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Mark Scheme (Results)
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GCE

GCE Chemistry (6244) Paper 1

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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.

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1.(a)(i)	Ionic	Giant ionic or electrovalent		1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1.(a)(ii)	Covalent	Giant covalent	Convalent	1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1.(b)(i)	Basic	Base or alkali or alkaline		1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1.(b)(ii)	Acidic	Acid Weakly acidic Weak acid		1

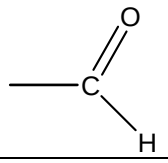
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1.(c)(i)	$3Na_2O + 2H_3PO_4 \rightarrow 2Na_3PO_4 + 3H_2O$ OR $Na_2O + H_3PO_4 \rightarrow Na_2HPO_4 + H_2O$ OR $Na_2O + 2H_3PO_4 \rightarrow 2NaH_2PO_4 + H_2O$ (1) Ignore state symbols			1

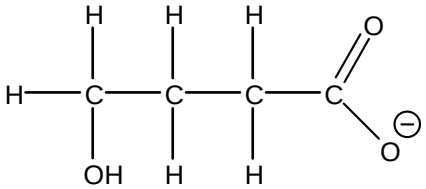
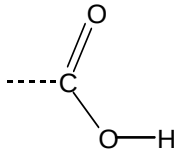
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1.(c)(ii)	$SiO_2 + 2NaOH \rightarrow Na_2SiO_3 + H_2O$ **(1)** Ignore state symbols	$SiO_2 + 2OH^- \rightarrow SiO_3^{2-} + H_2O$		1

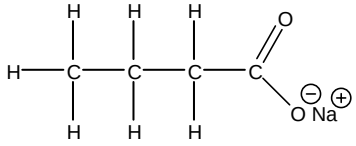
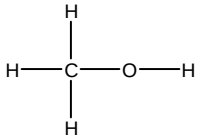
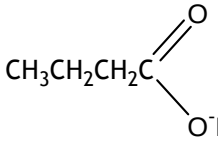
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1.(d)	**First mark:** $Al_2O_{3(S)} + 6H^+_{(aq)} \rightarrow 2Al^{3+}_{(aq)} + 3H_2O_{(l)}$ **(1)** *This mark is for correct species and balancing* **Second mark:** $Al_2O_{3(S)} + 2OH^-_{(aq)} + 3H_2O_{(l)} \rightarrow 2Al(OH)^-_{4\ (aq)}$ OR $Al_2O_{3(S)} + 6OH^-_{(aq)} + 3H_2O_{(l)} \rightarrow 2Al(OH)^{3-}_{6\ (aq)}$ OR $Al_2O_{3(s)} + 2OH^-_{(aq)} \rightarrow 2AlO^-_{2\ (aq)} + H_2O(l)$ **(1)** *This mark is for correct species and balancing* **Third mark is for the state symbols (1)** Correct state symbols in **either** equation, *but all species must be correct.* *This mark may be awarded from an unbalanced equation.*	Two correct 'molecular' equations with correct state symbols scores (2)		3

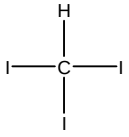
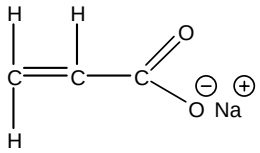
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1.(e)	$PbO_2 + 4HCl \rightarrow PbCl_2 + Cl_2 + 2H_2O$ Ignore state symbols	$PbO_2 + 6HCl \rightarrow H_2PbCl_4$ $Cl_2 + 2H_2O$		1

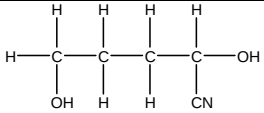
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
1.(f)	**First mark**: Tin more stable in the +4 oxidation state (than the +2 oxidation state) whereas lead more stable in the +2 oxidation state (than in the +4 oxidation state) OR +2 oxidation state becomes more stable **relative to +4** oxidation state as group descended. **(1)** **Second Mark:** (So) I_2 **reduced** to I^- (by Sn^{2+}) OR $Sn^{2+} + I_2 \rightarrow Sn^{4+} + 2I^-$ OR Therefore tin(II) is a strong(er) reducing agent (than lead(II)) **(1)**	redox reaction between Sn^{2+} and I_2 OR Sn^{2+} oxidised (to Sn^{4+}) OR Sn(II) acts as (a strong) reducing agent	Sn^{2+} ions less stable than Pb^{2+} OR Pb(II) is more stable than Sn(II)	2

