

Chemistry B (Salters)

Advanced GCE

Unit **F335**: Chemistry by Design

Mark Scheme for January 2012

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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).

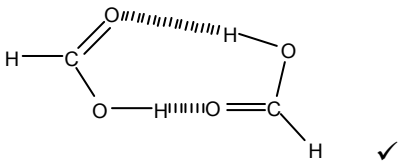
Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	separates marking points
not	answers which are not worthy of credit and which will CON a correct answer
ignore	statements which are irrelevant and will NOT 'CON' a correct answer
allow	answers that can be accepted
()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

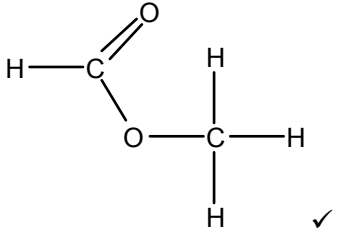
Annotations used in scoris:

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)	<p>(rate) – molecules/particles in smaller volume OR increases concentration ✓</p> <p>greater frequency of collision ✓</p> <p>(yield) – fewer moles/molecules/particles on RHS(ora) ✓</p> <p><u>equilibrium</u> (posn): moves to right / moves to products OR moves to oppose change ✓</p>	4	<p>Please use annotations ALLOW molecules/particles closer together Use of other particles (eg atoms) CONS first mark (only) IGNORE 'reactants' (for 'particles') ALLOW less [or smaller] space [or area]</p> <p>NOT just 'more collisions'; the answer must imply frequency IGNORE 'chance/likelihood of collision'</p> <p>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</p>
		(ii)	a lot of energy/electricity (needed for compressor) OR thick pipes/strong materials/materials to withstand high pressure needed ✓	1	<p>ALLOW 'specialised plant', 'specialist equipment' (but not just 'plant', 'equipment') IGNORE 'safety precautions'</p>
		(iii)	<p>(forward) reaction exothermic (ora) ✓</p> <p><u>equilibrium position</u>: moves to oppose (change) AW OR moves in endothermic direction/to endothermic side (ora) ✓</p> <p>yield decreases / less methanol formed ✓</p>	3	<p>IGNORE references to rates</p> <p>ALLOW 'left side is endothermic' (ora)</p> <p>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</p> <p>no ecf</p>

Question		Answer	Mark	Guidance
	(iv)	$[\text{CH}_3\text{OH}]/[\text{CO}] [\text{H}_2]^2$ ✓	1	must have square brackets. IGNORE state symbols terms in divisor may have dot or 'x' between them, NOT '+'
	(v)	1000 ✓ $\text{dm}^6 \text{mol}^{-2}$ ✓	2	ALLOW 1030 or more sf ALLOW standard form ALLOW ecf from (a)(iv) unless plus sign used ALLOW $\text{mol}^{-2} \text{dm}^6$ OR $(\text{mol dm}^{-3})^{-2}$ OR $(\text{dm}^3 \text{mol}^{-1})^2$ or ecf from (a)(iv)
(b)	(i)	$240 - (2 \times 131) - 198$ ✓ = -220 ✓	2	Award one mark for: • +220 (with sign) • -89 (factor of 2 missing) • correct evaluation of expression opposite with one S° 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)	<p>methanol: has no (C=O) around 1700 OR (O-H) at 3600 – 3640 / 3200 – 3600 / 3200 – 3640 ✓</p> <p>methanal has no (O-H) at 3600 – 3640 / 3200 – 3600 / 2500 – 3200 / 'above 3000' / 2950 OR (C=O) at 1720 – 1740 ✓</p> <p>methanoic acid has (O-H) at 2500 – 3200 OR (C=O) at 1700 – 1725 ✓</p> <p>O-H related to one correct range as above ✓ C=O related to one correct range as above ✓</p>	5	<p>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)</p> <p>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</p> <p>IGNORE atoms with no bond (eg 'OH') or descriptions (eg 'alcohol') IGNORE '-C=O'</p>
(iii)	<p>CH₃O/OCH 3.3 – 4.8 3 none</p> <p>COH 0.5 – 4.5 1 none</p> <p><i>proton+shift</i> ✓✓ <i>relative no + splitting</i> ✓✓</p>	4	<p>IGNORE bonds (eg CH₃– 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 <i>chemical shift value</i> (not 'type of proton')</p>
(iv)	<p>Data suggests $M_r = 92$, which is double expected (AW) ✓ (two) molecules of methanoic acid must be joined ✓</p> <p>diagram showing hydrogen bonding of two molecules with two hydrogen bonds:</p> 	3	<p>ALLOW 'volume is half expected' 'half a mole of gas'</p> <p>ALLOW any reference to hydrogen bonding between molecules (or on diagram)</p> <p>This diagram scores mpts 2 and 3</p>

