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Mark Scheme (Final)
January 2009

GCE

GCE Chemistry (6244/01)

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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.

Using the mark scheme

1 / means that the responses are alternatives and either answer should receive full credit.
2 ( ) 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.
3 [ ] words inside square brackets are instructions or guidance for examiners.
4 Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
5 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.

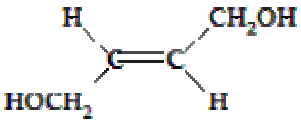
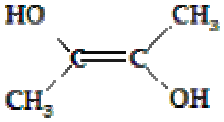
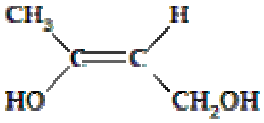
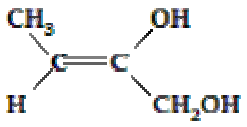
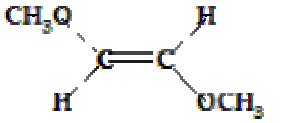
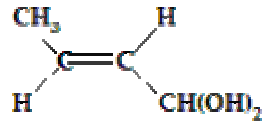
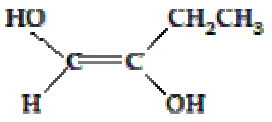
If more than the correct number of answers is given penalise (-1) for each wrong answer.
Answers can be A or a, etc.

