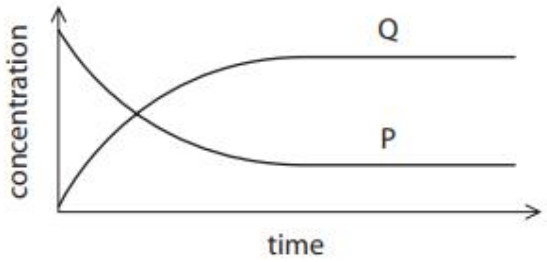
Summer 2019

Pearson International Advanced Subsidiary Level In Chemistry (WCH12) Paper 01 Energetics, Group Chemistry, Halogenoalkanes and Alcohols

Section A (Multiple Choice)

Question number	Answer	Mark
1	**The only correct answer is B** (pressure) ***A*** *is not correct because concentration of the acid does affect the rate of reaction* ***C*** *is not correct because surface area of the solid does affect the rate of reaction* ***D*** *is not correct because temperature does affect the rate of reaction*	**(1)**

Question number	Answer	Mark
2	**The only correct answer is D** (64) ***A*** *is not correct because it assumes the relationship between temperature and rate is linear* ***B*** *is not correct because it suggests a rate increase of 6 x 2* ***C*** *is not correct because it suggests a rate increase of 6^2 instead of 2^6*	**(1)**

Question number	Answer	Mark
3	**The only correct answer is A**  ***B*** *is not correct because it shows the concentration of both reactants and products decreasing* ***C*** *is not correct because both concentration of reactants and products are still changing* ***D*** *is not correct because concentrations of P and Q remain unchanged*	**(1)**

Question number	Answer	Mark
4	**The only correct answer is D** ($2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$) ***A*** *is not correct because the equilibrium will move to the left hand side (more molecules)* ***B*** *is not correct because the equilibrium will not change as both sides have the same number of molecules* ***C*** *is not correct because the equilibrium will move to the left hand side (more molecules)*	**(1)**

Question number	Answer	Mark
5	**The only correct answer is C** (hydrogen chloride is formed in the reaction) ***A*** *is not correct because chlorine does not increase oxidation state when HCl (misty fumes) forms* ***B*** *is not correct because sulfur does not increase oxidation state when HCl (misty fumes) forms* ***D*** *is not correct because chlorine will not be evident as misty fumes and does not form in the reaction*	**(1)**

Question number	Answer	Mark
6	**The only correct answer is C** (+6) ***A*** *is not correct because the oxidation number of S in a compound is not always −2* ***B*** *is not correct because this is the value for the* SO_3^{2-} *ion* ***D*** *is not correct because the sum of all the oxidation states should be equal to the charge on the ion, not 0*	**(1)**

Question number	Answer	Mark
7	**The only correct answer is B** ($6NaOH + 3Br_2 \rightarrow 5NaBr + NaBrO_3 + 3H_2O$) ***A*** *is not correct because it is a neutralisation reaction* ***C*** *is not correct because only Al is oxidised and only H is reduced* ***D*** *is not correct because no oxidation numbers change*	**(1)**

Question number	Answer	Mark
8	**The only correct answer is B** ($BaSO_4$) ***A*** *is not correct because solubility of sulfates decreases down Group 2 and Ca is above Ba* ***C*** *is not correct because Group 1 sulfates are soluble* ***D*** *is not correct because Group 1 sulfates are soluble*	**(1)**

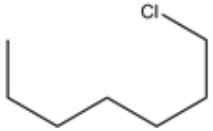
Question number	Answer	Mark
9	**The only correct answer is B** (-75 kJ mol^{-1}) ***A*** *is not correct because the 2 equations have been added together* ***C*** *is not correct because the second equation has been subtracted from the first equation* ***D*** *is not correct because both equations have been reversed and added together*	**(1)**

