

Mark Scheme (Results)

June 2010

GCE

GCE Chemistry (6CH04/01)

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Summer 2010

Publications Code UA023636

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Section A (multiple choice)

Question Number	Correct Answer	Mark
1 (a)	D	1

Question Number	Correct Answer	Mark
1 (b)	D	1

Question Number	Correct Answer	Mark
1 (c)	A	1

Question Number	Correct Answer	Mark
2	B	1

Question Number	Correct Answer	Mark
3	C	1

Question Number	Correct Answer	Mark
4	D	1

Question Number	Correct Answer	Mark
5	B	1

Question Number	Correct Answer	Mark
6	A	1

Question Number	Correct Answer	Mark
7 (a)	C	1

Question Number	Correct Answer	Mark
7 (b)	B	1

Question Number	Correct Answer	Mark
7 (c)	D	1

Question Number	Correct Answer	Mark
8	B	1

Question Number	Correct Answer	Mark
9	D	1

Question Number	Correct Answer	Mark
10	D	1

Question Number	Correct Answer	Mark
11	B	1

Question Number	Correct Answer	Mark
12	A	1

Question Number	Correct Answer	Mark
13	B	1

Question Number	Correct Answer	Mark
14	C	1

Question Number	Correct Answer	Mark
15	C	1

Question Number	Correct Answer	Mark
16	A	1

Section B

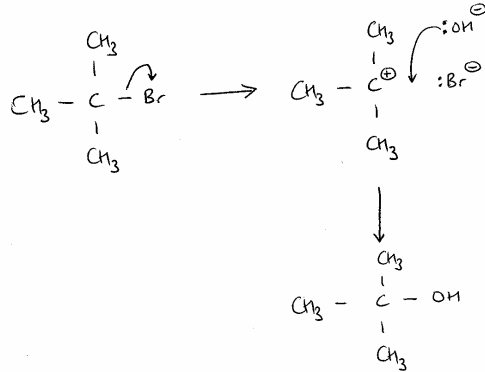
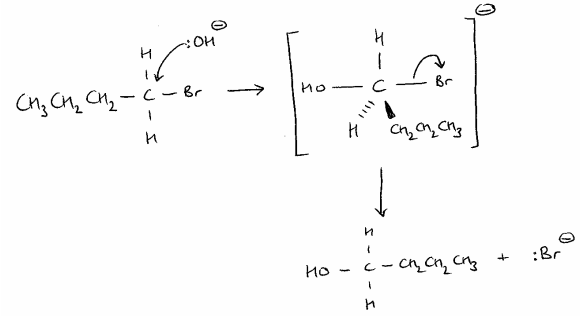
Question Number	Acceptable Answers	Reject	Mark
17 (a)(i)	5.7×10^{-5} / 5.71×10^{-5} / 5.714×10^{-5} / 0.000057 <i>IGNORE</i> SF except 1 (ie don't accept 6×10^{-5})		1

Question Number	Acceptable Answers	Reject	Mark
17 (a)(ii)	<p>C_4H_9Br: first order / 1 (1)</p> <p>(going from first to second experiment) rate doubles when concentration / number of moles doubles (and $[OH^-]$ constant)/ rate and concentration increase in proportion (1) <i>ALLOW</i> 'time halves' instead of 'rate doubles'</p> <p>OH^- : zero order / 0 and (going from second to third expt) as increase in concentration does not affect rate (and $[C_4H_9Br]$ constant) (1)</p> <p><i>ALLOW</i> 'doubling in concentration of OH^- instead of 'increase in concentration'</p> <p><i>ALLOW</i> time increases by the same factor as increase in hydroxide concentration (5/3)</p> <p>May refer to experiment number rather than concentrations</p>		3

Question Number	Acceptable Answers	Reject	Mark
17 (a)(iii)	<p>Rate = $k[C_4H_9Br]$ OR Rate = $k[C_4H_9Br]^1[OH^-]^0$</p> <p><i>ALLOW</i> k in lower or upper case</p> <p>Rate equation must be consistent with orders in (a)(ii) If no order is given for hydroxide in (ii) mark cannot be given</p>		1

