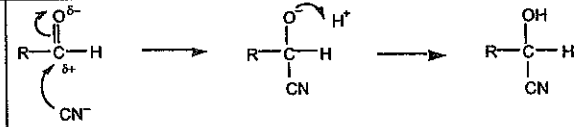
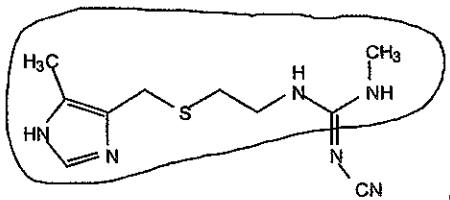
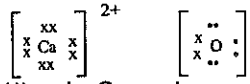
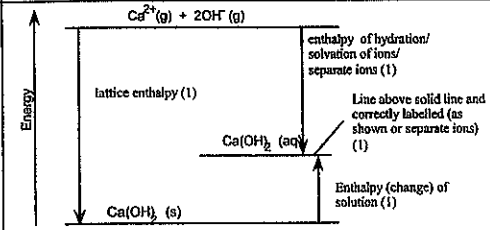
Question	Expected Answers	Marks
1 a i	nitrogen dioxide/ nitrogen(IV) oxide *nothing else*	1
1 a ii	Manufacture of fertilizers/explosives/dyes *can be named ones.* *'Making' must be implied* *Named* lab use, eg nitration of benzene	1
1 b	–3 +4 *(allow 2 x +4)* +5 (1) each *max 2 if plus signs missing or signs after numbers.* *ALLOW Roman numerals.*	3
1 c i	increases (1) *mark separately*; More molecules/particles collide (1); (with) energy greater than activation enthalpy/energy *(ignore "barrier")*(1) *"successful collisions" can score second mark only.*	3
1 c ii	(forward) reaction exothermic (*ora*) (1); equilibrium (position) moves to oppose change/in endothermic direction (1); lower yield (1) *must follow some correct reasoning (which can be in (c)(i))* *Apart from this, c(i) and c(ii) must be answered in the correct places to score.*	3
1 d	this temperature a compromise/balance (AW)(1); between rate and yield (1);	2
1 e i	$Kp = p\,N_2O_4/pNO_2^2$ (1) for mathematical expression N_2O_4/NO_2^2 whatever symbols (1) for indicating partial pressures correctly. *Ignore ( ), allow* p^2NO_2. *Mark separately*	2
1 e ii	atm^{-1}(1) *ecf from expression but NOT concentration units* *ALLOW atmos^{-1}, atmospheres^{-1}, 1/atm.*	1
1 e iii	$pN_2O_4 = Kp \times pNO_2^2 = 8.7 \times 0.60^2 = 3.1$ (1) 2 sig figs (1) *mark separately provided SOME working*	2
1 f	Be, B, C, F *Any two (Names [allow small mis-spellings] or symbols [must be correct])* *ALLOW names or correct formulae of oxides.*	2
1 g i	*two from:* toxic/ poisonous/ specific effect (eg respiratory problems); (gives rise to) acid rain/ causes corrosion of metal/stone; (photochemical) smog/ more ozone; *NOT depletes ozone* greenhouse gas /global warming	2
1 g ii	recycled/used again/some reference to using it in **Equation 1.1.**	1
1 h i	negative, fewer (gas) molecules on right	1
1 h ii	positive, exothermic/ΔH negative/reference to $-\Delta H/T$	1
1 h iii	positive(1) because the reaction goes/ is spontaneous(1) *mark separately* *"$\Delta S = 0$ for an equilibrium" scores (1)*	2

1 i i	complete reaction (with water)/fully dissociated/ almost fully dissociated/ $K_a > 1$	1
1 i ii	HNO_3 (*ignore "+aq"*) ⟶ (⇌) H^+ (1)+ NO_3^- (1) *or reaction with* H_2O *to give* H_3O^+	2
1 i iii	pH = $-\lg[H^+]$ *stated or implied* (1) = – lg (0.05) = 1.3 (1)	2

