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Mark Scheme (Results)

June 2011

GCE Chemistry (6CH04) Paper 01
General Principles of Chemistry

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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. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

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	Mark
1	C	**1**

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

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

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

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

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

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

Question Number	Correct Answer	Mark
8 (a)	C	**1**

Question Number	Correct Answer	Mark
8 (b)	D	**1**

Question Number	Correct Answer	Mark
8 (c)	B	**1**

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

Question Number	Correct Answer	Mark
10 (a)	D	**1**

Question Number	Correct Answer	Mark
10 (b)	A	**1**

Question Number	Correct Answer	Mark
10 (c)	D	**1**

Question Number	Correct Answer	Mark
11 (a)	C	**1**

Question Number	Correct Answer	Mark
11 (b)	D	**1**

Question Number	Correct Answer	Mark
11 (c)	B	**1**

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

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

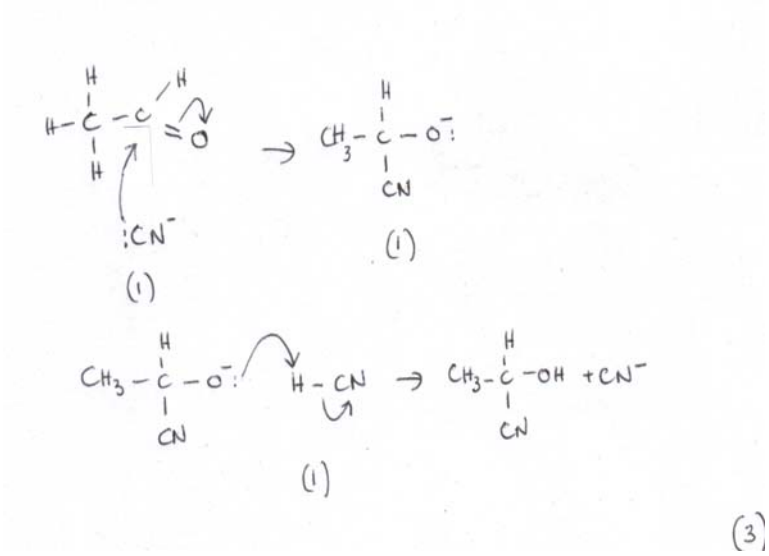
Question Number	Correct Answer	Mark
14	D	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
15 (a)(i)	Addition **(1)** Nucleophilic **(1)** Either order	SN1 SN2	**2**

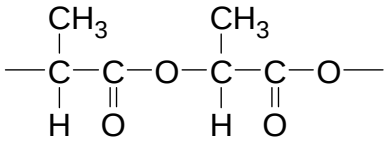
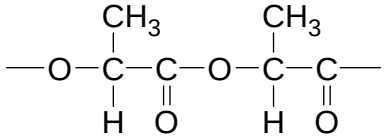
Question Number	Acceptable Answers	Reject	Mark
15 (a)(ii)	Hydrogen cyanide / HCN **(1)** Potassium cyanide / KCN/ sodium cyanide/ NaCN **(1)** OR Potassium cyanide / KCN **(1)** With hydrochloric acid / sulfuric acid (to generate HCN) **(1)** Ignore concentration of acids Mark for HCl etc is consequential on KCN OR Hydrogen cyanide / HCN **(1)** With sodium hydroxide / other base (to make cyanide ions) **(1)** Mark for NaOH etc is consequential on HCN	 Just CN^- Just CN^- Just acid/ H^+ any weak acid Just OH^-	**2**

Question Number	Acceptable Answers	Reject	Mark
15 (a)(iii)	 (3) Both arrows in first step of mechanism above correctly drawn **(1)** Correct intermediate with charge **(1)** Both arrows in second step with correct organic product (CN^- is not required) **(1)** Use of HCN for first step max 2 marks Allow omission of lone pair on CN^- and O^- Allow curly arrow from negative charge or elsewhere on cyanide ion Allow arrow from O^- in 2nd step to H^+ (no other product or only one product) or H_2O (with OH^- formed)	C=O breaking before attack by CN^- Arrows from atoms when they should be from bonds and vice versa	**3**