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2.(a)	*IGNORE 'alkane'* in any answer X : ester **(1)** Y : **both** alkene **and** alcohol or hydroxyl **(1)** Z : **both** alcohol or hydroxyl **and** aldehyde **(1)**	 carbon-carbon double bond "hydroxy" "hydroxy"	 carbonyl OH^- or "hydroxide" OH^- or "hydroxide" or "carbonyl" Just the formula 	3

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2.(b)	X : no reaction **(1)** Y : no reaction **(1)** Z :  **(1)** do not award if the bond from the carbon atom is **clearly** to the H of the OH group	  $-O^-\ Na^+$ or -ONa	 Any formula with the alcohol group oxidised	3

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2.(c)(i)	$CH_3CH_2CH_2COONa/CH_3CH_2CH_2COO^-Na^+/$  **(1)** Allow C_3H_7 / $C_2H_5CH_2$ $CH_3OH/$  **(1)**	 / $CH_3CH_2CH_2COO^-$ / $CH_3CH_2CH_2CO_2Na$ / $CH_3CH_2CH_2CO_2^-Na^+$	Carboxylic acid Or $...O^-—Na^+$	2

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2.(c)(ii)	CHI_3 /  **(1)**  / $CH_2CHCOONa$ / CH_2CHCO_2Na / /$CH_2CHCOO^-Na^+$ / $CH_2CHCO_2^-Na^+$ /CH_2=$CHCOONa$ /CH_2=$CHCO_2Na$ /CH_2=$CHCOO^-Na^+$ /CH_2=$CHCO_2^-Na^+$ **(1)**	CH_2CHCOO^- Allow carboxylic acid as product e.g. $CH_2CHCOOH$		2

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
2.(c)(iii)	 /$CH_2(OH)CH_2CH_2CH(CN)OH$ / $CH_2(OH)CH_2CH_2CH(OH)CN$ **(1)**			1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3.(a)(i)	To slow down the reaction/to stop the reaction OR to quench the reaction OR to freeze the (position of) equilibrium *OWTTE* **(1)** so that the (equilibrium) concentrations/amounts do not change **(1)**	To stop equilibrium shifting to the left		2

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3.(a)(ii)	**First mark:** $\left[H_{2(g)}\right] = \left[I_{2(g)}\right]$ OR Use of $(5.0\times10^{-4})^2$ **(1)** **Second mark:** $\left[HI_{(g)}\right]^2 = \frac{\left(5.0\times10^{-4}\right)^2}{0.019}$ OR $0.019 = \frac{(5.0\times10^{-4})^2}{[HI_{(g)}]^2}$ OR $[HI(g)] = \sqrt{\left(\frac{(5.0 \times 10^{-4})^2}{0.019}\right)}$ **(1)** **Third mark:** $\left[HI_{(g)}\right] = 3.6 \times 10^{-3}$ (mol dm^{-3}) **(1)** Correct answer scores 3 marks. Ignore state symbols. Ignore units unless wrong. Ignore s.f.	If [HI] not squared, first mark only.	If first mark not awarded, total **(0)**.	3

