OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry B (Salters)

Advanced GCE

Unit **F335:** Chemistry by Design

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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Facsimile: 01223 552610
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Annotations used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

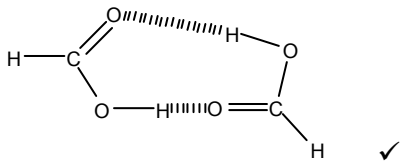
Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	separates marking points
not	answers which are not worthy of credit and which will CON a correct answer
ignore	statements which are irrelevant and will NOT 'CON' a correct answer
allow	answers that can be accepted
( )	words which are not essential to gain credit
__	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

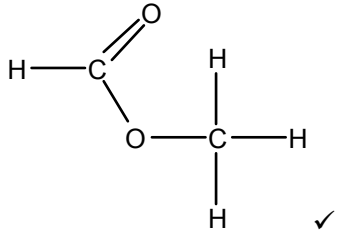
Annotations used in scoris:

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

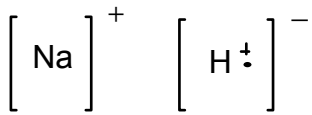
Question			Answer	Mark	Guidance
1	(a)	(i)	(rate) – molecules/particles in smaller volume **OR** increases concentration ✓ greater frequency of collision ✓ (yield) – fewer moles/molecules/particles on RHS(ora) ✓ <u>equilibrium</u> (posn): moves to right / moves to products **OR** moves to oppose change ✓	4	**Please use annotations** **ALLOW** molecules/particles closer together Use of other particles (eg atoms) **CON**s first mark (only) **IGNORE** 'reactants' (for 'particles') **ALLOW** less [or smaller] space [or area] **NOT** just 'more collisions'; the answer must imply frequency **IGNORE** 'chance/likelihood of collision' **NOT** 'atoms' (**CON** first mark but not second) 'RHS' can be implied by equilibrium shift (eg 'equilibrium shifts to right as there are fewer molecules' scores both marks) 'right' can be implied by 'greater yield' Mark separately **ALLOW** abbreviations of 'equilibrium' and 'equilibria' 'equilibrium moves to side with fewer molecules(etc)' scores 1
		(ii)	a lot of energy/electricity (needed for compressor) **OR** thick pipes/strong materials/materials to withstand high pressure needed ✓	1	**ALLOW** 'specialised plant', 'specialist equipment' (but not just 'plant', 'equipment') **IGNORE** 'safety precautions'
		(iii)	(forward) reaction exothermic (ora) ✓ <u>equilibrium position</u>: moves to oppose (change) AW **OR** moves in endothermic direction/to endothermic side (ora) ✓ yield decreases / less methanol formed ✓	3	**IGNORE** references to rates **ALLOW** 'left side is endothermic' (ora) this is the QWC link point (but mark separately with ecf from first marking point) must say 'equilibrium position' [or abbreviations or 'equilibria'] **ALLOW** 'moves to left' / 'moves towards reactants' (ora) if first marking point scored Mark separately no ecf

Question			Answer	Mark	Guidance
		(iv)	$[CH_3OH]/[CO]\,[H_2]^2$ ✓	1	must have square brackets. **IGNORE** state symbols terms in divisor may have dot or 'x' between them, **NOT** '+'
		(v)	1000 ✓ $dm^6\ mol^{-2}$ ✓	2	**ALLOW** 1030 or more sf **ALLOW** standard form **ALLOW** ecf from (a)(iv) unless plus sign used **ALLOW** $mol^{-2}\ dm^6$ **OR** $(mol\ dm^{-3})^{-2}$ **OR** $(dm^3\ mol^{-1})^2$ or ecf from (a)(iv)
	(b)	(i)	240 – (2x131) – 198 ✓ = –220 ✓	2	Award one mark for: • +220 (with sign) • –89 (factor of 2 missing) • correct evaluation of expression opposite with **one** S^o wrong
		(ii)	91000/T = 220 **OR** T = 91000/220 ✓ T = 410 ✓	2	**ALLOW** ecf from b(i) **ALLOW** ecf for second mark for correct evaluation of an expression: x/T = y only (eg T = 0.41 scores one mark) **ALLOW** 2 or more sf (413.63636) **NOT** rounding errors Negative values score no marks
	(c)	(i)	distil ✓ acid(ified) dichromate ✓	2	**IGNORE** 'heat' **NOT** 'reflux' mark separately **ALLOW** sulfuric/sulphuric acid **AND** potassium/sodium dichromate **ALLOW** dichromate(VI) **ALLOW** correct formulae for these (or dichromate ion) **ALLOW** small spelling errors **IGNORE** conc(entrated)

