Mark Scheme (Results)

January 2020

Pearson International Advanced 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 D** ($\frac{1}{2}H_2(g) + \frac{1}{2}I_2(s) \longrightarrow HI(g)$) ***A*** *is incorrect because neither element is in its molecular form* ***B*** *is incorrect because 2 mol of hydrogen iodide is formed* ***C*** *is incorrect because iodine is not in its standard state*	**1**

Question Number	Answer	Mark
2	**The only correct answer is C** (8.7 ^{o}C) ***A*** *is incorrect because the ratio of 3:4 rather than 4:3 has been used* ***B*** *is incorrect because the change in volume of the final solution has been ignored* ***D*** *is incorrect because the change in moles and the change in volume of HCl* has been ignored	**1**

Question Number	Answer	Mark
3	**The only correct answer is D** (391 kJ mol^{-1}) ***A*** *is incorrect because only 1 mol of hydrogen has been used* ***B*** *is incorrect because the enthalpy of the reaction has been subtracted in the calculation* ***C*** *is incorrect because the enthalpy of the reaction has been ignored in the calculation*	**1**

Question Number	Answer	Mark
4	**The only correct answer is C** (6.0) ***A*** *is incorrect because a 1:1 ratio has been used* ***B*** *is incorrect because that is the moles produced in the stoichiometric equation* ***D*** *is incorrect because oxygen is in excess and has not been taken into account*	**1**

Question Number	Answer	Mark
5	**The only correct answer is B** ($CH_3CH_2CH_2CH_2CH_2CH_3 > (CH_3)_2CHCH_2CH_2CH_3 > (CH_3)_3CCH_2CH_3$) ***A*** *is incorrect because as the chain length of alkanes increases the boiling temperature increases* ***C*** *is incorrect because as the number of hydroxyl groups increases so the amount of hydrogen bonding will increase and the boiling temperature will increase* ***D*** *is incorrect because as the number of electrons increases so the boiling temperature increases*	**1**

Question Number	Answer	Mark
6(a)	**The only correct answer is B** (iodide ions reduce chlorine) ***A*** *is incorrect because the chlorine is reduced* ***C*** *is incorrect because the iodide ions are oxidised* ***D*** *is incorrect because iodide ions are oxidised and chlorine is reduced*	**1**

Question Number	Answer	Mark
6(b)	**The only correct answer is A** (the upper layer is purple) ***B*** *is incorrect because cyclohexane is less dense than water* ***C*** *is incorrect because iodine forms a purple (molecular)solution in cyclohexane* ***D*** *is incorrect because iodine is considerably more soluble in cyclohexane than in water*	**1**

Question Number	Answer	Mark
7	**The only correct answer is B** (first ionisation energy decreases) ***A*** *is incorrect because ionic radius increases with increasing atomic number* ***C*** *is incorrect because metallic bonding becomes weaker with increasing atomic number* ***D*** *is incorrect because the reactivity with water increases as the atomic number increases*	**1**

Question Number	Answer	Mark
8	**The only correct answer is C** (thermal stability of Group 2 nitrates increases) ***A*** *is incorrect because solubility of sulfates decreases going down Group 2* ***B*** *is incorrect because solubility of hydroxides increases going down Group 2* ***D*** *is incorrect because the thermal stability of carbonates increases going down Group 2*	**1**

Question Number	Answer	Mark
9	**The only correct answer is D** (6, 3, 5, 1, 3) ***A*** *is incorrect as the oxygen atoms do not balance* ***B*** *is incorrect as the oxygen atoms do not balance* ***C*** *is incorrect as the iodine atoms do not balance*	**1**

Question Number	Answer	Mark
10(a)	**The only correct answer is A** (is yellow in colour and is insoluble in concentrated aqueous ammonia) ***B*** *is incorrect because silver iodide is insoluble in concentrated aqueous ammonia* ***C*** *is incorrect because silver iodide is not cream* ***D*** *is incorrect because silver iodide is not cream and is insoluble in concentrated aqueous ammonia*	**1**

Question Number	Answer	Mark
10(b)	**The only correct answer is D** (73%) ***A*** *is incorrect because only the numbers of atoms are used in the calculation* ***B*** *is incorrect because the sum of the reactants and products are used in the calculation* ***C*** *is incorrect because only the numbers of products are used in the calculation*	**1**

Question Number	Answer	Mark
11 (a)	**The only correct answer is D** (substitution) ***A*** *is incorrect because a chlorine atom has been replaced* ***B*** *is incorrect because a hydroxyl group has been added to the reactant molecule* ***C*** *is incorrect because the reaction is not redox*	**1**