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1 (a)(i)	A (1) E (1)			**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1 (a)(ii)	B (1) F (1)			**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1 (a)(iii)	A (1) C (1) D (1)			**3**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1 (a)(iv)	A (1) D (1)			**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1 (b)	*Cis* isomer **(1)** and *trans* isomer **(1)** of any of the following (*trans* isomer only shown):       	Isomers based on cyclobutane or methylcyclopropane Molecules with bond angles 90° provided that the *cis* and *trans* structures are clearly different. Allow any other structure that is plausible. Allow CH_3— etc	Bonds shown as: CH_2OH— —CH_3O —HO. Penalise once only if *cis* and trans otherwise correct. Any *cis* and *trans* isomers of molecules other than C_4H_8O.	**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2 (a)	*Dilute:* **small** amount of (ethanoic) acid in **large** volume of water/solvent **(1)** OR low concentration **(1)** *Weak:* slightly ionised **(1)** **OR** low concentration of hydrogen ions / H_3O^+/ H^+ **compared with** the concentration of the acid **(1)**		Low concentration of H_3O^+ or H^+ ions; less concentrated; water added to lower the concentration; high concentration of water; dissolved in excess water very dilute; not fully ionised; partially ionised; incompletely ionised; dissolved in excess water; any argument based on pH	**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2 (b)(i)	$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$ Ignore $K_a = \frac{[H_3O^+]^2}{[CH_3COOH]}$ if it appears after the correct expression. If it is the only answer given it scores **(0)**	$-CO_2^-$ for $-COO^-$ $[H^+]$ for $[H_3O^+]$	any expression including $[H_2O]$; [HA] instead of $[CH_3COOH]$.	**1**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2 (b)(ii)	If an incorrect expression for K_a is used the last three marks cannot score. Ignore significant figures unless they are rounded to one s.f. anywhere during the calculation: penalise once only. Answer of 1.59×10^{-5} or with 1.592×10^{-5} and correct units of mol dm^{-3}, and working, scores **(4)** **First mark** $pH = -\log_{10}[H_3O^+] = 3.2$ $[H_3O^+] = 6.31 \times 10^{-4}$ **(1)** **Next three marks** **Approximate calculation:** $K_a = \frac{[H_3O^+]^2}{0.025}$ **(1)** OR $K_a = \frac{[H_3O^+]^2}{[CH_3COOH]}$ $K_a = 1.59 \times 10^{-5}$ **(1)** mol dm^{-3} **(1)** The unit mark can be awarded if the unit is given in (b)(i) rather than here but must be mol dm^{-3}. The last 3 marks can be awarded CQ on an incorrect value of $[H_3O^+]$ provided that $[H_3O^+] > 10^{-7}$ mol dm^{-3}, i.e. the solution **must** be acidic. **OR without approximation:** $K_a = \frac{[H_3O^+]^2}{0.025 - 6.31 \times 10^{-4}}$ **(1)** $K_a = 1.63 \times 10^{-5}$ **(1)** mol dm^{-3} **(1)**	Use of $[H^+]$ for $[H_3O^+]$ This can be credited if it appears in 2(b)(i) but is not given here. 1.592×10^{-5}		**4**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2 (b)(iii)	**First mark** $[H_3O^+] = [CH_3COO^-]$ **because** all H_3O^+ is from the acid *or* none/insignificant amount of H_3O^+ comes from water **Second mark** In the denominator $6.31 \times 10^{-4} << 0.025$ (so can be ignored) OR because degree of ionisation is **very** small *or* negligible **then** $[CH_3COOH] = 0.025$ **(1)** If the answer to part (ii) uses $0.025 - 6.31 \times 10^{-4}$ in the calculation score this 2nd mark then ignore any other second assumption(s) suggested even if they are wrong. Ignore any references to 'standard temperature'.	Use of $[H^+]$ for $[H_3O^+]$	Just $[H_3O^+] = [CH_3COO^-]$ on its own	**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2 (c)(i)	**1st mark** The mixture is a buffer **(1)** **2nd mark** there are large amounts of /a large reservoir of the acid **and** its conjugate base/anion/salt **(1)** **3rd mark** **EITHER** $CH_3COOH + OH^-$ $\rightarrow CH_3COO^- + H_2O$ **(1)** **OR both** of $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ $H^+ + OH^- \rightarrow H_2O$ **and** the equilibrium moves to RHS. **4th mark** and so the ratio of /the value of **both** $[CH_3COOH]$ and $[CH_3COO^-]$ hardly changes **(1)** Ignore any references to addition of H_3O^+	both equations in words	Not $\rightleftharpoons$ for $\rightarrow$	**4**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2 (c)(ii)	**First mark:** Refer to diagram. Both ranges shown so that the one for MO is between about pH 2 and 5 (**outside** the vertical section), the one for phenolphthalein is between about 7 and 10.3, and is **wholly within** the vertical section **(1)** The extent of the ranges within the above values is unimportant provided there is a range and not just a point at the quoted values. **Second mark** Methyl orange is already yellow/orange *or* has already changed colour **before the vertical section** *or* before/not on the vertical section **(1)** **Third mark** Phenolphthalein changes from colourless to red/magenta/pink/purple **(1)** **Fourth mark** over a range which is **within** the vertical part of the graph **(1)**	 before the endpoint between pH 7 and 10.3	 Methyl orange is the indicator for a strong acid and a weak base and ethanoic acid is a weak acid. 'clear' for 'colourless' Phenolphthalein is the indicator for a titration of a weak acid with a strong base.	**4**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2 (d)	Equilibrium moves to LHS **OR** Equilibrium moves to reactants **(1)** **pH** goes up/rises/increases **(1)** stand alone. If it is said that the equilibrium moves to RHS then score **(0)** overall.		 Just 'becomes more alkaline', 'becomes less acidic' on its own.	**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3 (a)(i)	$K_p = \frac{p(NH_3)^2}{p(N_2)p(H_2)^3}$ **(1)**	$K_p = \frac{P_{NH3}^2}{P_{N2}\ P_{H2}^3}$ $p^2(NH_3)$ etc Ignore the position of brackets.	Any use of square brackets [ ] $p^2(NH_3)^2$	**1**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3 (a)(ii)	$p(NH_3) = \frac{0.2 \times 160}{3.8} = 8.42$ atm $p(N_2) = \frac{0.9 \times 160}{3.8} = 37.9$ atm $p(H_2) = \frac{2.7 \times 160}{3.8} = 114$ atm **(1)** for dividing moles of gas by 3.8 **(1)** for multiplying by 160 **(1)** for all three values, and the unit given at least once. Answers to 2 s.f. or more otherwise max **(2)** All three answers to 2 s.f. or more with the unit scores **(3)** whether working shown or not.	$\frac{160}{19}$ atm $\frac{720}{19}$ atm $\frac{2160}{19}$ atm x 160 atm for the unit mark even if not stated again		**3**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3 (a)(iii)	$K_p = \frac{(8.42)^2}{(37.9)(114)^3}$ $= 1.26 \times 10^{-6}$ (atm^{-2}) **(1)** unit not necessary, but if given must be correct to score the mark. CQ on values in (ii) and/or on an incorrect expression in (i).	1.26×10^{-6} (atm^{-2}) to 1.28×10^{-6} (atm^{-2}) depending on the number of s.f. used. CQ on K_p being the wrong way up in (i) leads to 781250 – 793650 (atm^2)		**1**

