

GCE

Chemistry B (Salters)

Unit **F334**: Chemistry of Materials

Advanced GCE

Mark Scheme for June 2014

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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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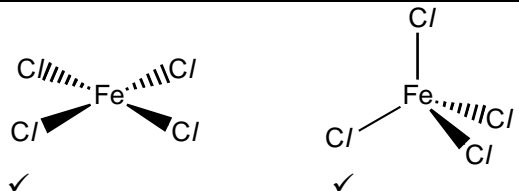
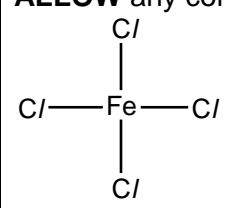
Annotations used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
BP	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
/	alternative and acceptable answers for the same marking point
✓	separates marking points
not	answers which are not worthy of credit and which will CON a correct answer
ignore	statements which are irrelevant and will NOT 'CON' a correct answer
allow	answers that can be accepted
()	words which are not essential to gain credit
<u> </u>	underlined words must be present in answer to score a mark
e cf	error carried forward
AW	alternative wording (replaces the old 'or words to that effect')
ora	or reverse argument

Annotations used in scoris:

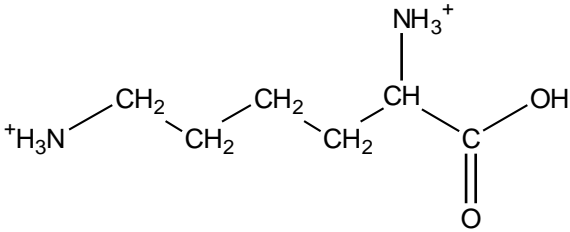
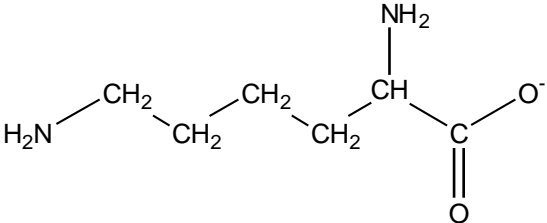
Annotation	Meaning
✓	correct response
✘	incorrect response
bod	benefit of the doubt
nbod	benefit of the doubt not given
ECF	error carried forward
^	information omitted
I	Ignore
R	Reject

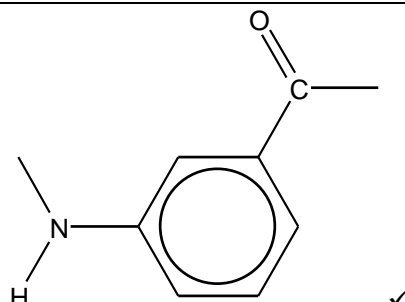
Question		Answer	Mark	Guidance
1	a	1. $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$ ✓ oxidation ✓ 2. $2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^- \rightarrow 4\text{OH}^-$ ✓ reduction ✓ 3. $\text{Fe}^{2+} + 2\text{OH}^- \rightarrow \text{Fe}(\text{OH})_2$ ✓ (ionic) precipitation ✓	6	MARK reaction TYPE independently of EQUATION IGNORE state symbols ALLOW $\text{H}_2\text{O} + 1/2\text{O}_2 + 2\text{e}^- \rightarrow 2\text{OH}^-$ ✓ ALLOW OXIDISATION, OXIDISE, REDUCE, PRECIPITATE ECF for e used than e^- (<i>i.e. only penalise once</i>)
	b	i	+3 ✓	1 DO NOT ALLOW 3, Fe^{3+} or 3+ ALLOW +III NOT III
	b	ii	low oxygen (concentration in ground around pipes) ✓	1 ALLOW lack of oxygen, or answers that imply not enough oxygen to oxidise Fe to Fe^{3+} BUT NOT answers implying no oxygen IGNORE water
	c		<u>iron(II)</u> sulfate/ <u>iron(II)</u> sulfate(VI) ✓	1 ALLOW sulphate IGNORE any formula
	d	i	(central) metal ion / cation / atom ✓ bonded to /surrounded by /attached to / linked ligands / negative ions / molecules AW ✓ molecule / ion: which has (at least one) lone pair OR which forms dative (covalent)/coordinate bond ✓ (polydentate ligand can form) more than one bond / donate at least two lone pairs to (central) atom/ion OR has more than one atom with a lone pair which are used to bond AW ✓	4 ALLOW 'species' DO NOT ALLOW 'many/multiple/several lone pairs', 'more than 2 lone pairs etc.' AW ALLOW 'has more than 1 attachment site to the central (central) atom/ion'
	d	ii	$[\text{Fe}(\text{C}_6\text{H}_5\text{O}_7)]^-$ correct formula ✓ correct charge (only award if formula is correct) ✓	2 ALLOW without any brackets ALLOW -1 or 1- ALLOW skeletal formula of citrate For 1st mark ONLY ALLOW charges on metal ion and ligand if correct IGNORE 3 if before the formula for the complex

