MARK SCHEME

Que	stion	l	Answer	Mark	Guidance
1	а		CO₂ covalent ✓	2	IGNORE 'molecular', small molecules, etc but any suggestion of a giant structure is CON
			CaO <u>giant ionic</u> ✓		The words 'giant' and 'ionic' must be there, but other correct chemical words (eg 'lattice' can be ignored) If compounds are not identified, assume order of answers is that of question
1	b	i	+161	1	plus sign must be present
1	b	ii	$\Delta S_{\text{tot}} = 161 - 180000/298 \checkmark$ = - 443 \checkmark	2	Award the following without consulting working: 2 marks for -443 (to 3 or more sf) 1 mark for +160(.395) (failure to multiply by 1000) 1 mark for +765 (not 765) (adding not subtracting) ALLOW ecf from 1bi NB Zone for (i) is shown above answer
1	b	iii	T (= 180000/161) = 1118 K ✓ (Temperature) above which/at which reaction is feasible ora	2	 ALLOW ecf on 161 from 1(b)(i) and on non-use of 1000 from (b)(ii) (i.e. 1.1 K scores the first mark if (+)160 given in 1 (b)(ii)) IGNORE + sign. ALLOW 2 or more sig figs ALLOW 'spontaneous' or 'favourable' or 'viable' or
			AW OR temperature at which the system/reaction is at equilibrium \checkmark		'occurs' etc for 'feasible' ALLOW $K_c = 1$ Mark separately NB the zones for (i) and (ii) are shown below answer.
1	С	i	calcium hydrogencarbonate ✓	1	IGNORE gaps and capital letters ALLOW calcium(II) hydrogencarbonate NOT (calcium hydrogen) carbonate(IV) IGNORE 'bicarbonate'
1	C	ii	air/atmosphere ✓	1	ALLOW 'dissolved in rainwater' (not just 'in rainwater') IGNORE 'from fossil fuels' etc

Que	Question		Answer	Mark	Guidance
1	C	iii	CaCO ₃ is formed/ CaCO ₃ is limescale \checkmark <u>Position of</u> equilibrium moves to left/towards reactants \checkmark Gas/CO ₂ is released from solution <i>AW</i> \checkmark	3	ALLOW water boils away/ is removed IGNORE references to endothermic reaction
1	d		<u>Ca²⁺(g) (+) CO₃^{2–}(g)√</u>	4	ALLOW ecf on bottom line from wrong charges on top line IGNORE arrows between levels
			$\frac{\text{CaCO}_3(s)}{\text{Ca}^{2^+}(aq)} (+) CO_2^{2^-}(aq)/CaCO_2(aq) \sqrt{2^+}$		
			$\Delta H_{hyd} \operatorname{CO}_3^{2-} (\operatorname{aq}) = -(2800 + 12 - 1650) = -1162\checkmark$	10	mark is for final answer (with sign) not working
			lotal	16	

Que	stion		Answer	Mark	Guidance
2	а	i	$C_8H_{12}N_2 \checkmark$	1	ALLOW elements in any order
2	а	ii	109° ✓ four pairs/groups/sets of electrons/ four areas of electron density (around N) ✓ repel and get as far away from each other as possible/ minimise repulsion ✓	3	ALLOW 106 – 110° ALLOW three bonding pairs and one lone pair 3rd point must be in terms of electrons repelling IGNORE bonds repelling IGNORE '(repel) as much as possible' Mark separately
2	b		Br	1	must be a skeletal formula
2	С		Benzene/A undergoes substitution (more easily than addition) ✓ mention of delocalised electrons (in A) ✓ Benzene/A does not undergo addition (readily) ✓ because it has no double bonds/alkene ✓ OR B undergoes addition ✓ because it has double bonds/alkene ✓	4	IGNORE references to mechanism or products IGNORE references to stability or bond length QWC (in second set of two marks) only award addition mark if mention of double bonds. Addition must be mentioned not just implied
2	d		$HO \longrightarrow N$ $H \rightarrow H$	2	ALLOW HO N H or any correct structural formula including mixtures of structural and skeletal