Question Number	Answer	Mark
11(b)	**The only correct answer is A** (higher because ethanol molecules can hydrogen bond) ***B*** *is incorrect because the number of atoms is irrelevant* ***C*** *is incorrect because the boiling temperature of ethanol is higher* ***D*** *is incorrect because the boiling temperature of ethanol is higher*	**1**

Question Number	Answer	Mark
11(c)	**The only correct answeris B** (faster because the C-Br bond is weaker than the C-Cl bond) ***A*** *is incorrect because the rate of the reaction depends on the bond strength rather than polarity* ***C*** *is incorrect because the rate is faster* ***D*** *is incorrect because the rate is faster*	**1**

Question Number	Answer	Mark
12 (a)	**The only correct answer is B** (11.2) ***A*** *is incorrect because the volume of unreacted oxygen has been ignored* ***C*** *is incorrect because the volume of unreacted oxygen has been ignored and the water produced has been treated as steam* ***D*** *is incorrect because the water produced has been treated as steam*	**1**

Question Number	Answer	Mark
12(b)	**The only correct answer is B** (1600) ***A*** *is incorrect because the volume of unreacted oxygen has been ignored* ***C*** *is incorrect because the reaction of carbon dioxide with sodium hydroxide has been ignored and the volume of unreacted oxygen has also been ignored* ***D*** *is incorrect because the volume of unreacted oxygen has been ignored and the water produced has been treated as steam*	**1**

Question Number	Answer	Mark
13	**The only correct answer is D** (2-chloro-2-methylpropane) ***A*** *is incorrect because because 1-*chlorobutane *is a primary halogenoalkane and would not react immediately* ***B*** *is incorrect because 2-*chlorobutane *is a secondary halogenoalkane and would not react immediately* ***C*** *is incorrect because 1-*chloro-2-methylpropane *is a primary halogenoalkane and would not react immediately*	**1**

Question Number	Answer	Mark
14(a)	**The only correct answer is B** (29) ***A*** *is incorrect because propanone would be expected to have a fragment peak at m/z 15* ***C*** *is incorrect because propanone would be expected to have a fragment peak at m/z 43* ***D*** *is incorrect because propanone would be expected to have a molecular ion peak at m / z 58*	**1**

Question Number	Answer	Mark
14(b)	**The only correct answer is C** (warm with acidified potassium dichromate(VI), turns green, no change) ***A*** *is incorrect because propanone does not give a positive result with Fehling's solution* ***B*** *is incorrect because neither propanal nor propanone contains an OH group* ***D*** *is incorrect because neither propanal nor propanone contains a -COOH group*	**1**

Section B

Question Number	Answer	Additional Guidance	Mark
15(a)(i)	• the hydrated crystals already have a certain amount/ 4.5 g / 5 moles of /(more) water or 4.5 g is the difference in mass between the hydrated and anhydrous salt **(1)** • so that the total amount/mass/ volume of water is kept the same/ 50 cm^3/ 58 g **(1)**	Allow: anhydrous crystals have **no** water Do not award: less water Ignore references to differences in solubility Do not award: 58 cm^3	**2**

Question Number	Answer	Additional Guidance	Mark
15 a(ii)	• calculation of energy transferred = mass x 4.2 x ΔT **(1)** • calculation of moles = mass ÷ M_r **(1)** • calculation of $\Delta_{soln}H$ = − Energy in kJ ÷ moles **(1)**	Example of calculation: 50 x 4.2 x 16.0 = 3360 (J) / 3.360kJ 8 / 159.6 = 0.050125 Allow 8 / 159.5 = 0.050157 3.36 ÷ 0.0501 = −67.03242 /−66.98965 (kJ mol $^{-1}$) (−67.066 /−66.932/ from rounded values) Ignore SF except 1 SF Do not award M3 for a positive answer or no sign TE throughout Comment: ~~If mass of salt has been added i.e. 58 g then M1 is lost but value for heat energy produced will be 3.8976 kJ~~ ~~M2 can be scored and also M3 for −77.758 kJ~~ mol^{-1} ~~If value of moles has been rounded to 0.05 value~~ for M3 is -67.2 kJ mol^{-1} Accept answer in J mol^{-1} ~~if units given~~ Do not penalise mol^{-}	**3**

Question Number	Answer	Additional Guidance	Mark
15(a)(iii)	• two arrowheads both pointing down	Ignore: additional arrows(working)	**1**

