Mark Scheme (Results)

October 2020

Pearson Edexcel International Advanced Subsidiary Level
In Chemistry (WCH12)
Paper 1: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

Section A

Question Number	Answer	Mark
1	**The only correct answer is C**(+121.5) ***A** is incorrect because this is the enthalpy of atomisation of 2 mol of chlorine atoms* ***B** is incorrect because the enthalpy of atomisation is endothermic and refers to 2 mol of chlorine atoms* ***D** is incorrect because the enthalpy of atomisation is endothermic*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is A** (exothermic, increases) ***B** is incorrect because in exothermic reactions, temperatures increase* ***C** is incorrect because reactions with a negative enthalpy change are not endothermic* ***D** is incorrect because reactions with a negative enthalpy change are not endothermic and the temperature increases*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is D** (water is a good solvent for ionic compounds) *A is incorrect because the less open structure of water compared to ice is due to hydrogen bonding* *B is incorrect because the reduction in density of ice compared to water is due to hydrogen bonding* *C is incorrect because the expansion of volume of ice compared to water is due to hydrogen bonding*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is D** (X,Z,Y) *A is incorrect because Y has the highest boiling temperature and X will have a boiling temperature below that of the singly branched chain alkane Z* *B is incorrect because although X has the lowest boiling temperature, Y will have a boiling temperature above that of the singly branched chain alkane, Z* *C is incorrect because Y has the highest boiling temperature and X has the lowest boiling temperature*	**(1)**

Question Number	Answer	Mark
5(a)	**The only correct answer is B** (disproportionation) *A is incorrect because no species has been replaced/displaced* *C is incorrect because no species has been eliminated* *D is incorrect because water is produced and no species is hydrolysed*	**(1)**

Question Number	Answer	Mark
5(b)	**The only correct answer is B** (4.2×10^{-5} mol s^{-1}) *A is incorrect because incorrect units for the Molar Volume of a gas has been used* *C is incorrect because the stoichiometry has not been taken into account* *D is incorrect because the stoichiometry is incorrect*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is A** (14,6,7) *B is incorrect because the charges do not balance and the number of electrons is incorrect* *C is incorrect because the oxygen atoms do not balance and the charges do not balance* *D is incorrect because the charges do not balance and the oxygen atoms do not balance*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is D** (KO_2) *A is incorrect because in this oxide potassium would have an oxidation number of +1/4* *B is incorrect because in this oxide potassium would have an oxidation number of +1/2* *C is incorrect because in this oxide potassium would have an oxidation number of +3/4*	**(1)**

Question Number	Answer	Mark
8(a)	**The only correct answer is B** (lithium nitrate) *A is incorrect because barium has a green colour in the flame test* *C is incorrect because magnesium does not have a red colour in the flame test* *D is incorrect because rubidium nitrate does not produce nitrogen dioxide when heated*	**(1)**

Question Number	Answer	Mark
8(b)	**The only correct answer is A** (brown and blue to red) ***B*** *is incorrect because nitrogen dioxide would have no effect on damp red litmus paper* ***C*** *is incorrect because nitrogen dioxide is brown* ***D*** *is incorrect because nitrogen dioxide is brown and would have no effect on damp red litmus paper*	**(1)**

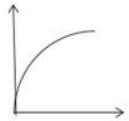
Question Number	Answer	Mark
9	**The only correct answer is A** (hydrogen fluoride only) ***B*** *is incorrect because sulfuric acid is not a strong enough oxidising agent to oxidise the fluoride ion* ***C*** *is incorrect because the fluoride ion is not a strong enough reducing agent to reduce sulfuric acid* ***D*** *is incorrect because the fluoride ion is not a strong enough reducing agent to reduce sulfuric acid and sulfuric acid is not a strong enough oxidising agent to oxidise the fluoride ion*	**(1)**

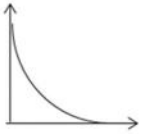
Question Number	Answer	Mark
10(a)	**The only correct answer is B** (v) *A is incorrect because u is the activation energy for the reaction R→ P* *C is incorrect because w is the activation energy for the reaction P→ R* *D is incorrect because x is the enthalpy change for the reaction P→ R*	**(1)**

