

# Equilibria

## Mark Scheme 7

<b>Level</b>	International A Level
<b>Subject</b>	Chemistry
<b>Exam Board</b>	CIE
<b>Topic</b>	Equilibria
<b>Sub-Topic</b>	
<b>Paper Type</b>	Theory
<b>Booklet</b>	Mark Scheme 7

**Time Allowed:** 74 minutes

**Score:** /61

**Percentage:** /100

**Grade Boundaries:**

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

1 (a)  $K_c = \frac{[H_2][I_2]}{[HI]^2}$  (1) [1]

(b)  $K_c = \frac{0.274 \times 0.274}{(1.47)^2} = 0.035$  (1) [1]

(c) At room temperature:

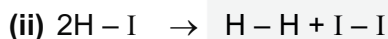
iodine is a solid/solids not  $K_c$  expression (1)

$[I_2(g)]$  is small/concn too small to be measured (1)

it takes longer to reach equilibrium/reaction is slower (1)

[2 max]

(d) (  $\Delta H_{\text{reacn}} = \Delta H$  for bonds broken –  $\Delta H$  for bonds made (1)



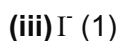
$2 \times 299$                       436 151 values (1)

$\Delta H = 2 \times 299 - (436 + 151)$

$= + 11 \text{ kJ mol}^{-1}$  (1)

[3]

(e) An acid that is completely ionised (1)



[3]

[Total 10]

CHEMISTRY ONLINE  
— TUITION —

- 2 (a) (i) strong, because final pH is about 14 [1]
- (ii)  $(\text{pH} = 0.70) \Rightarrow [\text{H}^+] = 10^{-0.7} = 0.20 \text{ (mol dm}^{-3}\text{)}$  [1]
- $\therefore [\text{H}_2\text{SO}_4] = (0.10 \text{ mol dm}^{-3})$  ecf [1]
- (iii) (end point is at  $34.0 \text{ cm}^3 (\pm 0.5 \text{ cm}^3)$ , so)
- amount of  $\text{H}^+$  used =  $0.2 \times 25/1000 = 0.0050 \text{ mol}$  ecf from (ii) [1]
- moles of guanidine = moles of  $\text{H}^+$  =  $0.0050 \text{ mol}$
- [guanidine] =  $0.005 \times 1000/34.0 = \mathbf{0.147} \text{ (mol dm}^{-3}\text{)}$  [1]
- allow range:  $0.145 - 0.149$  ecf in 0.005 or 34.0
- (iv)  $M_r = 8.68/0.147 = \mathbf{59}$  (allow range 58 – 60) ecf from (iii) [1] 6
- (b) (i)  $\longrightarrow \text{CaSO}_4 + 3 \text{Ca}(\text{H}_2\text{PO}_4)_2 + 2 \text{HF}$  [1]
- (ii)  $M_r$  values:  $2\text{PO}_4)_2 = 234.1, \text{H}_2\text{SO}_4 = 98.0$  [1]
- $234.1 \times 3 = \mathbf{702.3}$   $98 \times 7 = \mathbf{686}$  both [1]
- ecf from ratios in equation, and from  $M_r$  values
- $\therefore$  mass of  $\text{H}_2\text{SO}_4$  needed =  $1.0 \times 686/702.3 = \mathbf{0.98} \text{ kg}$  [1]
- (correct answer = [3] marks. accurate value is: 0.977 kg.  
Allow ecf from incorrect  $M_r$  or incorrect multipliers) 4
- (c) (i) A solution that **resists** changes in pH [NOT: results in **no** pH change] [1]
- when **small amounts** of  $\text{H}^+$  or  $\text{OH}^-$  are added [1]
- (ii)  $\text{pH} = -\log_{10}(6.3 \times 10^{-8}) + \log_{10}(0.1/0.2) = \mathbf{6.9}$  [1]
- or  $[\text{H}^+] = (6.3 \times 10^{-8}) \times 0.2/0.1 = 1.26 \times 10^{-7}$
- $\therefore \text{pH} = -\log_{10}(1.26 \times 10^{-7}) = \mathbf{6.9}$