Question Number	Answer	Additional Guidance	Mark
15 a (iv)	• use of correct Hess cycle $\Delta_r H$ = $\Delta_{soln}H$(anhydrous) − $\Delta_{soln}H$(hydrated) i.e. correct application of Hess cycle **(1)** • correct evaluation including sign **(1)**	<u>Example of calculation:</u> -67.0 –12.6 = −79.6(kJ mol^{-1}) TE from (a)(ii) but not from (a)(iii) Ignore SF	**2**

Question Number	Answer	Additional Guidance	Mark
15(b)	An answer that make reference to one reason for each direction. Forward • adding water to the anhydrous salt will produce a solution **and** does not form a solid • some of the water may turn to steam/be lost (because the forward reaction is exothermic) • difficult to determine when exactly 5 mol water to 1 mol $CuSO_4$ has been added to **form asolid** • the temperature of a solid is difficult tomeasure **(1)** Reverse • the hydrated salt has to be heated/ the energy from the Bunsen burner is difficult to take into account/ hard to measure the temperature when heating • the temperature of a solid is difficult tomeasure • the salt may decompose further **(1)**	Ignore references to ΔH measurements in both forward and reverse Ignore "heat loss (tothe surroundings)" Do not award if same reason given for "forward"	**2**

Question Number	Answer	Additional Guidance	Mark
15(c)	An description that makes reference to the following points: • (water molecules) break the (ionic) lattice/solid **(1)** • (water molecules) can hydrate/surround the ions / ion-dipole interactions form **(1)**	Accept Dissociate the ions Do not award references to atoms/molecules of coppersulfate Do not award references to hydrogen bonding of Cu^{2+}/ reactions between copper sulfate and water	**2**

Question Number	Answer	Additional Guidance	Mark
15(d)(i)	• calculation of moles HCl in mean titre **(1)** • calculation of moles sodium carbonate in 25 cm^3 and 250 cm^3 **(1)**	Example of calculation: 25.60 x 0.0900 ÷ 1000 = 0.002304 / 2.304 x 10^{-3} (mol) 0.002304 ÷ 2 = 0.001152 / 1.152 x 10^{-3} (mol) 0.001152 x 250/25 = 0.01152 /1.152 x 10^{-2} (mol) Ignore SF except 1 SF/ units TE at each stage	**2**

Question Number	Answer	Additional Guidance	Mark
15 d(ii)	Method 1 M1 calculation of mass sodium carbonate in solution **(1)** M2 calculation of mass of water of crystallisation **(1)** M3 calculations of moles of water **(1)** M4 calculation of water : Na_2CO_3 mole ratio and value of x to a whole number **(1)** Method 2 M1 calculation of mass of 1 mole **(1)** M2 calculation of mass of water in sample **(1)** M3 calculation of moles of water **(1)** M4 value of x to a whole number **(1)**	Examples of calculation: 0.01152 × 106 =1.22112 3.29 – 1.22112 =2.06888 2.06888 ÷ 18 =0.114938 0.114938 ÷ 0.01152 = 9.98 = 10 3.29 ÷ 0.01152 = 285.59 285.59 – 106 = 179.59 179.59 ÷ 18 = 9.977 = 10 TE at each step and from(i) Correct answer scores M4 only ~~Comment: if candidatehas used 25 cm^3 answer in (i) might be 1.125 x 10^{-2} and TE in (ii) could give 10.35 rounded to 10 4 marks~~	**4**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*16 (a)</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

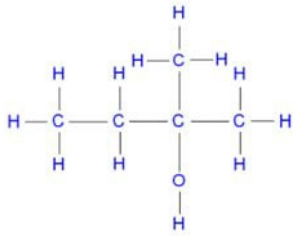
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

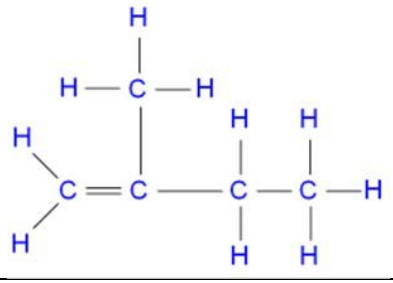
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
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 of answer and sustained line of reasoning</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning.</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured.</td><td>0</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.
If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s).</td><td>6</td></tr>
</table>

	Indicative content • IP1 methane has (only) London forces / dispersion forces / instantaneous dipole - induced dipole forces • IP2 London forces are weak**er** than hydrogen bonds • IP3 NH_3/ H_2O / HF have hydrogen bonds • IP4 the hydrogen bond is strong**er** in HF than H_2O / NH_3 or London forces are same/similar as they have the same number of electrons • IP5 Fluorine has high**er** electronegativity than N or O / is the **most** electronegative element/ H-F bond is the **most** polar • IP6 Water has **more** hydrogen bonds (than ammonia/ HF)	Any mention of breaking covalent bonds or a different number of electrons negates 1 reasoning mark Allow van der Waals' forces Allow reverse Do not award ammonia having dipole-dipole bonds ratherthan hydrogen bonds Allow ratio of 2:1 in H_2O with NH_3/HF	

