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Mark Scheme (Results)

October 2016

Pearson Edexcel International GCE in Chemistry (WCH02) Paper 1

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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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

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 (multiple choice)

Question Number	Correct Answer	Mark
1	C	**(1)**
	Incorrect answers A – BF_3 is not pyramidal B – BF_3 is not pyramidal and PH_3 is not trigonal planar D - PH_3 is not trigonal planar	

Question Number	Correct Answer	Mark
2	B	**(1)**
	Incorrect answers A – graphite is not 109.5^o C – diamond is not 120^o and graphite is not 109.5^o D - diamond is not 120^o	

Question Number	Correct Answer	Mark
3	D	**(1)**
	Incorrect answers A – C-Cl is not non-polar and the molecule is not non-polar B - C-Cl is not non-polar C - the molecule is not non-polar	

Question Number	Correct Answer	Mark
4	D	**(1)**
	Incorrect answers A – is linear and has the highest boiling temperature B – has 1 branch and has 2^{nd} highest boiling temperature C has 2 branches and has 3^{rd} highest boiling temperature	

Question Number	Correct Answer	Mark
5	B	**(1)**
	Incorrect answers A – is not a redox reaction so cannot be disproportionation C – is a redox reaction but is not disproportionation D - is not a redox reaction so cannot be disproportionation	

Question Number	Correct Answer	Mark
6	B	**(1)**
	Incorrect answers A – solubility of sulfates does not decrease C – solubility of hydroxides does not increase and solubility of hydroxides does not decrease D – solubility of hydroxides does not increase	

Question Number	Correct Answer	Mark
7	A	**(1)**
	Incorrect answers B – peak is too far to the right and line touches x axis C – peak is too far to the right D – lines touches x axis	

Question Number	Correct Answer	Mark
8	C	**(1)**
	Incorrect answers A – activation energy does not decrease B- activation energy does not decrease and particles do not collide with more energy D - particles do not collide with more energy	

Question Number	Correct Answer	Mark
9	D	**(1)**
	Incorrect answers A – doubling the size of particles will decrease the rate and so will decreasing the temperature B - doubling the size of particles will decrease the rate C – decreasing the temperature will decrease the rate	

Question Number	Correct Answer	Mark
10	A	**(1)**
	Incorrect answers B – is not the activation energy C – is not the activation energy D - is not the activation energy	

Question Number	Correct Answer	Mark
11	D	**(1)**
	Incorrect answers A – is incorrect as there will be a change B – incorrect colour C – incorrect colour	

Question Number	Correct Answer	Mark
12	A	**(1)**
	Incorrect answers B – equilibrium position does not shift to the right with an increase in temperature C – equilibrium position does not shift to the right with a decrease in pressure D - equilibrium position does not shift to the right with a decrease in pressure and equilibrium position does not shift to the right with an increase in temperature	

Question Number	Correct Answer	Mark
13	B	**(1)**
	Incorrect answers A – incorrect empirical formula C - incorrect empirical formula D - incorrect empirical formula	

Question Number	Correct Answer	Mark
14	C	**(1)**
	Incorrect answers A – P is not primary B – P and S are not primary D – Q is primary but R is also primary	

Question Number	Correct Answer	Mark
15	C	**(1)**
	Incorrect answers A – incorrect number of alkenes B - incorrect number of alkenes D - incorrect number of alkenes	

Question Number	Correct Answer	Mark
16	A	**(1)**
	Incorrect answers B – incorrect mass C - incorrect mass D - incorrect mass	

Question Number	Correct Answer	Mark
17	C	**(1)**
	Incorrect answers A – carbon monoxide has a polar bond B – carbon dioxide has 2 polar bonds D – water has 2 polar bonds	

Question Number	Correct Answer	Mark
18	D	**(1)**
	Incorrect answers A – incorrect percentage B - incorrect percentage C - incorrect percentage	

Question Number	Correct Answer	Mark
19	D	**(1)**
	Incorrect answers A – not the molecular ion B – not the molecular ion C – this is the molecular ion without a carbon-13 isotope	

Question Number	Correct Answer	Mark
20	A	**(1)**
	Incorrect answers B – has fewer oxygen atoms than A C - has fewer oxygen atoms than A D - has fewer oxygen atoms than A	

