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Mark Scheme (Results)
June 2010

GCE

GCE Chemistry (6CH04/01)

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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

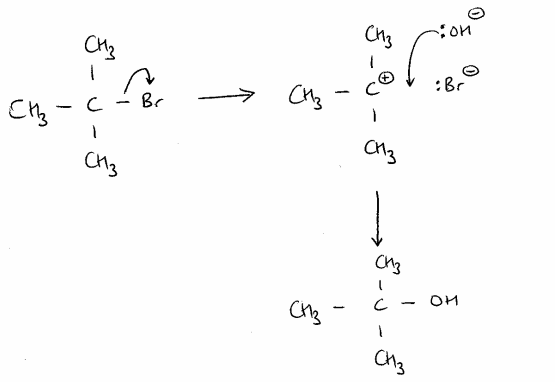
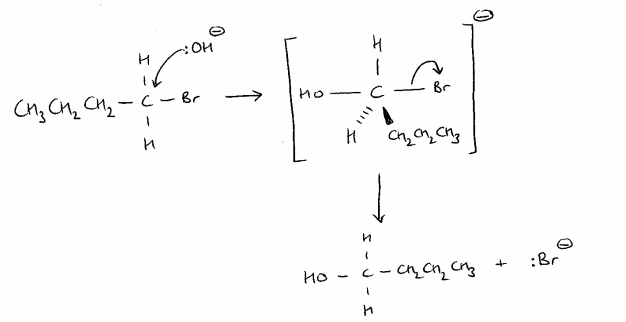
Question Number	Acceptable Answers	Reject	Mark
17 (a)(i)	5.7×10^{-5} / 5.71×10^{-5} / 5.714×10^{-5} / 0.000057 *IGNORE* SF except 1 (ie don't accept 6×10^{-5})		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(ii)	C_4H_9Br: first order / 1 **(1)** (going from first to second experiment) rate doubles when concentration / number of moles doubles (and $[OH^-]$ constant)/ rate and concentration increase in proportion **(1)** *ALLOW* 'time halves' instead of 'rate doubles' 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)** *ALLOW* 'doubling in concentration of OH^- instead of 'increase in concentration' *ALLOW* time increases by the same factor as increase in hydroxide concentration (5/3) May refer to experiment number rather than concentrations		**3**

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

Question Number	Acceptable Answers	Reject	Mark
17 (a)(iv)	$k = \frac{2.9 \times 10^{-5}}{0.017}$ **=** 1.7×10^{-3} / 1.71×10^{-3} / $1.706 \times 10^{-3}\ s^{-1}$ *ALLOW* $k = 1.68 \times 10^{-3}$ (value obtained from experiment 2 or 3) value of k **(1)** units **(1) stand alone mark** *ALLOW* TE from (a)(iii) *IGNORE* SF except 1 Rate = $k[C_4H_9Br]^2$ gives k= 0.10036 $dm^3\ mol^{-1}s^{-1}$ Rate = $k[C_4H_9Br][OH^-]$ gives k= 1.42 $dm^3\ mol^{-1}s^{-1}$ *ALLOW* k=1.39 $dm^3\ mol^{-1}s^{-1}$ (value obtained from experiment 2 or 3) Rate = $k[C_4H_9Br][OH^-]^2$ gives k= 1184.6 $dm^6\ mol^{-2}s^{-1}$ Rate = $k[C_4H_9Br]^2[OH^-]$ gives k= 83.62 $dm^6\ mol^{-2}s^{-1}$		**2**

Question Number	Acceptable Answers	Reject	Mark
17(b)	$[OH^-]$ is (in chemical equation but) not in rate equation / not in rate determining step (so is in a step other than rate determining step) OR Only C_4H_9Br is in rate equation / rate determining step (so OH^- is in a step other than rate determining step)		**1**