Question		Answer	Mark	Guidance
e	i	iron/Fe/Fe ²⁺ is oxidised ✓ because O.S. of Fe changes from <u>+2 to +3</u> ✓ hydrogen/H is reduced ✓ because O.S. of H changes from <u>+1 to 0</u> ✓	4	ALLOW answers in terms of loss of an electron – oxidation BUT must have oxidation states/formulae of ions ALLOW Roman numerals and 2+ etc. here DO NOT ALLOW H ⁺ is reduced ALLOW gain of an electron – reduction BUT must have oxidation states
e	ii	moles of green rust = $100 / (55.8 + 34.0) = 1.11$ ✓ volume of H ₂ = $1.11 \times 24 / 3 = 8.9$ dm ³ ✓	2	ALLOW M _r = 90 for Fe(OH) ₂ If the only error is incorrect M _r then give 1 mark ALLOW 8.91, 8.88, 8.8 or 9 dm ³ , any sfs Dividing by 3 twice gives 2.96/2.97 for 1 mark
f			2	IGNORE charges AND brackets around structure DO NOT ALLOW for tetrahedral, angles of 90° or all bonds drawn in one plane ALLOW any correctly drawn structure for square planar e.g.  for square planar NOTE if you are not sure if it is correct shape give it nbod
Total			23	

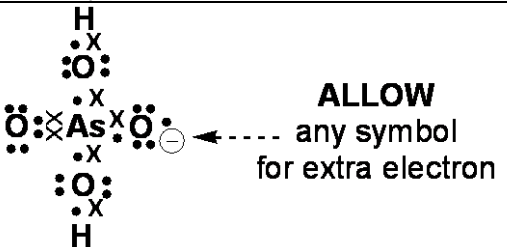
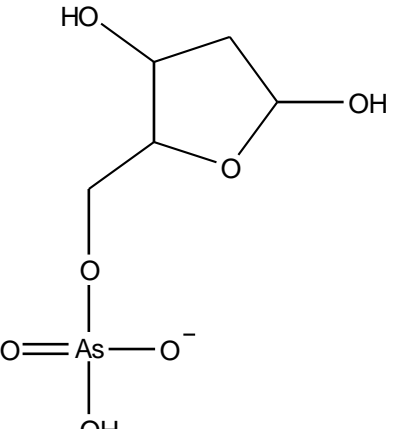
Question		Answer	Mark	Guidance	
2	a	2-hydroxypropanoic acid 2-hydroxy ✓ propanoic acid ✓	2	IGNORE 'dashes & commas' & space between 'hydroxy' and 'propanoic' acid DO NOT ALLOW propanoic acid, hydroxyl, hydroxo	
	b	moles of NaOH = $1.00 \times 33.6 / 1000$ ✓ = 0.0336 moles of acid in 25.0 cm ³ = 0.0336 ✓ moles of acid in sample = $4 \times$ ✓ 0.0336 = 0.134 mass of acid in sample = $90.0 \times$ ✓ 0.134 = 12.096 g % by mass = $12.096 \times 100 / 25.0 = 48.4$ % ✓	5	ecf ecf ecf MUST BE 3 sig. figs. for final answer	
	c	mix a constant/fixed/measured volume of B with a constant/fixed/measured volume of each NaOH(aq) AW ✓ zero colorimeter ✓ use suitable/correct filter OR filter of complementary colour ✓ measure absorbance/absorption of sample at known times / over time AW ✓	4	ALLOW calibrate (with water) ALLOW yellow, green or blue filters Complementary must be linked to 'colour' MUST link measurement of absorbance/absorption to time	
	d	i	dilute B by known amounts AW ✓ measure absorbance/absorption ✓ plot graph of absorbance/absorption against [B] /concentration (or [B] v abs.) (to get linear relationship) ✓	3	IGNORE make up standard solutions / solutions of known concentration of B DO NOT ALLOW 'plot a calibration curve' without reference to what is plotted: i.e. absorbance/absorption v concentration IF NaOH used instead of B and then only the 2 nd mark is available
		ii	1 st order ✓ (initial) gradient / slope doubles as concentration doubles AW ✓	2	ALLOW gradient/slope halves as concentration halves ALLOW when concentration doubles (reaction) time halves IGNORE references to rate/half-life (<i>need to use data from graph</i>)