Question Number	Acceptable Answers	Reject	Mark
17 (a)(iv)	$k = \frac{2.9 \times 10^{-5}}{0.017}$ $= 1.7 \times 10^{-3} / 1.71 \times 10^{-3} / 1.706 \times 10^{-3} \text{ s}^{-1}$ <p><i>ALLOW</i> $k = 1.68 \times 10^{-3}$ (value obtained from experiment 2 or 3)</p> <p>value of k (1)</p> <p>units (1) stand alone mark</p> <p><i>ALLOW</i> TE from (a)(iii) <i>IGNORE</i> SF except 1</p> <p>Rate = $k[\text{C}_4\text{H}_9\text{Br}]^2$ gives $k = 0.10036 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$</p> <p>Rate = $k[\text{C}_4\text{H}_9\text{Br}][\text{OH}^-]$ gives $k = 1.42 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ <i>ALLOW</i> $k = 1.39 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ (value obtained from experiment 2 or 3)</p> <p>Rate = $k[\text{C}_4\text{H}_9\text{Br}][\text{OH}^-]^2$ gives $k = 1184.6 \text{ dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$</p> <p>Rate = $k[\text{C}_4\text{H}_9\text{Br}]^2[\text{OH}^-]$ gives $k = 83.62 \text{ dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$</p>		2

Question Number	Acceptable Answers	Reject	Mark
17(b)	<p>$[\text{OH}^-]$ is (in chemical equation but) not in rate equation / not in rate determining step (so is in a step other than rate determining step)</p> <p>OR</p> <p>Only $\text{C}_4\text{H}_9\text{Br}$ is in rate equation / rate determining step (so OH^- is in a step other than rate determining step)</p>		1

Question Number	Acceptable Answers	Mark
17 (c)	<p>First mark Choice of bromoalkane must be consistent with rate equation in (a)(iii). If $[\text{OH}^-]$ is not in rate equation, secondary/tertiary bromoalkane. If $[\text{OH}^-]$ is in rate equation, primary/secondary bromoalkane. (1)</p> <p>Second and third marks Either SN1 or SN2 mechanism can score 2 marks regardless of choice of bromoalkane.</p>  <p>Lone pairs not required</p> <p>Curly arrow from C-Br bond to Br (making Br^-) (1)</p> <p>Curly arrow from anywhere on $\text{OH}^- / \text{HO}^-$ to C^+ in correct intermediate (making alcohol) (1)</p> <p>OR</p>  <p>Both curly arrows from OH^- and from C-Br bond to Br (may both be shown at start) (1)</p> <p>Transition state including minus charge (and product) (1)</p> <p>Do not penalise if C_2H_5 shown instead of C_3H_7. Bonds in transition state can be dotted. Do not penalise the missing H atoms in alkyl groups in mechanism.</p>	3

Question Number	Acceptable Answers	Reject	Mark
17 (d) QWC	<p>(Primary and tertiary) carbocation intermediates have different stabilities (1) as (inductive effects of) alkyl groups stabilise tertiary carbocation (1)</p> <p>OR</p> <p>Steric hindrance differs for attack on primary and tertiary carbon (in the molecule) / less space available for attack by OH⁻ on tertiary carbon / more space for attack by OH⁻ on primary carbon (1) as bulky / three alkyl groups obstruct attack (1)</p>	<p>"Tertiary bromoalkanes react by SN1" without further explanation</p> <p>carbocation intermediates have different reactivity</p> <p>steric hindrance in carbocation</p>	2

Question Number	Acceptable Answers	Reject	Mark
18 (a)(i)	(Acid) hydrolysis	substitution	1

Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	$K_2Cr_2O_7$ / $Na_2Cr_2O_7$ / $Cr_2O_7^{2-}$ Potassium dichromate(VI) / sodium dichromate(VI) / dichromate(VI) ions <i>ALLOW</i> manganate(VII) ions, etc	Just "dichromate" chromates Correct formula with wrong name and vice versa Incorrect oxidation number	1

Question Number	Acceptable Answers	Reject	Mark
18 (a)(iii)	Lithium tetrahydridoaluminate/ lithium aluminium hydride/ $LiAlH_4$ (in dry ether)	Just $[H^-]$	1

Question Number	Acceptable Answers	Reject	Mark
18 (a)(iv)	Methyl butanoate (1) $CH_3CH_2CH_2COOH + CH_3OH \rightarrow CH_3CH_2CH_2COOCH_3 + H_2O$ (1) <i>ALLOW</i> \Rightarrow <i>IGNORE</i> state symbols even if wrong	Methyl butoate	2

Question Number	Acceptable Answers	Reject	Mark
18 (a)(v)	$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-C}\begin{array}{l} \text{=O} \\ \text{Cl} \end{array}$ <p>Don't penalise undisplayed methyl groups as here. COCl must be displayed as above.</p>	C ₃ H ₇ for CH ₃ CH ₂ CH ₂	1

Question Number	Acceptable Answers	Reject	Mark
18 (b)(i)	<p>Nitrogen inert / unreactive / less reactive (than oxygen)</p> <p>OR</p> <p>Oxygen might react with chemicals going through column / sample might oxidise</p>		1

Question Number	Acceptable Answers	Reject	Mark
18 (b)(ii)	<p>Solubility (in liquid / stationary phase)</p> <p>OR</p> <p>Interaction with liquid / stationary phase</p> <p>OR</p> <p>Interaction between mobile and stationary phase</p> <p>OR</p> <p>Attraction for liquid / stationary phase</p> <p>OR</p> <p>Strength of (named) intermolecular forces</p> <p>OR</p> <p>Adsorption on liquid / stationary phase</p> <p>OR</p> <p>Absorption on liquid / stationary phase</p>	<p>Size of molecule / molar mass</p> <p>Polarity, unless with explanation</p> <p>Boiling point / volatility</p> <p>Viscosity</p> <p>Attraction for carrier gas</p> <p>Just a named intermolecular force</p> <p>Just 'retention time'</p> <p>Density</p>	1

Question Number	Acceptable Answers	Reject	Mark
18 (c)(i)	$\left[\text{O}-\underset{\text{CH}_3}{\overset{\text{H}}{\text{C}}}-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\underset{\text{CH}_3}{\overset{\text{H}}{\text{C}}}-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}} \right]$ <p>OR</p> $\left[\underset{\text{CH}_3}{\overset{\text{H}}{\text{C}}}-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\underset{\text{CH}_3}{\overset{\text{H}}{\text{C}}}-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{O} \right]$ <p>Ester link including C=O (1) Rest of polymer with oxygens at end correct (1)</p> <p>All H atoms must be shown.</p> <p><i>PENALISE</i> lack of displayed C=O once only <i>ACCEPT</i></p> <p>Without brackets around formula but bonds at end should be shown More than two correct units <i>IGNORE</i> n after brackets</p>		2

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	Hydrolysis OR Splits / breaks ester link OR polymer breaks down to monomers OR equation showing hydrolysis	Just 'breaks polymer down'	1

Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	$(K_p =) \frac{p_{\text{CH}_3\text{CO}_2\text{H}}}{p_{\text{CH}_3\text{OH}} (x) p_{\text{CO}}}$ Partial pressure symbol can be shown in various ways, eg pp, p_{CO} , (CO)p, etc ALLOW p in upper or lower case, round brackets IGNORE units	[] State symbols given as (l) + in bottom line	1

Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	$P_{\text{CH}_3\text{OH}} = 4.9 \text{ (atm) (1)}$ $P_{\text{CO}} = 4.9 \text{ (atm) (1)}$ 1 mark for recognition that pressures are equal IGNORE units		2