Question			Answer	Mark	Guidance
		(ii)	methanol: has no (C=O) around 1700 **OR** (O-H) at 3600 – 3640 / 3200 – 3600 / 3200 – 3640 ✓ methanal has no (O-H) at 3600 – 3640 / 3200 – 3600 / 2500 – 3200 / 'above 3000' / 2950 **OR** (C=O) at 1720 – 1740 ✓ methanoic acid has (O–H) at 2500 – 3200 **OR** (C=O) at 1700 – 1725 ✓ O–H related to one correct range as above ✓ C=O related to one correct range as above ✓	5	**Please annotate** For each compound, one mark for the wavenumber range Mark any correct range for each compound first and **IGNORE** other ranges, even if they have small errors (eg 3500 – 3640 for 3600 – 3640) **IGNORE** units of wavenumber ranges **IGNORE** correct but irrelevant peaks (eg C–H) Compounds must be named to score (i.e. not just 'alcohol') **ALLOW** indistinguishable 'methanol'/'methanal' from context **IGNORE** atoms with no bond (eg 'OH') or descriptions (eg 'alcohol') **IGNORE** '–C=O'
		(iii)	CH_3O/OCH 3.3 – 4.8 3 none COH 0.5 – 4.5 1 none *proton+shift* ✓✓ *relative no + splitting* ✓✓	4	**IGNORE** bonds (eg CH_3 – O) in 'type of proton' **ALLOW** 'hydroxyl' for 'OH' but **IGNORE** 'methyl' **IGNORE** units for chemical shift **ALLOW** 'singlet', 'unsplit' '1', 'no' etc in 'splitting' Second pair of marking points dependent on *chemical shift value* (not 'type of proton')
		(iv)	Data suggests M_r = 92, which is double expected (AW) ✓ (two) molecules of methanoic acid must be joined ✓ diagram showing hydrogen bonding of two molecules with two hydrogen bonds:  ✓	3	**ALLOW '**volume is half expected' 'half a mole of gas' **ALLOW** any reference to hydrogen bonding between molecules (or on diagram) This diagram scores mpts 2 and 3

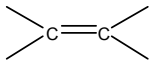
Question			Answer	Mark	Guidance
	(d)	(i)	 ✓ methyl methanoate ✓	2	**ALLOW** $-CH_3$ **IGNORE** bond angles **IGNORE** other correct non-full structural formulae Mark separately no ecf from wrong formula to name or vice-versa
		(ii)	ester has permanent (dipole) – permanent dipole ✓ methanol has hydrogen bonding ✓ more <u>energy</u> needed in methanol (ora): to break (bonds) **OR** to separate (molecules) ✓	3	no abbreviations **ALLOW** small spelling errors **ALLOW** third mark even if wrong imb are given, but not covalent bonds
		(iii)	sodium methanoate ✓	1	**ALLOW** 'methanoate <u>ion</u>' but not 'sodium methanoate ion' **ALLOW** 'formate for 'methanoate'
			Total	**35**	