Question		Answer	Mark	Guidance
	iii	keep $[\text{OH}^-]$ / $[\text{NaOH}]$ constant AW ✓ <u>vary/change/alter/double/halve [B]</u> ✓	2	IGNORE 'have excess NaOH' If B not mentioned, it must be clear they are referring to B (see question)
e	i	(strong) peak at <u>1742</u> indicates <u>C=O</u> ✓ in ester ✓ (broad) peak between 3200(or 3300)-3600 / at (about) 3400 indicates <u>OH</u> ✓	3	ALLOW carbonyl and hydroxyl for C=O and OH DO NOT ALLOW peak at 1735-1750 or any other range IGNORE references to arenes, phenols, alcohols
	ii	purple colour / reaction with Fe(III) indicates phenol ✓	1	ALLOW indicates (OH is) phenol DO NOT ALLOW 'alcohol is a phenol'
f		A has a chiral / asymmetric C / C with 4 different groups ✓ non- <u>superimposable mirror images</u> OR <u>mirror images</u> cannot be <u>superimposed</u> ✓	2	ALLOW molecule chiral / A has a chiral centre IGNORE C with 4 different functional groups QWC: superimposable/superimposed must be spelled correctly for second mark
g	i	it has two functional groups which can react together / undergo condensation OR -OH (alcohol) and COOH (acid) can react together / in one/same molecule (may be implied) AW ✓ ester ✓	2	
	ii	biodegradable / breaks down in soil AW ✓ renewable/ sustainable source for making A /avoids use of fossil fuels etc. / not made from crude oil AW ✓	2	DO NOT ALLOW 'decomposes faster' alone IGNORE references to physical properties, water, toxicity or atom economy

Question	Answer	Mark	Guidance
h	<p>acidic</p>  <p>one -NH_2 group protonated on the correct molecule ✓ both protonated and rest of ion correct ✓</p> <p>alkaline</p>  <p>ion correct ✓</p>	3	<p>ALLOW positive charge as shown or on N</p> <p>ALLOW delocalised negative charge or COO^- for carboxylate anion</p>
		31	

Question		Answer	Mark	Guidance
3	a	carbonyl / ketone ✓ ether ✓	2	
	b	i	1	IGNORE H ₂ O
	b	ii	1	
		iii	5	NOT at which IGNORE soften(s) This may be implied by combining the last two marking points IGNORE reference to intermolecular forces DO NOT ALLOW more energy to break/separate polymer chains
	c	i	1	IGNORE brackets and any 'n' outside brackets MUST have the two unlinked bonds to the N and C atoms ALLOW -NH , -CO NOT -HN
				
	c	ii	1	acylation ✓
	d	i	1	(secondary) amide ✓ DO NOT ALLOW peptide

Question			Answer	Mark	Guidance
		ii	(chains in Twaron are straighter) so chains/molecules are closer together / more tightly packed ✓ (hydrogen) bonds/intermolecular forces between chains will be stronger ✓	2	IGNORE more intermolecular bonds/forces OR more ordered chains OR more crystalline IGNORE more points of contact IGNORE references to energy ALLOW 'intermolecular' for 'between chains'
				14	