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iii)	$K_p = ((22.2)/(4.9)^2)$ $= 0.925 \text{ (1)}$ $\text{atm}^{-1} \text{ (1)}$ stand alone mark but must match expression used in (a)(iii) OR $9.25 \times 10^4 \text{ Pa}^{-1} / 92.5 \text{ kPa}^{-1} \text{ (2)}$ ALLOW TE from (a)(i) if inverted and/or (a)(ii)	Answers to other than 3 significant figures	2

Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	<p>CH₃OH: 3.2 CO : 3.2 (1) for both values</p> <p>CH₃CO₂H: 46.8 (1)</p> <p><i>ALLOW</i> TE for moles of ethanoic acid based on numbers of methanol and carbon monoxide used, as long as moles of methanol and carbon monoxide are equal and moles ethanoic acid + moles methanol = 50</p>		2

Question Number	Acceptable Answers	Reject	Mark
19 (b)(ii)	<p>$\left(\frac{46.8 \times 32}{53.2}\right) = 28.2 / 28.1504 \text{ (atm)}$</p> <p><i>IGNORE</i> sf except 1</p> <p>Value = 28.16 if mol fraction rounded</p> <p><i>ALLOW</i> TE from (b)(i)</p>	<p>28.1</p> <p>$\frac{46.8 \times 32}{50} = 29.95 \text{ (atm)}$</p>	1

Question Number	Acceptable Answers	Reject	Mark
19 (b)(iii)	<p>exothermic as yield / pp of ethanoic acid / conversion of reactants/ K_p is higher at lower temperature / as equilibrium moves (right) at lower temperature</p> <p><i>ALLOW</i> if partial pressure of ethanoic acid < 22.2 atm in (b)(ii), endothermic as yield / pp of ethanoic acid / conversion of reactants/ K_p is lower at lower temperature</p>		1

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	No effect and other concentrations change to keep K_p constant / K_p is only affected by temperature/ as equilibrium moves (right) to keep K_p constant / change in pressure does not change K_p	As K_p is a constant	1

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	Yield increased to restore fraction / quotient / partial pressure ratio back to K_p <i>ALLOW</i> (equilibrium moves) to use up the methanol /answers based on entropy or Le Chatelier Correct prediction in (c)(i) and (c)(ii) with inadequate explanations scores 1 mark in (c)(ii)	Just 'equilibrium moves to the right'	1

Question Number	Acceptable Answers	Reject	Mark
19 (d)	Mark independently Reaction can occur at lower temperature / has lower activation energy / requires less energy (1) less fuel needed / fewer emissions (from fuels) / fewer raw materials needed / less natural resources used (1) OR Enables use of an alternative process with higher atom economy (1) fewer raw materials needed / less natural resources used (1)	Answer based on car exhaust emissions	2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	<p>Correct answer with or without working scores 2 marks</p> $[H^+] = (1.00 \times 10^{-14} / 0.250) = 4 \times 10^{-14} \quad (1)$ <p>pH = (13.39794 \Rightarrow) 13.4 (1)</p> <p>OR</p> <p>pOH = -log 0.250 = 0.602 (1)</p> <p>pH = (13.39794 \Rightarrow) 13.4 (1)</p> <p><i>ALLOW</i> TE in second mark if error in $[H^+]$ calculation gives pH more than 7 3 or more sf <i>IGNORE</i> rounding errors e.g. accept 13.39</p>		2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	<p>$(K_a =) \frac{[CH_3COO^-][H^+]}{[CH_3COOH]} \quad (1)$</p> <p><i>ALLOW</i> H_3O^+ instead of H^+ $\frac{[A^-][H^+]}{[HA]}$ if key to symbols given <i>IGNORE</i> state symbols</p>	$\frac{[H^+]^2}{[CH_3COOH]}$	1