		Answer	Mark	Guidance
2	е	1. (substrate is) serotonin ✓	4	ALLOW '(CH ₂)NH ₂ group of serotonin'
		 2. moclobemide/inhibitor binds with <u>active/receptor site</u> AW ✓ 3. (moclobemide) blocks (the <u>active/receptor site</u>) OR (moclobemide) competes with <u>the substrate</u> OR <u>substrate</u> cannot bind (as well) / enzyme-<u>substrate</u> complex cannot form (as well) ✓ OR fewer/less active sites available for <u>substrate</u> 4. (increased serotonin/substrate concentration allows) increased rate ✓ 		 ALLOW 'bonds', 'fits', 'forms complex' instead of 'binds' in 2. ALLOW 'serotonin' for substrate or ecf on substrate name from 1. IGNORE moclobemide reacting with substrate IGNORE reasons
2	f	1. <u>electrons</u> move up(AW) <u>energy levels</u> ✓	5	reference to d electrons is CON to this mark only
		 2. light/ radiation is absorbed (with frequency related to energy gap by) ∆E = hv/hf ✓ 3. complementary colour/frequency OR colours/frequencies not absorbed are <u>reflected/ transmitted</u> ✓ 		IGNORE 'E=hv' unless 'energy gap/difference' mentioned in close proximity ALLOW 'frequency proportional to energy gap' accept the two parts of 2 . if they are separated in the answer. ALLOW 'complimentary' Any reference to electrons falling and giving out/emitting light CONs 3 .
		 4. phenelzine has small(er) chromophore/less delocalisation (therefore) larger ∆E/energy gap/v/frequency (ora for coloured/'aromatic' molecules)√ 		4. may be split through answer
		5. uv has higher frequency/ higher energy (than visible light) ora ✓		This can be scored if a reference to phenelzine absorbing in uv immediately follows the second part of 4 .('larger ΔE /energy gap/v/frequency')
			20	

Que	stion		Answer	Mark	Guidance
3	а	i	propene 🗸	1	NOT prop-1-ene
3	а	ii	similarity: C-C bond formed/ C atom attached to benzene OR alkylation OR hydrocarbon (chain)(AW) attached/substituted/added ✓ difference: no use of halogen compound OR only one product/ no HCl (or H ⁺) formed/lost ✓	2	IGNORE references to alkenes as reactants ALLOW 'eliminated'
3	b	i	 more/greater/higher yield OR more/greater amount of compound B/product ✓ fewer molecules/particles/moles on right-hand side/product ora ✓ molecules/particles in smaller volume/space (not area) ORcloser together ORmore concentrated AW ✓ greater frequency of collisions AND faster rate (of reaction) AW ✓ 	4	IGNORE 'equilibrium moves to the right' unless it indicates which side has fewer moles QWC marking point 1 depends on marking point 2 being scored 'molecules have increased energy' CONs this point marking points 3 and 4 can be marked separately 4. frequency must be implied (not just 'more collisions') IGNORE 'chance of collision'
3	b	ii	 (Forward) reaction exothermic (ora) AND equilibrium constant smaller AW ✓ Rate (too) slow(er)/takes too long to reach equilibrium below 250 AW ✓ 	2	IGNORE 'equilibrium moves to the left' but 'equilibrium moves to left (AW) in endothermic direction' will score first part of marking point. IGNORE 'compromise'
3	b	iii	100% ✓ no waste (product) (to be disposed of) ✓	2	IGNORE 'high' IGNORE reference to toxic/harmful NOT 'no by-product'

