

GCE

Chemistry B (Salters)

Unit **F334**: Chemistry of Materials

Advanced GCE

Mark Scheme for June 2015

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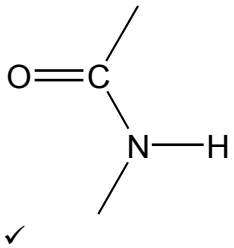
Annotations used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

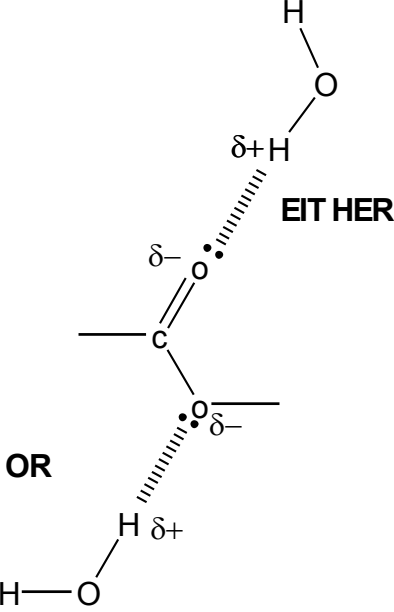
Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	separates marking points
not	answers which are not worthy of credit and which will CON a correct answer
ignore	statements which are irrelevant and will NOT 'CON' a correct answer
allow	answers that can be accepted
()	words which are not essential to gain credit
<u> </u>	underlined words must be present in answer to score a mark
ecf	error carried forward
AW	alternative wording (replaces the old 'or words to that effect')
ora	or reverse argument

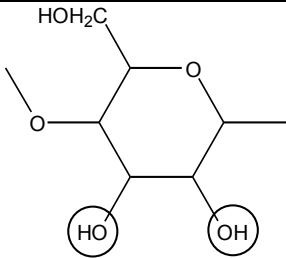
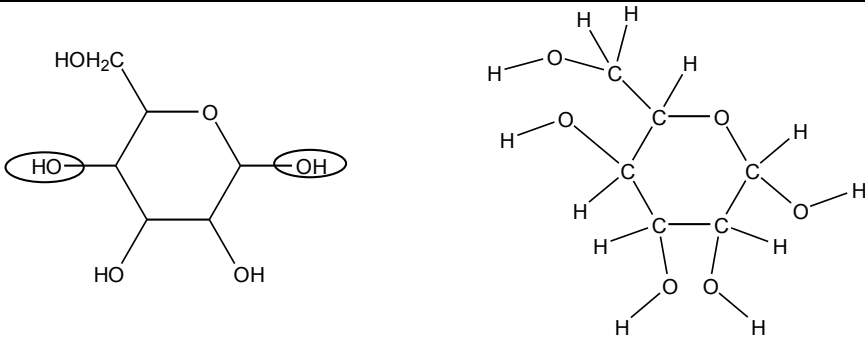
Annotations used in scoris:

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

Subject-specific Marking Instructions that apply across the whole question paper to be included here.

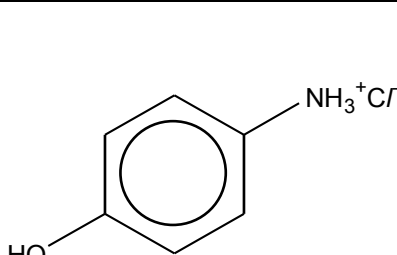
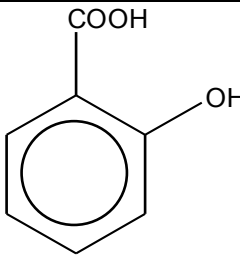
Question	Answer	Mark	Guidance
1 a i	ammonia / NH_3 ✓	1	NH_4^+ is a CON DO NOT ALLOW ammonium hydroxide, ammonium salt IGNORE conc., state
1 a ii	N (atom) has lone pair (of electrons) ✓ which can accept a proton / hydrogen ion / H^+ ✓	2	
1 b i	addition elimination ✓	1	ALLOW circles instead of underlining
1 b ii	 ✓	1	IGNORE additions to this linkage, but bonds must be shown on C and N.

