OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry B (Salters)

Advanced GCE

Unit **F334:** Chemistry of Materials

Mark Scheme for January 2012

Oxford Cambridge and RSA Examinations

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All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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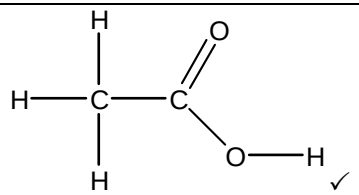
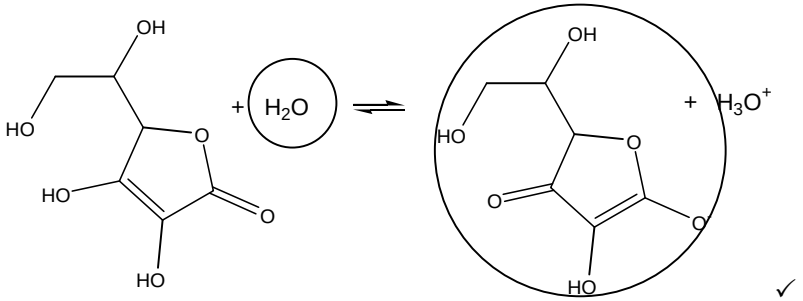
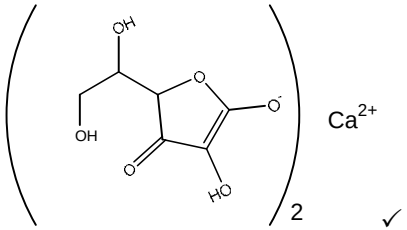
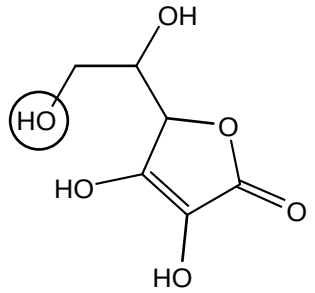
Annotations

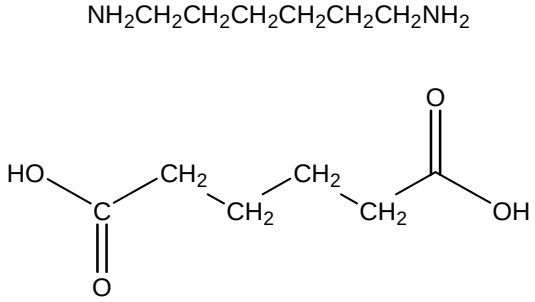
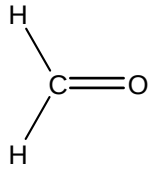
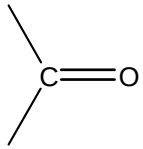
Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	separates marking points
not	answers which are not worthy of credit
reject	answers which are not worthy of credit
ignore	statements which are irrelevant
allow	answers that can be accepted
( )	words which are not essential to gain credit
__	underlined words must be present in answer to score a mark
ecf	error carried forward
AW	alternative wording
ora	or reverse argument
	Correct point
	Incorrect point
	Benefit of the doubt
	No benefit of doubt given
	Error carried forward
	Omission mark
	Ignore
	Reject

Question	Answer	Marks	Guidance
1 (a)	 ✓	1	**DO NOT ALLOW** missing Hs **ALLOW** –OH group
(b) (i)	acidified ✓ (potassium) dichromate / (sodium) dichromate / $Cr_2O_7^{2-}$ ✓ heat (under) reflux / reflux ✓	3	Any concentration of sulfuric acid / H_2SO_4 **DO NOT ALLOW** hydrochloric *or* nitric acids **IGNORE** oxidation state of dichromate **DO NOT ALLOW** heat alone **ALLOW** heat with condenser
(ii)	(strong) peak/trough at about 1720–1740 (cm^{-1}) indicates C=O/carbonyl group ✓ no broad peak/trough at approx. 2500–3200 (cm^{-1}) so no –OH/hydroxyl (in –COOH) present **OR** no –OH/hydroxyl peak/trough at 2500–3200 *AW* ✓ ethanal / CH_3CHO ✓	3	C=O may be shown on the diagram of the spectrum by the correct peak/trough **ALLOW** specific frequency from within range **IGNORE** references to aldehyde or carboxylic acid for the 1720-1740 cm^{-1} peak **ALLOW** correct full structural and skeletal formulae **ALLOW** acetaldehyde
(c) (i)	a proton / H^+ acceptor ✓	1	

