Equilibria

Mark Scheme 8

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Equilibria
Sub-Topic	
Paper Type	Theory
Booklet	Mark Scheme 8

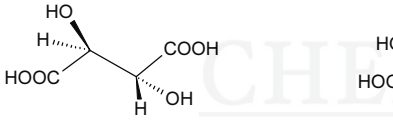
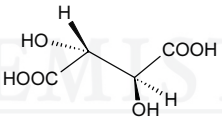
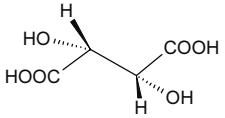
Time Allowed: **62 minutes**

Score: **/51**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1	**(a)**	(HC*l*) strong**er** acid / more dissociated / ionised in solution (HC*l* has) more ions / higher concentration of ions	**1** **1**	**[2]**
	(b) (i)	A solution that resists changes in the pH / keeps pH *fairly* constant when **small** quantities / amounts / vols of acid / H^+ or base / OH^- are added	**1** **1**	
	(ii)	add (ethanoic acid) to NaOH **OR** an equation excess (ethanoic acid) **OR** mix with sodium ethanoate	**1** **1**	**[4]**
	(c)	$CH_3CH(NH_2)COOH + H^+ \rightarrow CH_3CH(NH_3^+)COOH$ $CH_3CH(NH_2)COOH + OH^- \rightarrow CH_3CH(NH_2)COO^- + H_2O$	**1** **1**	**[2]**
	(d) (i)	pKa 2.99  pKa 4.40 	**1** **1**	
	(ii)	 (S,R)  (R,S)  (R,R) any two of the above	**2**	**[4**

2 **(a) (i)** $NaOH + HCl \rightarrow NaCl + H_2O$ (1)

$(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_3 + Na_2SO_4 + 2H_2O$ (1)

allow ionic equations in each case

(ii) $n(NaOH) = n(HCl) = \frac{39.2 \times 2.00}{1000} = 0.0784$ (1)

(iii) $n(NaOH) = n(HCl) = \frac{29.5 \times 2.00}{1000} = 0.059$ (1)

(iv) $n(NaOH) = 0.0784 - 0.059 = 0.0194$ (1)

(v) $n[(NH_4)_2SO_4] = \frac{0.0194}{2} = 9.7 \times 10^{-3}$ (1)

(vi) mass of $(NH_4)_2SO_4 = 9.7 \times 10^{-3} \times 132.1 = 1.2814$ g (1)

(vii) % of $(NH_4)_2SO_4 = \frac{1.2814 \times 100}{2.96} = 43.30405405 = 43.3$

give one mark for the correct expression (1)
give one mark for answer given as 43.3 – i.e. to 3 sig. fig. (1)
allow ecf where appropriate [9]

(b) fertiliser in the river causes
excessive growth of aquatic plants/algae **or** algal bloom (1)
when plants and algae die O_2 is used up **or** fish or aquatic life die (1)

(c) manufacture of HNO_3 **or** explosives **or** nylon **or**
as a cleaning agent **or** as a refrigerant
not detergent (1)

[Total:12]

3 **(a)** $K_P = \dfrac{p(H_2O)}{p(NH_3)^4\, p(O_2)^5}$ (1)

atmospheres **or** Pa **or** kPa (1)
allow ecf on incorrect powers [2]

(b) (**increasing temperature**
yield of NO is decreased **or** reaction moves to LHS (1)
forward reaction is exothermic (1)

(ii) decreasing the pressure
yield of NO is increased **or** reaction moves to RHS (1)
more moles/molecules of gas on RHS **or**
fewer moles/molecules of gas on LHS (1)

(c) let $\Delta H_f^{\ominus}$ for NO be y kJ mol^{-1}

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$

$\Delta H_f^{\ominus}$ $4 \times (-46.0)$ $4y$ $6 \times (-242)$ (1)

