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Mark Scheme (Results)
January 2011

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)	B	**1**

Question Number	Correct Answer	Mark
1 (c)	A	**1**

Question Number	Correct Answer	Mark
2	D	**1**

Question Number	Correct Answer	Mark
3	D	**1**

Question Number	Correct Answer	Mark
4	B	**1**

Question Number	Correct Answer	Mark
5	C	**1**

Question Number	Correct Answer	Mark
6	C	**1**

Question Number	Correct Answer	Mark
7 (a)	A	**1**

Question Number	Correct Answer	Mark
7 (b)	A	**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	C	**1**

Question Number	Correct Answer	Mark
11	D	**1**

Question Number	Correct Answer	Mark
12	D	**1**

Question Number	Correct Answer	Mark
13	A	**1**

Question Number	Correct Answer	Mark
14	B	**1**

Question Number	Correct Answer	Mark
15	C	**1**

Question Number	Correct Answer	Mark
16	A	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17 (a)	ΔS_{system} = (3x2x65.3 +197.6) – (186.2 + 188.7) Correct data for CH_4 and CO (186.2 and 197.6) **(1)** = (+) **214.5 / 215** (J mol^{-1} K^{-1}) / (+) **0.2145 / 0.215 kJ** (mol^{-1} K^{-1}) **(1)** Units must be shown if data has been converted to kJ Full marks (2) for correct answer without working Ignore sf except 1 Answer of -214.5 scores (1) Answer of +18.6 if entropy of H not doubled scores (1) Answer of –46.7 if entropy of H_2 not tripled scores (1) ALLOW TE in second mark for minor error in data e.g. writing 63.5 instead of 65.3. No TE if data used is not entropy of compounds.	**214** **0.214**	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)	$(\Delta S_{surroundings}) = \frac{-\Delta H}{T}$ Expression or use of expression, $\frac{-206.1x(1000)}{298}$ **(1)** = **-691.6 J** (mol^{-1} K^{-1})/ **-0.6916 kJ** (mol^{-1} K^{-1}) **(1)** Ignore sf except 1		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (c)	ΔS_{total} = (214.5+(-691.6)) = **-477.1** (J mol^{-1} K^{-1}) / - **0.4771** (kJ mol^{-1} K^{-1}) **(1)** ALLOW TE for answer to (a) plus answer to (b). If 214.5 is added to -0.69 no TE unless -0.69 is specified to be in joules. Ignore sf except 1 Negative / less than zero (so not spontaneous) / would be positive if spontaneous. **(1)** ALLOW "feasible" for spontaneous. If answer to calculation is positive, accept comment that it would be expected to be negative if not spontaneous	Addition of value in J to specified value in kJ Comments on kinetic stability	**2**

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>*17 (d) (i)</td><td>$K_p = \frac{(pH_2)^3 x (pCO)}{(pCH_4)(pH_2O)}$ (1)

4 Correct partial pressures (3)
<table>
<tr><td></td><td>CH_4</td><td>H_2O</td><td>CO</td><td>H_2</td></tr>
<tr><td>pp</td><td>0.25</td><td>0.25</td><td>0.375</td><td>1.125</td></tr>
</table>
ALLOW partial pressures as fractions

$K_p = \frac{(1.125)^3 x (0.375)}{(0.25)(0.25)}$ = 8.54 atm^2

value of K_p (1)

unit (1) (Stand alone mark)

Correct calculation without working scores the 5 calculation marks.

TE from K_p expression if inverted
Ignore sf except 1

If any partial pressures are incorrect:
Calculating total number of moles (6.4) (1)

Calculating mole fractions (0.125, 0.125, 0.1875, 0.5625 if total number of moles is correct) (1)

Multiplying mole fractions by total pressure (x 2 atm) (1)

value of K_p (1)

unit (1) (stand alone mark)

ALLOW TE in value of K_p only from incorrect partial pressures, not using values in question as not using equilibrium moles

If treated as a K_c calculation following K_p expression :
K_p expression (1)
units atm^2 (1)

Max. mark (2)</td><td>Square brackets

TE for K_p expression with addition, not multiplication</td><td>6</td></tr>
</table>