Question Number	Answer	Mark
10(b)	**The only correct answer is C** (w) *A is incorrect because u is the activation energy for the reaction R→ P* *B is incorrect because v is the enthalpy change for the reaction R→ P* *D is incorrect because x is the enthalpy change for the reaction* P→R	**(1)**

Question Number	Answer	Mark
10(c)	**The only correct answer is C** (u −w = v) *A is incorrect because v+x =0 and u+w is the sum of the activation energies* ***B** is incorrect because w-x = u* ***D** is incorrect because u-v = w (not x)*	**(1)**

Question Number	Answer	Mark
11(a)	**The only correct answer is B** (1.20 dm^3) *A is incorrect because the limiting factor of the hydrochloric acid has been neglected* ***C** is incorrect because the limiting factor of the hydrochloric acid has been neglected and the answer would be correct if the units were cm^3* ***D** is incorrect because the answer would be correct if the units were cm^3*	**(1)**

Question Number	Answer	Mark
11(b)	**The only correct answer is B**  *A is incorrect because the volume of gas is shown decreasing with time* *C is incorrect because the gradient is shown increasing with time* *D is incorrect because the gradient is shown as constant*	**(1)**

Question Number	Answer	Mark
11(c)	**The only correct answer is A**  *B is incorrect because the rate is shown increasing with time* *C is incorrect because the rate is shown as constant* *D is incorrect because the rate is shown increasing with time*	**(1)**

Question Number	Answer	Mark
12(a)	**The only correct answer is D** (*E*-oct-5-en-3-ol) ***A** is incorrect because the wrong priority has been assigned and the E/Z nomenclature is incorrect* ***B** is incorrect because the wrong priority has been assigned* ***C** is incorrect because this is the name of the Z isomer*	**(1)**

Question Number	Answer	Mark
12(b)	**The only correct answer is A** ($Cl_2(g)$) ***B** is incorrect because only one chlorine atom would be added* ***C** is incorrect because PCl_5 does not react with a C=C bond* ***D** is incorrect because potassium chloride does not react with either a C=C bond or -OH group*	**(1)**

Question Number	Answer	Mark
12(c)	**The only correct answer is C** ($PCl_5(s)$) ***A** is incorrect because chlorine does not react with an alcohol* ***B** is incorrect because hydrogen chloride does not react with an alcohol* ***D** is incorrect because potassium chloride does not react with either a C=C bond or -OH group*	**(1)**

(Total for Section A = 20 marks)

Section B

Question Number	Answer	Additional Guidance	Mark
13(a)(i)	All three arrowheads down at any point in/on the line **(1)** AND coefficients are 3 for CO_2 **and** 4 for H_2O		**(1)**

Question Number	Answer	Additional Guidance	Mark
13(a)(ii)	• calculation for enthalpy change on LHS **(1)** • correct application of Hess's Law and answer with correct sign **(1)**	Example of calculation; (3 x −393.5) + (4 x−285.8) = (−1180.5) + (− 1143.2) = −2323.7(kJ mol^{-1}) +2219 -2323.7 = -104.7/-105 (kJ mol^{-1}) Correct answer with sign (2)	**(2)**

Question Number	Answer	Additional Guidance	Mark
13(b)(i)	An explanation that makes reference to the following points: • each alkane differs from the next by -CH_2/one carbon atom and two hydrogen atoms/same number of C-C bonds and same number of C-H bonds/ forms a homologous series/ has a general formula C_nH_{2n+2} **(1)** • bonds broken and/or made increase regularly/ each -CH_2 combusted adds almost the same amount of energy/ bond energies are very similar **(1)**	Ignore references to intermolecular forces/boiling points	**(2)**

Question Number	Answer	Additional Guidance	Mark
13(b)(ii)	An explanation that makes reference to **two** of the following points: • butane is a gas and pentane is a liquid (at 298 K / under standard conditions) **(1)** • liquids vaporise before burning/combustion **(1)** • (pentane is a liquid so) some of the energy released by combustion is used to vaporise / vaporisation is endothermic OR More energy is needed to break intermolecular forces in pentane or reverse argument **(1)**	Pentane vaporises before combustion **and** butane is (already) a gas would score M1 and M2	**(2)**