Question number	Answer	Mark
10	**The only correct answer is B** (-122) ***A*** *is not correct because it is the sum of formation of all product and reactant bonds* ***C*** *is not correct because the energy to break the bonds is less than the energy released when the new bonds form* ***D*** *is not correct because it is the sum of breaking all product and reactant bonds*	**(1)**

Question number	Answer	Mark
11	**The only correct answer is C** ($\frac{1}{2}Br_2(l) \rightarrow Br(g)$) ***A*** *is not correct because 2 moles of Br atoms form and* Br_2 *is in gaseous state* ***B*** *is not correct because 2 moles of Br atoms form* ***D*** *is not correct because* Br_2 *is in gaseous state*	**(1)**

Question number	Answer	Mark
12	**The only correct answer is A** (*an increase of 6.0*°C) ***B*** *is not correct because neutralisation reactions are exothermic, so temperature will rise not fall* ***C*** *is not correct because the total volume of solution is 100* cm^3*, not 50* cm^3 ***D*** *is not correct because neutralisation reactions are exothermic, so temperature will rise not fall and because the total volume of solution is 100* cm^3*, not 50* cm^3	**(1)**

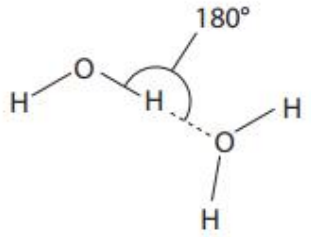
Question number	Answer	Mark
13	**The only correct answer is A** (NH_4^+) ***B*** *is not correct because the carbon has a lone pair of electrons* ***C*** *is not correct because the oxygen has a lone pair of electrons* ***D*** *is not correct because the nitrogen has a lone pair of electrons*	**(1)**

Question number	Answer	Mark
14	 **The only correct answer is A** ***B*** *is not correct because it is an isomer with 1 branch, so lower London forces* ***C*** *is not correct because it is an isomer with 2 branches, so lower London forces* ***D*** *is not correct because it is an isomer with 3 branches, so lower London forces*	**(1)**

Question number	Answer	Mark
15(a)	**The only correct answer is C** (strontium bromide) ***A*** *is not correct because the chloride will give a white precipitate* ***B*** *is not correct because the chloride will give a white precipitate* ***D*** *is not correct because the barium will give a green flame*	**(1)**

Question number	Answer	Mark
15(b)	**The only correct answer is *D*** (red light is emitted as electrons return to lower energy levels) ***A*** *is not correct because the electrons absorb heat as they are promoted* ***B*** *is not correct because the electrons emit light when they return to ground state* ***C*** *is not correct because light energy is emitted when the electrons return to the ground state*	**(1)**

Question number	Answer	Mark
16(a)	**The only correct answer is C** (H-H bond enthalpy is greater than Si-H bond enthalpy) ***A*** *is not correct because hydrogen bonding does explain why ice has a lower density than water* ***B*** *is not correct because hydrogen bonding does explain why HF has a higher boiling temperature then HCl* ***D*** *is not correct because hydrogen bonding does explain why alcohols are less volatile than similar alkanes*	**(1)**

Question number	Answer	Mark
16(b)	**The only correct answer is A**  ***B*** *is not correct because the 2 water molecules do not form a hydrogen bond between two hydrogen atoms* ***C*** *is not correct because the hydrogen bond angle is not 104.5˚* ***D*** *is not correct because the angle between 2 water molecules should be 180˚ and water molecules should not have a bond angle of 180˚*	**(1)**

Question number	Answer	Mark
17	**The only correct answer is B** (d ÷ a) *A is not correct because it is not a gradient of a tangent and is inverse of the rate* *C is not correct because it is the average rate* *D is not correct because it is the initial rate*	**(1)**

Question number	Answer	Mark
18	**The only correct answer is D** (CH_3CH_2COOH) *A is not correct because it will not have a major peak at m/z = 57* *B is not correct because it will not have a major peak at m/z = 57* *C is not correct because it will not have a major peak at m/z = 57*	**(1)**

