Mark Scheme (Results)

Summer 2018

Pearson Edexcel International Advanced Level in Chemistry (WCH02) Paper 01 Application 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.

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 meaning 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

Question Number	Answer	Mark
1	**The only correct answer is A** ***B*** *is not correct because* NH_3 *is trigonal pyramidal* ***C*** *is not correct because* H_3O^+ *is trigonal pyramidal* ***D*** *is not correct because* PCl_3 *is trigonal pyramidal*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is D** ***A*** *is not correct because* BF_3 *is trigonal pyramidal* ***B*** *is not correct because* CH_4 *is tetrahedral* ***C*** *is not correct because* H_2O *is V-shaped*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is C** ***A*** *is not correct because the fluoride ion is the least polarisable* ***B*** *is not correct because the fluoride ion is the least polarisable* ***D*** *is not correct because the fluoride ion is the least polarisable*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is A** ***B*** *is not correct because the bonding electron pair will be closer to the chlorine* ***C*** *is not correct because the hydrogen will be* $\delta+$ *and the chlorine* $\delta-$ ***D*** *is not correct because the bonding electron pair will be closer to the chlorine and the hydrogen will be* $\delta+$ *and the chlorine* $\delta-$	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is C** ***A*** *is not correct because equilibria are dynamic and the reactions continue* ***B*** *is not correct because equilibrium concentrations do not need to be equal* ***D*** *is not correct because this will only be true when* $\Delta H = 0$*, and is independent of the establishment of equilibrium*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is C** ***A*** *is not correct because oxidising agents are reduced* ***B*** *is not correct because oxidising agents are reduced and gain electrons* ***D*** *is not correct because oxidising agents gain electrons*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is C** ***A*** *is not correct because atomic radius increases as atomic number of Group 2 metals increases* ***B*** *is not correct because electronegativity decreases as atomic number of Group 2 metals increases* ***D*** *is not correct because thermal stability increases as atomic number of Group 2 metals increases*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is A** ***B*** *is not correct because this value has the correct magnitude but is negative* ***C*** *is not correct because this is the enthalpy change of the reverse reaction* ***D*** *is not correct because this is the enthalpy change of the reaction*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is B** ***A*** *is not correct because calcium compounds give a yellow-red flame test* ***C*** *is not correct because calcium compounds give a yellow-red flame test and calcium chloride would form a neutral solution* ***D*** *is not correct because potassium chloride would form a neutral solution*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is B** ***A*** *is not correct because this compound has six carbon atoms not seven* ***C*** *is not correct because this compound has eight carbon atoms not seven* ***D*** *is not correct because this compound has eight carbon atoms not seven*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is A** ***B*** *is not correct because barium hydroxide is the most soluble Group 2 hydroxide* ***C*** *is not correct because is not correct because barium hydroxide is the most soluble Group 2 hydroxide* ***D*** *is not correct because is not correct because barium hydroxide is the most soluble Group 2 hydroxide*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is D** ***A*** *is not correct because when expanding the bracket on the LHS, the* $1H_2$ *has been subtracted rather than added* ***B*** *is not correct because when expanding the bracket on the LHS, the* $1H_2$ *has been omitted* ***C*** *is not correct because when expanding the bracket on the LHS, the* $1H_2$ *has not been been changed to 2H for the hydrocarbon formula*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is A** ***B*** *is not correct because ozone does not reflect UV radiation* ***C*** *is not correct because ozone does not break down chlorofluorocarbons* ***D*** *is not correct because ozone does not reflect chlorofluorocarbons*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is C** ***A*** *is not correct because this ignores the charge balance and miscalculates the oxidation number of chlorine as +4* ***B*** *is not correct because this neglects the negative charge on the RHS* ***D*** *is not correct because this ignores the charge balance and miscalculates the oxidation number of chlorine as +6*	**(1)**