Que	estion		Answer	Mark	Guidance
3	С	i	2-hydroxy-2-methylpropan(e)nitrile / (propanone) cyan(o)hydrin ✓ HCN/KCN/NaCN ✓	2	 IGNORE dashes, commas and spaces ALLOW: 'hydroxy' and 'methyl' reversed; 2-cyanopropan-2-ol; 2-methylpropan-2-olnitrile; 2-cyano-2-hydroxypropane NOT a mixture of names with 'cyanhydrin' ALLOW CN⁻ and names
3	С	ii	alkene / carbon to carbon double bond ✓ (primary) amide ✓	2	IGNORE 'C=C' 'secondary' is CON
3	С	iii	methanol / CH ₃ OH ✓	1	
3	C	iv	addition (polymerisation) since C=C / carbon-carbon double bond/alkene double bond/unsaturated ✓ H H-C-H H H -C-C-C- H C=O O H-C-H H C=O	2	both points needed to score first mark ALLOW 'CH ₃ ' groups not displayed, but everything else must be full structural IGNORE brackets and 'n'
3	d	i	electrophilic substitution ✓	1	
3	d	ii	C ₆ H₅OCI ✓	1	ALLOW atoms in any order
3	d	iii	3 ✓	1	
3	е	i	three proton/H/hydrogen <u>environments</u>	1	

Question		۱	Answer	Mark	Guidance	
	е	ii	OH Cl	1	ALLOW hydrogen atoms shown on ring (for part (iii))	
	е	iii	OH G $E \rightarrow E_F$ $F \rightarrow C_l$ one mark for labelling G one mark for labelling E and F (which can be reversed)	2	If e(ii) is an incorrect isomer, award one mark for G if it labels the OH hydrogen E and F must be indicated on both sides to score second mark.	
	e	iv	Protons are attached to a carbon atom where OR the proton environment has the adjacent carbon with one proton ✓	1	must imply 'adjacent' eg 'neighbouring' etc and mention both carbons (unless 'proton environment' replaces the first carbon) and both protons. ALLOW hydrogen/H (not H ⁺) for 'proton'	
3	f		$\begin{matrix} I \\ \bullet \\$	3	ALLOW formula of any iodophenol but must be monosubstituted NOT hydrogens on the ring here 'addition' is CON	
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Que	estior	า	Answer	Mark	Guidance
4	а		$\begin{array}{rcl} \text{CaO} + 3\text{C} &\rightarrow & \text{CO} + \text{CaC}_2 \\ \textbf{OR} \\ 2\text{CaO} + 5\text{C} &\rightarrow & \text{CO}_2 + 2\text{CaC}_2 \checkmark \end{array}$	1	IGNORE state symbols
4	b	i	$CaCN_2 + 3H_2O \rightarrow CaCO_3 + 2NH_3 \checkmark \checkmark$	2	For one mark: • correct substances but unbalanced equation • the correct balanced equation with an error (eg Ca(CO ₃)) • CaCN ₂ + $3H_2O \rightarrow CaO + CO_2 + 2NH_3$ • CaCN ₂ + $4H_2O \rightarrow Ca(OH)_2 + CO_2 + 2NH_3$
4	b	ii	(nitrogen is unreactive/inert) (nitrogen) has a (strong) <u>triple</u> bond (oÆN N) ✓ OR high (AW) (activation) energy/enthalpy to break bond	1	
4	b	iii	nitrogen <u>compounds</u> are needed (by plants) for: growth/ making protein/ making amino acids/DNA ✓	1	ALLOW for 'nitrogen compounds': named (appropriate) nitrogen compounds or 'nitrates' or 'ammonium ions' (or formulae) IGNORE references to fertilisers
4	b	iv	(28 x 100/ 80.1 =) 35.0 % ✓ to 3sf ✓	2	Any answer that rounds to 35 scores first mark Second mark is for correct answer to 3sf i.e. 35.0
4	С	i	-3 +2 🗸	1	signs must precede numbers
4	С	ii	nitrogen monoxide ✓	1	ALLOW nitrogen(II) oxide (allow gaps), NOT nitrogen(II) monoxide no ecf from (c)(i)
4	С	111	(50-4x) + (50-5x) + 4x + 6x = 105 x = 5 % conversion = (20 x 100/50) = 40% $\checkmark \checkmark$	2	40% on answer line scores 2 marks without reference to working. ALLOW, for 1 mark, one of: • $(50-4x) + (50-5x) + 4x + 6x = 105$ • $(50-x) + (50-1.25x) + x + 1.5x = 105$ • 20 cm ³ of NH ₃ reacted OR 30 cm ³ of NH ₃ left