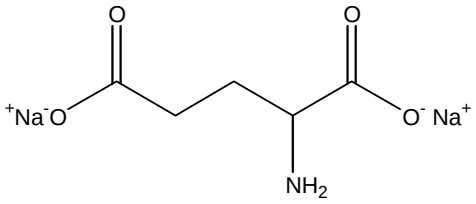
Question	Answer	Marks	Guidance
(ii)	 ✓ **ALLOW** If only $-O^-$ is circled	1	both circles required
(iii)	carbon dioxide / CO_2 ✓  ✓	2	**ALLOW** $(C_6H_7O_6)_2Ca$ / $(C_6H_7O_6)^-{}_2Ca^{2+}$ **ALLOW** slight error in formula of ion *i.e.* number of H(6-8) and O(5-7) **ALLOW** with or without correct charges but not half and half
(iv)	E300 is a stronger acid (than phenol) ✓ it fizzes/reacts with a carbonate but phenols don't ✓	2	**ALLOW** E300 is more acidic/in solution has a lower pH **IGNORE** references to stability of ions and/or electron delocalisation
(d) (i)	**moles of KIO_3^-** = 0.00500 x (25.0/1000) ✓ = **0.000125** **moles of I_2** = 3 x 0.000125 = **0.000375** (3.75×10^{-4}) ✓	2	**please annotate marks given with ticks** **ACCEPT** 3.8×10^{-4} ecf for **moles of KIO_3**
(ii)	**moles of thiosulfate$^-$** = 0.00500 x (20.4/1000) ✓ = **0.000102** **moles of I_2** = 0.5 x 0.000102 = **0.000051** (5.1×10^{-5}) ✓	2	**please annotate marks given with ticks** ecf for **moles of thiosulfate**

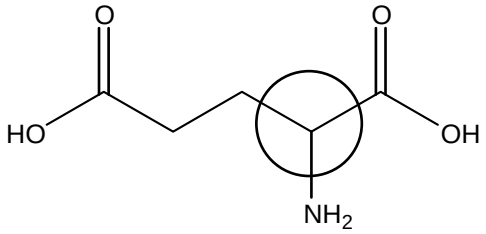
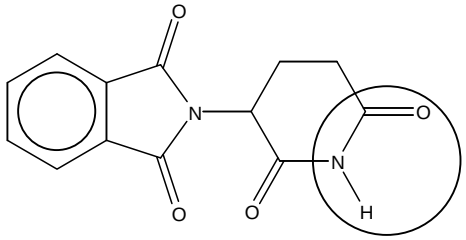
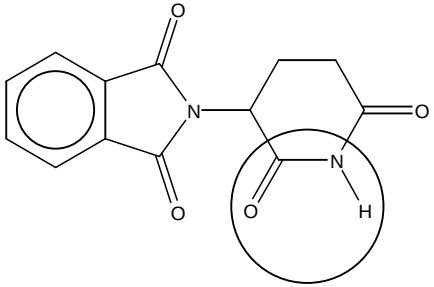
Question	Answer	Marks	Guidance
(iii)	1. **moles of E300** = **moles of I_2 from d(i) – moles of I_2 from d(ii)** ✓ = 0.000375 – 0.000051 = **0.000324** 2. **concentration of E300** = 0.000324 x 1000/250.0 = ✓ **0.001296** mol dm^{-3} 3. = 0.001296 x 176 = **0.228 g dm^{-3}** (this is over the allowed limit - NO) ✓ (228 mg dm^{-3})	3	**please annotate marks given with ticks** **REJECT** any negative answer for the 1st mark at this stage ecf from parts **d(i)** and **d(ii)** ecf for second mark **Note** the calculations in marking points 2 & 3 may be reversed A correct answer at any stage scores all previous marks answer must be in **g dm^{-3}** or **mg dm^{-3}** for 3rd mark AND correct comment If 228(.096) mg dm^{-3} has been calculated but concentration has been given as 0.001296 mol dm^{-3} then award 3 marks. ecf from above **ALLOW** 'not over the allowed limit' – YES if appropriate answer must be given to at **least 2 sig figs**
(iv)	the concentration of E300 would be too low *AW* ✓ because it would appear as if there is more unreacted I_2 *AW* ✓	2	
(e)	restricted rotation around the C=C bond ✓ each C atom (in C=C bond) has two different groups/atoms attached to it ✓ the two –OH groups can only be on the same side of the C=C because the ring structure will not allow them to be on opposite sides / rotate *AW* ✓	3	may be shown using structural formulae **IGNORE** aromatic **DO NOT ACCEPT** needs additional explanation to **ring structure**