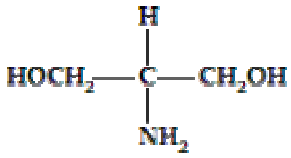
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3 (b)	The reaction is exothermic **because** K_p increases with decrease in temperature **(1)** Argument consequential on value of K_p from (a)(iii).		Any answer not based on values of K_p. Just 'reaction is exothermic' alone	**1**

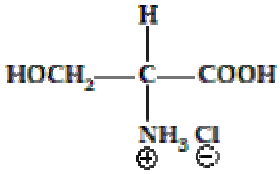
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3 (c)(i)	Increases **(1)** Ignore any comment on yield	faster/quicker	sooner	**1**

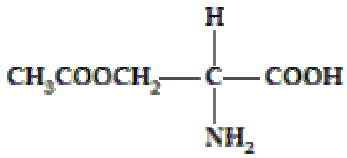
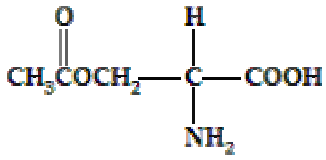
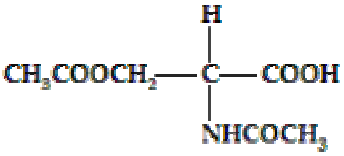
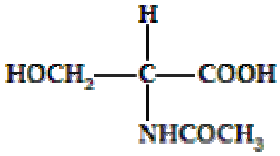
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3 (c)(ii)	Increases **(1)** Ignore any comment on yield	faster/quicker; rate of forward and back reactions increase **equally**.		**1**

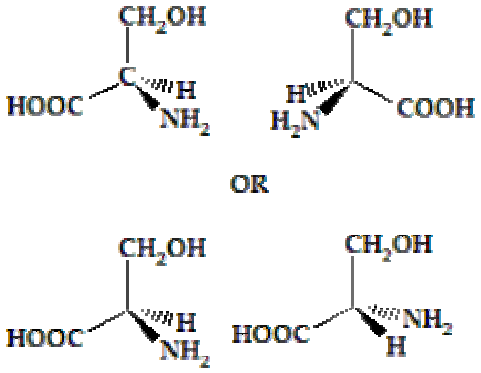
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3 (d)	Any answer which states or implies that the value of *K* alters scores **zero** overall. **First mark:** K_p remains constant **(1)** **Second mark:** Increase of partial pressure increases the value of the denominator *or* decreases the value **of the fraction** (and causes the equilibrium to move to RHS *or* increases amount of product) **(1)** **Third mark:** Hydrogen partial pressure is raised to power 3 *or* is cubed but nitrogen is raised only to power 1 so the doubling has greater effect. **(1)**	Maintain K_p	...decreases value of K_p. Any answer based on le Chatelier, i.e. not referring to K_p, does not score the second mark nitrogen partial pressure is raised to no power; nitrogen partial pressure is third order	**3**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4 (a)	2-amino-3-hydroxypropanoic acid **(1)**	3-hydroxy-2-amino-propanoic acid Allow 'ammino'	Any answer based on the name of an alcohol; propionic instead of propanoic.	**1**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4 (b)(i)			CH_2OH- on left	**1**

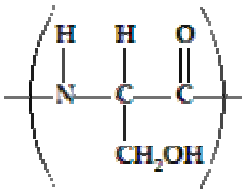
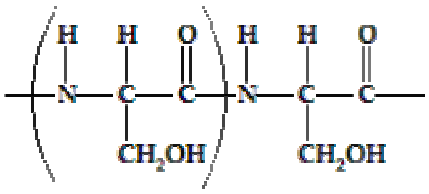
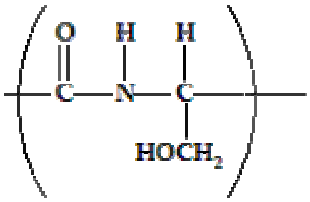
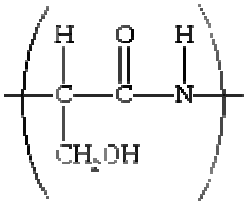
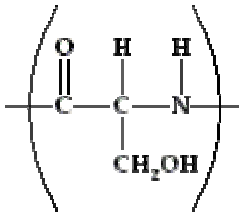
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4 (b)(ii)		NH_3^+ or $NH_3^+Cl^-$ or NH_3Cl	$-HOOC$	**1**