Que	stior	١	Answer	Mark	Guidance
4	C	iv	NO is <u>oxidised by oxygen / reacts with oxygen</u> to form NO ₂ \checkmark NO ₂ is brown \checkmark	2	ALLOW 'it' for 'NO'
4	d	i	_180(°) ✓ H–C≡C – H ✓	2	 Structure mark can be awarded if not linear Angle mark depends on: correct structure being given. structure being linear curve indicating the angle starting and finishing on bonds rather than an atom <i>Give benefit of doubt on rubbed out structures where</i> <i>possible (also in following parts)</i>
4	d	ii	ring of eight carbons ✓ correct double bonds ✓	2	If a correct non-skeletal structural formula is given, award one mark only. Do not award either mark if there are any extra carbons on ring. Second mark depends on first.
4	d	III	$Br \\ Br \\ Br \\ Br \\ Br \\ Br \\ Fr \\ Fr \\ $	1	must be skeletal to score
4	е	i	Ca ₃ P ₂ ✓	1	
4	e	ii	н [*] , н [*] ,••,• н √	1	

Question		1	Answer	Mark	Guidance
4	e	iii	 1.ammonia/NH₃ (not just N) forms hydrogen bonds with/in water ✓ 2.phosphane/PH₃ (not just P) forms id-id bonds with/in water ✓ 	4	ALLOW forms no/weaker hydrogen bonds OR forms permanent dipole-permanent dipole bonds/ forms Van der Waals ALLOW abbreviations/spelling errors and 'forces' for 'bonds'
			3.P is less electronegative (than N) ora ✓		
			 4. consideration of relative energies more energy is needed to break the hydrogen bonds in water than is released/made by making the imb/named imb (between phosphane and water) OR hydrogen bonds in water are stronger than imb/named imb (between phosphane and water) OR similar energy is needed to break the hydrogen bonds in water than is released/made by forming the hydrogen bonds (between) ammonia (and water) OR hydrogen bonds in water are of similar strength(AW) to those (between) ammonia (and water) √ 		 IGNORE 'more energy is needed to break the hydrogen bonds in water than is <i>needed</i> to break the imb' etc 'in water' must be stated or implied IGNORE reference to number of bonds broken and made ALLOW statements that suggest that the hydrogen bonding in water is weaker than that between ammonia and water
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Question		า	Answer	Mark	Guidance
5	а		methylpropanoic acid / 2-methylpropanoic acid 🗸	1	IGNORE gaps and dashes
5	b	i	H O H H H H −C−O−C−C−C−C−H H H H H H H H H H H −C−O−C−C−C−C−H H H H H H H H −C−O−C−C−C−C−H H H H H H H H H H H H H H −C−O−C−C−C−C−H H O H H H H H H H −C−O−C−C−C−C−H H O H H H H O H H H H O H H H	2	ester groups wrong way round scores zero
5	b	ii	No carbon-carbon double bonds/ No C=C OR all C-C bonds are single ✓	1	Not just 'double bonds' for 'C=C'
5	С	i	$C_4H_8O_2(aq) \rightleftharpoons C_4H_7O_2^-(aq) + H^+(aq) \checkmark$	1	State symbols required ALLOW H_2O + $C_4H_8O_2 \rightleftharpoons C_4H_7O_2^- + H_3O^+$ ALLOW $C_3H_7COO^-$ or $C_3H_7CO_2^-$ for $C_4H_7O_2^-$
5	С	ii	Weak acid/ incompletely ionised/ incompletely dissociated \checkmark	1	
5	C	iii	No/not enough H ⁺ / H₃O ⁺ ions/ protons ✓ (H ⁺) react (with carbonate) ✓	2	ALLOW 'needs water to ionise' for first mark Second mark depends on first