Question Number	Answer	Additional Guidance	Mark
16b	An answer that makes reference to the following points: Similarities • **both** produce hydrogen halides **(1)** • formation of hydrogen halideis protonation **(1)** • **both** give offmisty/steamy fumes **(1)** Differences • only the reaction of potassium bromide is redox/brom**ide** ions are stronger reducing agents than chlor**ide** ions **(1)** • (red)-brown fumes/liquid produced with potassium bromide **(1)** • sulfur dioxide/bromine given off with potassium bromide **(1)**	Both similarities and differences can be shown in equations or with observations Accept $KX + H_2SO_4 \rightarrow HX + KHSO_4$ Allow $2KX + H_2SO_4 \rightarrow 2HX + K_2SO_4$ Do not award white smoke/fumes Accept $2HBr + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O$ Do not award rotten egg smell/references to yellow solid ~~Comment:~~ ~~This can be awarded from an incorrect/unbalanced equation~~	**4**

Question Number	Answer	Additional Guidance	Mark
17(a)		Allow –OH Ignore connectivity of OH unless horizontal Ignore skeletal andstructural formulae Ignore length of bonds Do not award CH_3/C_2H_5 or missing H	1

Question Number	Answer	Additional Guidance	Mark
17(b)(i)	• (concentrated) phosphoric((V)) acid / H_3PO_4	Accept (concentrated) sulfuric acid / H_2SO_4 Do not award dilute sulfuric acid If formula and name are given, both must be correct Allow aluminium oxide / Al_2O_3	1

Question Number	Answer	Additional Guidance	Mark
17 b (ii)		Allow skeletal or structural formulae, $CH_2C(CH_3)C_2H_5$, or any combination	**1**

Question Number	Answer	Additional Guidance	Mark
17(b)(iii)	An explanation that makes reference to the following points: • (in both cases) there are two identical (functional) groups/atoms on one carbon (of the double bond) **(1)** • neither display geometric isomerism **(1)**	Comment Allow "on ends/ sides of the double bond" Ignore reference to restricted rotation about the doublebond Do not award molecules for groups/atoms M2 dependent on M1 ~~Comment: M2 can be awarded for e.g. "both have two methyl groups on one carbon (of the double bond)"~~ ~~Allow Max (1) for correct description of 2-methylbut-2-ene~~	**2**

Question Number	Answer	Additional Guidance	Mark
17(c)	• $CH_3CH_2CCl(CH_3)_2$ **(1)** • **tertiary carbocations** are more stable (than secondary carbocations)/have more electron donating groups **(1)**	Allow displayed or skeletal formulae Do not award $C_5H_{11}Cl$ or bromoalkane Ignore references to product stability Do not award just a comparison with primary carbocation stability	**2**

Question Number	Answer	Additional Guidance	Mark
17(d)(i)	• $(C_5H_{11}OH + PCl_5)$ $C_5H_{11}Cl + POCl_3 + HCl$	Ignore state symbols even if incorrect Accept PCl_3O	**1**

Question Number	Answer	Additional Guidance	Mark
17(d)(ii)	• this reaction is one step / the other method is a two-step process **(1)** • yield is higher because in the 2 step process both steps give 2 isomers/this reaction has no isomers /no organic by-products /no minor product **(1)**	Ignore higher atom economy,(non)reversible References to temperature and pressure	**2**

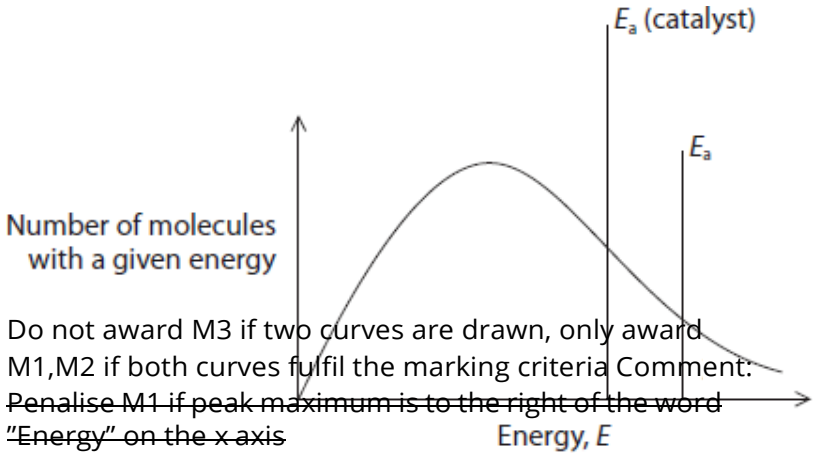
Question Number	Answer	Additional Guidance	Mark
17(d)(iii)	O-H (stretch) **and** 3750-3200 (cm^{-1})	Allow OH Do not award —OH	**1**

