

# 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)	$\Delta S_{\text{system}} = (3 \times 2 \times 65.3 + 197.6) - (186.2 + 188.7)$ <p>Correct data for CH<sub>4</sub> and CO (186.2 and 197.6) (1)</p> <p>= (+) 214.5 / 215 (J mol<sup>-1</sup> K<sup>-1</sup>) / (+) 0.2145 / 0.215 kJ (mol<sup>-1</sup> K<sup>-1</sup>) (1)</p> <p>Units must be shown if data has been converted to kJ</p> <p>Full marks (2) for correct answer without working Ignore sf except 1</p> <p>Answer of -214.5 scores (1)</p> <p>Answer of +18.6 if entropy of H not doubled scores (1)</p> <p>Answer of -46.7 if entropy of H<sub>2</sub> not tripled scores (1)</p> <p>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.</p>	<p>214</p> <p>0.214</p>	2
Question Number	Acceptable Answers	Reject	Mark
17 (b)	$(\Delta S_{\text{surroundings}}) = \frac{-\Delta H}{T}$ <p>Expression or use of expression, <math>\frac{-206.1 \times (1000)}{298}</math> (1)</p> <p>= -691.6 J (mol<sup>-1</sup> K<sup>-1</sup>) / -0.6916 kJ (mol<sup>-1</sup> K<sup>-1</sup>) (1)</p> <p>Ignore sf except 1</p>		2

Question Number	Acceptable Answers	Reject	Mark
17 (c)	$\Delta S_{\text{total}} = (214.5 + (-691.6)) = -477.1 \text{ (J mol}^{-1} \text{ K}^{-1}) /$ $- 0.4771 \text{ (kJ mol}^{-1} \text{ K}^{-1}) \text{ (1)}$ <p>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</p> <p>Negative / less than zero (so not spontaneous) / would be positive if spontaneous. (1)</p> <p>ALLOW “feasible” for spontaneous.</p> <p>If answer to calculation is positive, accept comment that it would be expected to be negative if not spontaneous</p>	<p>Addition of value in J to specified value in kJ</p> <p>Comments on kinetic stability</p>	2

Question Number	Acceptable Answers	Reject	Mark										
*17 (d) (i)	<p><math>K_p = \frac{(p_{H_2})^3 \times (p_{CO})}{(p_{CH_4})(p_{H_2O})}</math> (1)</p> <p>4 Correct partial pressures (3)</p> <table border="1" data-bbox="296 432 761 607"> <tr> <td></td> <td>CH<sub>4</sub></td> <td>H<sub>2</sub>O</td> <td>CO</td> <td>H<sub>2</sub></td> </tr> <tr> <td>pp</td> <td>0.25</td> <td>0.25</td> <td>0.375</td> <td>1.125</td> </tr> </table> <p>ALLOW partial pressures as fractions</p> <p><math>K_p = \frac{(1.125)^3 \times (0.375)}{(0.25)(0.25)} = 8.54 \text{ atm}^2</math></p> <p>value of <math>K_p</math> (1)</p> <p>unit (1) (Stand alone mark)</p> <p>Correct calculation without working scores the 5 calculation marks.</p> <p>TE from <math>K_p</math> expression if inverted Ignore sf except 1</p> <p><b>If any partial pressures are incorrect:</b> Calculating total number of moles (6.4) (1)</p> <p>Calculating mole fractions (0.125, 0.125, 0.1875, 0.5625 if total number of moles is correct) (1)</p> <p>Multiplying mole fractions by total pressure (x 2 atm) (1)</p> <p>value of <math>K_p</math> (1)</p> <p>unit (1) (stand alone mark)</p> <p>ALLOW TE in value of <math>K_p</math> only from incorrect partial pressures, not using values in question as not using equilibrium moles</p> <p>If treated as a <math>K_c</math> calculation following <math>K_p</math> expression : <math>K_p</math> expression (1) units <math>\text{atm}^2</math> (1)</p> <p>Max. mark (2)</p>		CH <sub>4</sub>	H <sub>2</sub> O	CO	H <sub>2</sub>	pp	0.25	0.25	0.375	1.125	<p>Square brackets</p> <p>TE for <math>K_p</math> expression with addition, not multiplication</p>	<p>6</p>
	CH <sub>4</sub>	H <sub>2</sub> O	CO	H <sub>2</sub>									
pp	0.25	0.25	0.375	1.125									

