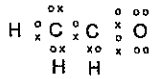
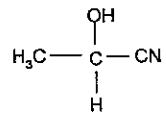
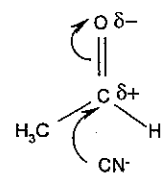
The following annotations may be used when marking:

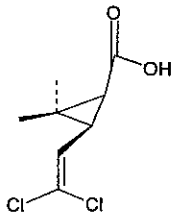
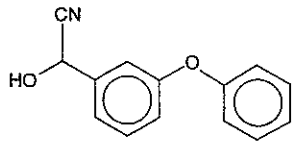
X	=	incorrect response (errors may also be underlined)
^	=	omission mark
bod	=	benefit of the doubt (where professional judgement has been used)
ecf	=	error carried forward (in consequential marking)
con	=	contradiction (in cases where candidates contradict themselves in the same response)
sf	=	error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

Abbreviations, annotations and conventions used in the Mark Scheme:

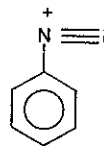
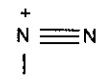
/	=	alternative and acceptable answers for the same marking point
;	=	separates marking points
NOT	=	answers not worthy of credit
( )	=	words which are not essential to gain credit
___ (underlining)	=	key words which must be used
ecf	=	allow error carried forward in consequential marking
AW	=	alternative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

Question			Expected Answers	Marks
1	(a)	(i)	2-hydroxypropanoic acid; 1 for prop- ; 1 for rest (not hydroxyl) ;	2
		(ii)	(A) O-H (allow OH but not name) ; (B) C=O (don't allow CO or name) ;	2
	(b)	(i)	reactant (in a chemical process) / starting material / raw materials in reaction ;	1
		(ii)	crude oil / (cracking) polymers / coal / alkanes / ethane / hydrocarbons / ethanol ;	1
	(c)	(i)	 both lone pairs on oxygen ; double bond ; single bonds ;	3
		(ii)	3 regions of electron density / bonds / groups ; electrons repel ; as far apart as possible / to minimise repulsion ;	3
		(iii)	chemical shifts correct (2.2 and 10) ; relative intensities correct (3:1) ; only 2 peaks shown (other than TMS at 0) ;	3
	(d)	(i)	 (Note : bonds must be unambiguously in the correct place)	1
		(ii)	nucleophilic ; addition ;	2
		(iii)	 3 out of 4 for: 1 for each arrow (of any kind) ; 1 for polarisation ; 1 for correct intermediate ;	3
	(e)	(i)	chiral centre correct ; tetrahedral appearance, using wedges and dashes ; mirror image or other enantiomer ;	3
		(ii)	2 out 3 of :- molecular fit ; receptor ; enzymes / isomers are stereospecific / made from chiral precursor;	2
	(f)		5 g ethanal = $\frac{5}{44}$ mol, therefore should produce $\frac{5}{44}$ mol lactic acid ; $\Rightarrow \frac{5 \times 90}{44}$ g lactic acid (= 10.227 g) ; % yield = $\frac{7.02 \times 100}{10.227}$ = 68.4 to 68.6%;	4
				[Total: 30]

Question			Expected Answers	Marks
2	(a)		$K_a = \frac{[H^+(aq)]\,[CO_3^{2-}(aq)]}{[HCO_3^-(aq)]}$ 1 for top line (aq not necessary) ; 1 for rest correct ;	2
	(b)	(i)	alkaline solution reacts with H^+ / lower concentration of H^+ ; equilibrium in $CO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$ shifts to the right : allowing more CO_2 to react / lessening (extent of) reverse reaction ; (thus) shifting equilibrium in 2.1 to the right / causing more $CO_2(g)$ to dissolve;	4
		(ii)	pH = -log[H^+] ((aq) not essential) 1 mark for [H+] ; 1 mark for rest ;	2
	(c)		**QWC (clarity of explanation and correct use of scientific terms)** SEVEN FROM: bonds in CO_2 are polar ; carbon carries ⇧ + and oxygen carries ⇧ - ; due to a difference in electronegativity / oxygen has greater pull / attraction for electrons ; carbon dioxide forms H-bonds with water ; to the hydrogen on water ; hydrogen forms H-bonds with the lone pair of electrons on oxygen in CO_2 ; oxygen and nitrogen no charge separation / bonds or molecules non-polar ; (therefore) only ID-ID attractions / van der Waals forces / do not form H-bonds ; these are weaker than H-bonds ; **(Note:** allow a maximum of 6 if CO_2 is stated as being a polar molecule.)	7 + 1
	(d)	(i)	$\Delta S\hat{\Uparrow}_{sys}$ = (214 + 38) - 93 ; (products - reactants) gains 1 mark ; = +159 J mol^{-1} K^{-1} ; value and sign necessary for 1 mark ;	2
		(ii)	$\Delta S_{surr} = \frac{-180{,}000}{1300}$ converts ΔH → J ; = -138.5 J mol^{-1} K^{-1} (allow -140, -139, -138) value ; sign ;	3
		(iii)	$\Delta S_{total} = \Delta S_{sys} + \Delta S_{surr}$ (stated or implied) / = +159 + (-138.5) (right way round, signs correct) ; = +20.5 J mol^{-1} K^{-1} value (allow ecf from (ii));	2
		(iv)	Yes WITH EXPLANATION (ΔS_{total} is positive / total entropy increases, therefore spontaneous change) (allow ecf from (iii))	1
	(e)		$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$ formulae ; balanced ; state symbols ;	3
				[Total: 27]

