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Mark Scheme (Results)

June 2014

GCE Chemistry (6CH04/01)
General Principles of Chemistry I

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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	Reject	Mark
1 (a)	B		**1**

Question Number	Correct Answer	Reject	Mark
1 (b)	C		**1**

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

Question Number	Correct Answer	Reject	Mark
1 (d)	D		**1**

Question Number	Correct Answer	Reject	Mark
2 (a)	B		**1**

Question Number	Correct Answer	Reject	Mark
2 (b)	D		**1**

Question Number	Correct Answer	Reject	Mark
2 (c)	D		**1**

Question Number	Correct Answer	Reject	Mark
2 (d)	C		**1**

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

Question Number	Correct Answer	Reject	Mark
4 (a)	B		**1**

Question Number	Correct Answer	Reject	Mark
4 (b)	B		**1**

Question Number	Correct Answer	Reject	Mark
4 (c)	C		**1**

Question Number	Correct Answer	Reject	Mark
5	B		**1**

6 (a)	B		**1**

Question Number	Correct Answer	Reject	Mark
6 (b)	C		**1**

Question Number	Correct Answer	Reject	Mark
6 (c)	D		**1**

Question Number	Correct Answer	Reject	Mark
6 (d)	A		**1**

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

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

Question Number	Correct Answer	Reject	Mark
8	A		**1**

Section B

Question Number	Acceptable Answers	Reject	Mark
9 (a)(i)	+89.6 – [+32.7 + 165] **(1)** = −108.1 J mol^{-1} K^{-1}/ J K^{-1} mol^{-1} Value, sign and **units** **(1)** Ignore SF except one Internal TE for recognisable numbers allowed, for example: $\Delta H^{\ominus}_{at}$ magnesium chloride (147.7→ -223.1) Halving $S^{\ominus}$ [Cl_2] (82.5 → -25.6) Correct answer with no working **(2)** +/no sign 108.1 J mol^{-1} K^{-1}/ J K^{-1} mol^{-1} **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
9 (a)(ii)	(The sign is negative because) Any two from: • (A solid and) a gas reacting to form a solid. OR (Entropy decreases because) a gas reacting to form a solid. • There are fewer ways of arranging particles in a solid than a gas or vice-versa. OR Decrease in disorder as solid more ordered than gas or vice versa • Two mol(es) of reactant forming one mole of product. (Ignore two molecules form one molecule) OR Number of mol(es)/molecules decreases OR Fewer/less mol(es) of products than reactants	Energy... '(Positive) Answer is as expected...' **(0)**	**2**

Question Number	Correct Answer	Reject	Mark
9 (b)	$\Delta S^{\ominus}_{total} = \Delta S^{\ominus}_{surroundings} + \Delta S^{\ominus}_{system}$ OR = +2152 + (-108.1) = (+)2043.9 Value 2043.9 / 2044 **(1)** = (+)2040 (J mol^{-1} K^{-1}) 3SF This mark conditional on correct value or correct TE value from (a)(i) **(1)** Accept TE from (a)(i), for example, -223.1 → +1928.9 → +1930 -25.6 → +2126.4 → +2130 Correct answer (2040, etc) with or without working scores 2		**2**

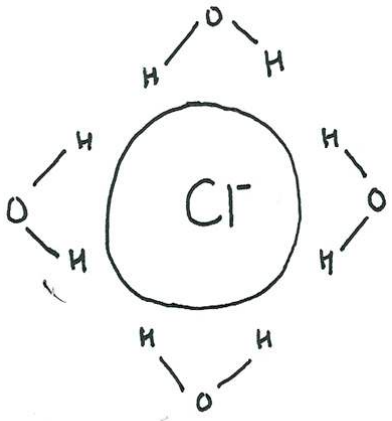
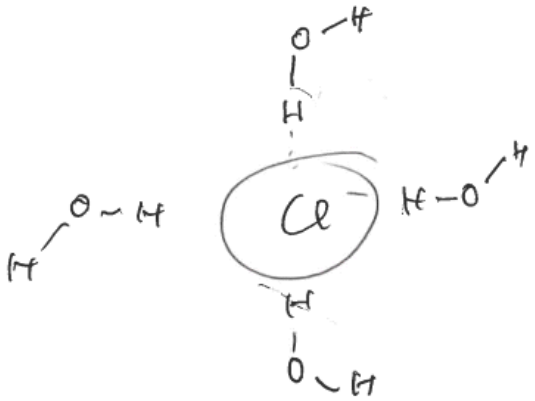
Question Number	Correct Answer1	Reject	Mark
9 (c)	$\Delta S^{\ominus}_{surroundings} = - \frac{\Delta H^{\ominus}}{298}$ $\Delta H^{\ominus} = - \Delta S^{\ominus}_{surroundings} \times 298$ OR $\Delta H^{\ominus} = -2152 \times 298$ **(1)** $= -641.296$ $= -641.3$ (kJ mol^{-1}) **(1)** ALLOW $= -641.3 \times 10^3$ **J mol^{-1}** Note 1. -640.1338 = -640.1 (if 2040/answer to part (b) used to recalculate entropy change of surroundings first.) **(2)** 2. $\Delta H^{\ominus} = +641.3$ (kJ mol^{-1}) **(1)** 3. $\Delta H^{\ominus} = - \frac{\Delta S^{\ominus}_{surroundings}}{298}$ **(0)** Ignore SF except one		**2**