Que	stion		Answer	Mark	Guidance
5	С	iv	 (added) H⁺/acid reacts with (AW) C₄H₇O₂⁻ ORmoves equilibrium to left and forms acid√ (added) OH⁻ /alkali/ (sodium)hydroxide reacts with (AW) C₄H₈O₂/H⁺ ORmoves equilibrium to right to replace H⁺/ butanoic acid dissociates/ionises√ 	4	ALLOW A ⁻ or 'salt' or 'anion' or 'butanoate' or '(conjugate) base' or ecf from(c)(i)* for $C_4H_7O_2^-$ throughout ALLOW HA or '(butanoic) acid' or ecf from(c)(i)* for $C_4H_8O_2$ throughout IGNORE 'base' for 'alkali' (added)
			 3. C₄H₇O₂⁻ (concentration) and C₄H₈O₂ (concentration) large/ reservoir/ in excess AW ✓ 4. pH does not change (much) ✓ 		References to large amounts/reserves of H^+ or OH^- are CON
					needed.
5	d	i	$[H^+] = (√(1.51 \times 10^{-5} \times 0.02)) = 5.5(0) \times 10^{-4} \checkmark$ pH = 3.26 ✓	2	Any pH value rounding to 3.3 scores 2 ALLOW ecf for second mark if $[H^+] < 0.02$ To score either mark alone, first mark must include $'[H^+] = '$ or 'H ⁺ = '
5	d	ii	1. calculation of $[OH^-]$ $[OH^-] = 5 \ge 0.02/55 = 1.82 \ge 10^{-3} \checkmark$ 2. calculation of $[H^+]$ from $[OH^-]$ $[H^+] = 1 \ge 10^{-14}$ 'calculated $[OH^-]$ ' eg 1 $\ge 10^{-14}$ / 1.82 $\ge 10^{-3} = 5.49 \ge 10^{-12} \checkmark$ 3. calculation of pH from $[H^+]$ pH = 11.3 \checkmark	3	Allow the following answers (to 1dp) without reference to working: 3 marks: 11.3 2 marks: 12.0 (just dilution of NaOH) 2 marks: 12.3 (pH of 0.02M NaOH Either working or values score first two marks ALLOW ecf for second mark provided ' $[OH^-]/OH^- = '$ shown ALLOW ecf for third mark if ' $[H^+]/H^+ = '$ shown and value is < 1 x 10 ⁻¹⁰
5	e	i		1	OR other way round bond angles can vary

Question		ו	Answer	Mark	Guidance
5	е	ii	CH₃CH₂CH₂COC/ ✓	1	ALLOW any correct structural or skeletal formula or mixture IGNORE C ₃ H ₇ COC <i>I</i> (chain could be branched)
5	e	iii	permanent (dipole)–permanent dipole AND instantaneous (dipole)–induced dipole ✓ acid has hydrogen bonding ✓ more <u>energy</u> required to separate particles/break bonds in acid (ora) so ester has lower bpt (ora) ✓	3	type of imb must not be abbreviated or mis-spelled (QWC) 'hydrogen bonding' CON s first mark
5	f	i	• O + H unpaired electron ✓	2	IGNORE 'lone', 'single', 'unbonded' Mark separately
5	f	ii	Ć H ✓	1	arrows must be 'half-arrows' and (when projected) start on bond and end on atoms
5	f	iii	homolytic (fission) ✓	1	ALLOW homolysis
5	f	iv	only 5.4 initiation ✓ rest propagation ✓	2	mark separately
5	f	v	O_2 + R-CH ₂ -CH ₂ - \rightarrow R-CH(OOH)-CH ₂ - \checkmark	1	ALLOW R–C(OOH)H–CH ₂ – but end bonds must be there

Question	Answer	Mark	Guidance
5 f vi	aldehyde ✓ ((conc) sulfuric/hydrochloric) acid AND (potassium/sodium) dichromate AND heat/warm/reflux/distil AND green/ blue ✓	2	ALLOW alkanal IGNORE carbonyl ALLOW formulae instead of names for second mark, but IGNORE incorrect formulae if correct names given IGNORE oxidation state of dichromate IGNORE 'orange' but any other starting colour is CON ALLOW: 'silver nitrate and ammonia'/Tollens reagent and 'black ppt /silver' Fehling's/ Benedict's reagent and 'red ppt' 'acid permanganate' (names or formulae) and 'colourless' no ecf from first mark and second mark depends on first being scored.
		31	