Question Number	Answer	Additional Guidance	Mark
13(b)(iii)	An explanation that makes reference to the following points: • the intermolecular forces are London / dispersion forces / instantaneous dipole – induced dipole forces **(1)** • these forces depend on the number of electrons which increase (as the number of carbon atoms increase) **(1)** • more **energy** is needed to break these intermolecular forces/to separate the molecules (so the boiling temperature increases) **(1)**	Any reference to hydrogen bonding or permanent dipole interaction loses M1 and M2 ALLOW: Van der Waals forces for London forces ALLOW: increase in surface area/more points of contact (as the number of carbon atoms increase) Any reference to breaking of covalent bonds loses M3	**(3)**

(Total for Question 13 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
14(a)	• balanced equation **(1)** • state symbols correct **(1)**	Example of equation $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$ ALLOW 1 mark for LHS or RHS totally correct	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(b)	• moles of hydrochloric acid in titre **(1)** • moles $Ca(OH)_2$ in 1 dm^3 **(1)** • mass $Ca(OH)_2$ in 1 dm^3 **(1)** • answer to 2 or 3 SF **(1)**	Example of calculations: $23.40 \times 0.0500 \div 1000 = 0.00117/1.17 \times 10^{-3}$ (moles) $0.00117 \div 2 = 0.000585$ (moles) in 25 cm^3 $0.000585 \times 1000 \div 25 = 0.0234/2.34 \times 10^{-2}$ (moles/moles dm^{-3}) $0.0234 \times 74.1/74 = 1.7339/1.7316$ (g) 1.7/1.73 (g dm^{-3}) to 2 or 3 SF Penalise incorrect units once only Answer to 2 or3 SF from a calculated mass Correct answer with no working scores 4 Allow TE throughout	**(4)**

Question Number	Answer	Additional Guidance	Mark
14(c)	• as magnesium hydroxide is less soluble/concentration of hydroxide ions would be smaller **(1)** • titre value would be smaller **(1)**	Allow reverse argument Do not award magnesium hydroxide is insoluble M2 depends on correct M1 except when magnesium hydroxide is described as insoluble ALLOW a value less than 23.00	**(2)**

(Total for Question 14 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
15(a)	• Silver is oxidised from 0 to +1 **(1)** • Nitrogen is reduced from +5 to +4 **(1)**	These may be shown on the equation ALLOW one mark for silver is oxidised **and** nitrogen is reduced or all oxidation numbers correct ALLOW 1 or 1+ for +1	**(2)**

Question Number	Answer		Additional Guidance	Mark
15(b)(i)	• calculation of energy change	(1)	Examples of calculation Q = 50.0 ÷ 1000 x 4.18 x 5.2 = 1.0868 (kJ)/1086.8(J)	(3)
	• calculation of no of moles	(1)	1.0868 ÷ 36.1 = 0.030105/3.0105 $x10^{-2}$ (moles)	
	• calculation of concentration	(1)	0.030105 ÷ 50 x 1000 = 0.602105(mol dm^{-3}) = 0.602/0.60/0.6 (mol dm^{-3}) Ignore SF	

Question Number	Answer		Additional Guidance	Mark
15(b)(ii)	• calculation of moles of ppt	(1)	Example of calculation 5.96 ÷ 187.8 = 0.0317359 (moles)	(2)
	• calculation of concentration	(1)	0. 00317359 ÷ 50 x 1000 = 0.634718(mol dm^{-3}) Ignore SF except 1 SF ALLOW use of 188 as M_r Penalise incorrect rounding once only	

Question Number	Answer	Additional Guidance	Mark
15(b)(iii)	An explanation that makes reference to: • the calorimetry method (student A) is lower because heat may be lost to the surroundings /absorbed by the container or apparatus **(1)** • the gravimetric method (student B) is higher because the product may have been wet/ have impurities **(1)**	Do not award: non-standard conditions, just "incomplete reaction", human error, incorrect solution density/heat capacity ALLOW: not all the **solution** reacted	**(2)**

(Total for Question 15 = 9 marks)