Question Number	Correct Answer	Reject	Mark
9 (d)(i)	50 x 4.2 x 22.5 = 4725 (J) Ignore sign ALLOW 4.725 **kJ** Ignore SF except one		**1**

Question Number	Correct Answer	Reject	Mark
9 (d)(ii)	There are two legitimate answers to this part. If **both** methods have been used, you **must** send the item to review under mark scheme (−)4725 ÷ 0.0300 = −157.5 (kJ mol^{-1}) /−157500 **J mol^{-1}** OR (−)4725 ÷ 0.0500 = /−94.5 (kJ mol^{-1}) /−94500 **J mol^{-1}** ALLOW TE answer (d)(i) ÷ 0.0300/0.0500 Ignore SF except one Value **(1)** Sign **(1)** The mark for the negative sign is awarded for their calculation even if value is wrong, providing any **energy divided by moles or energy multiplied by 1/number of moles** calculation has been done.		**2**

Question Number	Correct Answer	Reject	Mark
9 (d)(iii)	There are two correct answers: Using 0.03 gives the answer of -381.75 kJ mol^{-1} Using 0.05 gives the answer of -350.25 kJ mol^{-1} Both these answers score full marks with or without correct working. **First mark** Appreciation of Hess's Law either in words, numbers, symbols or on the diagram For example, $\Delta H_{solution}$ + Lattice energy $= \Delta H_{hydration}\, Mg^{2+} + (2)\Delta H_{hydration}\, Cl^{-}$ **(1)** **Second mark** $2\ \Delta H_{hydration}\, Cl^{-} = -2526 - 157.5 - (-1920) = -763.5$ OR $2\ \Delta H_{hydration}\, Cl^{-} = -2526 - 94.5 - (-1920) = -700.5$ ALLOW Any number or group of numbers minus (-1920) **(1)** **Third mark** $\Delta H_{hydration}\, Cl^{-} = -381.75$ (kJ mol^{-1}) OR $\Delta H_{hydration}\, Cl^{-} = -350.25$ (kJ mol^{-1}) Any number, wherever it has come from,		**3**

	divided by two can score this mark, provided that the sign is consistent. **(1)** Ignore SF except one Use of lattice energy – 2326 gives −281.75/−250.25 scores **(2)** ALLOW TE from (d)(ii)		

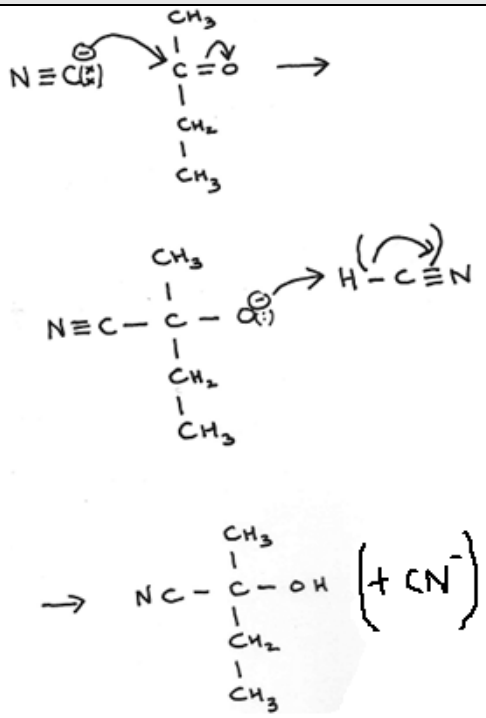
Question Number	Correct Answer	Reject	Mark
9 (d)(iv)	 OR  • One/several water molecule(s) all correctly orientated. • $H^{\delta+}$/ hydrogen (one or two hydrogens from each water molecule) towards chloride ion • with negative charge either on chlorine or on the whole hydrated ion. ALLOW • A minus sign with a ring around it for the Cl^- • Bonds shown by lines/broken lines/dotted lines/wedges	**$Cl^-.H_2O$** $H^{\delta-}$ / H^+ / H^- $Cl^{\delta-}$ / Cl (with no charge)	**1**