Question Number	Acceptable Answers	Reject	Mark
***15 (a)(iv)**	Attack (by nucleophile on the C) is from both sides (equally)/ above and below (at the planar reaction site in the aldehyde group) **(1)** So a mixture of two enantiomers/(optical)isomers **in equal proportions** forms OR racemic mixture forms **(1)** **First and second marks are independent**	Attack on **intermediate in reaction mechanism** is from both sides Attack from both ends/two angles Just "both enantiomers form"	**2**

Question Number	Acceptable Answers	Reject	Mark
15 (b)	Any named (aqueous) strong acid or its formula. Allow (aqueous) sodium hydroxide followed by named acid or formula Ignore references to concentration	Water H^+ Potassium dichromate + sulfuric acid Carboxylic acids	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (c)(i)	2-hydroxypropanoic acid	2-hydroxylpropanoic acid 2-hydroxopropanoic acid 2-hydroxypropan-1-oic acid	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (c)(ii)	 OR  All bonds in ester link must be shown More than 2 units may be shown but structure shown should be a repeat unit Ignore brackets/n	A dimer Missing H atoms Missing bonds at ends	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (c)(iii)	**Ester** (link/bond) in PLA can be hydrolysed/broken down (by enzymes) **OR Ester** (link/bond) in PLA can be broken down	Just "it can be hydrolysed"	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (c)(iv)	Ethene is (from crude oil so) non-renewable/ milk is from a renewable source/ energy required to make ethene is **high**/ high temperatures needed to make ethene/ energy requirements for process from sour milk **less**/ process from milk doesn't use toxic chemicals / process from milk doesn't use cyanide Allow process from ethene requires many steps **so** expensive/**so** loss of material occurs at each step /**so** more reagents needed Ignore references to cost, unless answer gives a reason for lower cost.	Milk is more readily available Greater atom economy No other chemicals needed in process from milk Just "process from ethene requires many steps" Just "cheaper"	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (a)(i)	**O_2** : first order as increasing $[O_2]$ x 2 increases rate x 2 / as rate is (directly) proportional to oxygen concentration **(1)** (Experiments 1 and 2 or [NO] constant) **NO:** second order as increasing [NO] x 2 increases rate x 4/ by 2^2 **(1)** (Experiments 2 and 3 or $[O_2]$ constant) Two correct orders with no explanation **(1)** only	Two correct orders based on stoichiometry	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (a)(ii)	Rate = k $[O_2][NO]^2$ Rate equation must be consistent with answer in (a)(i)	Just k $[O_2][NO]^2$ i.e. no rate/R Non square brackets	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (a)(iii)	Rate = k$[O_2][NO]^2$ TE from (i) k=((5.10 x 10^{-4})/(0.005)$(0.0125)^2$) = 652.8 / 653/650 OR k=((10.2 x 10^{-4})/(0.0100)$(0.0125)^2$) = 652.8 / 653/650 OR k=((40.8 x 10^{-4})/(0.0100)$(0.025)^2$) = 652.8 / 653/650 **(1)** TE for value of k from rate equation given $dm^6\ mol^{-2}\ s^{-1}$ (allow any order) **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