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iii)	<p>Correct answer with or without working scores 2 marks</p> $1.7 \times 10^{-5} = \frac{[H^+]^2}{0.125} \quad (1)$ <p>$[H^+] = 1.46 \times 10^{-3}$ pH = 2.84/2.8 (1)</p> <p>no TE from an incorrect $[H^+]$</p>		2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iv)	<p>pH = 4.8 / 4.77 (1)</p> <p>pH = $pK_a / [H^+] = K_a$ (when acid is half neutralized) (1)</p>	$H^+ = K_a$	2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(v)	<p>Sigmoid curve starting between pH 2 and 4 (2.8), ending between pH 12 and 14 inclusive (1)</p> <p>with steep rise (may be vertical or gently sloping) of between 3 - 7 units between pH 6 and 12. Sloping section should not extend over more than 5cm³. (1)</p> <p>When 12.5 cm³, NaOH added. (1) <i>ALLOW</i> tolerance for grid</p> <p>Reverse curves lose first mark</p>		3

Question Number	Acceptable Answers	Reject	Mark
20 (a)(vi)	<p>First mark Thymolphthalein more suitable as it changes (from colourless to blue) in steep region of titration (pH 8.3 to 10.6)/ at the equivalence point / at the end point OR thymolphthalein has pH range in steep region of titration (1)</p> <p>Second mark Methyl yellow changes (from red to yellow at pH 2.9 to 4) before equivalence point / before the end point / doesn't change in steep section OR Methyl yellow has pH range before / outside steep region of titration (1)</p> <p><i>ALLOW</i> 'Thymolphthalein more suitable as it changes at the equivalence point but methyl yellow does not.' This scores 2 marks</p> <p>OR</p> <p>First mark $pK_{in} \pm 1$ must lie within vertical region on titration curve (1)</p> <p>Second mark hence thymolphthalein is suitable and methyl yellow is not (1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
20 (b)	<p>Sodium ethanoate/ CH_3COONa Potassium ethanoate / CH_3COOK</p> <p><i>ALLOW</i> other cations as alternatives to sodium</p>	Use of sodium hydroxide (because it's in food)	1

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	$\Delta S_{\text{system}}^{\ominus} = 109.2 + (6 \times 69.9) - 343 \quad (1)$ $= (+)185.6 (\text{J mol}^{-1} \text{K}^{-1}) \quad / \quad (+)186 (\text{J mol}^{-1} \text{K}^{-1}) \quad (1)$ <p>OR</p> $(+0.186 (\text{kJ mol}^{-1} \text{K}^{-1}) \quad (2)$ <p>IGNORE units even if incorrect</p> <p>correct answer with no working scores 2</p> <p>Value using 1 for H₂O = -163.9 scores 1</p> <p>Use of value for H₂O(g) (188.7) gives 898.4 (J mol⁻¹ K⁻¹) (1)</p> <p>correct value with incorrect sign scores 1</p>	185	2

Question Number	Acceptable Answers	Reject	Mark
21 (a)(ii)	<p>Yes as (solid and) liquid forms (from solid) / number of moles increases</p> <p>OR</p> <p>If $\Delta S_{\text{system}}^{\ominus}$ in (i) is negative the sign is not as expected as liquid forms from solid / number of moles increases</p>	Disorder increases, with no ref to liquid or number of moles	1

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iii)	<p>First mark $\Delta S^{\circ}_{\text{surroundings}} = \frac{-88.1 \times (1000)}{298}$ (1)</p> <p>Second mark = -295.6375 = -295.6 J mol⁻¹ K⁻¹ (1) correct units must be shown but order not important</p> <p>OR</p> <p>-0.2956 kJ mol⁻¹ K⁻¹ (1) correct units must be shown but order not important</p> <p>correct answer with or without working and correct units scores (2) ignore sf except 1</p> <p>correct value with positive sign scores 1</p>		2