Question Number	Correct Answer	Reject	Mark
9(d)(v)	Both marks may be awarded in either part. **First mark** (Temperature increases) because the reaction/process/dissolving/hydration of ions is **exothermic**. OR Strong(er) forces between the δ+ H and Cl^- OR Strong(er) forces between the δ– O and Mg^{2+} OR Strong(er) ion-dipole forces OR Formation of bonds releases energy OR Strong(er) bonds formed OR Enthalpy of hydration is greater than lattice energy **(1)** **Second mark** (Volume decreases so) shorter bonds between ion and water molecules ALLOW Water molecules more tightly arranged/pack better/occupy less space OR Water molecules more ordered/ clustered (around the ions). **(1)**	The breaking of the lattice is exothermic. Ions more tightly arranged Ions more ordered	**2**

Total for Question 9 = 17 marks

Question Number	Correct Answer	Reject	Mark
10(a)(i)	Sodium/potassium dichromate ((VI)) **and** (Dilute/concentrated) sulfuric acid OR correct formulae / H^+ **and** $Cr_2O_7^{2-}$ ALLOW H^+ **and** $Cr_2O_7^{2-}$/acidified dichromate((VI)) **(1)** Reflux/distil Ignore 'heat', 'warm', and 'boil' alone. ALLOW Just 'under reflux' Just 'under distillation' **(1)** Second mark depends on mention of dichromate/$Cr_2O_7^{2-}$ in first part OR $KMnO_4$ and acid with heat **(1)**	Hydrochloric acid	**2**

Question Number	Correct Answer	Reject	Mark
10 (a)(ii)	Carbonyl group – addition of 2,4-dinitrophenylhydrazine / 2,4-DNP(H) / Brady's reagent **(1)** to give yellow/orange/red precipitate/ppt/ppte/solid/crystals ALLOW recognisable spelling e.g., percepitate **(1)** $CH_3C{=}O$ reaction with iodine in alkali/NaOH/KOH/OH^- ALLOW Iodoform/tri-iodomethane/haloform AND reaction/test **(1)** to form (pale) yellow / cloudy precipitate/solid/crystals **(1)** Ignore references to smell Ignore heat in either part **Note** • In both cases result mark depends on test being recognisably correct even if it did not score a mark Examples: DNP gives yellow ppt Iodine test gives yellow ppt • Tests for aldehydes with correct results, no marks	2-DNP/4DNP Just DNP Brick red ppt	**4**

Question Number	Correct Answer	Reject	Mark
10 (b)(i)	 Arrow (from carbon) of CN^- to carbon of C=O AND Arrow from part of C=O double bond to oxygen ALLOW Two steps via a charged canonical form **(1)** Intermediate anion with C-CN bond. **(1)** Arrow from resulting O^- to hydrogen of $HCN/H^+/H_2O$ **(1)** **Note** Arrow directions must be correct to score each mark Penalise half-headed arrows each time in both parts ALLOW skeletal formulae.	CN without negative charge ...C-NC bond	**3**