Question	Answer	Marks	Guidance
(f) (i)	 ✓	1	**ALLOW** if adjacent C is included in the circle
(ii)	–OOC ✓	1	**ALLOW** any correct ester structure **OR** full structural formula **ALLOW** $C_{17}H_{35}COO–$ **OR** –CO.O–C etc.
(iii)	<u>concentrated</u> sulfuric/hydrochloric acid	1	**ACCEPT** correct formula for either acid
(iv)	water ✓	1	**ALLOW** H_2O
	Total	**29**	

Question	Answer	Marks	Guidance
2 (a) (i)	$NH_2CH_2CH_2CH_2CH_2CH_2CH_2NH_2$  ✓✓  ✓	3	**ALLOW** skeletal formulae or (eg) HOOC $(CH_2)_4$ COOH OR COOH $(CH_2)_4$ COOH If structural formulae are drawn **DO NOT ALLOW** missing H atoms. **ALLOW** CH_2O **REJECT** 
(ii)	ether ✓	1	
(iii)	in *heating under reflux* the condenser is vertical **OR** mixture is evaporated and condensed/liquefied and returned to mixture *AW* **OR** no material/reactants/products/chemicals/substance is lost from the mixture *AW* ✓ in *distillation* the condenser is slope downwards / horizontal /attached at the side **OR** mixture/chemicals/molecules are evaporated and condensed (or liquefied) and collected **OR** mixture/chemicals/molecules are separated ✓	2	**ALLOW** use of correct diagrams with condenser labelled **IGNORE** any reference to flammability

Question	Answer	Marks	Guidance
(b)	*water absorption is greater in nylon because*... 1. it can form hydrogen bonds with <u>water</u> ✓ 2. because it has both –NH and C=O groups whereas POM has only an –O– group **OR** because it has more electronegative atoms (and suitable Hs) to form hydrogen bonds *AW* **OR** because it can form <u>more</u> hydrogen bonds with water than POM can ✓ **QWC** – hydrogen bonding needs to be mentioned for both polymers to gain number 2 of these first two marks *POM has a lower melting point because*... 1. weaker intermolecular bonds/forces between polymer chains/molecules ✓ 2. less <u>energy</u> needed to separate chains/molecules/IMBs ✓ *POM is more rigid because*... 1. polymer chains/molecules can not move/slide over each other so easily ✓ 2. chains are aligned/packed more closely **OR** crystallinity is greater ✓	6	**please annotate marks given with ticks** **ORA** **ALLOW** N atoms instead of more electronegative atoms **IGNORE** any names of intermolecular force given, this is a comparison mark ***ORA*** *nylon-6 is more flexible because*... polymer chains/molecules can move over each other more easily ✓ chains are aligned less closely / crystallinity is less / more amorphous ✓
(c)	plasticiser ✓	1	**IGNORE** references to copolymerisation
	Total	**13**	