16 (b)(i)	$NO_2 + CO \rightarrow NO + CO_2$ Allow multiples	Equation not cancelled down eg NO_3 on both sides.	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (b)(ii)	Rate = $k[NO_2]^2$ OR Rate = $k[NO_2]^2[CO]^0$ OR Rate = $k[NO_2]^2[CO]^0[NO_3]^0$ **(1)** Only molecules/reactant in slow step are (2)NO_2 OR CO appears after the rate determining/slow step (and $2NO_2$ molecules in slow step) OR CO is not involved in rate determining / slow step OR Only the molecules in the slow step are in the rate equation OR Step 1 is slowest so determines rate equation **(1)** **Second mark:** **No TE on rate equation containing incorrect species. Only allow TE if k missing in correct rate equation**	Equations involving CO to power other than zero	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(i)	$\Delta S_{system,}$ = ((2 x 192.3) –(2 x 95.8) – (2x3x65.3)) **(1)** = **-198.8 / -199** (J mol^{-1} K^{-1}) Allow – 200 (2 SF) If units are not those in which data is given, must be correct. **(1)** *Note check working* Correct answer without working **(2)** Correct choice of multiples and data but wrong answer scores first mark **(1)** Correct value with wrong sign based on entropy of reactants – entropy of products (giving +199) **(1)** TE for second mark if multiples for hydrogen, nitrogen and ammonia are missed/ incorrect, but correct data used. or multiples correct and one error in data.	198	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(ii)	**If answer to (a)(i) is negative:** Disorder decreases / order increases (as reaction goes forward) **(1)** Reference to order or disorder required for the mark. As number of (gas)molecules/moles/particles decreases **(1)** OR 4 moles of gas produces 2 moles Ignore comments on number of different types of molecule in equilibrium mixture **If answer to (a)(i) is positive:** Must say this is unexpected with correct reasons to score 2 marks No marks if the positive answer is expected	Just "entropy decreases"	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(i)	ΔS_{surr} = -(-110.2 x 1000)/ 700 **(1)** (+157.4285) **=** (+) **157.4 / 157** (J mol^{-1} K^{-1}) OR (+) 0.1574 / 0.157 **kJ mol^{-1} K^{-1} (1)** Ignore sf except 1 Correct answer without working **(2)** Correct value with negative sign **(1)** Use of $\Delta S_{surr} = -\Delta H/T$ but wrong answer **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(ii)	($\Delta S_{system} = \Delta S_{total} - \Delta S_{surr}$) =(-78.7-157.4)) = **-236.1/ -236** (J mol^{-1} K^{-1}) OR -0.2361 / -0.236 (kJ mol^{-1} K^{-1}) Allow -235.7 if 157 used and -238.7 if 160 used Ignore units unless value in kJ given as J or vice versa TE from (b)(i)	values in kJ added to values in J	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iii)	Reactants predominate / more nitrogen and hydrogen (than ammonia)	Just "Equilibrium lies to the left" Just "no ammonia is present". The gases are present in ratio 1:3:2	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(i)	$K_p = (pNH_3)^2/ (pN_2)(pH_2)^3$ **(1)** Can be written in other formats eg p^2NH_3 etc $pH_2 = (150 - 21 - 36) =$ **93** (atm) **(1)** $K_p = ((36)^2/ (21)(93)^3) = (7.6724994 \times 10^{-5})$ $=$**7.67×10^{-5} (1)** Ignore sf except 1 TE on incorrect pH_2 atm^{-2} **(1)** TE for units on incorrect K_p expression Correct answer including units without quoting K_p **expression scores 3**	Square brackets in first mark No TE for value on incorrect K_p Expression Units other than atm	**4**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(ii)	(Yield of ammonia is increased) because there are fewer moles / molecules (of gas) on the right OR System tries to reduce the pressure by going to the side with fewer moles/ molecules (of gas) Ignore comments about value of K_p changing Ignore comments about more collisions occurring/more molecules having energy greater than or equal to activation energy	Just 'equilibrium moves right'	**1**