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3.(b)(i)	$K_p = \dfrac{p_{HI}^2}{p_{H_2} \times p_{I_2}}$ Ignore position of any **( )**		**[ ] scores (0)**	1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3.(b)(ii)	*Each step of this calculation must be looked at.* 1st mark is for calculating equilibrium moles $\mathrm{H_2} = 0.2$ $\mathrm{I_2} = 0.2$ $\mathrm{HI} = 1.6$ **(1)** 2nd mark is for dividing these by 2 (to get mole fractions) $x_{H_2} = \dfrac{0.2}{2.0} = 0.1$ $x_{I_2} = \dfrac{0.2}{2.0} = 0.1$ $x_{HI} = \dfrac{1.6}{2.0} = 0.8$ **(1)** 3rd mark is for multiplying by 1.1 (to get partial pressures) $\mathrm{P}_{H_2} = \dfrac{0.2}{2.0} \times 1.1$ $= 0.11$ (atm) $\mathrm{P}_{I_2} = \dfrac{0.2}{2.0} \times 1.1$ $= 0.11$ (atm) $\mathrm{P}_{HI} = \dfrac{1.6}{2.0} \times 1.1$ $= 0.88$ (atm) **(1)** 4th mark is for substituting into their expression and calculating K_p $K_P = \dfrac{(0.88)^2}{(0.11) \times (0.11)}$ $= 64$ **(1)** *Ignore s.f.* *Correct answer with no working scores (1)*	Mark consequentially Mark consequentially Mark consequentially If moles HI given as 0.8, $K_p = 16$ max **(3)**		4

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
3.(b)(iii)	Same number of moles on each side OR (Total) pressure cancels OR (Pressure) units cancel (May be shown by crossing out etc. in b(ii))	'Powers cancel' OR 'They cancel' OR 'Same number of molecules on each side'	'**Partial** pressures cancel' OR 'mol dm^{-3} cancel'	1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4.(a)(i)	ΔH_6			1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4.(a)(ii)	$\frac{\Delta H_5}{2} OR \frac{1}{2}\Delta H_5$		ΔH_5	1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4.(b)	Either $\Delta Hf = \Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5 + \Delta H_6$ OR ΔHf = (+178)+(1735)+2×(+218)+2×(-73) + (-2389) $= -186$ (kJ mol^{-1}) (1) Correct answer with no working (2) *Ignore kJ*	[First mark only if doubles both ΔH_{at} and electron affinity for hydrogen] [2nd mark is only consequential on failure to multiply either ΔHat or electron affinity or both giving: −404 / −113 /−331 (kJ mol-1)]	+186 scores **(0)** +404 / +113 /+331 scores **(0)**	2

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4.(c)	**EITHER** **First mark:** Magnesium/Mg **ion** smaller (radius) than calcium/Ca **ion** Or the sum of the ionic radii in MgH_2 smaller (than in CaH_2) **(1)** **Second mark:** but charges the same **(1)** **Third mark:** (so) stronger (forces of) **attraction** between **ions** (in MgH_2) **(1)** [Correct reverse arguments can score both marks] **OR** **First and second mark combined:** $Mg^{2+}(ion)$ or $Mg^{2+}(cation)$ smaller (radius) than Ca^{2+} **(2)** **Third mark:** (so) stronger (forces of) **attraction** between **ions** (in MgH_2) **(1)** [Correct reverse arguments can score both marks] Ignore references to polarisation of the hydride ion or "covalent character" in the hydrides. Ignore references to "energy required to separate ions/break bonds"	Magnesium ion has greater charge density than calcium ion for first mark. "stronger **ionic** bonding" for 3rd mark in either case.	Reference to 'atoms' or 'molecules' or 'H_2' scores zero **overall**. If "H^+ ions" or "hydrogen ions" referred to, 3rd mark cannot be awarded in either case If just "stronger bonding in MgH_2", 3rd mark cannot be awarded in either case	3

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4.(d)(i)	Enthalpy/energy/heat change when 1 mol of **gaseous ions** (1) Is dissolved in (a large) excess of water Or Is dissolved until further dilution causes no further heat change (1) Ignore any reference to "standard conditions" Mark independently	Heat released….. $X^+(g) + aq \rightarrow X^+(aq)$ **and** statement of energy change per mole for first mark. "Added to water" or "reacts with water " instead of "dissolved" "Infinitely dilute solution" "Is completely surrounded by water molecules"	Any implication of endothermic, do not award 1st mark "Dissolves completely"	2

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
4.(d)(ii)	δ^-O (in water) attracted to positive ions/cations (1) δ^+H (in water) attracted to negative ions/anions (1)	'forms (dative) bonds' instead of 'attracted' Just "attraction between water (molecules) and ions" (1 max)	Reference to full charges on water molecules scores zero overall "energy required" or implication of an endothermic process scores (0) overall. Dipole-dipole attractions and/or "polarisation" scores zero overall	2