Question	Answer	Marks	Guidance
3 (a)	2-aminopentan(e)dioic acid 2-amino ✓ pentan(e)dioic acid ✓	2	mark independently **IGNORE** dashes and commas; absence of 'e' before 'dioic'; 1,5 between 'pentan(e)' and 'dioic' **DO NOT ALLOW** dicarboxylic acid **DO NOT ALLOW** amine; other numbers between 'pentan(e)' and 'dioic' (2nd mark is lost)
(b) (i)	acids will react with the amino/–NH_2 group *AW* ✓ alkalis/bases will react with the carboxyl/–COOH group *AW* ✓	2	**ALLOW** the amino/–NH_2 group can be protonated / is a proton/H^+ acceptor **ALLOW** the carboxyl/–COOH group can lose a proton/H^+ / is a proton/H^+ donor **ALLOW** hydroxyl/-OH group instead of –COOH group **IGNORE** any reference to acidic or basic.
(ii)	it forms a zwitterion **OR** an ion which has both a negative charge and a positive charge ✓ (these zwitterions/ions) attract each other very strongly **OR** zwitterions form a giant lattice **OR** ionic bonding is (very strong) ✓ high energy/heat required to separate particles ✓	3	**IGNORE** any reference to hydrogen bonding and other intermolecular bonds **ALLOW** a diagram for describing zwitterion
(c)	one carboxylate group shown correctly ✓ rest correct including charges ✓  	2	**ALLOW** without Na^+ **ALLOW** any type of correct structural formula

Question	Answer	Marks	Guidance
(d) (i)	*type of isomerism* = optical isomerism ✓ (the C atom in box) is chiral / is bonded to 4 different groups / is asymmetric ✓ so its mirror image is non-superimposable *AW* ✓	3	**ALLOW** stereoisomerism **IGNORE** any reference to enantiomers
(ii)		1	**IGNORE** any adjacent C atom or NH_2 group included in circle
(e) (i)	Either ✓  or 	1	

Question	Answer	Marks	Guidance
(ii)	**two** answers from the following: more effective / faster acting ✓ less expensive/cheaper (to manufacture) ✓ smaller dose required ✓ easier to formulate/administer *AW* ✓ fewer side-effects ✓ can treat other symptoms / wider application ✓	2	**DO NOT ALLOW** 'better' for 'more effective' **ALLOW** 'worked better than...'
(iii)	**one** answer from the following: safety tests on drugs for use during pregnancy ✓ test to see if drug can pass through placenta *AW* ✓ longer period of testing / longer clinical trials ✓ testing on (pregnant) animals ✓	1	**ALLOW** optical isomers can now be separated
	Total	**17**	

Question	Answer	Marks	Guidance
4 (a) (i)	*oxidation states of Br:* in BrO_3^- = +5 **AND** in Br^- (aq) = -1 ✓ oxidation state of Br **decreases / is reduced** in the reaction *AW* ✓	2	 ecf **IGNORE** any reference to electron loss or gain
(ii)	$BrO_3^- + 6H^+ + 6Fe^{2+} \rightarrow Br^- + 3H_2O + 6Fe^{3+}$ correct formulae for reactants and products ✓ equation balanced ✓	2	**DO NOT ALLOW** $FeBr_3$ **IGNORE** any extra electrons
(iii)	to provide H^+ / acidic conditions *AW* **OR** act as an antioxidant **OR** as a reducing agent *AW* ✓	1	**IGNORE** catalyst
(b) (i)	*any 2 marking points from the following:* BrO_3^- and Br^- are colourless but Br_2 is brown/ red-brown/dark red/orange/coloured ✓ Increase in / change in colour in the reaction ✓ Increase/change in absorbance in a colorimeter in the reaction ✓	2	 **ALLOW** the reactants are colourless but product is coloured etc **ALLOW** only bromine is coloured **IGNORE** any named colour **NOTE** colour changes from colourless to red-brown(etc.) as Br_2 is formed from BrO_3^- and Br^- scores 2 marks
(ii)	Rate = k x $[BrO_3^-$ (aq)$]$ ✓ x $[Br^-$ (aq)$]^2$ ✓ x $[H^+$(aq)$]$ ✓	3	The concentration terms must be multiplied together **NOT** added **ALLOW** without 'x' signs and state symbols **If curved brackets () penalise once, rest ecf**