Question			Answer	Mark	Guidance
4	a	i	(As & P) are in same group (in the periodic table) OR they both have 5/ same number of electrons in the outer shell ✓	1	
	a	ii	 <p>5 electrons for As AND OH groups correct ✓ rest correct i.e. including extra electron and As=O correct ✓</p>	2	ALLOW without negative charge 'dots and crosses' may be interchanged between As & O DO NOT ALLOW →xx for double bond
	a	iii	4 areas of electron density ✓ repel and get as far away from each other as possible AW ✓ tetrahedral ✓ any value in range 107 – 110 ✓	4	ALLOW QWC: third mp can only be scored if first two mp are correct
	a	iv	condensation ✓	1	ALLOW addition-elimination but NOT elimination without addition
	a	v	 <p>primary OH used ✓ (water eliminated to form) As-O-CH₂-ring OR As-O-ring ✓ rest correct with negative charge on O ✓</p>	3	ALLOW any correct form of structural formula use of P for As fails to gain 3 rd mark if secondary OH used and no other errors then award 2 marks

Question		Answer	Mark	Guidance
	b	i		
		H_3AsO_4 ✓	1	ALLOW any molecular formula with correct atoms e.g. $\text{H}_2\text{AsO}_3\text{OH}$, $\text{AsO}(\text{OH})_3$ DO NOT ALLOW use of AS for As in parts b and c Penalise first time use then ECF
	b	ii		
		$\text{H}_2\text{AsO}_4^- + 2\text{OH}^- \rightleftharpoons \text{AsO}_4^{3-} + 2\text{H}_2\text{O}$ AsO_4^{3-} ✓ rest of equation correct & balanced ✓	2	
	b	iii		
		$\text{H}_2\text{AsO}_4^- + \textcircled{2\text{OH}^-} \rightarrow \textcircled{\text{AsO}_4^{3-}} + 2\text{H}_2\text{O}$ ✓	1	ALLOW ECF for incorrect formula for arsenate ion in bii
	c	i		
		(H_3AsO_4 reacts because) E^\ominus / electrode potential for $\text{SO}_4^{2-}/\text{SO}_2$ is more negative than E^\ominus for $\text{H}_3\text{AsO}_4/\text{H}_3\text{AsO}_3$ ✓ (H_3PO_4 does not react because) E^\ominus for $\text{SO}_4^{2-}/\text{SO}_2$ is more positive than E^\ominus for $\text{H}_3\text{PO}_4/\text{H}_3\text{PO}_3$ ✓ OR (using E^\ominus_{cell} calculations) for H_3PO_4 $E^\ominus_{\text{cell}} < 0$ / (-0.45 V) so is not feasible ✓ for H_3AsO_4 $E^\ominus_{\text{cell}} > 0$ / (+0.39 V) so is feasible ✓	2	ORA DO NOT ALLOW higher/lower or similar words DO NOT ALLOW E^\ominus_{cell} for E^\ominus ALLOW E^\ominus / electrode potential must be used at least once in the answer ALLOW correct identification of half-cell by one of the reactants only e.g. SO_2

Question		Answer	Mark	Guidance
	ii	$\text{H}_3\text{AsO}_4 + \text{H}_2\text{O} + \text{SO}_2 \rightarrow \text{SO}_4^{2-} + 2\text{H}^+ + \text{H}_3\text{AsO}_3$ <p>correct species with no cancelling of H^+ / H_2O / e^- ✓</p> <p>all correct ✓</p>	2	<p>ALLOW H_2SO_4 on RHS of equation</p> <p>DO NOT ALLOW an equilibrium arrow</p>
d	i	<p>1st order ✓</p> <p>because it has a constant half-life ✓</p>	2	<p>2nd mark depends on 1st</p> <p>so 'zero order because it has a constant half-life' does not score any marks etc.</p>
d	ii	<p>Evidence is for small molecules</p> <p>OR</p> <p>As-O bonds are not in a small molecule</p> <p>OR</p> <p>As-O bonds may be stabilised/ strengthened by the DNA structure ✓</p>	1	<p>LOOK FOR either</p> <p>comment on relative size of molecules</p> <p>or</p> <p>stability of As-O bonds</p> <p>ALLOW DNA is not a small molecule – this may be implied</p>
			22	

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