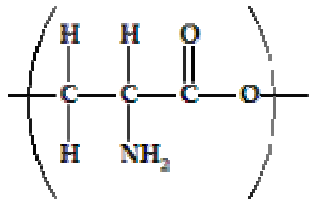
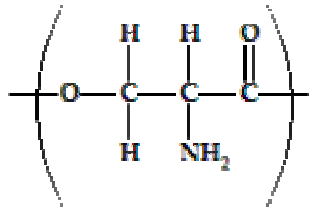
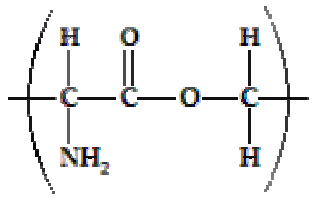
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4 (b)(iii)	 **OR**  **(1)**		CH_3OCO- for CH_3COO- 	**1**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4 (c)(i)	 OR exchange of any **two** substituent groups (not only H and NH_2) is acceptable. **(1)** for each isomer. The substituent groups can be in any order as long as the two isomers are mirror images. Structures that are clearly 3D score; it is not essential to use wedges. If the isomers are shown as mirror-imaged flat molecules (90^o bond angles) then answer can score **(1)** only for **both** structures being correct.		Incorrect compound scores **(0)** overall	**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4 (c)(ii)	(Angle of) **rotation** of plane of (plane) polarised (monochromatic) light **(1)** See answer to (c)(iii)		Twisting *or* bending *or* refracting *or* reflecting	**1**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4 (c)(iii)	One would rotate (plane polarised light) to the left *or* anticlockwise and one to the right *or* clockwise. **OR** Rotate (plane polarised light) in opposite directions **(1)** This can also be allowed if answer appears in (c)(ii) Do not penalise twist/bend/refract/reflect if they have been penalised in (c)(ii). If **rotation** is mentioned here but not in (c)(ii) then the mark for (c)(ii) can be awarded there, unless (c)(ii) is wrong when it scores **(0)**	One rotates (plane polarised light) in positive direction, one in negative.		**1**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4 (d)(i)	If structures have bonds to the atoms at each end score **(0)** Brackets are not essential if one repeat unit is shown.  **(2)** More of the chain than one repeat unit is allowable provided that the repeat unit is clearly shown, e.g.:  **(2)** Above structure with no, or incorrect, brackets scores (1) The C=O bond must be explicitly shown; if it is not but the structure is otherwise correct score **(1)** Also for **(1)** mark:  **OR** 	Allow inverse throughout, e.g.  etc.		**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4 (d)(ii)	 OR  **(2)** More of the chain than one repeat unit is allowable; the repeat unit need not be shown. If more units shown then: ester link **(1)** remainder of chain correct **(1) if** it is a whole number of repeat units The C=O bond must be explicitly shown; if it is not but the structure is otherwise correct score **(1)** Do not penalise here if already penalised in (d)(i). **For 1 mark only:** 	The methylene group can be shown as $-CH_2-$	ester link in a chain not derivable from serine	**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
5 (a)	The energy change when **one mol** of an ionic solid or ionic lattice **(1)** is formed from ions in the gaseous state **(1)** **OR** The energy change when **one mol** of solid/lattice is formed from its ions in the gaseous state **(2)** Ignore any reference to standard state.	enthalpy change, heat change, enthalpy *or* heat evolved formed from its gaseous ions	Energy *or* enthalpy *or* heat required formed from gaseous atoms; 1 mol of gaseous ions	**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