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	Green (flame) ALLOW any shade of green eg pale green, apple green	Any other colour in combination with green eg blue-green	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	Read the whole answer before awarding marks. If no mention of electrons only M3 may be awarded **First mark** Electrons excited/promoted to a higher energy level/shell (by thermal energy /heat from (Bunsen) flame) **(1)** IGNORE atom / ion **Second mark** (Promoted) electrons fall /drop /relax / return to a lower energy level /(sub)shell/ orbital OR Electrons return to ground state ALLOW Electrons drop back down / de-excited **(1)** IGNORE atom / ion **Third mark** Emitting (energy in the form of) radiation/ light /photons (in the visible region) **(1)** ALLOW release / give out for emit IGNORE colour / wavelength / frequency	Just 'electrons excited / promoted' Just 'energy lost' Just 'energy emitted'	**(3)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	$2NaNO_3 \rightarrow 2NaNO_2 + O_2$ OR $NaNO_3 \rightarrow NaNO_2 + ½O_2$ OR multiples IGNORE state symbols, even if incorrect		**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$ OR $Mg(NO_3)_2 \rightarrow MgO + 2NO_2 + ½O_2$ OR multiples IGNORE State symbols, even if incorrect Water of crystallisation NOTE If no marks awarded for (b)(i) or (b)(ii), allow 1 mark for all correct products in unbalanced equations in (b)(i) and (b)(ii)		**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(c)	**First mark – charge** Magnesium ion has a greater charge than sodium ion OR Magnesium is Mg^{2+} and sodium is Na^{+} ALLOW magnesium ion has a higher charge density ALLOW Mg have a charge of +2 and Na has a charge of +1 ALLOW mention of atoms **(1)** **Second mark – size** Magnesium **ion** is smaller than sodium ion OR Sodium **ion** is larger than magnesium ion ALLOW magnesium is smaller than sodium, or reverse argument, if ion is stated for first mark **(1)** IGNORE atomic radius **Third mark – comparison of polarising power** Magnesium / Mg^{2+} / cation / smaller ion causes more polarisation / distortion OR Sodium / Na^{+} / cation / larger ion causes less polarisation / distortion **(1)** **Fourth mark – what is polarised** C-O bonds / C=O bonds ALLOW (Electron cloud in) carbonate (ion) / CO_3^{2-} / anion / negative ion (and therefore magnesium carbonate decomposes more readily) **(1)** IGNORE magnesium carbonate is more polarised (than sodium carbonate)	Mg / Mg^{2+} is distorted N-O bonds / N=O bonds / nitrate ion / NO_3^{-} Bond between cation and anion is more easily broken	**(4)**

Question Number	Acceptable Answers	Reject	Mark
21(d)(i)	Correct answer with no working or an alternative method scores (3) marks mol HCl used = $\frac{16.65 \times 0.105}{1000}$ **(1)** $= 1.74825 \times 10^{-3}$ mol Na_2CO_3 in 25 cm^3 = $\frac{1.74825 \times 10^{-3}}{2}$ $= 8.74125 \times 10^{-4}$ TE on mol HCl **(1)** mol Na_2CO_3 in 250 cm^3 $= 8.74125 \times 10^{-4} \times 10$ $= 8.74125 \times 10^{-3}$ TE on mol Na_2CO_3 in 25 cm^3 **(1)** IGNORE SF except 1 SF	Incorrect rounding or use of 1SF once only in (d)(i) and (d)(ii)	**(3)**