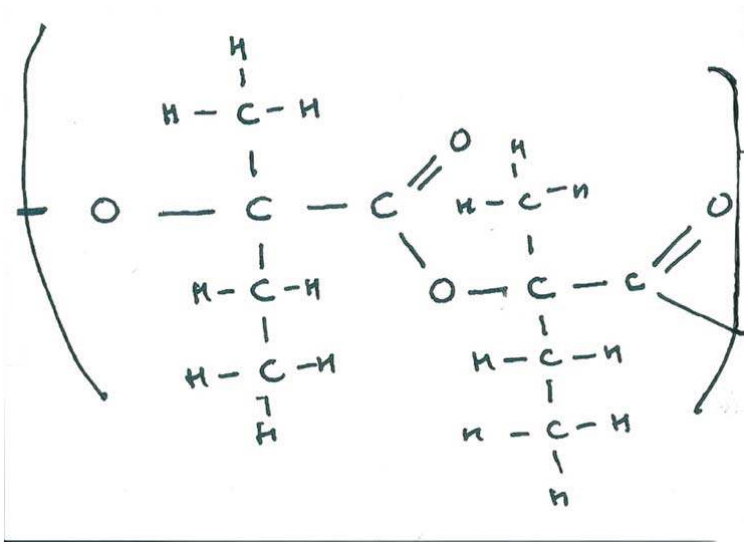
Question Number	Correct Answer	Reject	Mark
10 (b)(ii)	Forms a racemic mixture **(1)** Because bonds around C=O are planar OR Carbonyl group/reaction site is (trigonal) planar OR Bonds around carbonyl carbon are planar **(1)** Cyanide can attack from either side / above or below **(1)**	Butanone/molecule/it is planar C=O is planar Carbonyl bond is planar Intermediate is planar	**3**

Question Number	Correct Answer	Reject	Mark
10 (c)(i)	(Acid) hydrolysis OR Alkaline hydrolysis followed by acidification	Hydration	**1**

Question Number	Correct Answer	Reject	Mark
10 (c)(ii)	The O-H absorptions for alcohol and carboxylic acid overlap. OR OH absorption for an acid is very broad OR Quote data booklet values which must show some overlap, to include 3300 to 3200. ALLOW OH absorptions similar/the same.	Just 'both have OH groups' Just 'two OH groups present'	**1**

Question Number	Correct Answer	Reject	Mark
10 (c)(iii)	(Chemical shift δ) 2.0 - 4.0 (ppm) / any value within this range ALLOW Correct number followed by δ, eg 3δ		**1**

Question Number	Correct Answer	Reject	Mark
10 (c)(iv)	There is no hydrogen atom/proton on the adjacent/neighbouring carbon atom ALLOW No adjacent/neighbouring hydrogens/protons		**1**

Question Number	Correct Answer	Reject	Mark
10 (d)	 Ester linkage **(1)** Rest of molecule **(1)** ALLOW Attached chains as structural formulae Ignore n or other numbers outside bracket		**2**

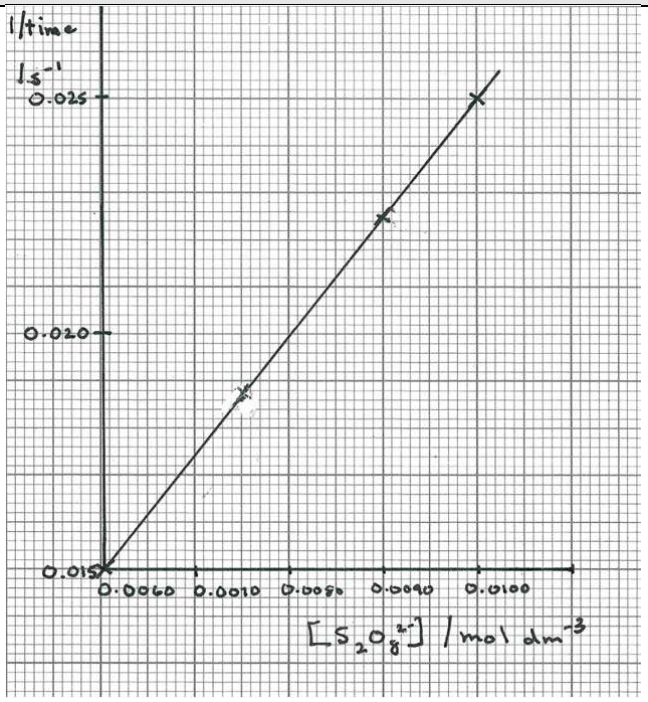
Total for Question 10 = 18 marks

Question Number	Correct Answer	Reject	Mark
11(a)	$S_2O_8^{2-} + 2I^- \rightarrow 2SO_4^{2-} + I_2$ ALLOW multiples Ignore state symbols even if incorrect		**1**

Question Number	Correct Answer	Reject	Mark
11 (b)(i)	Blue/black /blue-black OR Colourless to blue-black/ blue/black	Purple	**1**

