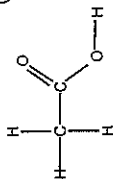
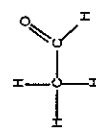
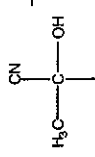
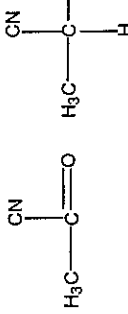


The following annotations may be used when marking:

- X = incorrect response (errors may also be underlined)
- A = omission mark
- pod = benefit of the doubt (where professional judgement has been used)
- ecf = error carried forward (in consequential marking)
- con = contradiction (in cases where candidates contradict themselves in the same response)
- sf = error in the number of significant figures

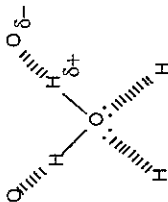
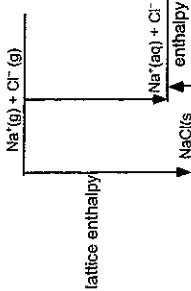
Abbreviations, annotations and conventions used in the Mark Scheme:

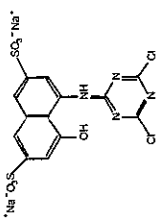

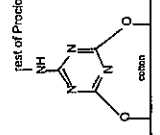
- / = alternative and acceptable answers for the same marking point
- ; = separates marking points
- NOT = answers not worthy of credit
- () = words which are not essential to gain credit
- ecf = key words which are not essential to gain credit
- AW = allow error carried forward in consequential marking
- ora = alternative wording
- = = or reverse argument

Question	Expected Answers	Marks
1 a i	ethanoic acid;(1)  (1) Allow -OH	2
1 a ii	potassium/sodium dichromate;(1) sulphuric acid (allow conc) (1) Allow dichromate, acid, correct formulae of ions or substances	2
1 b i	C-H	1
1 b ii	Water contains O-H bonds;(1) water is present in breath(1)	2
1 b iii	(the atoms in the O-H) bond(s);(1) vibrates;(1) more (vigorously) (1)	3
1 c i	oxidation ALLOW redox	1
1 c ii		1
1 c iii	NaBH ₄	1
1 c iv	 -CN and rest of molecule;(1) -OH(1)  Allow any clear type of structural formula score (1)	2
1 d	1720 - 1740 (NOT other ranges);(1) C=O (1) Ethanal - M _r worked out (44) (or some reasoning related to fragments);(1)	2
1 e	Mention of M ⁺ peak or some indication of how 44 deduced from spectrum;(1) A CH ₃ CO ⁺ (or C ₂ H ₃ O ⁺) (or "loss of H");(1) B CHO ⁺ ;(1) positive charges on ions. (1) If ethanol chosen, can score last three marks. A as above, B C ₂ H ₅ ⁺ , positive charges QWC: at least two sentences, logical. Correct use of at least two of the following technical terms: (molecular) ion, (relative) mol(ecular) mass/RMM/M _r , fragmentation/fragment(s)	6

Question	Expected Answers	Marks
2a i	+3 Allow 3+ here but mark "s" and check at 3bii	1
2a ii	O-H polar (or partial charges shown);(1) H ⁺ formed (1)	2
2b i	in equilibrium/ partial dissociation/ionisation	1
2b ii	$K_a = [H^+][H_2BO_3^-]/[H_3BO_3]$ top(1); bottom (1) missing [] scores max 1	2
2b iii	$[H^+] = \sqrt{K_a[H_3BO_3]}$ (1) = 7.6×10^{-6} ; (1) pH = 5.1 (1) accept "5" if working shown	3
2b iv	$H_3BO_3(aq) + NaOH(aq) \rightarrow NaH_2BO_3 \text{ (or ions)}(aq) + H_2O(l)$ reactants and products;(1) balancing;(1) state symbols (provided water formed) (1) Accept equations forming other salts.	3
2c i	pH 8.5 gives $[H^+] = 3.16 \times 10^{-9}$; (1) then either: $\frac{[salt]}{[acid]} = \frac{5.8 \times 10^{-10}}{3.16 \times 10^{-9}}$; (1) = 0.184;(1) Thus 0.018 mol of $H_2BO_3^-$ must be added. (1) or $[salt] = K_a \times [acid]/[H^+]$ (1); = $5.8 \times 10^{-10} \times 0.1/3.16 \times 10^{-9}$ (1) <i>subsumes last mark</i> = 0.018 (1)	4
2c ii	acid/alkali in eye causes damage/irritation/harm (1); buffers maintain pH/ neutralise (1); in presence of (small amounts of) acid/alkali/near 8.5/neutral pH/same pH as eye/ natural pH (1)	3
2c iii	Indication that acid is H ⁺ /alkali is OH ⁻ (1); (on adding acid) equilibrium moves to left/ buffer accepts H ⁺ /or equation (1); (on adding alkali) equilibrium moves to right/forms H ⁺ to neutralise/AW) (1); Because $[H_3BO_3]$ and $[H_2BO_3^-]$ large, pH remains constant. (1) QWC SPAG: spelling (allow one error), punctuation and grammar correct.	5