Question Number	Acceptable Answers	Reject	Mark
21(d)(ii)	**Molar mass** M_r of $Na_2CO_3.xH_2O$ = $\frac{2.50}{8.74125 \times 10^{-3}}$ $= 286(.0)$ **(1)** **Value of x** x **=** $\frac{286 - 106}{18}$ = 10 **(1)** Both marks TE on 21(d)(i) but do not award M2 if M_r of **hydrate** < 106 **Alternative method** **Value of x** Mass $Na_2CO_3 = 8.74125 \times 10^{-3} \times 106 = 0.92657$ (g) Mass $H_2O = 2.5 - 0.92657 = 1.57343$ (g) Moles $H_2O = 1.57343/18 = 0.087413$ Ratio $Na_2CO_3 : H_2O = 1 : 10$ **(1)** **Molar mass** M_r of $Na_2CO_3.10H_2O = 286$ TE on value of x **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(d)(iii)	Two matching pairs in either order. The effect on titration volumes is **conditional** on the error. Answers can be written on either set of lines **Error 1** Not washing the weighing bottle (with distilled water) OR Not re-weighing the weighing bottle ALLOW Not adding washings to volumetric flask OR Any indication that any solid left in the bottle needs to be accounted for OR Some solid is spilled when it is tipped into the volumetric flask **(1)** IGNORE some solid is undissolved / any reference to uncertainties **Effect on titration volumes 1** The titration volume is less because lower / decreased concentration (of sodium carbonate) **(1)** **Error 2** Not shaking / inverting / mixing the solution in the volumetric flask **(1)** **Effect on titration volumes 2** Titres inconsistent / varied because non-homogeneous solution **(1)**		**(4)**

(Total for Question 21 = 19 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)	iodine IGNORE I_2 / I	Iodide / I^-	**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(b)	Allow oxidation numbers written under species in equation or in the text below **First mark** - oxidation numbers of reactants F_2 F is 0 OH^- O is -2 **(1)** **Second mark** - oxidation numbers of products OF_2 O is +2 and F is -1 H_2O O is -2 F^- F is -1 **(1)** **Third mark** – redox Fluorine / F_2 is reduced as oxidation number decreases / changes from 0 to -1 **and** oxygen is oxidised as oxidation number increases / changes from -2 to +2 OR Fluorine / F_2 is an oxidising agent as oxidation number decreases / changes from 0 to -1 **and** oxygen is a reducing agent as oxidation number increases / changes from -2 to +2 ALLOW O^{2-} for oxygen **(1)** IGNORE gain / loss of electrons	Just 'ON F decreases and ON O increases' If O is –2 and F is +1 in OF_2, fluorine is oxidised from 0 to +1 and reduced from 0 to –1 (disproportionation)	**(3)**

Question Number	Acceptable Answers	Reject	Mark
22(c)	$S_2O_3^{2-} + 5H_2O + 4Cl_2 \rightarrow 2SO_4^{2-} + 10H^+ + 8Cl^-$ ALLOW multiples ALLOW $Na_2S_2O_3 + 5H_2O + 4Cl_2 \rightarrow Na_2SO_4 + H_2SO_4 + 8H^+ + 8Cl^-$ IGNORE working	uncancelled electrons reverse reaction	**(1)**

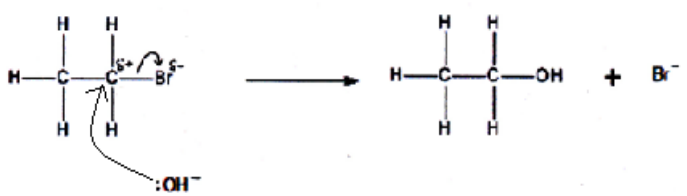
Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	Instantaneous / temporary dipole OR temporary asymmetric electron distribution (on one molecule) **(1)** Induces / creates / causes a dipole / charge **and** in adjacent / another molecule (and these opposite charges attract) **(1)** IGNORE ID – ID	Just 'induces a dipole'	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(d)(ii)	There are (18) more electrons in iodine (than bromine) OR There are more electrons in HI (than HBr) ALLOW There is a greater electron cloud in iodine (than bromine) ALLOW Iodide has more electrons (than bromide) ALLOW Iodine has a larger surface area (than bromine) IGNORE Iodine is larger / heavier / has larger instantaneous dipole / has a greater electron density / has more protons / has more neutrons (than bromine)	There are more electrons in I^- / iodide ions (than bromide ions / Br^-)	**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(d)(iii)	**Identification of intermolecular forces** HF (also) has hydrogen bonds **(1)** IGNORE HCl only has London forces **Comparison of strength** Hydrogen bonds are stronger than London forces / other intermolecular forces ALLOW Hydrogen bonding is stronger OR Hydrogen bonding is the strongest intermolecular force OR More energy is needed to break hydrogen bonds (than London forces) OR The intermolecular forces in HF are stronger (than those in HCl) **(1)** IGNORE Fluorine is more electronegative than chlorine / there is a greater electronegativity difference in HF than HCl	Any reference to breaking H-Hal bond London forces in HF are stronger (than those in HCl)	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(e)	(Shape $[PCl_4]^+$) tetrahedral **(1)** (Shape $[PCl_6]^-$) octahedral **(1)** **Justification** 4 electron / bond pairs in $[PCl_4]^+$ **and** 6 electron / bond pairs in $[PCl_6]^-$ **(1)** Electron/bond pairs / regions of electron density arranged to minimise repulsion ALLOW Maximum separation of electron/bond pairs **/** regions of electron density **(1)** IGNORE Lone pairs repel more than bond pairs / bond angles, even if incorrect	Penalise use of bonds for electron pairs once only Just 'minimise repulsion / maximum separation'	**(4)**