Question Number	Answer	Mark
15	**The only correct answer is D** ***A*** *is not correct because the conversion of butanoic acid to butan-1-ol is a reduction* ***B*** *is not correct because the conversion of butanoic acid to butan-1-ol is a reduction* ***C*** *is not correct because the conversion of butanoic acid to butan-1-ol is a reduction*	**(1)**

Question Number	Answer	Mark
16	**The only correct answer is C** ***A*** *is not correct because this is 40% of 8.4 g (the mass of the product)* ***B*** *is not correct because this is the mass required if the yield is 100%* ***D*** *is not correct because the molar masses have been used the wrong way round*	**(1)**

Question Number	Answer	Mark
17	**The only correct answer is B** ***A*** *is not correct because this compound is oxidised to form an aldehyde or a carboxylic acid* ***C*** *is not correct because this compound cannot be oxidised* ***D*** *is not correct because this compound is oxidised to form an aldehyde or a carboxylic acid*	**(1)**

Question Number	Answer	Mark
18	**The only correct answer is B** ***A*** *is not correct because this answer is based on 4 mol of nitrate ions per mole of calcium nitrate* ***C*** *is not correct because this answer is based on 1 mol of nitrate ions per mole of calcium nitrate* ***D*** *is not correct because this answer is based on 0.5 mol of nitrate ions per mole of calcium nitrate*	**(1)**

Question Number	Answer	Mark
19	**The only correct answer is B** ***A*** *is not correct because the calculation gives an* $A_r = 63.9$ *but* $A_r(Ca) = 40.1$ ***C*** *is not correct because the calculation gives an* $A_r = 63.9$ *but* $A_r(Mg) = 24.3$ ***D*** *is not correct because the calculation gives an* $A_r = 63.9$ *but* $A_r(Na \times 2) = 46$	**(1)**

Question Number	Answer	Mark
20	**The only correct answer is B** ***A*** *is not correct because tetrathionate is formed not thiosulfate* ***C*** *is not correct because tetrathionate is formed not sulphite* ***D*** *is not correct because tetrathionate is formed not peroxodisulfate*	**(1)**

Total for SECTION A = 20 marks

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	Iodide / I^-/Silver Iodide/AgI	Iodine ion /I/iodine	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	**EITHER** Chloride/Silver chloride / Cl^-/AgCl **OR** Bromide /Silver Bromide / Br^- /AgBr **ALLOW** Both	 chlorine / Cl /chlorine ions bromine / Br /bromine ions	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	$Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$ Species (1) All state symbols (1) M2 dependent on M1 (or near miss) **ALLOW** TE on incorrect halide in (a)(i) Max 2 If the halide in (a)(ii) is used in a completely correct equation award 1		**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	HCl(aq) / HCl(g) / HCl **IGNORE** Hydrogen chloride / hydrochloric acid		**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	$H_2SO_4 + KCl \rightarrow KHSO_4 + HCl$ **ALLOW** $H_2SO_4 + 2KCl \rightarrow K_2SO_4 + 2HCl$ **ALLOW** Multiples $HKSO_4$ **IGNORE** State symbols, even if incorrect		**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	(In H_2SO_4) +6 /+VI /6+ (1) (In SO_2) +4 /+IV / 4+ (1) Penalise omission of + sign once only		**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(c)(ii)	$H_2SO_4 + \mathbf{2}H^+ + \mathbf{2}Br^- \rightarrow Br_2 + SO_2 + \mathbf{2}H_2O$ **M1**: for both Br_2 **and** SO_2 as products (1) **M2**: for coefficients 2, 2 and 2 (1) **ALLOW** multiples M2 depends on M1 **IGNORE** state symbols even if incorrect		**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(d)	**ALLOW** products in either order with matching observation Hydrogen sulfide / H_2S (1) Smell of (rotten) eggs/pungent / bad **ALLOW** Lead ethanoate/nitrate paper turns black (1) Sulfur / S / S_8 (1) Yellow **and** solid /precipitate (1) If I_2 is included with the two reduction products then Max 3 Observation depends on correct product **IGNORE** further tests on products and results		**(4)**