Total for Section A = 20 marks

Section B

Question Number	Answer	Additional guidance	Mark
19(a)(i)	• $2I^- \rightarrow I_2 + 2e^{(-)}$ **(1)** • $2H^+ + 2e^- + H_2O_2 \rightarrow 2H_2O$ **(1)**	Allow $2I^- - 2e^{(-)} \rightarrow I_2$ Ignore state symbols, even if incorrect Allow multiples Allow equations in either order	**(2)**

Question Number	Answer	Additional guidance	Mark
19(a)(ii)	$2I^- + 2H^+ + H_2O_2 \rightarrow I_2 + 2H_2O$ OR $2HI + H_2O_2 \rightarrow I_2 + 2H_2O$	Ignore state symbols, even if incorrect Allow multiples No TE from (a)(i) Do not award uncancelled electrons	**(1)**

Question Number	Answer	Additional guidance	Mark
19(b)(i)	An answer that makes reference to the following points: (pale) yellow aqueous layer **(1)** Pink cyclohexane layer **(1)**	Do not award just 'brown' / colourless / orange allow light brown / pale brown / yellow-brown / straw Allow purple / violet Do not award red / grey	**(2)**

Question Number	Answer	Additional guidance	Mark
19(b)(ii)	An explanation that makes reference to the following points: Cyclohexane and iodine form London forces (between molecules) **(1)** Hydrogen bonds between water molecules are stronger than London forces (between iodine and water molecules so less soluble in aqueous layer) **(1)**	 Allow 'van der Waals' / dispersion forces / instantaneous dipole – induced dipole forces Allow 'Hydrogen bonds in water are strong' Allow one mark for answers that compare type of attraction without any reference to magnitude or answers based solely on polarity e.g. Just 'iodine forms London forces with cyclohexane but cannot form hydrogen bonds with water' scores 1 mark 'iodine and cyclohexane are non-polar, but water is polar' scores 1 e.g. 'Intermolecular forces formed by iodine and water are weaker than intermolecular forces in water' scores 1	**(2)**

Question Number	Answer	Additional guidance	Mark
19(c)	(Anhydrous) sodium sulfate /Na_2SO_4 / magnesium sulfate / $MgSO_4$ / calcium chloride / $CaCl_2$ / calcium sulfate / $CaSO_4$ / calcium oxide / CaO	Allow silica gel Do not award concentrated sulfuric acid / phosphoric acid Do not award $CuSO_4$ / $CaCO_3$	**(1)**

(Total for Question 19 = 8 marks)

Question Number	Answer	Additional guidance	Mark
20(a)(i)	• magnesium nitrate decomposes / breaks down (when heated with a Bunsen burner)	Ignore references to evaporation Do not award 'reacts with oxygen' Do not award **just** the idea that magnesium nitrate reacts Ignore products of decomposition even if incorrect Ignore 'spitting' / any references to removing water too quickly	**(1)**

Question Number	Answer	Additional guidance	Mark
20(a)(ii)	• calculate mass of water removed **(1)** • calculates moles of water removed **(1)** • calculates moles of anhydrous magnesium nitrate **(1)** • deduces x **(1)** **OR** • calculates moles of anhydrous magnesium nitrate **(1)** • Calculates Mr of hydrated salt **(1)** • Writes expression to find x in terms of mass and *M* **(1)** • deduces **x** **(1)**	Example of calculation 5.12 – 2.97 = 2.15 g 2.15 / 18 = 0.11944 (mol) M1 could be subsumed in M2 2.97/148.3 = 0.0200 (mol) 0.11944:0.0200 = 6:1 so x = 6 (must be integer) 2.97/148.3 = 0.0200 (mol) 5.12/0.0200 = 256 148.3 + 18x = 256 x = 6 (must be integer) Allow TE at each step Correct answer with no working scores M4 only Ignore SF apart from M4, which must be 1SF	**(4)**