Question	Expected Answers	Marks
3a i	Two FROM nitrogen unreactive/high E_{bond} , strong bond between atoms of nitrogen/much energy to break bond/stable molecule/, triple bond (1)	2
3a ii	TWO FROM to replace nitrogen removed; nitrogen is plant nutrient; nitrogen needed for (plant) growth; nitrogen taken in soluble form/through roots; nitrogen supplied in fertilizers/stored in soil	2
3b i	another product formed by the (main) reaction	1
3b ii	0;(1) -3;(1) +2;(1) (max 2 if signs after numbers and "s" recorded in 2 a (i))	3
3c	catalyst	1
3d	M_r values of N_2 (28) and NH_3 (17) stated or used correctly/ $1000/28 = 35.7$; (1) Ratio 4/5 stated or used correctly;(1) $4/5 \times 1/28 \times 17 = 0.49$ (kg) (1) 0.5/1/507 (mod/5) scores two without working) Allow 2/3 sf (486). If >3 sf mark "sf" and see 4b(i)	3
3e i	molecules move faster/more KE (1); more collisions;(1) with energy greater than activation enthalpy/energy/successful collisions (AW);(1) therefore faster (1) QWC 2 sentences, logical, correct use of terms collisions and activation enthalpy/energy (1)	5
3e ii	Endothermic;(1) increased temperature moves equilibrium position to right/ favours endothermic reaction;(1) because opposes change (AW);(1) more product (1) not from exothermic or equilibrium moving wrong way.	4
3f	(effect of pressure depends on) difference in no. of moles (of gas) on each side of equation (AW);(1) this is small/ 11 molecules to 10;(1)	2
3g i	400 – 500 °C;(1) 25 – 150 atm;(1) iron (1)	3
3g ii	One for each advantage and disadvantage. One for each explanation (only when linked to valid advantage/disadvantage) Advantage: low pressure/low temperature – cheaper/safer No need for hydrogen – saves money Water used – cheaper/safer Disadvantage: Slow reaction (at room temperature) – expensive Much nitrogen into co-product – waste/ less efficient NO produced - toxic/expensive to separate	4

Question	Expected Answers	Marks
4 a	UK is warmer	1
4 b i	 <p>one water molecule showing four hydrogen bonds between H and O;(1) two adjacent lone pairs shown on (at least one) oxygen;(1) + , - shown either side of at least one hydrogen bond;(1) -H-----O straight (1)</p>	4
4 b ii	CH ₃ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₃ or more displayed	1
4 b iii	instantaneous dipole - induced dipole(2) "induced dipole/ instantaneous - induced dipole" score (1)	2
4 b iv	THREE from: at any instant, electrons not evenly distributed; (1) causes instantaneous dipole;(1) which induces dipole in another molecule;(1) attraction between dipoles (1)	3
4 b v	4.18/2.26 = 1.9 times (Accept 2 or 1.85(0)) If >4. sf and "sf" recorded at 3d, do not award mark	1
4 c i		2
4 c ii	the number "14" scores (1); +14 kJmol ⁻¹ with sign and unit scores (2).	2
4 d	Mg ²⁺ smaller/higher charge density than Ca ²⁺ ; (1) more water molecules round Mg ²⁺ ; (1) more bonds formed/ stronger attraction/ more energy released(1).	3

Question	Expected Answers	Marks
5 a	Circle round -OH group on structure. ALLOW circle including the ring bearing the -OH	1
5 b	-SO ₃ ⁻ (Na ⁺) IGNORE words which attempt to qualify. NOT -OH	1
5 c i	 <p>lack of any group at coupling position (provided some other correct detail added);(1) rest of structure correct (1)</p>	2
5 c ii	NaNO ₂ (1) HCl/H ₂ SO ₄ (NOT conc);(1) below 5°C (1) Mark separately. Addition of alkali is "CON" for acid mark	3
5 d i	benzene NOT benzene ring	1
5 d ii	conc (+ one correct acid)(1); nitric and sulphuric acids(1); temp below 55 °C (1) Mark separately	3
5 d iii	 <p>(1) Sn, conc HCl, reflux (1)</p>	2
5 e i	aromatic/ arenes ALLOW benzene(s)/benzene rings	1
5 e ii	electrons are not associated with particular bonds/atoms (NOT atom)/spread out over several atoms/over compound.	1
5 f i	condensation/ nucleophilic substitution	1
5 f ii	 <p>correct points connected;(1) by O atoms (1)</p>	2
5 g i	hydrogen bonding;(1) appropriate H atom specified(1); bonded to appropriate atom on other structure. (1)	3
5 g ii	Direct Red would wash out more easily/ more red colour in Direct Red beaker/ cotton gets paler in Direct red beaker;(1) hydrogen bonds are broken by water/heating/dye hydrogen bonds to water;(1) covalent bonds are not (1) ALLOW (1) of last (2) for "procion bonds stronger" (AW)	3