(Total for Question 21 = 14 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)	To increase the surface area (of the solid) **OR** to increase rate (of reaction)/goes faster/speeds up **IGNORE** To ensure complete reaction		**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(b)	$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$ **OR** $MgCO_3(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(l) + CO_2(g)$ Species (1) Balancing and all state symbols (1) M2 dependent on M1 **ALLOW** M2 for fully correct equation with $H_2CO_3(aq)$		**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(c)	**M1**: Maximum rate at start / starts fast and (gradually) slows (until it stops)/rate decreases **ALLOW** the rate is constant over the first minute (as it is almost a straight line) (1) **M2**: Collision frequency decreases/number of (successful) collisions decreases **AND** concentration of hydrochloric acid decreases / surface area of mineral decreases/concentration of reactants/ reactants used up (1) **M3**: Rate is zero / reaction stops (between 3.5 - 4 min) when all $MgCO_3$ /solid has reacted (1)	Between molecules/atoms Concentration of $MgCO_3$ Just activation energy reasoning All the acid/ reactants used up	**(3)**

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	**1st mark:** Reading off 200 cm^3 from graph (1) **2nd mark:** mol CO_2 = mol $MgCO_3$ (= 200 ÷ 24000) = 0.008333 (mol)/ 8.333×10^{-3} (mol) or fraction 1/120(mol) **IGNORE** SF except 1 SF (1) Correct answer with or without working scores (2) No TE on incorrect reading from graph		**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(d)(ii)	**MP1** Mass $MgCO_3$ (= 0.008333333 x 84.3) = 0.7025 /0.703 (g) **ALLOW** 0.702 (g) Use of 84 g mol^{-1} = 0.70(0) g (1) TE from d(i) Correct answer with or without working scores 1 **MP2** % of $MgCO_3$ = $\frac{0.7025}{0.936}$ x100% % of $MgCO_3$ = 75.0534% **ALLOW** Use of 84 g mol^{-1} giving 74.78632% (1) Correct answer with or without working scores 1 **IGNORE** SF except 1 SF in MP1 and MP2 TE from incorrect no of moles from d (i) TE from incorrect Mr calculation in MP1 as long as the answer is less than 100 %		**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(e)	**M1** CO_2 (slightly) soluble/dissolves /absorbed in water (1) **ALLOW** Remains in water **M2** (volume of CO_2 collected is less) so mass / moles of $MgCO_3$ lower /reduced **OR** (volume of CO_2 collected is less) so % (by mass) of $MgCO_3$ lower (1) M2 is dependent on M1 or indication that the volume of CO_2 is less.	CO_2 escapes	**(2)**

(Total for Question 22 = 12 marks)

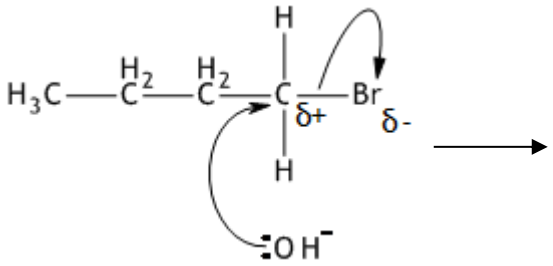
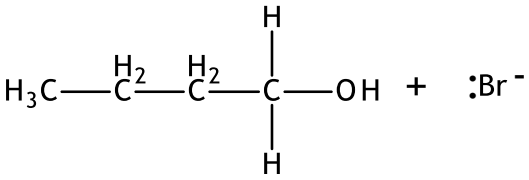
Question Number	Acceptable Answers	Reject	Mark
***23(a)(i)**	**M1**: The mixture (initially) goes darker (brown) (because the concentration increases) (1) **M2:** The mixture turns paler /colourless (on standing) **AND** … because the equilibrium shifts to the right **ALLOW** Suitable alternatives for "to the right", such as: towards the products towards N_2O_4 in forward direction favours the right (1) **M3**: Right-hand side has fewer (gaseous) moles/molecules **OR** Left-hand side has more (gaseous) moles/molecules (1) **IGNORE** References to rate	atoms	**(3)**