Question Number	Acceptable Answers	Mark
17 (c)	**First mark** Choice of bromoalkane must be consistent with rate equation in (a)(iii). If $[OH^-]$ is not in rate equation, secondary/tertiary bromoalkane. If $[OH^-]$ is in rate equation, primary/secondary bromoalkane. **(1)** **Second and third marks** Either SN1 or SN2 mechanism can score **2 marks** regardless of choice of bromoalkane.  Lone pairs not required Curly arrow from C-Br **bond** to Br (making Br^-) **(1)** Curly arrow from anywhere on OH^- / HO^- to C^+ in correct intermediate (making alcohol) **(1)** **OR**  Both curly arrows from OH^- and from C-Br bond to Br (may both be shown at start) **(1)** Transition state including minus charge (and product) **(1)** 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**.	**3**

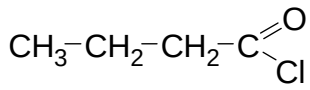
Question Number	Acceptable Answers	Reject	Mark
17 (d) **QWC**	(Primary and tertiary) carbocation intermediates have different stabilities **(1)** as (inductive effects of) alkyl groups stabilise tertiary carbocation **(1)** **OR** Steric hindrance differs for attack on primary and tertiary carbon (in 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)**	"Tertiary bromoalkanes react by SN1" without further explanation carbocation intermediates have different reactivity steric hindrance in carbocation	**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 *ALLOW* manganate((VII)) ions, etc	Just "dichromate" chromates Correct formula with wrong name and vice versa Incorrect oxidation number	**1**

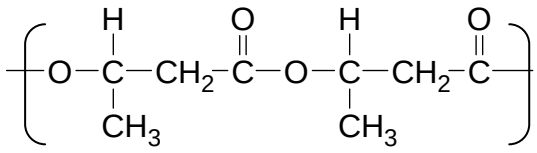
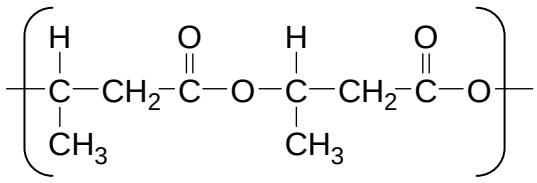
Question Number	Acceptable Answers	Reject	Mark
18 (a)(iii)	Lithium tetrahydridoaluminate/ lithium aluminium hydride/ $LiAlH_4$ (in dry ether)	Just [H^-]	**1**

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)** *ALLOW* $\rightleftharpoons$ *IGNORE* state symbols even if wrong	Methyl butoate	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (a)(v)	 Don't penalise undisplayed methyl groups as here. COCl must be displayed as above.	C_3H_7 for $CH_3CH_2CH_2$	**1**

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

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

Question Number	Acceptable Answers	Reject	Mark
18 (c)(i)	 OR  Ester link including C=O **(1)** Rest of polymer with oxygens at end correct **(1)** All H atoms must be shown. *PENALISE* lack of displayed C=O once only *ACCEPT* Without brackets around formula but bonds at end should be shown More than two correct units *IGNORE* n after brackets		**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 =) $\frac{pCH_3CO_2H}{pCH_3OH\ (x)\ pCO}$ 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 CH_3OH = 4.9 (atm) **(1)** P CO = 4.9 (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 **(1)** atm^{-1} **(1) stand alone mark but must match expression used in (a)(iii)** **OR** $9.25 \times 10^4\ Pa^{-1}$ / 92.5 kPa^{-1} **(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)	CH_3OH: 3.2 CO : 3.2 **(1)** for both values CH_3CO_2H: 46.8 **(1)** *ALLOW* 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		**2**