Question Number	Acceptable Answers	Reject	Mark
17 (d) (ii)	$\Delta S_{\text{total}} = (8.31 \ln 8.54) = (+)17.8 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$ 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 $\Delta S_{\text{total}} = 37.16 / 37.12$		1

Question Number	Acceptable Answers	Reject	Mark
17 (d) (iii)	$17.8 = 225 - \frac{206.1 \times 1000}{T} \quad (1)$ $T = \frac{(206.1 \times 1000)}{207.2} = 995 / 990 \text{ (K)} \quad (1)$  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 $T = 1097$  <b>OR</b>  If $\Delta S_{\text{total}}$ is taken as zero $0 = 225 - \frac{206.1 \times 1000}{T} \quad (1)$ $T = 916\text{K} \quad (1)$  $K_p$ value of 87.48 gives $T = 916$  Ignore sf except 1		2



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

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)	$K_a = \frac{[H^+][CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$ <p>ALLOW <math>[H_3O^+]</math> for <math>[H^+]</math></p> <p>ALLOW <math>C_2H_5</math> for <math>CH_3CH_2</math></p> <p>ALLOW <math>\frac{[H^+][A^-]}{[HA]}</math> if HA and <math>A^-</math> identified</p>	<p>Wrong / missing charge on <math>CH_3CH_2COO^-</math></p> $K_a = \frac{[H^+]^2}{[CH_3CH_2COOH]}$ <p>unless full expression also given</p>	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) <p><math>([H^+] = 1.8 \times 10^{-3})</math></p> <p>pH = 2.74 (1)</p> <p>Correct answer with no working scores (2) No TE for incorrect <math>[H^+]</math></p> <p>Ignore significant figures except 1 Minimum of 1 decimal place needed</p>		2

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

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

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

Question Number	Acceptable Answers	Reject	Mark
18 (c) (iv)	<p>S-shaped curve, vertical at 25 cm<sup>3</sup> (with kink at start ) (1)</p> <p>Starting at pH 2-3 (TE from (b)(ii), finishing at pH 12 -13 (1)</p> <p>Vertical section between 3 and 6 units high centred round a pH of between 8 and 9 (1)</p> <p>Vertical section should not extend over more than ±2.5cm<sup>3</sup> 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.</p> <p>Reverse curve maximum 2</p>		3

Question Number	Acceptable Answers	Reject	Mark
18 (c) (v)	<p>Either Need indicator changing in vertical region of curve / need indicator changing where pH changes sharply / bromocresol green changes before the vertical region (1)</p> <p><b>Not</b> bromocresol green which changes at <b>3.8 - 5.4</b> (1)</p> <p>OR</p> <p><math>pK_{in} \pm 1</math> must be in vertical section / sharply changing section (1)</p> <p><b>Not</b> bromocresol green because <math>pK_{in}</math> is <b>4.7</b> (1)</p> <p>TE from curve with vertical section including pH 3.7 - 5.7</p>	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 <sub>4</sub> / lithium tetrahydridoaluminate / lithium aluminium hydride (1)  Allow minor error in name if correct formula is given  Ignore solvent  ALLOW nucleophile AND H <sup>-</sup> for 1 mark	Lithal without correct name or formula	2

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

Question Number	Acceptable Answers	Reject	Mark
<b>19 (b)</b>	Starch (solution)		<b>1</b>

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

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



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

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

Question Number	Acceptable Answers	Reject	Mark
19 (f) (ii)	<p>First order wrt propanone with explanation (1)</p> <p>First order wrt hydrogen ions/ sulfuric acid, with explanation (1)</p> <p>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</p> <p>Rate = <math>k[\text{CH}_3\text{COCH}_3][\text{H}^+][\text{I}_2]^0</math> / Rate = <math>k[\text{CH}_3\text{COCH}_3][\text{H}_2\text{SO}_4][\text{I}_2]^0</math> (1)</p> <p>ALLOW names of propanone and sulfuric acid in place of formulae</p> <p>Ignore case of k in rate equation</p> <p>Ignore order wrt iodine even if wrong</p> <p>Third mark is consequential if incorrect orders of propanone and acid given.</p>	<p>Expressions without rate or k</p> <p>Expressions with <math>K_c</math></p> <p>R / r for rate</p>	3