Question Number	Answer	Additional Guidance	Mark
17(e)	• 2-methylbutan-2-ol is a **tertiary** alcohol cannot be oxidised (in the liver so isexcreted unchanged) **(1)** • 2-methylbutan-1-ol (is a primary alcohol and) would be oxidised to a aldehyde (whichis toxic) **(1)**	Ignore any reference to further oxidation	**2**

Section C

Question Number	Answer	Additional Guidance	Mark
18 (a)	• calculation of M_r **(1)** • calculation of % nitrogen **(1)**	Example of calculation: (14 x 2)+(1x2) +12 +16 (=60) % = (28/60) x 100 = 46.667% TE on incorrect M_r Ignore SF except 1SF Correct answer with no working scores (2)	**2**

Question Number	Answer	Additional Guidance	Mark
18(b)	Suggestions that make reference to the following points: • (It is used for crops such as rice because) the ammonia produced will dissolve/react in the water/form ammonium ions (and not be lost) **(1)** • (In areas of unpredictable rainfall the urea will breakdown/decompose and) ammonia willescape/vapourise or farmers don't know when to apply the urea as it may be wasted **(1)**	Ignore references to eutrophication, global warming Do not award references to acid rain ammonia is absorbedby crops	**2**

Question Number	Answer	Additional Guidance	Mark
18(c)(i)	• the curve should be asymmetric and should start at the origin **(1)** • and be asymptotic to the x axis and must not end horizontally **(1)** • the Activation Energies should both lie to the right of the maximum and should be in the order shown i.e. E_a no catalyst should lie at higher energy **(1)**	Example of graph  Do not award M3 if two curves are drawn, only award M1,M2 if both curves fulfil the marking criteria Comment: ~~Penalise M1 if peak maximum is to the right of the word "Energy" on the x axis~~	**3**

Question Number	Answer	Additional Guidance	Mark
18(c)(ii)	• larger proportion / larger number / more molecules have energy greater than or equal to E_a so there are more successful collisions / rate increases. **(1)** • (because) the area (under the curve) to the right of/at a greater energy than E_a is larger **(1)**	May be shown on labelled diagram	**2**

Question Number	Answer	Additional Guidance	Mark
18(c)(iii)	• Higher pressure moves position of equilibrium forward/ to the right/ increases yield/ makesmore ammonia **(1)** • 4 (gaseous) moles/molecules on LHS and 2 (gaseous) moles / molecules on RHS **(1)**	If position of equilibrium moves to the left score (0) Allow more (gaseous) moles/molecules on LHS	**2**

Question Number	Answer	Additional Guidance	Mark
18(d)(i)	No changes in oxidation number	If oxidation numbers are given they must becorrect May be shown on the equation Ignore no element is oxidised or reduced	**1**

Question Number	Answer	Additional Guidance	Mark
18(d)(ii)	• a high temperature increases the rate of the reaction **(1)** • so the ammonia formed reacts quickly with the exhaust gases **(1)**	Comment Allow alternative approach • the forward reaction / formation of ammonia is endothermic **(1)** • (so) a high temperature increases yield of ammonia/moves position of equilibrium to the right/cooling would move position of equilibrium to the left/cooling would reduce the yield of ammonia **(1)**	**2**

Question Number	Answer	Additional Guidance	Mark
18(d)(iii)	• **N** in NH_3 is oxidised from −3 to 0 **(1)** • **N** in NO is reduced from (+)2 to 0 / **O** in O_2 is reduced from 0 to −2 **(1)** • no (element in a) single compound / molecule/species is (simultaneously) oxidisedand reduced **(1)**	May be shown in the equation Max 1 from M1 and M2 if "oxidised/reduced" are missing or reversed	**3**

Question Number	Answer	Additional Guidance	Mark
18(d)(iv)	Any two from • oxides of nitrogen dissolve in water to form acid rain/nitric acid • oxides of nitrogen cause breathing problems / asthma • depletion of the ozone layer • formation of (photochemical) smog	IGNORE: NO is apollutant/is toxic Do not award global warming/greenhouse gas	**2**