Question Number	Answer	Additional guidance	Mark
20(b)(i)	An explanation that makes reference to the following points: • large(r) amount of energy required to break **ionic** bonds (in lattice / $MgCO_3$ / solid) **(1)** • small(er) amount of energy released during hydration (of ions) / when ions form bonds to water **(1)** **OR** Lattice energy is **more exothermic** **(1)** than the hydration enthalpies **(1)**	Do not award molecules / atoms / London forces Ignore references to H bonds If no other mark is awarded allow 1 for 'lattice energy is **greater** than hydration enthalpy'	**(2)**

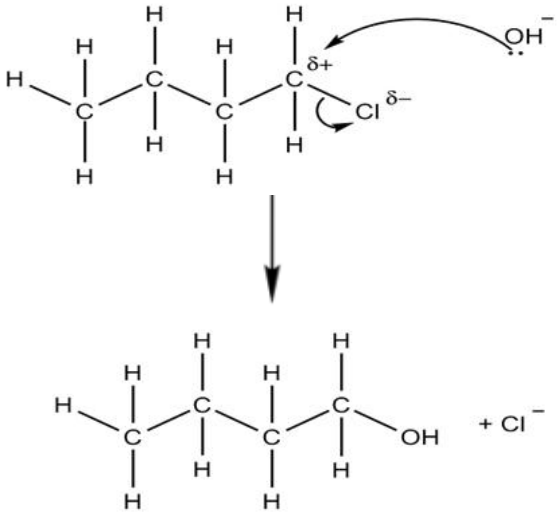
Question Number	Answer	Additional guidance	Mark
20(b)(ii)	• application of Hess's Law **(1)** • calculation of $\Delta_f H^{\ominus}$ **(1)**	Example of calculation: +(−394 –602) + 1096 **(+)** 100 (kJ mol^{-1}) Correct answer with no working scores 2 marks – 100 (kJ mol^{-1}) scores 1 mark (+) 702 (kJ mol^{-1}) scores 1 mark (+) 494 (kJ mol^{-1}) scores 1 mark – 2092 (kJ mol^{-1}) scores 1 mark (+) 2092 (kJ mol^{-1}) scores 1 mark Ignore units even if incorrect	**(2)**

Question Number	Answer	Additional guidance	Mark
20(b)(iii)	An explanation that makes reference to the following points • Group 2 carbonates increase in (thermal) stability as you go down the group **(1)** • size of the (metal) **ion** increases / charge density (of ion) decreases **(1)** • so metal ion is less polarising or (electron cloud of) anion less distorted **(1)** • so weakens (covalent) bonds in carbonate ion less / more energy needed to break (covalent) bonds in carbonate **(1)**	Accept reverse argument Each marking point is independent Ignore 'atomic radius" Allow C-O or C=O as alternative for 'bonds in carbonate'	**(4)**

(Total for Question 20 = 13 marks)

Question Number	Answer	Additional guidance	Mark
21(a)(i)	• water / H_2O / aqueous	Do not award **just** ethanol / alcohol But allow 'water and ethanol'	**(1)**

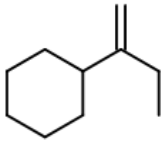
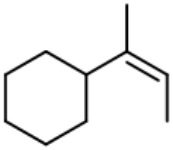
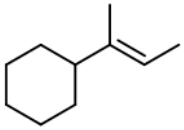
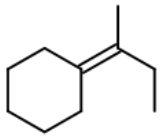
Question Number	Answer	Additional guidance	Mark
21(a)(ii)	• correct mechanism name and type	Nucleophilic substitution Allow nucleophile for nucleophilic Ignore S_N2 or S_N1 Ignore hydrolysis	**(1)**

Question Number	Answer	Additional guidance	Mark
21(a)(iii)	A mechanism that shows: • dipole on C-Cl bond and arrow from bond to Cl or just beyond **(1)** • arrow from lone pair on OH^- ion to carbon **(1)** • both products **(1)** 	Ignore S_N2 transition state Do not award M2 if covalent bond in KOH Allow KCl as a product if KOH or K^+ is shown on LHS Allow skeletal formulae / $C_3H_7CH_2Cl$ Penalise use of half arrows once only in M1 and M2	**(3)**