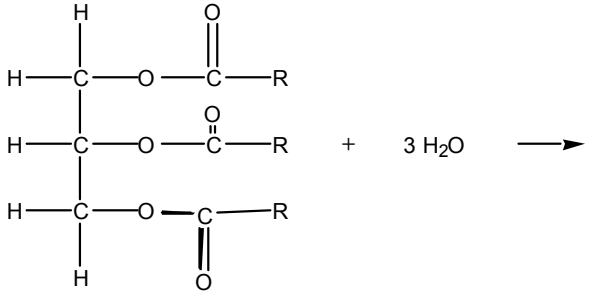
Question			Answer	Mark	Guidance
2	(a)	(i)	$1s^2\ 2s^2\ 2p^1$ ✓	1	**ALLOW** any size numerals and capital letters **NOT** subscripts
		(ii)	H B H H ✓	1	bond angles not important
		(iii)	trigonal (planar) ✓ three groups of electrons / three electron pairs / three areas of electron density ✓ electrons: repel and get as far away from each other as possible **OR** move to minimise repulsion ✓	3	**ALLOW** triangular / triangle / (bond angle) 120 First marking point must match diagram **ALLOW** ecf from number of pairs in a(ii) for second mark, but not first 3rd marking point must be in terms of electrons (not bonds/atoms etc) repelling but can be scored for any electron pairs or just 'electrons' **NOT** 'repel as much as possible'
	(b)	(i)	2 / two ✓	1	
		(ii)	it is useful for/works/good model for: many/most (simple) molecules/compounds/structures/ substances ✓	1	utility **AND** many/most/ 'generally (works)' AW
	(c)	(i)	ability of <u>atom</u> to attract AW <u>electrons</u> ✓ in a (covalent) <u>bond</u> ✓	2	**ALLOW** 'bonded/ bonding electrons', 'shared pair' for 'bond'
		(ii)	-1, +1, 0, +1 Both +1 ✓ –1 ✓ 0 ✓	3	**NOT** numbers alone; signs after numbers: no mark on first occasion, then allow as ecf

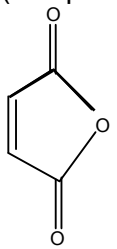
Question			Answer	Mark	Guidance
	(d)	(i)	(27.6 x 100/279.6) = 9.87 % ✓ much waste **OR** uneconomical / inefficient / unprofitable **OR** little useful product ✓	2	**ALLOW** 2 or more sf (9.8712446) must imply 'a lot of waste' not just 'waste' no ecf from a medium or large miscalculated atom economy **IGNORE** reference to the size of the number **ALLOW** second mark only if atom economy is less than 40%
		(ii)	ionic ✓  two electrons (dot-cross) on hydrogen ✓ rest correct ✓	3	Mark separately **ALLOW** eight electrons on sodium (all dot or all cross) **ALLOW** without square brackets (signs must be there) shared electron diagram scores no diagram marks
	(e)	(i)	$B_2H_6 + 3OF_2 \rightarrow B_2O_3 + 6HF$ B_2O_3 correct ✓ completely correct ✓	2	**IGNORE** state symbols
		(ii)	$\frac{25\times54}{27.6}$ ✓ × 3 ✓(= 146.7391g) 2 sf ✓ (150g)	3	**ALLOW** ecf on the mole ratio from equation in e(i) correct answer (to any sf) scores two marks regardless of working **ALLOW** different answers if intermediate rounding to 2 sf occurs (eg 0.91 from 25/27.6) **ALLOW** answers based on 2 sf A_r for B (11) [144.6 ---> 145] **ALLOW** intermediate rounding (even to 1sf) any number to 2 sf resulting from a shown correct evaluation scores this mark
		(iii)	BF_3 **OR** H_2O ✓	1	**IGNORE** names **ALLOW** B_2F_6
			Total	**23**	

Question			Answer	Mark	Guidance
3	(a)	(i)	3 ✓ $Co_3(AsO_4)_2$ ✓	2	**ALLOW** '3–' or '–3' **ALLOW** with some/all correct charges shown (eg $Co^{2+}{}_3(AsO_4)^{3-}{}_2$) ecf from first to second mark
		(ii)	$3d^7$ ✓	1	**ALLOW** capital letter and/or subscript or full size 7.
	(b)	(i)	Blue ✓ It reflects blue only/most **OR** it does not reflect any other colours ✓	2	'reflects blue only' scores both marks **ALLOW** 'absorbs all other colours' **OR** 'absorbs red, not blue' **ALLOW** 'high/good reflectance' for 'reflects' **ALLOW** 'violet' or 'purple' for 'blue' if in the context of absorbing beyond blue, (not blue/red mix) second mark depends on first
		(ii)	cobalt ✓ **A** d-orbitals / d-subenergy levels are split ✓ **B** electrons are excited **OR** electrons move to higher energy levels ✓ **C** absorbing (visible) light / red light / colour ✓ **D EITHER** $\Delta E = hv$ / frequency (absorbed) proportional/corresponds (AW) to energy difference AW **OR** complementary colour reflected/transmitted ✓	5	**Please use annotations** mark first mpt separately **ALLOW** 'cobalt(II)', 'cobalt ion' do not award mpt **A** if it appears to be a *consequence* of electrons being excited **Max 2** from A-D if electrons falling **and** emitting light mentioned **QWC** only award mpt **C** if mpt **B** scored Mpt **D** - must be 'ΔE' (not just 'E') unless supported by words **ALLOW** 'complimentary' **ALLOW** ecf from (b)(i) on actual colours absorbed/reflected

