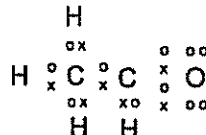
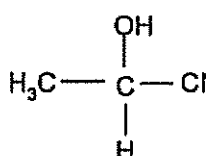
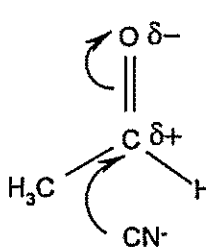


The following annotations may be used when marking:

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

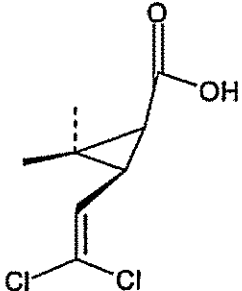
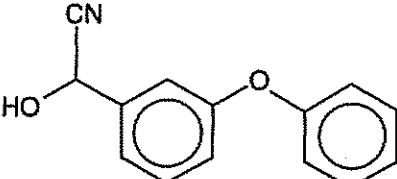
Abbreviations, annotations and conventions used in the Mark Scheme:

/	=	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 <u>must</u> 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 of 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) ; $\% \text{ yield} = \frac{7.02 \times 100}{10.227} = 68.4 \text{ to } 68.6\%$;	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;
(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 δ^+ and oxygen carries δ^- ; 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)	$\Delta S_{sys}^\ddagger = (214 + 38) - 93$; (products - reactants) gains 1 mark ; $= +159 \text{ J mol}^{-1} \text{ K}^{-1}$; value and sign necessary for 1 mark ;	2
(ii)	$\Delta S_{surr} = \frac{-180,000}{1300}$ converts $\Delta H \rightarrow J$; $= -138.5 \text{ J mol}^{-1} \text{ K}^{-1}$ (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) ; $= +20.5 \text{ J mol}^{-1} \text{ K}^{-1}$ 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 write) ; 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)	<div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;">  <p>Chemical structure of a bicyclic compound (bicyclo[2.2.1]heptane derivative) with a chlorine atom on a double bond and a carboxylic acid group.</p> </div> <div style="text-align: center;">  <p>Chemical structure of a biphenyl ether derivative with a hydroxyl group and a cyano group.</p> </div> </div> <p>(structural / display or skeletal earns mark if correct in both cases)</p>	2
(e)	<p>QWC (organising information / use of vocabulary) <u>(tlc plate) spotted with biocypermethrin AND mixture after</u> <u>hydrolysis ;</u> 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 ; <u>locate spots ;</u> <u>hydrolysis successful if only two spots are present</u> (three underlined marking points earn 1 each : two from rest)</p>	5 + 1
[Total:		25]

Question	Expected answers	Marks	
4	(a) (i) $K_p = \frac{p_{\text{CO}} \times p_{\text{H}_2}^3}{p_{\text{CH}_4} \times p_{\text{H}_2\text{O}}}$	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 ; $<55^{\circ}\text{C}$;	3
(ii)	electrophilic ; substitution ;	2
(c)		2
(d)	amine group / $-\text{NH}_2$; basic / accepts protons / acts as a base ;	2
(e) (i)	FIVE FROM: presence of chromophore / $\text{N}=\text{N}$ 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 / $\text{FeCl}_3(\text{aq})$ / $\text{Fe}^{3+}(\text{aq})$; turns purple / mauve ;	2
(iii)	sulphonate (ion) / SO_3 (Na^+) ; becomes hydrated / is charged / forms intermolecular bonds with water ;	2
[Total: 22]		