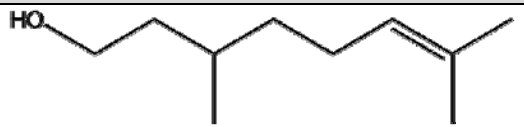
Question Number	Answer	Additional guidance	Mark
21 (b)	• moles of alcohol formed **(1)** • moles of 1-chlorobutane required **(1)** • mass of 1-chlorobutane required **(1)** • volume of 1-chlorobutane required, to 2 or 3SF **(1)**	<u>Example of calculation</u> 12.1 / 74.0 = 0.16351 (mol) (0.16351/64) x 100 = 0.25549 (mol) 0.25549 x 92.5 = 23.633 (g) 23.633 / 0.886 = 26.674 = 26.7 / 27 (cm^3) Correct answer with no working scores 4 marks Allow TE at each step Ignore rounding in steps 1-3 Ignore SF except 1 SF in steps 1-3 Units, if given, must be correct in M4	**(4)**

(Total for Question 21 = 9 marks)

Question Number	Answer	Additional guidance	Mark
22 (a)	An answer that makes reference to the following points: • add PCl_5 / phosphorus(V) chloride /phosphorus pentachloride **(1)** • misty fumes evolved (that turn damp blue litmus red / form white smoke with ammonia) **(1)** OR • Add sodium / Na **(1)** • Effervescence / bubbles seen / fizzing **(1)** OR • Add Lucas' Reagent **(1)** • Solution turns cloudy immediately / quickly **(1)**	M2 dependent on correct reagent seen in M1. Allow PCl_3 Allow steamy fumes / white fumes Do not award white smoke **unless** in conjunction with exposure of fumes to ammonia Ignore gas given off / hydrogen given off Do not award heat with acidified dichromate(VI) ions	**(2)**

Question Number	Answer	Additional guidance	Mark
22 (b)(i)	 **(1)**  **(1)**  **(1)**  **(1)**	Allow any unambiguous type of structure	**(4)**

Question Number	Answer	Additional guidance	Mark
22 (b)(ii)	A description that makes reference to any two from the four following points: • Peak at 3750 – 3200 (cm^{-1}) due to O-H bond present in reactant / absent in product **(1)** • Peak at 1000-1300 (cm^{-1}) due to C-O bond present in reactant / absent in product **(1)** • Peak at 1669 – 1645 (cm^{-1}) due to C=C bond present in product / absent in reactant **(1)** • Peak at 3095 – 3010 (cm^{-1}) due to **C-H bond** present in **alkene** in product / absent in reactant **(1)**	Allow two peaks quoted or two bonds for one mark Allow any wavenumber or range of wavenumbers within the allowable range.	**(2)**

Question Number	Answer	Additional guidance	Mark
22 (c)	• Longest chain has eight carbon atoms, with terminal OH group **(1)** • rest of structure correct **(1)**	 Accept structural , skeletal or displayed formulae Ignore connectivity except O-H-C Allow 1 mark for correct displayed formulae with missing hydrocarbon hydrogens Allow 1 mark for correct structure of 2,6-dimethylhept-5-en-1-ol	**(2)**

(Total for Question 22 = 10 marks)

Total for Section B = 40 marks

Section C

Question Number	Answer	Additional guidance	Mark
23 (a)	$CH_3CH_2CH_2OH + 2[O] \rightarrow CH_3CH_2COOH + H_2O$	Ignore state symbols even if incorrect Allow multiples Allow 2 correct equations via aldehyde Allow molecular formulae Ignore reagents above the arrow	**(1)**

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*23 (b)</td>
<td>This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning
<table>
<tr><th></th><th>Number of marks awarded</th></tr>
</table>
</td>
<td>Guidance on how the mark scheme should be applied.