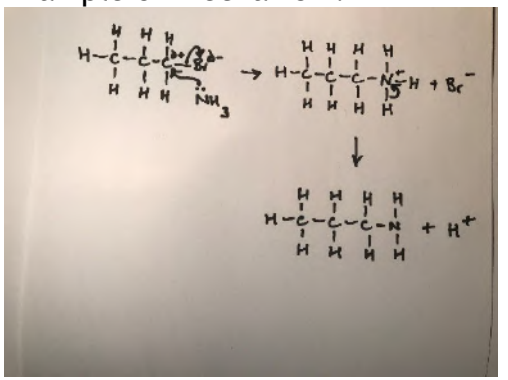
<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>16(a)</td><td>
<table>
<tr><th>Reaction</th><th>Reagent</th><th>Solvent</th><th>Type of reaction</th></tr>
<tr><td>1</td><td>(potassium Hydroxide)</td><td>Water/aqueous</td><td>substitution</td></tr>
<tr><td>2</td><td>(ammonia)</td><td>Ethanol/C_2H_5OH</td><td>substitution</td></tr>
<tr><td>3</td><td>sodium/potassium cyanide NaCN/KCN</td><td>(ethanol)</td><td>substitution</td></tr>
<tr><td>4</td><td>potassium/sodium hydroxide KOH/NaOH</td><td>Ethanol/C_2H_5OH</td><td>(elimination)</td></tr>
</table>
(1)
(1)
(1)
(1)
</td><td>IGNORE nucleophilic in first three reactions but penalise electrophilic/free radical once only
ALLOW alcoholic for reactions 2 and 4

Do not award: cyanide/CN^-/HCN

Do not award OH^-

8 correct scores 4 marks
6/7 correct scores 3 marks
4/5 correct scores 2 marks
2/3 correct scores 1 mark</td><td>(4)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
16(b)	butanenitrile **(1)**	ALLOW butane nitrile Butan(e)(1) nitrile Butanitrile Do not award 1-nitrile butane	**(1)**

Question Number	Answer	Additional Guidance	Mark
16(c)	• Curly arrow to show attack on C-Br carbon by lone pair of electrons on the N of ammonia and dipole C-Br **(1)** • Curly arrow to show loss of Br^- **(1)** • Curly arrow to show loss of H^+ from intermediate **(1)**	Example of mechanism:  Leaving groups must be shown for M2 and M3 but penalise only once Could show another molecule of ammonia or bromide ion acting as a base to remove H^+	**(3)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>16(d)</td>
<td>
This question assesses a 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 for structure and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated thoughout.</td><td>2</td></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, an answer 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 are no linkages between points, the same five 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 score zero marks for reasoning.
</td>
<td>(6)</td>
</tr>
</table>

	Answer is partially structured with some linkages and lines of reasoning.	1	If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s).	
	Answer has no linkages between points and is unstructured.	0		
	Indicative points: • (mechanism is nucleophilic) substitution		Ignore hydrolysis as given in the question	
	• (Precipitation/precipitate of) silver halide forms		Can be shown in an equation Incorrect colours of ppts loses 1RP	
	• the time taken for the precipitate to form/rate of reaction depends on the carbon – halogen bond strength		Ignore length of bond in IP3 and IP4 Incorrect reason for decrease loses 1 RP. Ignore references to electronegativity.	
	• Strength/bond enthalpy of the C-Halogen bond decreases going down group 7/any correct comparison of at least two Hal-C bond strengths (because the **atomic** radius increases)		Consideration of intermolecular forces loses 1 RP	
	• The reactivity/rate of reaction of the bromoalkanes increases $1^o < 2^o < 3^o$/		IP5 could be scored by correct comparison of the reactivity/rate of reaction of any 2 bromoalkanes	
	• 1-bromobutane is 1^o/2-bromobutane is 2^o /2-bromo-2-methyl butane is 3^o		ALLOW the production of the appropriate carbocation	

(Total for Question 16 = 14 Marks)

(Total for Section B = 41 Marks)

Section C

Question Number	Answer	Additional Guidance	Mark
17(a)(i)	An explanation that makes reference to the following points: EQUILIBRIUM • there are more (gaseous) moles/molecules on LHS / less (gaseous) moles on RHS **(1)** • (so high pressure) moves equilibrium to RHS / increases yield of methanol **(1)** OR KINETIC • an increase in pressure increases the number/rate of collisions (of molecules) **(1)** • (So) increases the rate of reaction **(1)**	NOTE If two marks are scored they must be derived from either the kinetic or equilibrium explanations. If both explanations are used any incorrect statement negates one mark. Any reference to atoms scores 0 for M1 If numbers of moles given, they must be correct M2 depends on M1 for both explanations	**(2)**