TOTAL FOR SECTION B = 50 MARKS

## Section C

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

Question Number	Acceptable Answers	Reject	Mark
20 (b) (i)	<p>Y = methanol / CH<sub>3</sub>OH (1)</p> <p>Any two of the following: Molecular ion / M<sup>+</sup> / M<sub>r</sub> / CH<sub>3</sub>OH<sup>+</sup> / methanol = 32 CH<sub>3</sub><sup>+</sup> = 15 CH<sub>3</sub>O<sup>+</sup> / CH<sub>2</sub>OH<sup>+</sup> = 31 CHOH<sup>+</sup> / CH<sub>2</sub>O<sup>+</sup> = 30 COH<sup>+</sup> = 29 CO<sup>+</sup> = 28 (1)</p> <p>Charges not required</p> <p>TE in second mark for two correct possible peaks from an incorrect compound.</p>		2

Question Number	Acceptable Answers	Reject	Mark
20 (b) (ii)	<p>Two (1) This mark may be scored if two shifts are given.</p> <p>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 CH<sub>3</sub> OH at 3.39 (ppm) (1)</p> <p>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)</p>	<p>CH in an alkane at 0.1-1.9</p> <p>Just CH<sub>3</sub> OH at 3.39</p>	2

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

Question Number	Acceptable Answers	Reject	Mark
20 (c) (ii)	<p>Z is an acid / contains -COOH / contains -CO<sub>2</sub>H/ contains a carboxylic acid group / contains H<sup>+</sup></p>		1

Question Number	Acceptable Answers	Reject	Mark
20 (c) (iii)	<p>Z is a secondary alcohol/ a ketone is <b>formed</b> from Z /</p> <p>Z contains <math>\begin{array}{c}   \\ -C-OH \\   \\ H \end{array}</math> (1)</p>	Z is a ketone	1

Question Number	Acceptable Answers	Reject	Mark
20 (c) (iv)	<p>(Iodoform produced ) so Z contains CH<sub>3</sub> CH(OH)-</p> <p>TE if Z is identified as a ketone in (iii): Z contains CH<sub>3</sub> C=O / Z is a methyl ketone</p>		1

Question Number	Acceptable Answers	Reject	Mark
20 (d)	<p>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.</p> <p>ALLOW TE marks for formulae which are chemically possible (ie no 5 bonded carbons etc) and based on most of the deductions but <b>not necessarily all</b>.</p> <p>Z is <math>\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{COOH}</math> (1) Stand alone mark</p> <p>ALLOW TE for an acid with OH in wrong position in Z if oxidation product identified as aldehyde</p> <p>TE for Z = <math>\text{CH}_3\text{COCH}_2\text{COOH}</math> if identified as ketone in (iii)</p> <p>X is <math>\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{COOCH}_3</math> (1) Stand alone mark TE for a methyl ester of Z</p>		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)	<p>(Vegetable) Fats/ oils are renewable (crude oil is not) /</p> <p>biodiesel comes from a renewable source /</p> <p>doesn't use up fossil fuel resources/</p> <p>carbon footprint is less /</p> <p>(closer to) carbon neutral / growing vegetables absorb CO<sub>2</sub></p> <p>If more than one answer is given, and one is incorrect, no mark</p> <p>Ignore comments on biodegradability</p>	<p>Just "made from plants"</p> <p>Just "crude oil is not sustainable"</p> <p>Less polluting produces less greenhouse gases / less CO<sub>2</sub></p> <p>Burns more cleanly</p> <p>Requires less energy for production</p>	1

Question Number	Acceptable Answers	Reject	Mark
21 (c)	<p>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)</p> <p>ALLOW absorption</p> <p>GC: <b>mobile</b> phase a (inert / unreactive) gas OR GC: <b>mobile</b> phase nitrogen / helium / argon / other named inert gas (1)</p> <p>GC: <b>Stationary</b> phase a <b>liquid</b> (on an (inert) solid) / a solid (1)</p> <p>HPLC: <b>stationary</b> phase a <b>solid</b> / silica (1)</p> <p>HPLC: <b>mobile</b> phase a <b>liquid</b> (1)</p>	<p>Different retention times without a reason why</p> <p>Different volatilities</p> <p>Different masses</p> <p>Different reactivity</p> <p>Different reactions</p> <p>Different interactions</p>	5

TOTAL FOR SECTION C = 20 MARKS

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