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	Equilibrium shifts to the left/backwards **And** in the endothermic direction / away from the exothermic side/because the (forward) reaction is exothermic **IGNORE** Colour change		**(1)**

Question Number	Acceptable Answers	Reject	Mark
***23(b)**	**M1**: (Addition of alkali) Alkali/OH^- reacts with H^+ / alkali removes H^+ / neutralises acid H^+ **ALLOW** $H^+ + OH^- \rightarrow H_2O$ (1) **IGNORE** increases the amount of water **M2:** Equilibrium (position) shifts to the right (forming yellow CrO_4^{2-}) **ALLOW** Suitable alternatives for "to the right", such as: towards the products towards CrO_4^{2-}/H^+ in forward direction favours the right (1) M2 is dependent on M1 or near miss		**(2)**

(Total for Question 23 = 6 marks)

Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	(Reagents): potassium hydroxide /KOH / sodium hydroxide / NaOH (1) (Conditions): Aqueous/water **and** heat **ALLOW** Warm/reflux/ high temperature for heat (1) The conditions mark depends on a correct reagent mark or near miss	OH^-	**(2)**

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	  **M1** Curly arrow from lone pair on OH^- to carbon (1) **M2** Curly arrow from C−Br bond to Br or just beyond (1) **M3** Dipole (1) **M4** Correct organic product and Br^- ion/KBr/NaBr (1) **OR** Correct S_N2 mechanism scores (4) **M1** Dipole and Curly arrow from C−Br bond to Br or just beyond (1) **M2** Curly arrow from lone pair to carbon (1) **M3** Correct intermediate showing dotted bonds to both Br and OH and negative charge. (1) **M4** Correct organic product and Br^- ion/KBr/ NaBr (1) **ALLOW** M1, M2 and M4 for S_N1 mechanism **IGNORE** Omission of lone pair on Br^- ion	Missing hydrogens/ wrong alcohol Missing hydrogens/ wrong alcohol	**(4)**

Question Number	Acceptable Answers	Reject	Mark
***24(b)**	**Any three from** **M1** Water forms **two** hydrogen bonds (1) **M2** butan-1-ol forms (one) hydrogen bond(s) (1) **M3** 1-bromobutane forms London Forces (1) **M4** butan-1-ol forms hydrogen bonds with water (1) **M5** butan-1-ol forms London Forces with 1-bromobutane (1) **M6** 1-bromobutane cannot form hydrogen bonds with water (1) **ALLOW** van der Waals' / dispersion forces **IGNORE** Dipole-dipole interactions/polarity		**(3)**

(Total for Question 24 = 9 marks)

Total for SECTION B = 41 marks

Section C

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	M_r / molecular ion / molar mass (of ethanol = 46) **IGNORE** Reference to ^{12}C not ^{13}C	atomic mass	**(1)**

Question Number	Acceptable Answers	Reject	Mark
25(a)(ii)	CH_2OH^+ **OR** Displayed formula **ALLOW** Charge on any part of the ion (1) CH_3 is lost (from the molecular ion)/C-C bond is broken (1) **IGNORE** Fragmentation/molecule breaks down Charge or dot on CH_3	CH_3O^+	**(2)**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	O—H **and** (between) 3750 — 3200 (cm^{-1}) **ALLOW** Any **range** that includes 3350 within the correct range	Single wavenumber Just 'Alcohol/ethanol'	**(1)**

Question Number	Acceptable Answers	Reject	Mark
***25(b)(i)**	**1st mark:** Atom / group of atoms /part of a molecule (1) **ALLOW** Examples such as C=C, O-H **2nd mark:** that determines its **chemical** properties /that determines its characteristic set of reactions/how it will react (1) **IGNORE** Physical properties	Just group Just alkene, alcohol	**(2)**