Question	Answer	Mark	Guidance
1 c	 hydrogen bond between O and H ✓ lone pair AND partial charges ✓	2	Water must be shown as either H₂O or HO₂ DO NOT ALLOW OH or H alone If water is given as HO₂ AND hydrogen bond(s) and detail correct then award 1 mark IGNORE bond angles If two examples given, both must be correct for 2 marks hydrogen bond must be as shown or dashed/dotted NOT a single line lone pair MUST BE in line with hydrogen bond
1 d	more hydrogen bonds ✓	1	ALLOW more groups/sites/places which can form H bonds, more electronegative atoms/N and O atoms which can form H bonds DO NOT ALLOW more Os which can form H bonds, bonds more easily
		8	

Question	Answer	Mark	Guidance
2 a i	ether ✓	1	
2 a ii	 either or both circled as above ✓	1	ALLOW if adjacent C is also circled
2 a iii	 both circled OH groups present ✓ full structural formula correct ✓	2	AWARD 1 mark if one of the circled OH groups is incorrect but rest of structure is correct
2 b i	ethanoic acid ✓	1	

Question	Answer	Mark	Guidance
2 b ii	cellulose triethanoate: <u>instantaneous dipole-induced dipole</u> & <u>permanent dipole-permanent dipole</u> polyester: <u>instantaneous dipole-induced dipole</u> & <u>permanent dipole-permanent dipole</u> marking: <u>instantaneous dipole-induced dipole</u> in both polymers ✓ <u>permanent dipole- permanent dipole</u> in both polymers ✓	2	ALLOW van der Waals for <u>instantaneous dipole-induced dipole</u> DO NOT ALLOW abbreviations DO NOT ALLOW instantaneous-induced dipole forces unless they have used <u>instantaneous dipole-induced dipole</u> once ALSO applies to permanent dipoles hydrogen bonding is a CON so does not gain pd-pd mark
2 b iii	longer chains / length of chains ✓ more intermolecular bonds/forces in longer chains ORA ✓ OR polymer molecules/chains closer ✓ intermolecular bonds stronger ✓ ORA OR shorter monomer chains ✓ more intermolecular bonds between polymer chains / intermolecular bonds more frequent along polymer chains ✓	2	NOTE amount of imb/fs per unit length will get 1 mark, needs to relate 'more' to 'stronger' for 2nd mark NOT how closely, more imbs may be inferred: linkages closer together IGNORE references to branch/side groups, crystallinity and any other factors
2 c	at temperatures <u>below</u> polymer's Tg ✓ chains / molecules cannot move/slide over one another ✓ chains / molecules break when force applied ✓	3	IGNORE references to polymers being brittle NOT polymers break/shatter chains/molecules may be implied by use of 'they' referring to polymer chains

Question	Answer	Mark	Guidance
2 d	peak around 3500/3600 / in range 3200-3600 indicates O-H / hydroxyl bond in alcohol ✓ so cellulose diethanoate since only 2 of the 3 OH groups in repeating unit of cellulose have reacted / one OH / no OH groups in cellulose triethanoate ora AW ✓	2	IGNORE references to no O-H peak in range 2500-3200 MUST relate OH group to answer DO NOT AWARD this mark if a COOH group is also given as present
		14	