The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would</td>
<td>(6)</td>
</tr>
</table>

		for structure of answer and sustained lines of reasoning	score zero marks for reasoning. If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s). Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning.	
	Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2		
	Answer is partially structured with some linkages and lines of reasoning	1		
	Answer has no linkages between points and is unstructured	0		

	Indicative content 1. The higher the concentration (of acid or $Cr_2O_7^{2-}$) the higher the rate 2. Because the collision frequency increases 3. The higher the temperature the faster the rate 4. Because more particles have an energy greater than the activation energy / more successful collisions 5. Excess / concentrated oxidising agent ensures complete oxidation 6. Heat under reflux ensures complete oxidation	I2 can be scored independent of I1 must be linked to heating / higher temperature. Allow 'more effective collisions', Allow 'only propanoic acid is formed' / 'no propanal is formed' as alternative for 'complete oxidation' in I5 and I6 Ignore any reference to pressure	

Question Number	Answer	Additional guidance	Mark
23(c)	• colour of the potassium dichromate(VI) / chromium(III) will mask the colour of the indicator or the reaction mixture will contain hydrogen ions / acid (present from the oxidising agent)	Ignore references to 'not a sharp colour change' Allow any named mineral acid	**(1)**

Question Number	Answer	Additional guidance	Mark
23(d)(i)	An answer that makes reference to the following points • colourless **(1)** to • (pale) pink **(1)**	Colours in the reverse order scores one Do not award red / purple	**(2)**

Question Number	Answer	Additional guidance	Mark
23(d)(ii)	An answer that makes reference to two of the following points: • First titre likely to be a rangefinder / rough titration / estimate (so done quickly) **(1)** • There was an air bubble (in the burette jet which fills before the titration starts) **(1)** • **Burette** rinsed with water (rather than sodium hydroxide) **(1)**	Allow 'not added dropwise' (near end point) / 'overshot at end point' Allow 'some water still in the burette after rinsing' **Ignore** pre-titration errors parallax errors water in conical flask **Do not award** lack of swirling of conical flask water in pipette	**(2)**

Question Number	Answer	Additional guidance	Mark
23(d)(iii)	• calculation of average titre **(1)** • calculation of moles of NaOH(aq) in average titre and deduction of moles of propanoic acid in 25.0 cm^3 **(1)** • calculation of moles of propanoic acid in 250 cm^3 **(1)** • Evidence of correct M_r **(1)** • calculation of mass of propanoic acid in the sample **(1)**	<u>Example of calculation</u> (22.20 + 22.10) / 2 = 22.15 cm^3 (22.15/1000) x 0.00668 = 1.47962 x 10^{-4} (mol) 1:1 reaction so = 1.47962 x 10^{-4} (mol) 1.47962 x 10^{-4} x 10 = 1.47962 x 10^{-3} (mol) 74 (g mol^{-1}) 1.47962 x 10^{-3} x 74 = 0.10949 (g) = 0.109 (g) / 0.11 (g) Correct answer with no working scores 5 Final answer to 2 or 3 SF Allow TE at each stage	**(5)**

Question Number	Answer	Additional guidance	Mark
23(d)(iv)	calculation of mass of propanoic acid in mg **(1)** calculation of mass of propanoic acid in mg kg^{-1} and comparison to limit **(1)**	Example of calculation 0.109 x 10^3 = 109 (mg) Comment This mark may be evident in d(iii) 109 x 20 = 2180 (mg kg^{-1}) so within permitted range M1 is subsumed by M2 Allow TE from (d)(iii) Ignore SF except 1 SF	**(2)**

Question Number	Answer	Additional guidance	Mark
23(d)(v)	An answer that makes reference to one of the following points: • (below the limit) the food would become mouldy (too quickly) / would not stop the food decomposing / would not be an effective preservative • (or above the limit) the food tastes bad / becomes (too) acidic / becomes inedible / becomes corrosive / becomes toxic	Ignore harmful	**(1)**

(Total for Question 23 = 20 marks)

Total for Section C = 20 marks

TOTAL FOR PAPER = 80 MARKS