Question Number	Answer		Additional Guidance	Mark
17(a)(ii)	An explanation that makes reference to the following points: • the (forward) reaction is exothermic • a lower temperature would increase the yield /move equilibrium to RHS or reverse argument • a (compromise) temperature is used to ensure the rate is fast enough (without the equilibrium position moving too far to the LHS) ALLOW (increased/high/stated) temperature increases the rate of reaction	**(1)** **(1)** **(1)**	Note: if (forward) reaction is identified as endothermic then neither M1 nor M2 can be scored Ignore references to cost/economics/environmental	**(3)**

Question Number	Answer	Additional Guidance	Mark
17(a)(iii)	An explanation that makes reference to one of the following points: (a catalyst) allows a lower temperature to be used / less energy is needed **(1)** (a copper catalyst is specific for methanol) so there is less waste/fewer other products/improves atom economy **(1)** (a catalyst) is not used up/can be used again **(1)**	Ignore just increases rate/ lowers activation energy	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(b)(i)	Reagents • sodium / potassium dichromate ((VI)) / $Na_2Cr_2O_7$/$K_2Cr_2O_7$/ $Cr_2O_7^{2-}$ **(1)** **and** acidified / H+ / sulfuric acid Reaction conditions • (Heat under) **reflux** **(1)**	Do not award potassium manganate(VII) M2 dependent on M1 or near miss	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(b)(ii)	$CH_3OH + 2[O] \longrightarrow HCOOH + H_2O$ **(1)**	Allow; CH_2O_2,CHOOH,HCO_2H	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(b)(iii)	Functional group test add any carbonate /hydrogencarbonate OR add magnesium (powder/ribbon) **(1)** OR addition of any alcohol (and strong acid to form an ester) Positive result **(1)** effervescence / bubbles / gas given off (turns lime water cloudy OR burns with a "pop") OR Fruity smell	Do not award the addition of Na or PCl_5 Ignore reference to indicator M2 depends on M1 or near miss	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(b)(iv)	• infra red absorption at 3750 – 3200 cm^{-1} /3300 cm^{-1} due to O-H of alcohol/methanol **(1)** • infra red absorption at 1725 - 1700 cm^{-1} /1700 cm^{-1} due to C=O group (of carboxylic acid/methanoic acid) **(1)** • peaks due to methanol/alcohol would disappear/be absent **(1)**	Allow the peak at 1020 for methanol in the fingerprint region Accept infra red absorption at 3300 – 2500 cm^{-1} /2500 cm^{-1} showing O-H group of COOH Allow the fingerprint region would change Penalise use of OH^-/-OH once only. In M1 and M2 penalise absence of bonds once only	**(3)**

Question Number	Answer	Additional Guidance	Mark
17(c)(i)	An explanation that makes reference to two of the following points: • burning (petrol/methanol/fuel) produces CO_2 /greenhouse gases/contributes to global warming **(1)** • the methanol is made from captured CO_2 / is made from CO_2 that would have been released anyway **(1)** • the increase in global temperatures will be reduced **(1)**	IGNORE references to ozone depletion Do not award : methane is produced	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(c)(ii)	• 352g carbon dioxide (released per mole octane) **(1)**	Example calculation: 8 x 44 = 352 (g)	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(c)(iii)	• Mass petrol reduction per year **(1)** • Mass CO_2 reduction **(1)** OR • Moles of petrol used per year **(1)** • 5% reduction in CO_2 **(1)** OR • 5% reduction in moles of petrol used per year **(1)** • Mass CO_2 produced **(1)**	Example of calculation: 1200 x 0.05 = 60 (kg) 60 ÷ 114 x 352 = 185.26 kg (1200 x 1000) ÷ 114 = 10526 (moles) 352 x 10526 x 5 ÷ 100 = 185260 g = 185.26 kg 1200 x 1000 x 0.05 ÷ 114 = 526.3 (moles) 526.3 x 352 ÷ 1000 = 185.26 kg IGNORE SF except 1 SF correct answer with no working scores 2	**(2)**

(Total for Section C = 19 Marks)

Total for paper = 80 Marks