Question	Answer	Marks	Guidance
(c) (i)	$4.5 \times 10^{-6} = k \times 7.00 \times 10^{-4} \times 5.00 \times 10^{-2} \times (2.00 \times 10^{-1})^2$ ✓ $k = 3.2$ ✓	2	**ALLOW** any correct rearrangement of equation ecf BUT must be to **2 sig figs**. for 2nd mark
(ii)	$mol^{-3}\ dm^{+9}\ s^{-1}$ ✓	1	**ALLOW** in any order **ALLOW** dm^9
(iii)	temperature ✓	1	**IGNORE** references to standard conditions
(iv)	slow step of the reaction / rds depends upon the species given in the rate equation ✓ in this case two H^+, BrO_3^- and a Br^- ✓ so the two H^+ and the BrO_3^- could combine to form $H_2BrO_3^+$ (in a fast step/s) ✓	3	**1st mark** is for relationship between rate equation / orders appearing in the rate equation and species forming transition state of slow step **2nd mark** for the 4 species involved **IGNORE** any reference to moles of species **3rd mark** for suggesting how the intermediate is formed
	Total	**17**	

Question	Answer	Marks	Guidance
5 (a)	(ions) **absorb** certain/specific/some frequencies/wavelengths/colours of (visible) light ✓ transmits complementary colour / other frequencies/wavelengths ✓ **QWC** – for following word, used correctly: absorb(s) / absorbing / absorption / absorbance / absorbed (spelling must be correct for **first mark**)	**2**	'absorbing colour/light' is insufficient for the 1st mark. use of 'emit' is a **CON** for the 2nd mark **IGNORE** radiation *alone* / transition metals **ALLOW** visible radiation **IGNORE** reflects **ALLOW** complementary colour is seen
(b)	**Any four of the following:** O_2 can oxidise V^{2+} / V^{2+} can reduce O_2 ✓ forming V^{3+} ✓ V^{3+} can be oxidised further (by O_2) to VO^{2+} which is <u>blue</u>, but not further/not to VO_2^+ ✓ (blue and not green) because electrode potential of O_2 / OH^- is more positive *ORA* ✓ (blue and not yellow) because electrode potential of O_2 / OH^- is less positive than VO_2^+ / VO^{2+} *ORA* ✓	**4**	**please annotate marks given with ticks** **ALLOW** electrons lost or gained **ALLOW** air (rather than oxygen) **DO NOT ALLOW** electronegativity **DO NOT ALLOW** higher/lower electrode potential

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>(c) (i)</td><td><table>
<tr><td>coordination number</td><td>6 ✓</td></tr>
<tr><td>shape of ion</td><td>octahedral ✓</td></tr>
<tr><td>name of ligand</td><td>water ✓</td></tr>
<tr><td>type of bonding between vanadium and ligand</td><td>dative (covalent) / coordinate / coordination ✓</td></tr>
</table></td><td>4</td><td>ALLOW ‘aqua’
DO NOT ALLOW name given for complex ion

DO NOT ALLOW covalent alone</td></tr>
<tr><td>(ii)</td><td>Ligand exchange / ligand substitution / ligand displacement / complex formation ✓</td><td>1</td><td>IF NOT ‘complex formation’ then answer must contain ‘ligand’</td></tr>
<tr><td>(d)</td><td>$3d^3$ ($4s^0$) ✓</td><td>1</td><td></td></tr>
<tr><td>(e)</td><td><table>
<tr><td></td><td>true</td><td>false</td></tr>
<tr><td>they can act as homogeneous catalysts because vanadium can exist in several oxidation states</td><td>✓</td><td></td></tr>
<tr><td>in heterogeneous reactions vanadium can only use s electrons to form weak bonds on the catalyst surface</td><td></td><td>✓</td></tr>
<tr><td>in heterogeneous catalysis there is a lowering of the activation enthalpy for the overall reaction</td><td>✓</td><td></td></tr>
</table></td><td>2</td><td>all correct ✓✓
two correct ✓</td></tr>
<tr><td></td><td>Total</td><td>14</td><td></td></tr>
</table>

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