Question		Answer	Mark	Guidance
(d)	(i)	 <p>methyl methanoate ✓</p>	2	<p>ALLOW –CH₃ IGNORE bond angles IGNORE other correct non-full structural formulae</p> <p>Mark separately no ecf from wrong formula to name or vice-versa</p>
	(ii)	<p>ester has permanent (dipole) – permanent dipole ✓ methanol has hydrogen bonding ✓</p> <p>more <u>energy</u> needed in methanol (ora): to break (bonds) OR to separate (molecules) ✓</p>	3	<p>no abbreviations ALLOW small spelling errors</p> <p>ALLOW third mark even if wrong imb are given, but not covalent bonds</p>
	(iii)	sodium methanoate ✓	1	<p>ALLOW 'methanoate <u>ion</u>' but not 'sodium methanoate ion' ALLOW 'formate for 'methanoate'</p>
Total			35	

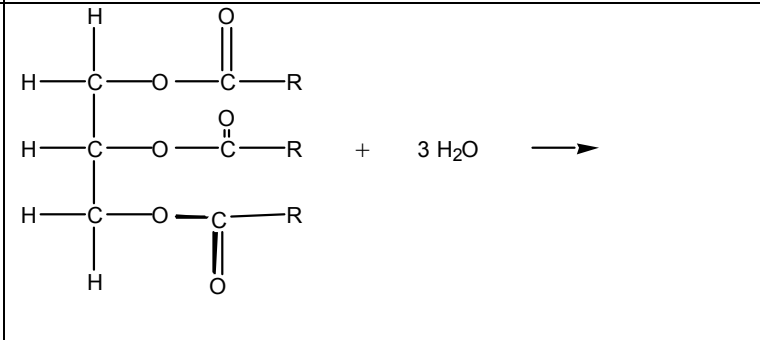
Question			Answer	Mark	Guidance
2	(a)	(i)	$1s^2 2s^2 2p^1$ ✓	1	ALLOW any size numerals and capital letters NOT subscripts
		(ii)	<pre> H +• B +• +• H H ✓ </pre>	1	bond angles not important
		(iii)	trigonal (planar) ✓ three groups of electrons / three electron pairs / three areas of electron density ✓ 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 3 rd 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