Question Number	Correct Answer	Reject	Mark
11 (b)(ii)	The mixture would change colour/ go blue/black /blue-black **immediately/straight away** ALLOW …too quick(ly)/too early …quicker ...no time delay		**1**

Question Number	Correct Answer	Reject	Mark
11 (b)(iii)	(As quickly as iodide reacts to form iodine it is) reduced/turned back to iodide by the thiosulfate ions ALLOW Persulfate reacts with thiosulfate first. OR Iodine reacts with thiosulfate.		**1**

Question Number	Correct Answer	Reject	Mark
11 (c)(i)	 **First mark** Correct graph of rate v concentration, with axes correct **and** values increasing on both axes labelled with quantity **and** units Note Units may be given in brackets with no slash. s/time meaning s divided by time is fine. **(1)** **Second mark** Sensible scales to use at least half the graph paper but allow graphs starting at the origin and points cover two by two big squares. Linear scales All points reasonably correct with straight line drawn **(1)** Second mark depends on correct graph of rate v concentration, but not other detail of first mark		**2**

Question Number	Correct Answer	Reject	Mark
11 (c)(ii)	First order This mark is independent of the graph drawn **(1)** Because the graph is a straight line (through the origin)/ rate is proportional to $[S_2O_8^{2-}]$ OR As concentration increases by (factor of) 2 rate increases by 2 (or any other numbers, including 'x') OR Rate increases linearly (with concentration) OR Gradient of line is constant **(1)** Second mark depends on first order	Just 'as concentration increases rate increases'	**2**

Question Number	Correct Answer	Reject	Mark
11 (c)(iii)	Rate = $k[S_2O_8^{2-}][I^-]$ **(1)** TE from (c)(ii) Units - $dm^3\,mol^{-1}\,s^{-1}$ ALLOW Internal TE from rate equation **(1)** Units in any order	Incorrect formulae	**2**

Question Number	Correct Answer	Reject	Mark
11 (d)(i)	**Method 1** **First mark** Gradient = $-E_a/R$ OR $E_a = -R \times$ gradient **(1)** **Second mark** (Gradient =) $\frac{-3.0-(-3.69)}{(3.30-3.41) \times 10^{-3}}$ OR = -6272.7 (K) Please award this mark if -6272.7 is seen anywhere! **(1)** **Method 2** **First mark** Setting up two simultaneous equations **(1)** **Second mark** Subtracting one equation from the other or other correct methods of solution **(1)** **Third mark (applies to both methods)** (E_a) = +52126 J mol^{-1} /+52.1(26)kJ mol^{-1} Note: TE can only be given if either method 1 or method 2 has been clearly carried out. Positive sign given OR Two negative signs clearly cancel in method and no sign given **(1)** Correct answer with or without working, with sign and units **(3)** Ignore SF unless only one	Negative sign	**3**

Question Number	Correct Answer	Reject	Mark
11 (d)(ii)	Either Take readings at different temperatures OR Repeat at the same two temperatures ALLOW Just 'repeat the experiment'		**1**

Total for Question 11 = 14 marks

Total for Section B = 49 marks

Section C

Question Number	Correct Answer	Reject	Mark
12(a)(i)	Mass of ethanoic acid = 0.04 x 60.1 = (2.404 g) **(1)** Volume of ethanoic acid = 2.404 ÷ 1.049 = 2.2917 = 2.3 (cm^3) **(1)** Correct answer with no working **(2)** Ignore SF except only one ALLOW 60.0 for molar mass which gives mass 2.4 and volume 2.288 = 2.3 cm^3 **(2)** OR First step 1.049 ÷ 60/60.1 to find number of moles in 1 cm^3 = 0.017 **(1)** Then volume = 0.04 ÷ 0.017 = 2.3529 (cm^3) But note, if whole calculation done on calculator, 60 gives 2.2879 and 61 gives 2.2917. **(1)** If units given, they must be correct, but penalise wrong units only once here.		**2**

Question Number	Correct Answer	Reject	Mark
12 (a)(ii)	Syringe ALLOW Burette Graduated/adjustable pipette	Gas syringe Biuret Just 'pipette'	**1**

Question Number	Correct Answer	Reject	Mark
12 (a)(iii)	To prevent… evaporation/vapour escaping water vapour entering OR To maintain a closed system OR To maintain a closed environment ALLOW To prevent: air oxidizing the alcohol reaction with air OR Due to volatility (of chemicals) IGNORE …gas escaping …HCl escaping		**1**