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
5.(a)(i)	One acid: $CH_3CH_2COOH(aq)$ Conjugate base: $CH_3CH_2COO^-(aq)$ (1) Other acid: $H_3O^+(aq)$ Conjugate base: $H_2O(l)$ (1) Ignore state symbols	Accept correct acids with conjugate bases in either order		2

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
5.(a)(ii)	WEAK: dissociates/ionises to a small extent (1) OWTTE ACID: proton donor (1)	'Few molecules dissociate' 'Incomplete' or 'partial' dissociation "Does not fully dissociate" Produces H_3O^+ / hydrogen / H^+ ions	"ions partially dissociate" Just "contains H_3O^+ ...."	2

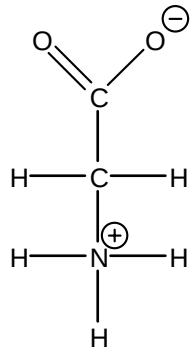
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
5.(b)(i)	$Ka = \frac{[CH_3CH_2COO^-][H_3O^+]}{[CH_3CH_2COOH]}$	$[H^+]$ instead of $[H_3O^+]$	Any expression containing $[H_2O]$	1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
5.(b)(ii)	$([H^+] =)$ 3.63 x 10^{-4} (mol dm^{-3}) (1) Or $10^{-3.44}$ $[CH_3CH_2COOH] = \frac{[H^+]^2}{1.30 \times 10^{-5}}$ Or $[CH_3CH_2COOH] = \frac{(3.63\times10^{-4})^2}{1.30\times10^{-5}}$ (1) = 0.010 (1) (mol dm^{-3}) (1) ASSUMPTIONS: **First assumption mark:** negligible $[H^+]$ from ionisation of water Or $[CH_3CH_2COO^-] = [H^+]$ (1) **Second assumption mark:** Ionisation of the (weak) acid is negligible Or $x-[H^+] \approx x$ where x is initial concentration of CH_3CH_2COOH Or [H+]<<[HA] (1)	If K_a expression incorrect in (b)(i) or $[H^+]$ not squared, only 1st mark available "No other source of H^+ ions" "**Very** slight ionisation ..." "the initial [HA] = equilibrium [HA]"	**Just** "$CH_3CH_2COO^- = H^+$" (ie no square brackets) Any mention of non-standard conditions or 'temperature not at 298 K'	5

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
5.(c)	$CH_3CH_2COO^-$ + H_2O ⇌ /→ CH_3CH_2COOH + OH^- Or CH_3CH_2COONa + H_2O ⇌ /→ CH_3CH_2COOH + NaOH (1) OH^- ions **produced** cause the solution to be alkaline (1) Mark independently	$CH_3CH_2COO^-$ + H^+ ⇌ CH_3CH_2COOH **and** causes the following eqm to shift to the right H_2O ⇌ H^+ + OH^- Causing an **excess** of OH^- ions (1)	"OH^- ions from water"	2

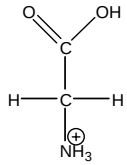
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
5.(d)(i)	Ignore "A solution of known pH which…." maintains **nearly** constant pH OR resists change in pH (1) OWTTE on adding **small amounts** of acid or alkali **(1)** Mark independently			2

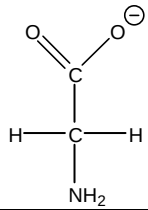
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
5.(d)(ii)	Working MUST be checked **First mark:** $[H^+] = K_a \times \frac{[acid]}{[salt]}$ (1) **Second mark:** Correct [acid] = 0.0025 and [salt] = 0.00375 (1) **Third mark:** Calculation of pH correct consequential on [acid] and [salt] used. $[H^+] = 1.30 \times 10^{-5} \times \frac{0.0025}{0.00375}$ $= 8.67 \times 10^{-6}$ (mol dm^{-3}) pH = 5.06 (1) Ignore sig fig OR **First mark:** $pH = pK_a - \log_{10} \frac{[acid]}{[salt]}$ (1) **Second mark:** Correct [acid] = 0.0025 and [salt] = 0.00375 (1) **Third mark:** Calculation of pH correct consequential on [acid] and [salt] used. $pH = 4.89 - \log_{10} \frac{[0.0025]}{[0.00375]}$ (1) $= 4.89 - (-0.18)$ $= 5.07$ (1) Ignore sig fig	$K_a = \frac{[H^+]x\ [salt]}{[acid]}$ If [salt] and [acid] inverted, pH is 4.71 (2 marks) Inverted with the original concentrations, pH = 5.19 (1 mark) In both cases, if [acid] = [0.0100] and [salt] = [0.00500], pH = 4.59 (2 marks) 5.06		3