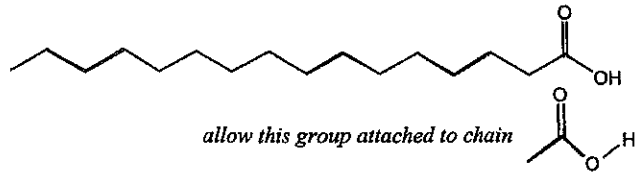
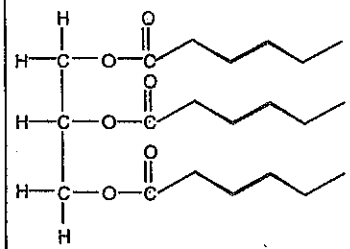
2 a	alkene, alcohol/hydroxy(l) *NOT 'hydroxide' or 'carbon-carbon double bond'*	2
2 b	*Five marks from:* mass spectroscopy: Mr /(relative) molecular mass/ molar mass (IGNORE total mass)(1); from M^+ peak/peak of highest mass /molecular/parent ion (AW) (1) *must follow from first marking point.* Fragments (from other peaks) (1) i.r: (max four points) C=C (1) at 1620 – 1680 (cm^{-1})(1) *ALLOW descriptions of groups* O–H (1) at 3600 – 3640 (cm^{-1})(1) *eg alkene etc* C–O (1) at 1050 – 1300(cm^{-1})(1) *within range* C – H *if qualified* 'alkane" or 'alkene' (1) with appropriate range (1) (2850–2950 or 3000 – 3010) *If nothing scored above for bonds, allow:* i.r. identifies bonds/ functional groups (1) *If nothing scored for absorptions* allow general statement about absorption values (1) *QWC 2 2 sentences, logical, 3 words from list below used correctly (or plurals, verbs),* *QWC 1 2 sentences, logical, 2 words from list below used correctly (or plurals, verbs)* molecular/molar mass; peak; molecular/parent ion; fragment; bond; absorption	5 2

2 c i		1
2 c ii	 Idea of CN^- attacking carbonyl carbon*/polarisation of C=O (1) Intermediate with O^-(1) *not* O^{2-} Rest of detail correct (1) (*partial charges optional*) *not single arrows here.* * can be HCN *here* but then do not award third marking point.	3
2 d i	2 peaks (1) 1:1 (AW) (1)	2
2 d ii	C_3H_7COOH/HOOC $(CH_2)_7$ COOH *(allow* HOOC $(CH_2)_8$ OH) Correct number of C atoms (4 or 9) (1); correct group(s) at end(s) (*if first mark scored*)(1)	2
2 e	**A** cis (1); **B** trans (1). *one mark for correct words the wrong way round.*	2
2 f	*Three from* Receptor site(s) *ALLOW active site;* will have a certain/specific shape; Pheromone molecule must fit/ If pheromone is not correct shape it will not be detected/ smelled; Bonding/ imf / binding occurs; pheromone fitting site triggers response (AW);	3
2 g i	bromine/Br_2 *Allow aqueous bromine*	1
2 g ii	–OH, alcohol, hydroxy(l)	1
2 g iii	heat/reflux (1); (Aqueous)NaOH (1); *mark separately.* *Extra reagents negate second mark.*	2

3 a i	carbon: 10 (1); hydrogen: 16 (1);	2
3 a ii	A 109 (1); B 120 (1); (*both ± 4, angle sign not required*)	2
3 b	Side-effects/suggested specific side-effect/ only active for a short time/ toxic Not very effective (or *molecular* descriptions implying this but NOT that it is ineffective)	1
3 c i	*Three from (can be obtained from a labelled diagram)* each carbon atom has four outer shell electrons; but only uses three to form bonds; six electrons; shared by/evenly spread/distributed over the carbon atoms/ conjugated; form rings (of electrons); above and below (plane of) molecule; *plus ONE from:* all C–C bonds equal in length; undergoes substitution (rather than addition reactions); more stable (AW); planar;	4
3 c ii	CH_3Cl (1); $AlCl_3$(1); Heat/reflux/no water (1) *mark separately* *Max 1 for reagent marks if extra reagents added.*	3
3 c iii	electrophilic	1
3 c iv	*Four from the following points.* **A***Coloured substances absorb (certain frequencies of)visible light; **B** (when) electrons excited (to higher energy-level); **C** more highly delocalised molecules(AW) need less energy to excite electrons; **D*** (burimamide/ metiamide/ benzene) do not absorb in visible/ are colourless – they absorb in u.v./at higher frequency/ energy; E energy level difference measures frequency absorbed/ E = hv; F visible light has lower energy than u.v. * if neither A nor D scored, can award "A/D" for idea of molecules absorbing e-m radiation or light. *If emission mentioned, max 2.*	4
3 d	 double bond may be included or not but N atom must not be. *Accept if drawn on metiamide structure*	1