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iv)	<p>(185.6-295.6) = -110 (J mol⁻¹ K⁻¹)</p> <p>OR</p> <p>-0.110 (kJ mol⁻¹ K⁻¹)</p> <p>could use 186 or 296 etc</p> <p>TE from (a)(i) and (iii)</p> <p>(+)602.8 (J mol⁻¹ K⁻¹) if value for 6H₂O(g) was used in (a) (i)</p> <p>-459.5 (J mol⁻¹ K⁻¹) if value for one H₂O was used in (a) (i)</p>	Answers where values in J are added to kJ	1

Question Number	Acceptable Answers	Reject	Mark
21 (a)(v)	<p>Decomposition (at 298 K) will not occur as $\Delta S^{\circ}_{\text{total}}$ is negative / Reactions are only spontaneous if total entropy change is positive / decomposition not thermodynamically feasible / (hydrated cobalt chloride) is thermodynamically stable</p> <p>TE if answer to (a)(iv) is positive showing decomposition (at 298 K) may occur</p> <p>OR</p> <p>Positive total entropy change doesn't indicate rate of reaction</p>		1

Question Number	Acceptable Answers	Reject	Mark
21 (b)(i)	<p>First mark Thermometer (1)</p> <p>Second mark (dependent on first) depends on choosing thermometer</p> <p>as temperature change is small / (%) error in balance smaller than for temperature reading (%) error in pipette smaller than for temperature reading (can be shown by calculation) / as scale with greater degree of precision needed / scale with more graduations needed (1) <i>IGNORE</i> any references to 'accurate thermometer'</p>		2

Question Number	Acceptable Answers	Reject	Mark
21 (b)(ii)	Use more cobalt chloride / less water (1) To increase temperature rise (1) Mark independently	Just 'use more reactants' Use more cobalt chloride and more water repeat expt add a lid or extra insulation to beaker use distilled water	2

Question Number	Acceptable Answers	Reject	Mark
21 (c)(i) QWC	Radius (of cation) increases (down group) OR any two values of radius: $Mg^{2+} = 0.072$, $Ca^{2+} = 0.100$ / $Sr^{2+} = 0.113$ (nm) data may be shown beside the table (1) Radius $Co^{2+} = 0.065$ nm OR Co^{2+} radius smaller than other ions (1) Data on EITHER Co^{2+} OR data showing increase in radius down Group II required for BOTH of first two marks Force of attraction between ions decreases (as radius of ions increases) / charge density of ions decreases / negative ion can come closer to nucleus of positive ion (1) <i>ALLOW</i> "weaker ionic bonds" Predict lattice energy -2550 to -2900 ($kJ\ mol^{-1}$) (1) IGNORE sign	Atomic radii unless ionic radii also given Radius of cobalt chloride Polarising power decreases	4

Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii) QWC	<p>First mark Reference to enthalpy of hydration (may be in equation $\Delta H_{\text{solution}} = -LE + \Delta H_{\text{hydration}}$) (1)</p> <p>Second mark Solubility depends on relative size of lattice energy and enthalpy of hydration (1)</p> <p>Third mark EITHER Solubility more likely if $\Delta H_{\text{solution}}$ is negative</p> <p>OR</p> <p>(If $\Delta H_{\text{solution}}$ is positive,) may / will dissolve if ΔS_{total} is positive</p> <p><i>ACCEPT</i> solvation instead of hydration</p>		3

Question Number	Acceptable Answers	Reject	Mark
21 (d) QWC	<p>First mark Third ionization energy high(er) for Mg / Mg = 7733 kJ mol^{-1}, (third ionization energy for Co = 3232 kJ mol^{-1}) (1)</p> <p>Second mark (Third ionization energy for Mg is high) because the electron is being removed from an inner shell / full shell / 2p level / 2p orbital (1)</p> <p>OR</p> <p>Not compensated by higher lattice energy for Mg^{3+} (and so $\Delta H_{\text{formation}}$ of MgCl_3 would be highly endothermic) (1)</p>		2