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

Question Number	Acceptable Answers	Reject	Mark
19 (b)(iii)	exothermic as yield / pp of ethanoic acid / conversion of reactants/ K_p is higher at lower temperature / as equilibrium moves (right) at lower temperature *ALLOW* 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		**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 *ALLOW* (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)	Correct answer with or without working scores **2 marks** $[H^+] = (1.00 \times 10^{-14} / 0.250) = 4 \times 10^{-14}$ **(1)** pH = (13.39794 =) 13.4 **(1)** **OR** pOH = -log 0.250 = 0.602 **(1)** pH = (13.39794 =)13.4 **(1)** *ALLOW* TE in second mark if error in $[H^+]$ calculation gives pH more than 7 3 or more sf *IGNORE* rounding errors e.g. accept 13.39		**2**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	$(K_a =) \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$ **(1)** *ALLOW* H_30^+ instead of H^+ $\frac{[A^-][H^+]}{[HA]}$ if key to symbols given *IGNORE* state symbols	$\frac{[H^+]^2}{[CH_3COOH]}$	**1**

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

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

Question Number	Acceptable Answers	Reject	Mark
20 (a)(v)	Sigmoid curve starting between pH 2 and 4 (2.8), ending between pH 12 and 14 inclusive **(1)** 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 5cm^3. **(1)** When 12.5 cm^3, NaOH added. **(1)** *ALLOW* tolerance for grid Reverse curves lose first mark		**3**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(vi)	**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)** **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)** *ALLOW* 'Thymolphthalein more suitable as it changes at the equivalence point but methyl yellow does not.' This scores **2 marks** **OR** **First mark** pK_{in} ± 1 must lie within vertical region on titration curve **(1)** **Second mark** hence thymolphthalein is suitable and methyl yellow is not **(1)**		**2**

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

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	$\Delta S^{\ominus}_{system}$ = 109.2 + (6x 69.9) – 343 **(1)** =(+)185.6(J mol^{-1} K^{-1}) / (+)186 (J mol^{-1} K^{-1}) **(1)** **OR** (+)0.186 (kJ mol^{-1} K^{-1}) **(2)** IGNORE units even if incorrect correct answer with no working scores 2 Value using 1 for H_2O = -163.9 scores 1 Use of value for $H_2O(g)$ (188.7) gives 898.4 (J mol^{-1} K^{-1}) **(1)** correct value with incorrect sign scores 1	185	**2**

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

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

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iv)	(185.6–295.6) **= -110 (J mol^{-1} K^{-1})** OR **-0.110 (kJ mol^{-1} K^{-1})** could use 186 or 296 etc TE from (a)(i) and (iii) **(+)602.8 (J mol^{-1} K^{-1}) if value for $6H_2O(g)$ was used in (a) (i)** **-459.5 (J mol^{-1} K^{-1}) if value for one H_2O was used in (a) (i)**	Answers where values in J are added to kJ	**1**

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

Question Number	Acceptable Answers	Reject	Mark
21 (b)(i)	**First mark** Thermometer **(1)** **Second mark** (dependent on first) depends on choosing thermometer 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)** *IGNORE* any references to 'accurate thermometer'		**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)** *ALLOW* "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	**First mark** Reference to enthalpy of hydration (may be in equation $\Delta H_{solution}$ = -LE + $\Delta H_{hydration}$) **(1)** **Second mark** Solubility depends on relative size of lattice energy and enthalpy of hydration **(1)** **Third mark** **EITHER** Solubility more likely if $\Delta H_{solution}$ is negative **OR** (If $\Delta H_{solution}$ is positive,) may / will dissolve if ΔS_{total} is positive *ACCEPT* solvation instead of hydration		**3**

Question Number	Acceptable Answers	Reject	Mark
21 (d) QWC	**First mark** **Third** ionization energy **high(er)** for Mg / Mg = 7733 kJ mol^{-1}, (third ionization energy for Co = 3232 kJ mol^{-1}) **(1)** **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)** **OR** Not compensated by higher lattice energy for Mg^{3+} (and so $\Delta H_{formation}$ of $MgCl_3$ would be highly endothermic) **(1)**		**2**