Question Number	Acceptable Answers	Reject	Mark
17 (d) (ii)	ΔS_{total} = (8.31 ln 8.54) = (+)**17.8** (J mol^{-1} K^{-1}) Accept any value that rounds to 17.8 TE from value in (i) K_p value of 87.48 (obtained by treating calculation in (i) as K_c) gives ΔS_{total} = **37.16 / 37.12**		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (d) (iii)	$17.8 = 225 - \frac{206.1 \times 1000}{T}$ **(1)** $T = \frac{206.1 \times 1000}{207.2}$ = **995 / 990** (K) **(1)** Correct answer with no working shown scores 2 Correct method with wrong answer or missing 10^3 scores 1 TE from (ii) K_p value of 87.48 gives T = **1097** **OR** If ΔS_{total} is taken as zero $0 = 225 - \frac{206.1 \times 1000}{T}$ **(1)** T = **916**K **(1)** K_p value of 87.48 gives T = **916** Ignore sf except 1		**2**

Question Number	Acceptable Answers	Reject	Mark
***17 (e)**	$\Delta S_{surroundings}$ / $\frac{-\Delta H}{T}$ becomes less negative making ΔS_{total} more positive (as T increases) **OR** $\Delta S_{surroundings}$ / $\frac{-\Delta H}{T}$ becomes less negative making ΔS_{total} greater (as T increases) **OR** (magnitude of) $\Delta S_{surroundings}$ becomes less / lower making ΔS_{total} more positive / greater (as T increases) **(1)** Because ΔS_{total} increases equilibrium constant increases **(1)** **OR** value of ΔS_{total} at new temperature is more than at 298K (1) (must be clear that the two ΔS_{total} values at the different temperatures have been considered) Because ΔS_{total} increases equilibrium constant increases (1)	Le Chatelier statements without reference to entropy changes Just 'as temperature increases ΔS_{total} increases'	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (a)	pH = (-log 0.25) = 0.602 / 0.60 / 0.6 Ignore significant figures		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b) (i)	$(K_a =) \frac{[H^+][CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$ ALLOW $[H_3O^+]$ for $[H^+]$ ALLOW C_2H_5 for CH_3CH_2 ALLOW $\frac{[H^+][A^-]}{[HA]}$ if HA and A^- identified	Wrong / missing charge on $CH_3CH_2COO^-$ $K_a = \frac{[H^+]^2}{[CH_3CH_2COOH]}$ unless full expression also given	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b) (ii)	$1.3 \times 10^{-5} = \frac{[H^+]^2}{0.25}$ / rearrangement of this expression **(1)** ($[H^+] = 1.8 \times 10^{-3}$) pH = **2.74** **(1)** Correct answer with no working scores (2) No TE for incorrect $[H^+]$ Ignore significant figures except 1 Minimum of 1 decimal place needed		**2**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (i)	$CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COO^{(-)}Na^{(+)} + H_2O$ OR $CH_3CH_2COOH + OH^- \rightarrow CH_3CH_2COO^- + H_2O$ Accept $CH_3CH_2CO_2H$, C_2H_5COOH, $C_2H_5CO_2H$	Equations for ethanoic acid	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (ii)	$1.3 \times 10^{-5} = \frac{[H^+][5 \times 10^{-2}]}{[7.5 \times 10^{-2}]}$ (concentration ratio) OR $1.3 \times 10^{-5} = \frac{[H^+](1 \times 10^{-3})}{(1.5 \times 10^{-3})}$ (ratio by moles) (ratio by moles allowed as volumes acid and salt equal) **(1)** ($[H^+]$ = **1.95×10^{-5}**) pH = **4.7** / 4.7099654 **(1)** Second mark dependent on first Correct answer with or without working **(2)** OR $pH = pK_a - \log \left(\frac{1.5 \times 10^{-3}}{1 \times 10^{-3}}\right)$ OR $pH = pK_a - \log \left(\frac{7.5 \times 10^{-2}}{5 \times 10^{-2}}\right)$ **(1)** pH = 4.7 **(1)** Correct answer with or without working **(2)** Accept any value which rounds to 4.7		**2**