4 a i	$CaCO_3 \longrightarrow CaO + CO_2$	1
4 a ii	Amount $CaCO_3$ = 1000/100 (= 10 moles) (1); Mass CaO = 10*ecf* x 56 = 560 g (1)	2
4 b	 (1) each. Ca may have no electrons. Oxygen may have all same symbol (dot or cross) *If all other detail correct but no charges shown, award (1). Square brackets optional.* *ALLOW charges on symbols or inner shells if correct*	2
4 c i	A - ionisation enthalpies/energies (1) B - O(g) (1) C - enthalpy (change) of formation (of CaO) (1) *ALLOW enthalpy (change) of combustion of calcium/Ca*	3
4 c ii	1st and 2nd Ea = –1748 – 635 – 178 – 249 – (– 3419) (1) = +(1) 609 (1) kJ mol^{-1} *ecf on sign; ecf on number, provided all quantities used in calculation.* *–609, 609 score (2)*	3
4 d i	 *Allow ΔH for "enthalpy"and accepted symbols, eg* ΔH_{LE}	4
4 d ii	increase down Group	1
4 e i	0.032 mol dm^{-3} (2) *one mark for* 0.016 mol dm^{-3}	2
4 e ii	$K_w = [H^+]\,[OH^-]$ *stated or implied* (1); $[H^+] = 10^{-14}/0.032 = 3.13 \times 10^{-13}$ (mol dm^{-3}) *ecf from (e)(i)*(1); (6.16 x 10^{-13} from 0.016) pH = $-\lg(3.13 \times 10^{-13})$ = 12.5 *ecf* (1); (12.2 from 6.16 x 10^{-13})	3
4 e iii	$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$ compounds (1); balancing *tied to first mark* (1)	2
4 e iv	Amount $Ca(OH)_2$ = 10 x 0.015/1000 (= 1.5 x 10^{-4} mol) (1) Amount HCl = twice this (3.0 x 10^{-4} mol) *ecf from ratio in equation, even if equation unbalanced* Volume HCl = 3.0 x 10^{-4} x 1000/0.02 = 15.(0)cm^3 (1) (*ecf 7.5(0)*cm^3 *from 1:1 ratio)*	2

4 f	*Five from the following points.* **A** Clays have a layer structure/ exist as sheets; **B** Water /ions can penetrate layers; **C** Layers/surface are/is negatively charged; **D** Because of O^{--}/Al replacing Si (*ALLOW* SiO_4^{4-}); **E** H^+ ions held by negative charge; **F** Calcium ions push out hydrogen ions by ion exchange; **G** Equilibrium effect; **H** 2 hydrogen ions for one calcium ion; **I** Ca^{2+} held more tightly since doubly charged *QWC Accurate spelling, punctuation and grammar (one spelling mistake allowed)*	5 1

5 a	**A** sample (of ointment) (1); *ALLOW 'ointment as gas'* **B** detector (1); **C** column (1); *ALLOW 'tube' with description of contents* **D** oven /heater (1)	4
5 b	(retention) time	1
5 c i	 *allow this group attached to chain* 16 carbon atoms (no C-H hydrogens shown, nor "dots"(1) *16th carbon can be part of COOH;* COOH skeletal detail, *provided no other groups are present* (1)	2
5 c ii	alkene *NOT C=C*	1
5 c iii	ends in "-ol"/ "anol"	1
5 c iv	hydrolysis	1
5 d	 glycerol residue correct (1) ester correct and full structural (1) *but can score this mark(not previous one) if COO rather than OOC.* carbon chains(1) (*allow dots and C-H hydrogens shown if penalised in 5(c)(i)) DO NOT award third mark if other substituents on chain, though double bonds allowed.*	3