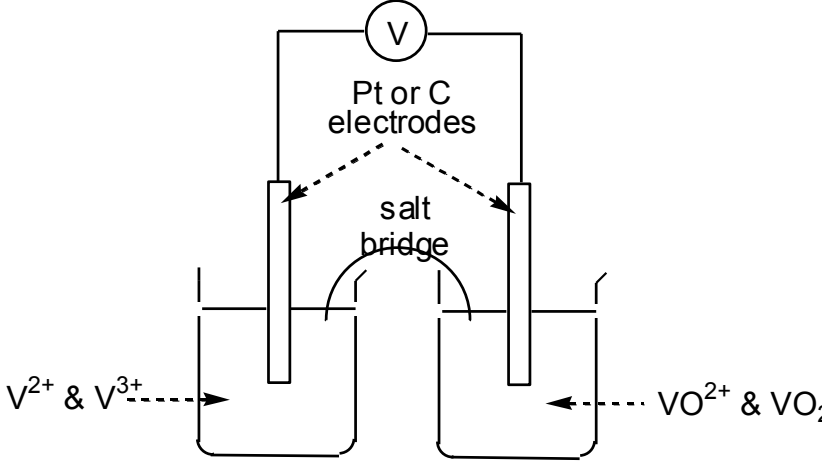
Question	Answer	Mark	Guidance						
3 a	<table><thead><tr><th>test</th><th>observations</th></tr></thead><tbody><tr><td>For C (add neutral) iron(III) chloride (solution) / FeCl₃ ✓</td><td>purple colour formed ✓</td></tr><tr><td>For D (add) Na₂CO₃ (s) or (aq) ✓</td><td>solution / mixture fizzes / bubbles / effervesces / (colourless) gas given off ✓</td></tr></tbody></table>	test	observations	For C (add neutral) iron(III) chloride (solution) / FeCl ₃ ✓	purple colour formed ✓	For D (add) Na ₂ CO ₃ (s) or (aq) ✓	solution / mixture fizzes / bubbles / effervesces / (colourless) gas given off ✓	4	DO NOT ALLOW iron chloride ALLOW violet NOT blue or red ALLOW NaHCO₃ / K for Na / Ca CO₃ / MgCO₃ / carbonate
test	observations								
For C (add neutral) iron(III) chloride (solution) / FeCl ₃ ✓	purple colour formed ✓								
For D (add) Na ₂ CO ₃ (s) or (aq) ✓	solution / mixture fizzes / bubbles / effervesces / (colourless) gas given off ✓								
3 b i	  1 mark for each correct structure ✓✓	2	Any clear structure acceptable ALLOW NH₃Cl. NH₃⁺ DO NOT ALLOW an OH group to be bonded to the ring via -HO						

Question	Answer	Mark	Guidance
3 b ii	draw pencil-line near bottom of plate/sheet ✓ place 1 drop (or similar word) of mixture AND a drop of each of the 2 compounds (on the line) AW ✓ place plate in solvent, line above solvent level AND add lid/cover ✓ when solvent nears top of plate AW, remove/dry plate ✓ locate spots with/ expose to UV light/iodine ✓ compare heights/position of spots from mixture with the two compounds AW OR calculate/measure/determine R_f values of spots and compare with those of the two compounds AW ✓	6	please annotate marks given with ticks ALL marking points may be gained from labelled diagram(s) ‘near bottom’ may be implied by what follows DO NOT ALLOW paper for plate/sheet BUT ecf for further use ALLOW draw base-line with pencil any other named locating agent is a CON DO NOT ALLOW ‘locating agent’ alone DO NOT ALLOW vague statements about comparing spots, MUST refer to positions DO NOT ALLOW vague statements about R_f values e.g. R_f values will identify compounds MUST indicate that spot heights or R_f values have been measured AND compared