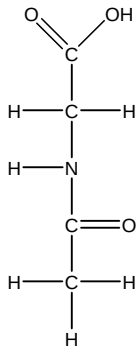
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6.(a)(i)	 Positive charge must be on the N atom The minus charge must be on the O in the C—O if no delocalisation shown	Delocalised carboxylate group with a negative charge shown	Compressed structural formula	1

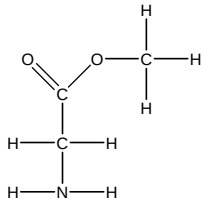
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6.(a)(ii)	(H^+ from) COOH (group) protonates the $-NH_2$(group)	Transfer of H^+ from COOH to NH_2 Or "self-protonation"	Just "protonation" Just "acid-base reaction"	1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6.(a)(iii)	**Read the whole answer!** **High energy** needed to overcome (strong) **ionic** attractions (1) **between** zwitterions (1) Ignore reference to "molecules" if clearly used in the context of attraction between ions	 "ionic bonds" or "ionic lattice" instead of "ionic attractions" **between** adjacent species	 **Just** "intermolecular forces" Or H bonding Or van der Waals' forces etc award zero overall	2

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6.(b)(i)	$^{+}NH_3CH_2COOH$ / $^{+}H_3NCH_2COOH$ / $^{+}H_3NCH_2COOH$ OR written right to left OR 	$-CO_2H$ OR $-NH_3^{+}Cl^{-}$ Or $-NH_3Cl$	Molecular formula	1

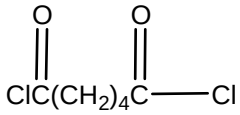
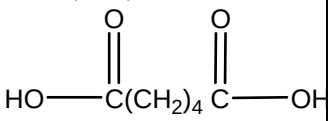
Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6.(b)(ii)	$NH_2CH_2COO^{-}$ / $NH_2CH_2CO_2^{-}$ / 	$-COONa$ or $-COO^{-}Na^{+}$	Molecular formula	1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6.(b)(iii)	$CH_3CONHCH_2COOH$/ 	$CH_3CONHCH_2CO_2H$ OR 'no reaction' **(1)**	Molecular formula	1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6.(b)(iv)	$NH_2CH_2COOCH_3$ / 	$NH_2CH_2CO_2CH_3$		1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6.(c)(i)	(Glutamic acid molecule) has four different groups attached to a C (atom) Or (Glutamic acid molecule) has four different groups attached to a chiral centre OR has mirror images which are not superimposable	Contains an asymmetric carbon (atom) Or molecule has no plane of symmetry	**Just** "has a chiral centre" Or **Just** "the molecule is asymmetrical"	1

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6.(c)(ii)	(the isomers) rotate the plane (or polarisation) of (plane-) polarised light (1) in **opposite** directions (1) Ignore any reference to polarimeter	"….rotate plane polarised light"	 Just "in different directions"	2

Question Number	Correct Answer	Acceptable Answers	Reject	Mark
6.(d)	$H_2N(CH_2)_6NH_2$ (1) $ClOC(CH_2)_4COCl$ /  (1) [Monomers can be given in either order]	$NH_2(CH_2)_6NH_2$ $HOOC(CH_2)_4COOH$ / $HO_2C(CH_2)_4CO_2H$ /  $COOH(CH_2)_4COOH$ Or $COCl(CH_2)_4COCl$		2