Question Number	Acceptable Answers	Reject	Mark
***18 (c) (iii)**	Mixture is a buffer **(1)** EITHER OH^- combines with H^+ in solution **(1)** Propanoic acid dissociates to replace H^+ **(1)** *Correct equations could gain these marks* OR OH^- reacts with propanoic acid **(1)** *Correct equation could gain this mark* Significant quantities of weak acid and salt are both present /ratio of acid and salt does not change **(1)** ALLOW a reservoir of weak acid and salt are present: Allow conjugate base for salt	NaOH combines	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (iv)	S-shaped curve, vertical at 25 cm^3 (with kink at start) **(1)** Starting at pH 2-3 (TE from (b)(ii), finishing at pH 12 -13 **(1)** Vertical section between 3 and 6 units high centred round a pH of between 8 and 9 **(1)** Vertical section should not extend over more than $\pm 2.5 cm^3$ This section should start between 5.5 and 7.5 and finish between 9.5 and 11.5 but do not penalise for very small differences. Reverse curve maximum 2		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (v)	Either Need indicator changing in vertical region of curve / need indicator changing where pH changes sharply / bromocresol green changes before the vertical region **(1)** **Not** bromocresol green which changes at **3.8 – 5.4** **(1)** OR pK_{in} ±1 must be in vertical section / sharply changing section **(1)** **Not** bromocresol green because pK_{in} is **4.7** **(1)** TE from curve with vertical section including pH 3.7 – 5.7	Just "the equivalence point is outside the bromocresol green range"	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (d) (i)	Dilute acid / dilute strong named acid or formula / NaOH(aq) followed by dilute acid /water plus dilute acid / water plus H^+	NaOH alone water any weak acid concentrated sulfuric acid HCN acid hydrolysis alone	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (d) (ii)	$CH_3CH_2COCl + H_2O \rightarrow CH_3CH_2COOH + HCl$ / $C_2H_5COCl + H_2O \rightarrow C_2H_5COOH + HCl$ Accept displayed formula	Equations with NaOH or OH^-	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (d) (iii)	Colour change orange to green / blue		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (e)	Reducing agent /Reduction (of the acid) occurs **(1)** Li Al H_4 / lithium tetrahydridoaluminate / lithium aluminium hydride **(1)** Allow minor error in name if correct formula is given Ignore solvent ALLOW nucleophile AND H^- for 1 mark	Lithal without correct name or formula	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (a)	Quenches reaction / stops reaction / slows reaction / freezes reaction **(1)** EITHER by neutralizing the acid / removing the acid / neutralizing the catalyst / removing the catalyst **OR** So that the acid does not react with the thiosulfate **(1)**	By neutralizing HI Just "by diluting the reaction mixture" just "by neutralizing the reaction mixture"	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b)	Starch (solution)		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (c)	**First mark** So that [propanone] and [acid] are (virtually) constant **OR** so that the [propanone] and $[H^+]$ do not affect the rate **OR** Propanone and acid are in excess so **changes in concentration** don't affect rate **(1)** **Second mark** And therefore rate changes would only depend on [iodine] **OR** so that the overall order is not determined ALLOW [Iodine] is the limiting factor **(1)** *NOTE* "so that only the $[I_2]$ changes" scores **(2)** "so that only the I_2 concentration changes" scores **(2)** "so that only the I_2 changes" scores **(1)**	Propanone and acid are in excess, without reference to further comments	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (d)	Zero order **(1)** (Gradient =) **rate** is constant / I_2 (concentration) doesn't affect **rate** / **rate** of change of I_2 (concentration) doesn't change with time **(1)** **Mark independently**	Just 'straight line' Or just 'gradient is constant' [Thiosulfate] or volume of Thiosulfate is proportional to time without reference to iodine Reference to half life $[I_2]$ is proportional to rate	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (e)	Measuring cylinder quicker / Measuring cylinder can measure a variety of volumes **(1)** ALLOW Measuring cylinder can be plastic so unbreakable Comment on lower cost of measuring cylinder if qualified with a reason Pipette more accurate / (graduated) pipette more precise / pipette can be used to extract samples from a reaction mixture (for titration) **(1)**	Just "Measuring cylinder easier to use" Easier to clean Measuring cylinder can be used for large volumes Pipette more reliable Ignore references to easier	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (f) (i)	To keep (total) volume constant / to make the (total) volume 32 cm^3 / to make concentrations proportional to volume of reactant	To keep concentrations constant	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (f) (ii)	First order wrt propanone with explanation **(1)** First order wrt hydrogen ions/ sulfuric acid, with explanation **(1)** Explanation can be in terms of experiments 1 and 3 (propanone) or 1 and 2 (acid) and can be in terms of concentration or volume **Rate = k**$[CH_3COCH_3][H^+]([I_2]^0)$ / **Rate = k**$[CH_3COCH_3][H_2SO_4]([I_2]^0)$ **(1)** ALLOW names of propanone and sulfuric acid in place of formulae Ignore case of k in rate equation Ignore order wrt iodine even if wrong Third mark is consequential if incorrect orders of propanone and acid given.	Expressions without rate or k Expressions with K_c R / r for rate	**3**