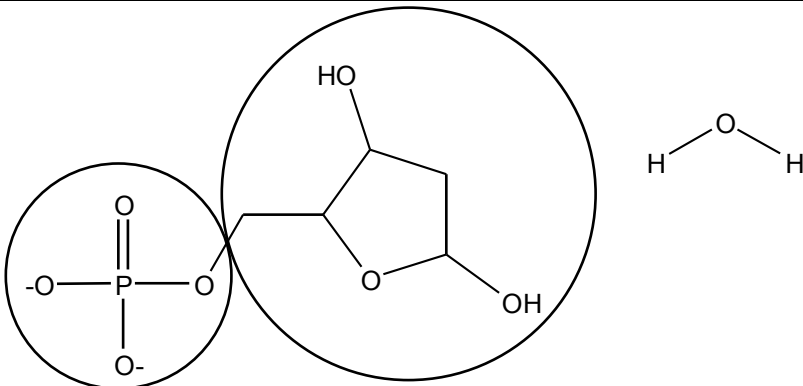
Question	Answer	Mark	Guidance
3 c i	for concentration to half: 1. 4.96×10^{-3} to $2.48 \times 10^{-3} = 220-30 = \mathbf{190 \text{ hours}}$ ✓ 2. 3.83×10^{-3} to $1.92 \times 10^{-3} = 290-100 = \mathbf{190 \text{ hours}}$ ✓ half-life constant (means 1 st order) ✓ OR every 70 hours, 1. from 30-100 hours = about 23% of conc. Is used up ✓ 2. from 220-290 hours = about 23% of conc. Is used up ✓ same proportion of starting conc. used up (means 1 st order) ✓ OR every 70 hours (a set time interval) for 1 st order the concentration drop will be a constant ratio ✓ 1. from 30-100 hours = about 1.295 ✓ 2. from 220-290 hours = about 1.292 ✓	3	units required for half-lives at least once otherwise 1 mark only for both times correct DO NOT ALLOW half-life MARK if no relevant data given IGNORE units IGNORE units NOTE any data referring to actual rates cannot be relevant/meaningful
3 c ii	average rate of reaction = $(5.55 - 1.92) \times 10^{-3} / 290$ ✓ $= 1.25 \times 10^{-5}$	1	Give mark for getting the working correct, may make an error with calculator IGNORE units for rate of reaction
3 c iii	$k = 4.96 \times 10^{-9} / 4.96 \times 10^{-3} = 1.0 \times 10^{-6} \text{ s}^{-1}$ ✓	2	ALLOW 1.00×10^{-6} or 1×10^{-6} or 10^{-6}
3 d i	change/alter/different functional/side groups (in structure / formula) ✓	1	ALLOW add / remove group(s) IGNORE references to altering shape, specific named groups
3 d ii	make a large number of related compounds (together quickly) AW ✓	1	DO NOT ALLOW 'test' instead of 'make' MUST refer to a large number in some way e.g. many NOT just 'compounds'
		20	

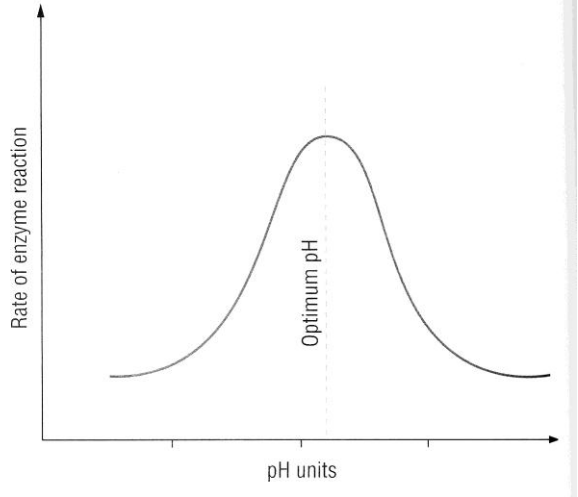
Question	Answer		Mark	Guidance										
4 a i	sulfur dioxide / sulfur trioxide OR chlorine ✓		1	IGNORE formulae ALLOW hydrogen chloride NOT hydrochloric acid or sulfur (di)chloride										
a ii	<table><tr><td>compound</td><td>oxidation state of vanadium</td></tr><tr><td>VS₄</td><td>+4</td></tr><tr><td>NaVO₃</td><td>+5</td></tr><tr><td>Na₂V₆O₁₆</td><td>+5</td></tr><tr><td>V₂O₅</td><td>+5</td></tr></table> VS ₄ correct ✓ rest correct ✓	compound	oxidation state of vanadium	VS ₄	+4	NaVO ₃	+5	Na ₂ V ₆ O ₁₆	+5	V ₂ O ₅	+5		2	ONLY penalise ONCE for lack of sign sign must be before number, ecf after first error
compound	oxidation state of vanadium													
VS ₄	+4													
NaVO ₃	+5													
Na ₂ V ₆ O ₁₆	+5													
V ₂ O ₅	+5													
a iii	step 1 ✓ oxidation state of V changes/increases ✓		2	more than step 1 is a CON but mark explanation separately ALLOW electron loss by V ALLOW ecf for the 2 nd mark, from wrong oxidation state for VS ₄ in table in aii , e.g. +8 (for VS ₄) to +5, so oxidation state decreases If two steps in first part , both reasons must refer correctly to the data in aii										