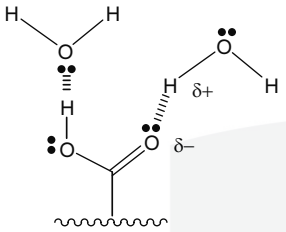
$\Delta H^{\ominus}_{reaction} = 4y + [6 \times (-242)] - [4 \times (-46.0)]$ (1)
$= 4y - 1452 + 184$

$\Delta H^{\ominus}_{reaction}$ is –906 kJmol^{-1} so
$4y = -906 + 1452 - 184 = 362$ (1)
whence y = $\Delta H_f^{\ominus}$ for NO = +90.5 kJ mol^{-1}
+ sign is require (1)

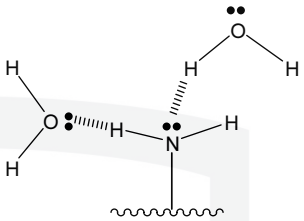
[Total: 10]

4 **(a** A (Bronsted-Lowry) acid is a proton donor. [1]
[1]

(b)



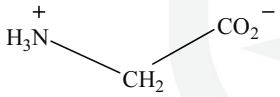
carboxylic acid



amino group

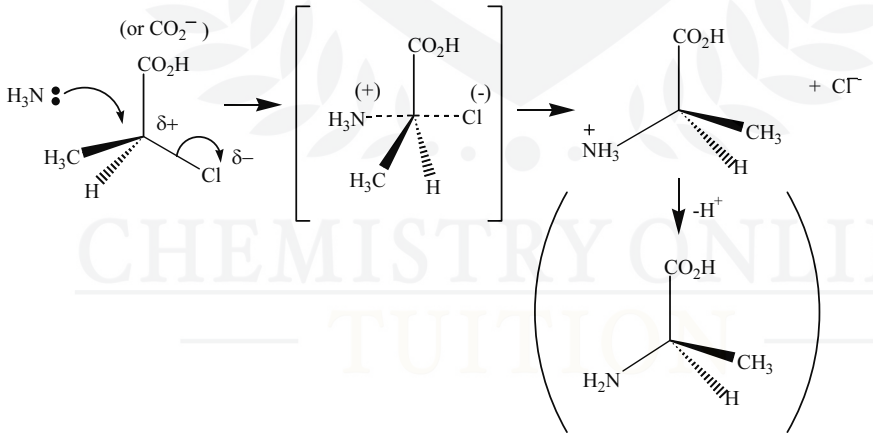
at least one H_2O molecule in the right orientation: attached to $–CO_2H$ [1]
attached to $–NH_2$ [1]
lone pair (on oxygen in H_2O *or* $–CO_2H$ *or* on nitrogen) shown at least once on a H-bond [1]
δ+ and δ– shown at least once (at each end of the same H-bond) [1]

(ii)



[1]
[5]

(c) allow either S_N1 or S_N2



any three of δ+ and δ– shown in C–C*l*
curly arrow from **lone pair on NH_3** to (δ+) carbon
curly arrow from C–C*l* bond to C*l*
5-coordinate transition state *or* carbocation intermediate if S_N1, with correct charge

[3]
[3]

(d) lysine @ pH 1: $^{+}NH_3(CH_2)_4CH(NH_3^{+})CO_2H$ [1]
aspartic acid @ pH 12: $^{-}O_2C\,CH_2\,CH(NH_2)CO_2^{-}$ [1]
[2]

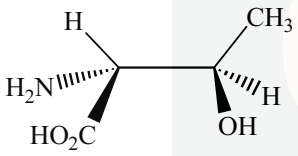
(e) 6 (six) [1]

(ii) *either* $H_2NCH(CH_3)CO–NHCH(CH_2OH)CO_2H$
or $H_2NCH(CH_2OH)CO–NHCH(CH_3)CO_2H$ [2
[3]

(f) Compounds have the same **structural** formula but ....
different (spatial) arrangement / position *or* orientation of atoms in space [1]

(ii) [1]

(iii)



[1]
[3]

[Total: 17]