Question Number	Acceptable Answers	Reject	Mark
***17 (c)(iii)**	**First mark** At higher temperature ΔS_{surr} is less positive/ decrease/more negative **(1)** **Second mark** making ΔS_{total} more negative / less positive/decreases No TE for 2nd mark if ΔS_{surr} is said to increase. **(1)** **Third mark** (so) K_p decreases **(1)** **Third mark depends on second mark being correct/neutral answer** **Fourth mark** so equilibrium position further left /in endothermic direction/ in reverse direction OR lower yield of ammonia / reaction is less feasible **(1)** **Fourth mark is a stand alone mark**		**4**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(iv)	Rate (of reaching equilibrium)is higher / faster Ignore comments about increasing numbers of successful collisions at higher temperature		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (a)	$K_a = (10^{-10.64}) =$ **2.3×10^{-11}** / 2.2909×10^{-11} (mol dm^{-3}) Ignore sf except 1		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b)(i)	$K_a = \frac{[HCOO^-][H^+]}{[HCOOH]}$ OR written as HCO_2^- and HCO_2H OR with H_3O^+ instead of H^+ Allow $K_a = \frac{[A^-][H^+]}{[HA]}$ if formula of HA and A^- given as HCOOH and $HCOO^-$	$K_a = \frac{[H^+]^2}{[HCOOH]}$ without also giving full expression	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b)(ii)	$1.6 \times 10^{-4} = \frac{[H^+]^2}{0.50}$ **(1)** $[H^+] = \sqrt{1.6 \times 10^{-4} \times 0.5}$ **(1)** $(= \sqrt{8 \times 10^{-5}} = 8.94 \times 10^{-3})$ pH = (2.048455) **= 2.05 / 2.0 (1)** Correct answer with no working **(3)** TE for third mark if $[H^+]$ calculated incorrectly No TE from incorrect K_a expression Ignore sf except 1	pH =2 pH =2.1	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (b)(iii)	All H^+ comes from acid / none from water / $[H^+] = [HCOO^-]$ OR $[H^+] = [A^-]$ OR Dissociation of acid is negligible / very small OR $[HA]_{initial} = [HA]_{equilibrium}$	K_a is measured at 298K Just "dissociation of acid is partial"	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(i)	HCOOH $CH_3COOH_2^+$ both correct **(1)**		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	(HIO + CH_3COOH ⇌) $H_2IO^+ + CH_3COO^-$ / (HIO + CH_3COOH ⇌) $HIOH^+ + CH_3COO^-$ Ignore position of positive charges		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (d)	(pH = 4.9) so $[H^+]$ = (1.2589254 x 10^{-5}) = **1.259 x 10^{-5} (1)** (K_a = $\frac{[HCOO^-]}{[H^+]\ [HCOOH]}$ = $\frac{1.6 \times 10^{-4}}{1.259 \times 10^{-5}}$) **= 12.7 (:1) / 13(:1) ($HCOO^-$ per HCOOH or base:acid)** (12.709252 from unrounded $[H^+]$ 12.708499 from $[H^+]$ rounded to 1.259 x10^{-5} 12.3 from $[H^+]$ rounded to 1.3 x10^{-5}) TE from error in **$[H^+]$** **Allow 800:63** **(1)** **Correct answer scores 2** Accept (0.0786828) = **0.079 HCOOH per $HCOO^-$ for acid:base ratio** (0.0786874) = 0.079 from rounded pH **OR** pK_a = -log K_a = 3.79 3.79 = 4.9 – log $\frac{[base]}{[acid]}$ (1) log $\frac{[base]}{[acid]}$ = 1.11 $\frac{[base]}{[acid]}$ = (12.882496) = **12.9 (:1) (1)** **Correct answer scores 2** Accept **0.0776/ 0.078 HCOOH per $HCOO^-$ for acid:base ratio** (0.0776247) TE from error in pK_a Ignore sf except 1		**2**