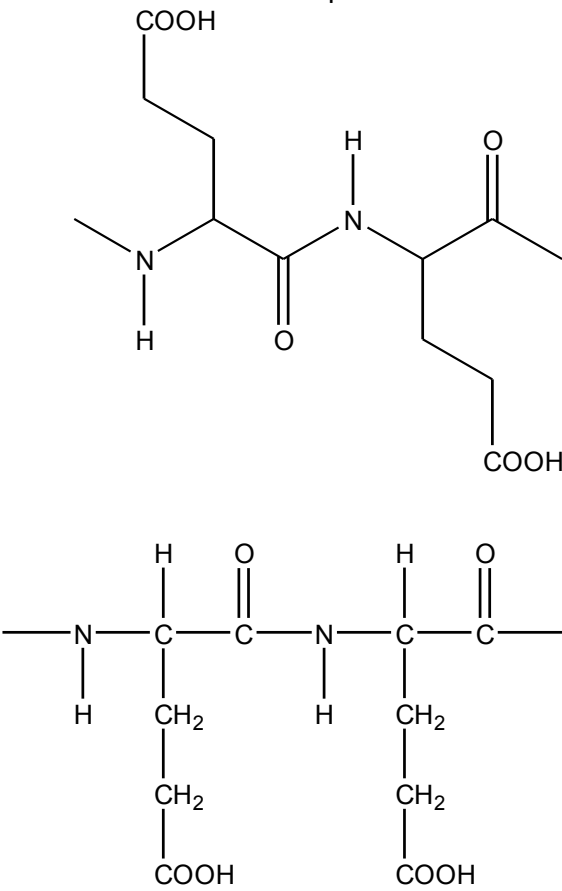
Question	Answer	Mark	Guidance
a iv	absorb (specific) frequencies (or wavelengths) in (specific) parts of the visible spectrum ✓  absorb must be spelled correctly to gain this mark transmit complementary colour / frequencies (or wavelengths) not absorbed / yellow light ✓	2	MUST use frequency/frequencies/wavelength(s) for 1st mark IGNORE any reference to energy levels and electrons ALLOW 'light' for visible or any of its variants e.g. absorbed, absorbing, absorption etc. ALLOW only complementary colour / frequencies (or wavelengths) can be seen DO NOT ALLOW reflect / emit / absorption
a v	$\text{V}_2\text{O}_5 + 5\text{Ca} \rightarrow 2\text{V} + 5\text{CaO}$ ✓	1	IGNORE state symbols
b	cooling / lowering / controlling temperature (of contents of furnace) ✓	1	ALLOW <i>statements which infer cooling e.g.</i> absorbs heat, prevents furnace getting too hot / thermal shock IGNORE references to cost, landfill

Question	Answer	Mark	Guidance
c i	 <i>diagram shows minimum requirements for 4 marks</i> both electrodes correct ✓ correct vanadium species in each cell ✓ H⁺ ions in VO²⁺ and VO₂⁺ solution ✓ salt bridge labelled & dipping into solutions AND voltmeter attached correctly AND circuit complete ✓	4	ALLOW half-cells reversed IGNORE anions, charges on electrodes, water, temperature and concentrations
c ii	$E_{\text{cell}} = 1.26 \text{ V}$	1	IGNORE any sign
c iii	temperature is not standard / 25°C ✓ concentrations of ions in a half-cell are not equal ✓	2	DO NOT ALLOW conditions not standard, must be specific to temperature and/or concentration ALLOW concentration not 1 mol dm⁻³ DO NOT ALLOW 1 mol(e) for concentration
c iv	$\text{VO}_2^+ + 2\text{H}^+ + \text{V}^{2+} \rightarrow \text{VO}^{2+} + \text{H}_2\text{O} + \text{V}^{3+}$ vanadium species correct ✓ equation correct ✓	2	GIVE 1 mark if equation has species and balancing correct but is reversed