Question			Expected Answers	Marks
3	(a)	(i)	C_2HCl_3O ;	1
		(ii)	chlorobenzene ;	1
	(b)	(i)	3 from :- chlorine ; anhydrous ; $AlCl_3$;	3
		(ii)	species containing an unpaired electron / lone electron / odd electron ;	1
		(iii)	remove by passing through water / alkali / base (eg limestone) (1) ; reason for safety or value of the method (1) ;	2
	(c)	(i)	hydrogen chloride / HCl ;	1
		(ii)	THREE FROM: DDE and DDT have different molecular shapes ; DDE is planar / DDT is non-planar ; DDE does not have the right shape to fit the receptor site / DDT does have the right shape to fit the receptor site (or wtte) ; DDT binds and has an effect whereas DDE binds but has no effect ;	3
	(d)	(i)	two from :- ester, ether, carbon-carbon double bond / alkene, arene, chloro ;	2
		(ii)	reflux (not just heat) ; with aqueous ; acid/ hydrochloric acid / sulphuric acid / H^+ with water, $H^+(aq)$, alkali ;	3
		(iii)	  (structural / display or skeletal earns mark if correct in both cases)	2
	(e)		**QWC (organising information / use of vocabulary)** (tlc plate) spotted with biocypermethrin AND mixture after hydrolysis ; place in chromatography tank with suitable solvent ; spots above solvent; cover / seal tank ; allow solvent to rise up plate / paper ; remove plate / paper when solvent front near the top ; locate spots ; hydrolysis successful if only two spots are present (three underlined marking points earn 1 each : two from rest)	5 + 1
				[Total: 25]

Question			Expected answers	Marks
4	(a)	(i)	$K_p = \frac{p_{CO} \times p^3_{H2}}{p_{CH4} \times p_{H2O}}$ 1 for correct partial pressures ; 1 for right way up ;	2
		(ii)	$K_p = \frac{0.3 \times (0.9)^3}{0.7 \times 0.7}$; = 0.45 (allow 0.4, 0.44, 0.4463 [or rounded versions]) ; (allow ecf from (i)) ; atm^2	3
	(b)		**QWC (organise information, correct terms, etc)** FIVE FROM: reaction endothermic, therefore high temperature favours production of hydrogen (or wtte) ; high temperature also increases rate ; more product molecules than reactant, therefore low pressure favours high yield of hydrogen ; rate slow if pressure is low ; catalyst with large surface area used to increase rate ; the pressure is a compromise between reasonable rate and acceptable yield (or wtte) ;	5 + 1
	(c)	(i)	pressure ~ 25 to 200 atm ; temperature ~ 400 to 600°C ; iron or rhenium catalyst ;	3
		(ii)	0 ; -3 ;	2
				[Total: 16]

Question			Expected Answers	Marks
5	(a)		FOUR FROM: each carbon atom has four outer shell electrons ; but only uses three to form bonds ; remaining electrons shared by all six carbon atoms ; delocalised electrons / delocalised charge / conjugated system ; stable molecule ; all C-C bonds are equal in length ; undergoes substitution, rather than addition reactions ;	4
	(b)	(i)	conc nitric acid ; conc sulphuric acid ; <55°C ;	3
		(ii)	electrophilic ; substitution ;	2
	(c)		 1 for  1 for Cl⁻	2
	(d)		amine group / $-NH_2$; basic / accepts protons / acts as a base ;	2
	(e)	(i)	FIVE FROM: presence of chromophore / N=N group ; conjugated / extended delocalised system ; in Orange II electrons need less energy to excite them ; dye absorbs in visible region ; benzene absorbs in uv region / outside the visible region ; uv is higher energy radiation; Orange II absorbs a complementary colour ;	5
		(ii)	(neutral) iron(III) chloride / $FeCl_3(aq)$ / $Fe^{3+}(aq)$; turns purple / mauve :	2
		(iii)	sulphonate (ion) / SO_3^- (Na^+) ; becomes hydrated / is charged / forms intermolecular bonds with water ;	2
				[Total: 22]