Question Number	Correct Answer	Reject	Mark
12 (a)(iv)	**First and second mark** Phenolphthalein **(1)** From colourless to (pale) pink/red **(1)** ALLOW Other indicators with pK_{in} in range 7.5 – 10 Some examples are: Thymol blue ((base)) (yellow to blue) Phen**ol** red (yellow to red) Thymolphthalein (colourless to blue) Second mark depends on correct indicator except bromothymol blue, which is incorrect but very close to range so allow colour yellow to blue. **Third mark** Sodium ethanoate is (slightly) alkaline OR Ethanoic acid is a weak acid OR Phenolphthalein pH range coincides with vertical section of the pH/titration curve OR Titration of weak acid with strong base OR Neutralisation/equivalence point is at 8-10/ any number between 8 and 10. OR pK_{in} +/-1 lies within vertical region **(1)** Third mark is independent	Litmus/universal indicator Pink to colourless Thymol blue **(acid)** Phenyl red Methyl red	**3**

Question Number	Correct Answer	Reject	Mark
12 (b)(i)	$CH_3COOH+CH_3CH_2OH \rightleftharpoons CH_3COOCH_2CH_3+H_2O$ ALLOW Single arrow $-CO_2H$ $-C_2H_5$ Displayed formulae IGNORE state symbols even if incorrect		**1**

Question Number	Correct Answer	Reject	Mark
12 (b)(ii)	Volume of alkali reacting with ethanoic acid = 77.1-11.7 = 65.4 cm^3 **(1)** Moles of ethanoic acid = $\frac{65.4 \times 0.200}{1000}$ = $0.01308/1.308\times10^{-2}$ (mol) **(1)** Correct answer no working (2) Ignore SF except 1 Allow internal TE for use of Moles of ethanoic acid = $\frac{77.1 \times 0.200}{1000}$ = $0.01542/1.542\times10^{-2}$ (mol) max**(1)**		**2**

Question Number	Correct Answer	Reject	Mark
12 (b)(iii)	Number of moles of ethanol = $0.01308/1.308\times10^{-2}$ (mol) TE same as (ii)		**1**

Question Number	Correct Answer	Reject	Mark
12 (b)(iv)	Number of moles of ethyl ethanoate =0.0400−0.01308 = 0.02692 (mol) Allow TE from (ii)/(iii) for example 0.01542 gives 0.02458		**1**

Question Number	Correct Answer	Reject	Mark
12 (b)(v)	$K_c = \frac{[CH_3CO_2CH_2CH_3][H_2O]}{[CH_3CO_2H][CH_3CH_2OH]}$ **(1)** $= \frac{0.02692 \times 0.02692}{0.01308 \times 0.01308}$ = 4.23579 = 4.24 **(1)** Ignore SF except one Allow TE from (ii), (iii) and (iv) for example 0.01542 etc gives 2.54 No TE for incorrect expression of K_c		**2**

Question Number	Correct Answer	Reject	Mark
12 (b)(vi)	The units cancel OR There are the same numbers of moles of reactants and products		**1**

Question Number	Correct Answer	Reject	Mark
12 (b)(vii)	(Concentrated) hydrochloric acid contains water		**1**

Question Number	Correct Answer	Reject	Mark
12 (c)(i)	First test tube esterification OR addition/elimination ALLOW Condensation **(1)** Second test tube (acid) hydrolysis **(1)** Two fully correct answers in wrong order **(1) max**	Alkaline hydrolysis followed by acidification	**2**

Question Number	Correct Answer	Reject	Mark
12 (c)(ii)	The values are the same within experimental error OR The values are concordant ALLOW The values are similar **(1)** The equilibrium can be approached from either direction OR The reaction is reversible OR Any comment relating equilibrium to reversibility IGNORE Dynamic equilibrium OR Rate of reverse reaction = rate of forward reaction **(1)**	Just...the same	**2**

Question Number	Correct Answer	Reject	Mark
12 (c)(iii)	(Acid) catalyst (makes it faster) OR Provides H^+ (as a catalyst) OR Protonates... OR Protonating agent... OR Donates protons OR Increases H^+ concentration	Initiates Reacts with... Protates	**1**

Total for Section C = 21 marks

Total for Paper = 90 marks

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