Question			Answer	Mark	Guidance
	(c)		Electrons fall (to lower energy-levels) ✓ light of specific frequency/colour emitted / (Δ)E = hv ✓ cobalt/elements has/have: own (set of) <u>energy levels</u> **OR** different energy gaps ✓	3	**Please use annotations** Can be scored from energy-level diagram provided only downward lines are shown (or labelling is clear) some idea of certain frequency of light needed, not just 'light' 2nd mpt must be in context of emission (or absorption followed by emission) **ALLOW** other elements have their own (different) energy levels **ALLOW** from a diagram of two sets of energy levels Mark independently
	(d)	(i)	idea that substrate fits/binds/bonds/forms enzyme-substrate complex with active site / has complementary shape to active site ✓ idea that this ability is lost when shape changed ✓ idea that substrate fitting (etc) goes on to cause a reaction (ora) ✓	3	**QWC** 'substrate' must be used (somewhere) and spelled correctly to score first mark can score first mpt here as well **ALLOW** 'substrate broken down'
		(ii)	<u>arsenic</u> combines/binds AW with SH groups (on dimercaprol) ✓ (arsenic has) less effect on enzyme / (arsenic) does not combine AW (so much) with enzyme / allows (normal) substrate to bind / does not inhibit enzyme ✓	2	**ALLOW** 'smalt' for 'arsenic'; must mention SH groups Mark separately
		(iii)	**one from:** what is a safe dose? relative toxicity compared with arsenic ✓	1	
			Total	**19**	

Question			Answer	Mark	Guidance
4	(a)		*Z* – the groups/chains/hydrogens are on the same side/one side... of the (carbon-carbon) double bond ✓	1	**ALLOW** link between Z and cis
	(b)	(i)	instantaneous (dipole) – induced dipole ✓	1	**ALLOW** small spelling errors if the sense is clear **ALLOW** Van der Waals (ignore spelling) **NOT** abbreviations
		(ii)	Molecules/chains can pack/ line up/ fit .... more closely ✓ <u>intermolecular</u> bonds/forces are stronger (ora) ✓ more energy required to break/melt (ora) ✓	3	must be a comparison **ALLOW** any named imb **IGNORE** 'more bonds' **ALLOW** 'more area for imb'; **ALLOW** 'stronger forces between chains' **ALLOW** breaking of anything except covalent bonds
	(c)	(i)	 + I_2 → –CHI–CHI– reacting with one mole of I_2 ✓ formula of product ✓	2	**ALLOW** any product formula that indicates one iodine on each carbon atom (H atoms need not be shown) **IGNORE** hydrogens on organic molecules
		(ii)	electrophile ✓	1	
		(iii)	253.8 (g I_2) shown somewhere ✓ (253.8 x 100/282) = 90.0 ✓	2	**ALLOW** ecf from wrong equation in (c)(i) **ALLOW** 254 **ALLOW** ecf Correct answer (or answer with ecf from wrong equation) scores both marks despite working. (45 similarly scores 1 mark) **ALLOW** 90 **ALLOW** ecf from wrong M_r for I_2
		(iv)	answer to c(iii) ✓ 0 ✓	2	**IGNORE** 'grams'