Question Number	Acceptable Answers	Reject	Mark
25(b)(ii)	$2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2$ OR $C_2H_5OH + Na \rightarrow C_2H_5ONa + 1/2\ H_2$ OR Other multiples Species (1) Balancing (1) **M2** dependent on award of **M1** or near miss such as $C_2H_5O—Na$ or incorrect charges on the ethoxide. **ALLOW** ionic charges on product **IGNORE** State symbols, even if incorrect	$C_2H_5O—Na$	**(2)**

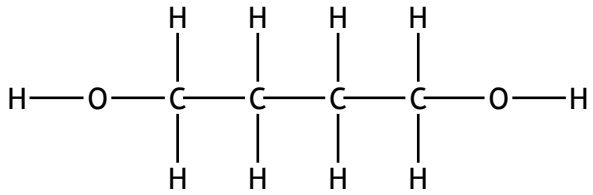
Question Number	Acceptable Answers	Reject	Mark
25(c)(i)	**MP1** Moles of CO_2 (= $\frac{1.79}{44(.0)}$) = 0.040681818 (mol) (1) **MP2**: Mass of C (= 12(.0) x 0.040681818) = 0.488 g **IGNORE** SF except 1 SF (1) Correct answer with or without working scores (2)		**(2)**

Question Number	Acceptable Answers	Reject	Mark
25(c)(ii)	Mass of O (= 1.20 — 0.0610 — 0.488) = 0.650818 = 0.651 (g) **IGNORE** SF except 1 SF **ALLOW** TE from (c)(i)		**(1)**

Question Number	Acceptable Answers	Reject	Mark
25(c)(iii)	**M1** (Mole ratios) C : H : O $\frac{0.488}{12(.0)}$ $\frac{0.0610}{1(.0)}$ $\frac{0.651}{16(.0)}$ = 0.0407 = 0.0610 = 0.0407 (1) **IGNORE** SF and rounding **M2** (Empirical formula) $C_2H_3O_2$ (1) No TE from incorrect mole ratio		**(2)**

Question Number	Acceptable Answers	Reject	Mark
25(c)(iv)	**E** has Structure **2** because **Either** M_r of empirical formula = 59 **and** $\frac{118}{59} = 2$ **OR** molecular formula of structure 2 is $C_4H_6O_4$ **OR** the molecular formula of structure 1 is $C_5H_8O_2$ which is not a multiple of the empirical formula **OR** the ratio of carbon to oxygen in structure 2 is 1:1 which is the same as the empirical formula **OR** the ratio of carbon to oxygen in structure 1 is 5:2 No TE from (c) (iii)		**(1)**

Question Number	Acceptable Answers	Reject	Mark
25(c)(v)	**M1** Test with bromine / bromine water (1) **M2** Structure **1** turns colourless (from orange / yellow/ brown) **and** Structure **2** no change (1) **OR** **M1** Test with acidified potassium manganate((VII))/$KMnO_4$(aq) (1) **M2** Structure **1** turns colourless (from purple/pink) **and** Structure **2** no change (1)		**(2)**

Question Number	Acceptable Answers	Reject	Mark
25(c)(vi)	 **ALLOW** OH for O–H Any combination of aldehydes, alcohols and a single carboxylic acid which can be oxidised **IGNORE** Skeletal and structural formulae Connectivity of a vertical OH	O–H–C	**(1)**

Question Number	Acceptable Answers	Reject	Mark
***25(c)(vii)**	**M1** Restricted rotation / no rotation/ **AND** around the C=C/double bond/ pi bond (1) **M2** **Each or both** C atom(s) of the (C=C) double bond is attached to (two) different groups/different atoms/functional groups This can be shown with 2 diagrams of structure 1 (1) **IGNORE** Different masses/different priorities	Two different molecules	**(2)**

(Total for Question 25 = 19 marks)

Total for SECTION C = 19 marks

TOTAL FOR PAPER = 80 MARKS

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