(Total for Question 22 = 14 marks)

Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	 **First mark** Dipole on C-Br **(1)** **Second mark** Curly arrow from **lone pair** on OH^- to $C^{\delta+}$ ALLOW the curly arrow at any angle but it must start close to lone pair **(1)** **Third mark** Curly arrow from C-Br **bond** to Br ALLOW to **just** beyond Br **(1)** IGNORE transition state, even if incorrect	full charges half arrows	**(3)**

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	**Nucleophilic** The oxygen (in the hydroxide ion) / hydroxide ion / negative ion donates a (lone) pair of / two electrons (to form a dative covalent bond) **(1)** **Substitution** The hydroxide (ion) / OH /OH^- replaces/ takes the place of / displaces / substitutes the bromine / Br ALLOW The hydroxide(ion) / OH / OH^- replaces/ takes the place of / displaces / substitutes the bromide(ion) / Br^- ALLOW The C-Br bond breaks and C-O bond forms **(1)** If no other mark is awarded, allow (1) for two generic definitions		**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(b)	$CF_3Cl \rightarrow CF_3\cdot + Cl\cdot$ IGNORE State symbols / uv / curly arrows, even if incorrect / additional steps even if incorrect	$CF_3Cl \rightarrow CF_2Cl\cdot + F\cdot$ omission of unpaired electron	**(1)**

(Total for Question 23 = 6 marks)

Section C

Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	$C_{10}H_{18}O$ ALLOW symbols in any order i.e. $C_{10}OH_{18}$ /$H_{18}C_{10}O$ /$H_{18}OC_{10}$ /$OC_{10}H_{18}$ / $OH_{18}C_{10}$ IGNORE any other formulae as working	$C_{10}H_{17}OH$	**(1)**

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	C_5H_8 ALLOW H_8C_5 IGNORE any other formulae as working		**(1)**

Question Number	Acceptable Answers	Reject	Mark
24(a)(iii)	Linalool and geraniol Both needed for the mark They can be in either order	Any additional names: limonene, citronellol	**(1)**

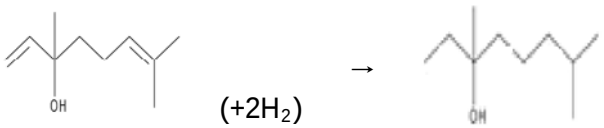
Question Number	Acceptable Answers	Reject	Mark
24(a)(iv)	Geraniol	Any additional names: limonene, linalool, citronellol	**(1)**

Question Number	Acceptable Answers	Reject	Mark
24(b)	**Alkene:** Bromine water /aqueous bromine / $Br_2(aq)$ ALLOW Bromine / $Br_2((l))$ **(1)** Decolorises / changes (from yellow / orange / brown / red) to colourless **(1)** ALLOW Acidified potassium manganate (VII)/ H^+ and MnO_4^- **(1)** Purple to colourless **(1)** **Alcohol:** Phosphorus(V) chloride / PCl_5 **(1)** Steamy fumes ALLOW Misty / white fumes **(1)** OR Sodium / Na **(1)** Effervescence / fizzing / bubbles **(1)** IGNORE dissolves / white solid OR Ethanoic acid / carboxylic acid and any strong acid **(1)** Fruity smell **(1)**	acidified potassium dichromate((VI)) / H^+ and $Cr_2O_7^{2-}$ white smoke	**(4)**