Question	Answer	Mark	Guidance
c v	VO_2^+ AND $E^\ominus(\text{I}_2/\text{I}^-)$ must be more negative/less positive than the V ion being reduced ORA ✓ $2\text{VO}_2^+ + 4\text{H}^+ + 2\text{I}^- \rightarrow 2\text{VO}^{2+} + 2\text{H}_2\text{O} + \text{I}_2$ ✓	2	ORA V half-cell is the only one with a more positive $E^\ominus$ than the I_2/I^- half-cell ALLOW balanced equation with $\frac{1}{2} \text{I}_2$ IGNORE state symbols
d i	moles of $\text{Cr}_2\text{O}_7^{2-}$ used = 0.02160 x 23.50 / 1000 = 0.0005076 (5.076×10^{-4}) ✓ moles of Fe^{2+} reacted = 6 x 0.0005076 ✓ = 0.0030456 (3.0456×10^{-3}) mass of Fe in alloy = 0.0030456 x 55.8 ✓ = 0.16994448 g % Fe = 0.16994448 x 100 / 0.1750 ✓ = 97.1 % ✓	5	DO NOT award marks for random numbers without any explanation to what they refer to marks are for working out shown in bold OR actual answers at each stage must be 3 sig. figs. 97% gains 4 marks, 97.1% 5 marks, irrespective of working
d ii	oxygen / air (and water) will oxidise/change Fe^{2+} (to Fe^{3+}) ✓ NaHCO_3 reacts with acid to form CO_2 ✓ air/gas is dispelled which cannot return AW ✓	3	
e i	green solution ✓ forms a green precipitate ✓	2	IGNORE any qualifying of green such as pale, dark, dirty, rust etc. ALLOW ppt ALLOW solid for precipitate
e ii	$\text{Fe}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{Fe}(\text{OH})_2(\text{s})$ formulae correct & balanced ✓ state symbols correct for precipitation reaction ✓	2	
		32	

Question	Answer	Mark	Guidance
5 a	1. to find out about their relatives / ancestors AW OR to diagnose illness / cure disease AW ✓ 2. they are police / criminal suspects AW ✓ 3. they have not been prosecuted OR they are innocent OR they have been found not guilty OR infringes privacy OR prevents access by other people AW ✓	3	NOTE they may have answered in a different order to the questions in the stem DO NOT ALLOW to be cleared of a crime AW IGNORE references to human rights/liberty
b i	nucleotide ✓	1	IGNORE any details of the constituents of nucleotides
b ii	 phosphate structure (circled) correct ✓ deoxyribose structure (circled) correct ✓ water structure ✓	3	ALLOW an OH group for an O⁻ on phosphate The phosphate MUST be joined at the primary OH ALLOW H₂O or any bond angle for water

Question	Answer	Mark	Guidance
c	base pairs held together by <u>hydrogen bonding/bonds</u> ✓ adenine-thymine 2 hydrogen bonds AND guanine-cytosine 3 hydrogen bonds ✓ hydrogen bonds between base pairs break ✓ (two single) helices / strands are formed ✓ each base (on these helices/strands) forms hydrogen bonds to a new (correct/complementary) base AW ✓  to gain this last point replication must be linked to breaking AND forming hydrogen bonds	5	May be implied by stating the number of hydrogen bonds in each case different numbers of H bonds is NGE May refer to just one strand IGNORE references to phosphodiester bonds <i>i.e.</i> both forming and breaking H bonds have to be mentioned in the answer
d	 Rate of enzyme reaction Optimum pH pH units curve correct shape ✓ label for optimum pH in line with fastest rate of reaction ✓	2	ALLOW any curve with a peak, not necessary to be symmetrical Optimum pH should indicate the peak of graph AND be labelled as such

Question	Answer	Mark	Guidance
e i	structure correct - 2 examples shown below  ✓	1	ALLOW any correct structure ALLOW without 'spare bonds' ALLOW dipeptide structure which must have its secondary amide/peptide between two chiral C atoms
e ii	((side) –COOH/carboxyl groups will (lose protons and)) form –COO[–]/carboxylate ions ✓	1	also forming NH_2^+ / NH_3^+ is a CON ALLOW carboxyl/COOH becomes deprotonated AW
		16	

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