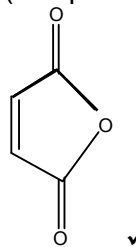
Question		Answer	Mark	Guidance
	(d) (i)	$(27.6 \times 100/279.6) = 9.87 \% \checkmark$ much waste OR uneconomical / inefficient / unprofitable OR little useful product \checkmark	2	ALLOW 2 or more sf (9.8712446) must imply 'a lot of waste' not just 'waste' no ecf from a medium or large miscalculated atom economy IGNORE reference to the size of the number ALLOW second mark only if atom economy is less than 40%
	(ii)	ionic \checkmark $\left[\text{Na} \right]^+ \quad \left[\text{H}^{\cdot\cdot} \right]^-$ two electrons (dot-cross) on hydrogen \checkmark rest correct \checkmark	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)	$\text{B}_2\text{H}_6 + 3\text{OF}_2 \rightarrow \text{B}_2\text{O}_3 + 6\text{HF}$ B_2O_3 correct \checkmark completely correct \checkmark	2	IGNORE state symbols
	(ii)	$\frac{25 \times 54}{27.6} \checkmark$ $\times 3 \checkmark (= 146.7391\text{g})$ 2 sf \checkmark (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 $\text{H}_2\text{O} \checkmark$	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 <u>reflects</u> blue only/most OR it does not <u>reflect</u> 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 <u>electrons</u> are excited OR <u>electrons</u> move to higher energy levels ✓ C absorbing (visible) light / red light / colour ✓ D EITHER $\Delta E = h\nu$ / frequency (absorbed) proportional/corresponds (AW) to energy <u>difference</u> AW OR <u>complementary</u> 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 <i>consequence</i> 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)	<p>Electrons fall (to lower energy-levels) ✓</p> <p>light of specific frequency/colour emitted / $(\Delta)E = hv$ ✓</p> <p>cobalt/elements has/have: own (set of) <u>energy levels</u> OR different energy gaps ✓</p>	3	<p>Please use annotations</p> <p>Can be scored from energy-level diagram provided only downward lines are shown (or labelling is clear)</p> <p>some idea of certain frequency of light needed, not just 'light'</p> <p>2nd mpt must be in context of emission (or absorption followed by emission)</p> <p>ALLOW other elements have their own (different) energy levels</p> <p>ALLOW from a diagram of two sets of energy levels</p> <p>Mark independently</p>
(d) (i)	<p>idea that substrate fits/binds/bonds/forms enzyme-substrate complex with active site / has complementary shape to active site ✓</p> <p>idea that this ability is lost when shape changed ✓</p> <p>idea that substrate fitting (etc) goes on to cause a reaction (ora) ✓</p>	3	<p>QWC 'substrate' must be used (somewhere) and spelled correctly to score first mark</p> <p>can score first mpt here as well</p> <p>ALLOW 'substrate broken down'</p>
(ii)	<p><u>arsenic</u> combines/binds AW with SH groups (on dimercaprol) ✓</p> <p>(arsenic has) less effect on enzyme / (arsenic) does not combine AW (so much) with enzyme / allows (normal) substrate to bind / does not inhibit enzyme ✓</p>	2	<p>ALLOW 'smalt' for 'arsenic'; must mention SH groups</p> <p>Mark separately</p>
(iii)	<p>one from:</p> <p>what is a safe dose?</p> <p>relative toxicity compared with arsenic ✓</p>	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)	<p>any three from the following:</p> <ul style="list-style-type: none"> hydrogen bonds are broken <u>in water</u> id-id bonds / a small number of hydrogen bonds are <u>broken 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) <p>✓✓✓</p>	3	<p>Please add annotations ALLOW abbreviations of inter-molecular bonds ALLOW just 'hydrogen bonds in water'</p> <p>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</p>
(e)	 <p>3 RCOOH + CH₂OHCHOHCH₂OH</p> <p>ester group correct (even if wrong way round) ✓ triglyceride formula ✓ formulae of products ✓ 3 H₂O and 3 RCOOH ✓</p>	4	<p>ALLOW any unambiguous formulae (not molecular for organics) except that ester groups must be full structural</p> <p>Mark separately</p>
	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 1 st mark ALLOW 'restricted rotation of C=C'
	(c)	(i) 2 / two ✓	1	
		(ii) (each chiral centre/carbon gives rise to a) <u>non superimposable mirror</u> image ✓ one isomer common to both AW ✓	2	can score from diagrams
	(d)	(i) HA ⇌ 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 ⁺] = √(K _a × 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 / K_a 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' CONS 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 ' $H^+ = \dots$ ' or ' $[H^+] = \dots$ ' 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	

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