5 (b)	Answer -2053 (kJ mol^{-1}) with some working scores **(3)**, with no working **(2)**. Ignore wrong or no units. (-859) = (+180) + 2(+122) + (+1468) + 2(−349) + ΔH_{latt} OR ΔH_{latt} = (-859) – (+180) - 2(+122) - (+1468) - 2(-349) **(2)** $\therefore \Delta H_{latt} = -2053$ (kJ mol^{-1}) **(1)** The following errors may arise: Failure to multiply -349 by 2; answer of −1931 with some working scores **(2)**, no working **(1)** Failure to multiply +122 by 2; answer of −2402 with some working scores **(2)**, no working **(1)** Failure to multiply both the above by 2; answer of −2280 **(1)** Any algebraic or transcription error, penalise **(1)** each time.	Equivalent information using symbols for the energy changes, or words		**3**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
5 (c)(i)	Theoretical model is based on 100% ionic bonding **(1)** If experimental Born Haber value is different *or* more exothermic/bigger this is due to some covalency *or* some covalent character in the bonding **(1)**			**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
5 (c)(ii)	Any answer based on atoms scores **(0)** overall. **First mark** Be^{2+} (ion) or beryllium **ion** is smaller (than the Ba^{2+} (ion)) or Barium **ion (1)** **OR** Cations get larger down the group (and have the same charge) **(1)** **Second mark** Be^{2+} ion polarises/distorts the chlor**ide** ion **more** (than Ba^{2+} does), leading to covalency/covalent character **(1)** The opposite argument starting from barium ions **(2)**	 Cation charge density decreases down the group.	 Be is smaller than Ba Atoms get larger down the group polarises the chlorine ion; polarises the chlorine; weakens the ionic bond; Be^{2+} ion being polarised. Any argument based on electronegativity differences	**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6(a)	**First mark** For showing reaction of PbO with H_3O^+ or any acid and with OH^- or any alkali, equations correct or not **(1)** **Second mark:** any one of $PbO + 2H^+ \rightarrow Pb^{2+} + H_2O$ $PbO + 2H_3O^+ \rightarrow Pb^{2+} + 2H_2O$ $PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$ $PbO + 2HCl \rightarrow PbCl_2 + H_2O$ $PbO + H_2SO_4 \rightarrow PbSO_4 + H_2O$ **(1)** **Third mark:** any one of $PbO + 2OH^- \rightarrow PbO_2^{2-} + H_2O$ $PbO + 2OH^- + H_2O \rightarrow [Pb(OH)_4]^{2-}$ **(1)** Ignore any state symbols Allow multiples	H^+ for H_3O^+ $PbO + 4HCl \rightarrow PbCl_4^{2-} + 2H^+ + H_2O$ $PbO + 2NaOH \rightarrow Na_2PbO_2 + H_2O$ $Pb(OH)_4^{2-}$ $PbO + 2NaOH + H_2O \rightarrow Na_2Pb(OH)_4$		**3**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6 (b)(i)	$PbCl_2$ Ionic **(1)** $SnCl_4$ Covalent **(1)**	Electrovalent Convalent	 dative covalent	**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6 (b)(ii)	**EITHER** Lead (IV) is less stable than lead (II) so PbO_2 is an oxidising agent *or* is reduced **(1)** Tin (IV) is more stable than tin (II) so SnO_2 reacts as a base **(1)** **OR** Stability of (+4) state relative to (+2) state decreases down the group / from tin to lead **(1)** PbO_2 oxidising agent, SnO_2 a base. **(1)**	Lead (+2) etc for lead(II)		**2**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6 (c)(i)	HCl shown as a product in both equations **(1)** $PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$ **(1)** $PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$ OR $PCl_5 + H_2O \rightarrow POCl_3 + 2HCl$ **(1)** Allow multiples Ignore any state symbols	$H^+ + Cl^-$ for HCl throughout $P(OH)_3$ for H_3PO_3		**3**

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6 (c)(ii)	**First mark** NaCl pH 7 and PCl_3 pH any value $-1 \leq pH < 4$ **(1)** Credit pH values independently of any reasoning. **Second mark** NaCl dissolves to hydrated/aqueous ions **OR** $NaCl(s)\ (+aq) \rightarrow Na^+(aq) + Cl^-(aq)$ **(1)** **Third mark** PCl_3 hydrolyses **(1)**	 reacts to produce acid(s)	Neutral for pH 7; acidic	**3**