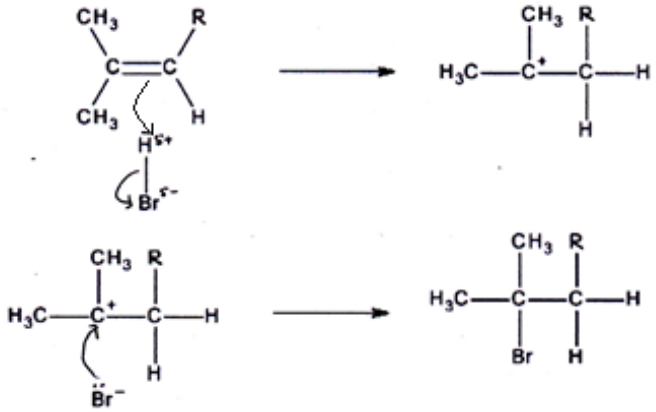
Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	Limonene can be identified as there will be no peak / absorbance for OH (bond/group) **(1)** IGNORE Citronellol can be identified as there will be fewer C=C peaks / a weaker peak/absorbance for C=C (as it has one C=C and the other three compounds have two C=C) IGNORE stretching / wavelength / wavenumber The other three compounds / linalool, geraniol and citronellol will all have a peak/absorbance for OH and C=C /same functional groups so cannot be distinguished OR Fingerprint region will be different for all of them ALLOW Linalool and geraniol will both have a peak/absorbance for OH and two C=C/same functional groups so cannot be distinguished **(1)** IGNORE All 4 have a peak / absorbance for C=C	OH^-	**(2)**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	**First mark - reagents** Add potassium/sodium dichromate((VI)) **and** dilute sulfuric acid to both (and warm / heat) ALLOW Acidified dichromate((VI)) ions (and warm / heat) OR Acidified potassium/sodium dichromate((VI)) (and warm / heat) ALLOW correct formulae eg $Cr_2O_7^{2-}/H^+$ **(1)** **Second mark - observations** Geraniol - orange to green/blue **and** Linalool – no change /stays orange **(1)** **NOTE** M2 is conditional on mention of dichromate((VI)) in M1	Use of $KMnO_4$	**(2)**

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	(Raney) nickel / Ni / platinum / Pt palladium /Pd (catalyst)	Additional metals e.g. iron	**(1)**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	 (+2H_2) → ALLOW mark for just correct formula of product as displayed, structural, skeletal or any combination of these / $C_{10}H_{22}O$ / $C_{10}H_{21}OH$ IGNORE C–OH connectivity / conditions If more than one type of formula is given, all must be correct		**(1)**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	Correct answer with no working scores (3) marks Mass linalool in lavender oil = 2.55 x 70 / 100 = 1.785 g **(1)** Mol linalool = 1.785 / 154 = 0.01159 TE from mass linalool **(1)** **Alternative for first two marks** Mol linalool if pure = 2.55/154 = 0.016558 **(1)** Actual mol linalool = 0.016558 x 70 /100 = 0.01159 **(1)** Volume hydrogen = 2 x 0.01159 x 24.0 = 0.5564 /0.56 dm^3 OR 560 cm^3 ALLOW Volume hydrogen = 0.01159 x 24.0 = 0.27818 /0.278 dm^3 OR 278 / 280 cm^3 TE from mol linalool **(1)** IGNORE SF except 1 SF	Incorrect unit eg dm^3 mol^{-1} or dm^{-3} / missing unit	**(3)**

Question Number	Acceptable Answers	Reject	Mark
24(e)			**(4)**
	Dipole on HBr **(1)**	Full charges	
	Both curly arrows on first structure, arrow from C=C to H **and** arrow from H-Br bond to Br ALLOW Second curly arrow to just beyond Br **(1)**		
	Correct carbocation **(1)**	Partial charge on C	
	Curly arrow from Br^- arrow can come from anywhere on Br, including the charge, lone pair not needed **(1)**		
	ALLOW 4 marks for correct mechanism leading to the minor product **NOTE** If incorrect alkene is used, M1, M2 and M4 can still score		

(Total for Question 24 = 21 marks)