TOTAL FOR SECTION B = 50 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
20 (a)	Q: O-H ALLOW OH – O – H **(1)** R: C=O ALLOW – C = O | – C = O **(1)** IGNORE names ACCEPT answers written on spectrum	Just 'alcohol' — OH Just 'carbonyl' – C O | C-O	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (b) (i)	Y = methanol / CH_3OH **(1)** Any two of the following: Molecular ion / M^+ / M_r / CH_3OH^+ / methanol = 32 CH_3^+ = 15 CH_3O^+ / CH_2OH^+ = 31 $CHOH^+$ / CH_2O^+ =30 COH^+ = 29 CO^+ = 28 **(1)** Charges not required TE in second mark for two correct possible peaks from an incorrect compound.		**2**

Question Number	Acceptable Answers	Reject	Mark
20 (b) (ii)	Two **(1)** This mark may be scored if two shifts are given. Any two shifts correctly identified: -**OH** at 2.0-4.0 / any value in this range **H**-C-O at 3.0- 4.2 / any value in this range **H** in C**H**$_3$ OH at 3.39 (ppm) **(1)** Allow TE for ethanol with three peaks **(1)** and three correct shift values: -**OH** at 2.0-4.0 / any value in this range **H**-C-O at 3.0- 4.2 / any value in this range CH in an alkane at 0.1–1.9 **(1)**	 CH in an alkane at 0.1–1.9 Just CH_3 OH at 3.39	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (c) (i)	Z contains two –OH/ one alcohol + one acid ALLOW two alcohol groups / is a diol		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c) (ii)	Z is an acid / contains –COOH / contains –CO_2H/ contains a carboxylic acid group / contains H^+		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c) (iii)	Z is a secondary alcohol/ a ketone is **formed** from **Z** / Z contains –C(H)(OH)– **(1)**	**Z** is a ketone	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c) (iv)	(Iodoform produced) so **Z** contains CH_3 CH(OH)- TE if **Z** is identified as a ketone in (iii): **Z** contains CH_3 C=O / **Z** is a methyl ketone		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (d)	Answers will be based on several pieces of information (molecular formula, products of ester hydrolysis, answers to (c)) which may be contradictory if errors have been made. ALLOW TE marks for formulae which are chemically possible (ie no 5 bonded carbons etc) and based on most of the deductions but **not necessarily all**. **Z** is $CH_3CH(OH)CH_2COOH$ **(1)** Stand alone mark ALLOW TE for an **acid** with OH in wrong position in **Z** if oxidation product identified as aldehyde TE for **Z** = CH_3COCH_2COOH if identified as ketone in (iii) **X** is $CH_3CH(OH)CH_2COOCH_3$ **(1)** Stand alone mark TE for a methyl ester of **Z**		**2**

Question Number	Acceptable Answers	Reject	Mark
21 (a) (i)	Transesterification Ethanol transesterification	Substituted esterification	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (a) (ii)	To prevent hydrolysis/ to stop fatty acids forming / to stop breakdown of esters / water reacts with esters/ water is a better nucleophile than ethanol	To dilute ethanol Ethanol would react with water A reaction would occur (unspecified)	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (b)	(Vegetable) Fats/ oils are renewable (crude oil is not) / biodiesel comes from a renewable source / doesn't use up fossil fuel resources/ carbon footprint is less / (closer to) carbon neutral / growing vegetables absorb CO_2 If more than one answer is given, and one is incorrect, no mark Ignore comments on biodegradability	Just "made from plants" Just "crude oil is not sustainable" Less polluting produces less greenhouse gases / less CO_2 Burns more cleanly Requires less energy for production	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (c)	Substances to be separated have different (forces of) attraction to / affinity for / solubilities in / adsorption to one or both of the mobile and stationary phases OWTTE **(1)** ALLOW absorption GC: **mobile** phase a (inert / unreactive) **gas** OR GC: **mobile** phase nitrogen / helium / argon / other named inert gas **(1)** GC: **Stationary** phase a **liquid** (on an (inert) solid) / a solid **(1)** HPLC: **stationary** phase a **solid** / silica **(1)** HPLC: **mobile** phase a **liquid** **(1)**	Different retention times without a reason why Different volatilities Different masses Different reactivity Different reactions Different interactions	**5**

TOTAL FOR SECTION C = 20 MARKS

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