Question	Answer	Mark	Guidance
(d)	*any three from the following:* • hydrogen bonds are broken <u>in water</u> • id-id bonds / a small number of hydrogen bonds are <u>broken</u> <u>in oleic acid</u> • id-id bonds / pd-id bonds / (a small number of) hydrogen bonds are made between <u>oleic acid and water</u> • more energy required to break bonds than make them (AW) ✓✓✓	3	**Please add annotations** **ALLOW** abbreviations of inter-molecular bonds **ALLOW** just 'hydrogen bonds in water' **ALLOW** 'it' for 'oleic acid' to score third bullet, must have correct imb **AND** idea of 'between acid and water' **ALLOW** 'more bonds broken than made' **OR** 'bonds broken stronger than bonds made' (ora) **ALLOW** wrongly named imb for last bullet
(e)	 3 RCOOH + $CH_2OHCHOHCH_2OH$ ester group correct (even if wrong way round) ✓ triglyceride formula ✓ formulae of products ✓ 3 H_2O and 3 RCOOH ✓	4	**ALLOW** any unambiguous formulae (not molecular for organics) **except** that ester groups must be full structural Mark separately
	Total	**19**	

Question			Answer	Mark	Guidance
5	(a)		CHO ✓	1	**ALLOW** any order of atoms
	(b)		(compound X:)  ✓ need to rotate C=C ✓ high energy needed ✓	3	any unambiguous representation of structure **ALLOW** any anhydride formed between 2 molecules of maleic/fumaric for 1st mark **ALLOW** 'restricted rotation of C=C'
	(c)	(i)	2 / two ✓	1	
		(ii)	(each chiral centre/carbon gives rise to a) non superimposable mirror image ✓ one isomer common to both AW ✓	2	can score from diagrams
	(d)	(i)	$HA \rightleftharpoons H^+ + A^-$ ✓	1	**NOT** with square brackets **ALLOW** reversed State symbols must be (aq) if present
		(ii)	HA ⇌ $H^+ + A^-$ conjugate acid conjugate base ✓	1	**ALLOW** with square brackets here. **IGNORE** state symbols
		(iii)	$[H^+] = \sqrt{(K_a \times 0.1)}$ (= 9.6×10^{-3}) ✓ pH = 2.02 ✓	2	either working **OR** correct answer scores first mark, must say 'H^+ =...' or '$[H^+]$ =...' to score **ALLOW** 2.0 or more decimal places ('2' and '2.01' score 1 mark) **ALLOW ecf** from a stated $[H^+]$ ('$[H^+]$ =.....' or 'H^+ =....)

Question			Answer	Mark	Guidance
		(iv)	$[H^+] = [A^-]$ / all H^+ comes from acid/HA ✓ initial [HA] = equm [HA] (AW) ✓ second (is more inaccurate) since pH low / Ka high / acid quite strong (AW) ✓ appreciable amounts of HA (compared with initial amount) will react (AW) ✓	4	**Please add annotations** **ALLOW** $H^+ = A^-$ **ALLOW** 'concentration of HA is the same' **OR** 'very small amount of dissociation'
	(e)	(i)	maintains pH / little change in pH ✓ when small amount ✓ of acid or alkali added ✓ add H^+/acid moves equm (posn) to left/towards reactants **OR** add OH^-/alkali moves equm (posn) to right ✓ $[A^-]$ large (AW) ✓	5	**Please add annotations** Mark second and third independently from first second mark depends on mention of acid **or** alkali **both** acid and alkali need to be mentioned for third mark **ALLOW** 'alkaline' for 'alkali' **IGNORE** 'base' 'weak acid/ alkali' **CON**s third marking point. **ALLOW** ecf from equation in (d)(i) (eg if reversed) **ALLOW** 'reservoir of A^-'
		(ii)	$[H^+] = K_a \times 0.5$ **OR** $2[H^+] = K_a$ **OR** $[H^+] = 4.65 \times 10^{-4}$ ✓ pH = 3.33 ✓	2	either working **OR** answer scores first mark, must say 'H^+ =...' or '$[H^+]$ =...' to score Correct pH scores both marks **ALLOW** 3.3 or more sf; **DO NOT ALLOW** ecf unless '$[H^+] = K_a \times 2$' is shown or implied, when 1 mark can be awarded for 2.7(3....)
	(f)	(i)	4.5 ✓	1	
		(ii)	2.73 ✓	1	**ALLOW** 2.7 or more sf
			Total	**24**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

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Head office
Telephone: 01223 552552
Facsimile: 01223 552553