TOTAL FOR SECTION B = 50 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
19 (a)	Alcohol; (2)-methylpropan-2-ol **(1)** Catalyst: sulfuric acid OR any named strong acid Ignore concentration of acid **(1)** Accept formula for acid	Formula of alcohol Just acid/H^+ for catalyst	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	Tap funnel / separating funnel	Buchner funnel Filter funnel	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(ii)	To neutralize / remove/ react with (excess) acid Allow To neutralize / remove / react with (excess) H^+ To remove acidic impurities To remove ethanoic acid To remove the acid (used as a) catalyst Ignore additional comments on quenching or reaction stopping	To purify it To remove excess acid **and** alcohol Just "to quench acid catalyst/stop reaction"	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(iii)	Add (anhydrous) calcium chloride/ sodium sulfate/ magnesium sulfate/ Allow silica gel Allow formulae of drying agents	Conc. sulfuric acid Anhydrous copper sulphate Just "silica"	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(iv)	Round bottomed or pear-shaped flask + still head with stopper or thermometer + heat source **(1)** This mark cannot be given if apparatus is completely sealed /large gaps between components Downwards sloping condenser (with correct water flow) **+** collection vessel **(1)** Thermometer in correct position with bulb opposite condenser opening **(1)** Ignore fractionating column if included between flask and condenser	Conical flask Flat bottomed flask	**3**

Question Number	Acceptable Answers	Reject	Mark
***19 (c)**	**First mark** (Two signals so) two hydrogen environments **(1)** This mark may be gained by a description of the only two environments, but reference to hydrogen must be made. **Second mark** (Numbers of hydrogen in each environment are/ are predicted to be) in ratio 3:9 or 1:3 OR Peak due to $(CH_3)_3$ is 3x higher than peak due to CH_3 **(1)** **Third mark** Environments are CH_3COO and $(CH_3)_3$ (H may have been specified in first marking point) These may be shown on a diagram of the formula of the molecule OR H-C-C=O (peak at 2.1) and H-C-C (peak at 1.3) (**1)** **Fourth mark** Singlets/ no splitting as no H on adjacent C OR Singlets as the hydrogen environments are not adjacent to other H environments Allow "only one peak" for no splitting **(1)**	Just "the peaks are due to $(CH_3)_3$ and CH_3	**4**

Question Number	Acceptable Answers	Reject	Mark
19 (d)(i)	$CH_3COOCH_2CH(CH_3)_2$ Or correctly displayed Allow $CH_3COOCH_2CH(CH_3)$ CH_3		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d)(ii)	The H on the CH_3COO Accept circle round all of first methyl group Accept a hydrogen in this environment if rest of molecule is incorrect	Circle round C of first methyl group	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (e)(i)	Any acid with 6C (5C + COOH) which is chiral, so will have a branched chain $C_3H_7CH(CH_3)COOH$ OR $C_2H_5CH(CH_3)CH_2COOH$ OR $(CH_3)_2CHCH(CH_3)COOH$ **(1)** Infrared indicates (O-H present in a) carboxylic acid **(1)** High boiling temperature due to hydrogen bonding (between atoms in OH groups so not an ester.) Hydrogen bonds must be possible for structure shown Allow acids can form dimers. Allow TE from formula of straight chain molecule with explanation that London forces are higher in a linear molecule **(1)** (Optically active so) contains chiral C/ C bonded to four different groups The formula suggested must contain a chiral carbon to score this mark This may be shown by a chiral carbon being labelled in the formula **(1)** Carbonyl compound/ Carbonyl group/ Aldehyde **and** ketone absent (as no reaction with 2,4-dinitrophenylhydrazine)/ Allow carboxylic acids do not react with 2,4-dinitrophenylhydrazine/ **(1)**	Infrared indicates O-H Infrared indicates alkyl group Just "does not contain C=O (group)"	**5**

Question Number	Acceptable Answers	Reject	Mark
19 (e)(ii)	No because the isomers (which are carboxylic acids) contain same bonds / groups (C=O, C-O, C-H etc) **(1)** OR Yes because could be distinguished by infrared fingerprint **(1)**	 Yes because spectrum is unique	**1**

TOTAL FOR SECTION C = 20 MARKS

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