**Total 13**

- 3 (a)  $N_2 + 3H_2 \rightleftharpoons 2NH_3$  (1) exothermic [2]
- (b) Pr. 50 atm upwards; Temp 400-600°C; catalyst of iron  
(1 each, conditions stated) [3]
- (c) Too high a temp and equilibrium favours LHS, less ammonia at equilibrium (1)  
Too low a temp, rate too slow/not enough molecules have  $E_{act}$  (1) [2]
- (d) (i)  $K_p = \frac{P_{N_3}^2}{P_{N_2} \times P_{H_2}^3}$  (1)
- (ii)  $K_p = \frac{37.2^2}{44.8 \times 105.6^3}$  (1)  
 $= 2.62 \times 10^{-5} \text{ atm}^{-2}$  (1) calculation and un [3]
- (e) Excess (hence uncontrolled) nitrates leach out of fields into streams, seas (1)  
 Bacteria or algae grow fast/use oxygen/clog up water (1)  
 Balance destroyed/fish unable to live (1)  
 Process called eutrication (1) any 3 [3]

[Total: 13]

CHEMISTRY ONLINE  
 — TUITION —

4	(a) (i)	use restriction enzymes <b>or</b> using an enzyme to break (the DNA) down into smaller fragments	1								
	(ii)	use the polymerase chain reaction <b>or</b> use DNA polymerase to replicate/copy (the sample of DNA)	1								
	(iii)	<ul style="list-style-type: none"> <li>amino acids have different charges due to their side-chain/R group/pH/CO<sub>2</sub><sup>-</sup> <b>and</b> NH<sub>3</sub><sup>+</sup> groups</li> <li>DNA fragments have negatively-charge phosphates(or PO<sub>4</sub>) <b>or</b> DNA has PO<sub>4</sub><sup>3-</sup> groups</li> </ul>	1 1								
	(iv)	<table border="1"> <tr> <td>A piece of leather from an Egyptian tomb</td> <td></td> </tr> <tr> <td>A sample of skin from a mummified body</td> <td></td> </tr> <tr> <td>A fragment of ancient pottery</td> <td><b>X</b></td> </tr> <tr> <td>A piece of wood from a Roman chariot</td> <td></td> </tr> </table>	A piece of leather from an Egyptian tomb		A sample of skin from a mummified body		A fragment of ancient pottery	<b>X</b>	A piece of wood from a Roman chariot		1
A piece of leather from an Egyptian tomb											
A sample of skin from a mummified body											
A fragment of ancient pottery	<b>X</b>										
A piece of wood from a Roman chariot											
	(b) (i)	the electron density in the molecule <b>or</b> positions of atoms <b>or</b> interatomic distance/spacing between the atoms	1								
	(ii)	phosphorus has the most electrons <b>or</b> phosphorus has the highest electron density	1								
	(c) (i)	equilibrium constant (for the solution) of a solute between two (immiscible) solvents  <b>or</b> ratio of the concentration of the solute in (each of the) two solvents  <b>or</b> ratio of the solubility of the solute in (each of the) two solvents	1								
	(ii)	$\frac{x}{(25/1000)}$ $\frac{(0.0042-x)}{(25/1000)}$ $x = 0.0252 - 6x$ $x = \mathbf{0.0036g}$	1 1								
<b>[Total: 10]</b>											

- 5 (a) (i) **B and D** [1] + [1]
- (ii) **D** [1]
- 3**
- (b) heat with dilute  $\text{H}^+(\text{aq})$  or  $\text{H}_2\text{SO}_4(\text{aq})$  [1]
- 1**
- (c)  $K_a$  larger than that for ethanol because the ethanoate ion /  $\text{CH}_3\text{CO}_2^-$  is stabilised by charge delocalisation  
or  
the O–H bond is weakened due to its proximity to C=O / carbonyl group or the second electronegative / oxygen atom [1]
- $K_a$  smaller than that for chloroethanoic acid because electron-withdrawing / electronegative chlorine (atom) makes the anion more stable or O–H bond weaker or H more easily lost [1]
- (ii)  $[\text{H}^+] = \sqrt{([\text{CH}_3\text{CO}_2\text{H}] \times K_a)} = \sqrt{(0.1 \times 1.75 \times 10^{-5})} = \mathbf{1.32(3) \times 10^{-3}}$  (mol dm<sup>-3</sup>) [1]
- pH =  $-\log_{10}[\text{H}^+] = \mathbf{2.88 (2.9)}$  [1]
- 4**
- (d) n(NaOH) at start =  $0.1 \times 20/1000 = 2.0 \times 10^{-3}$  mol  
n(NaOH) at finish =  $\mathbf{1.0 \times 10^{-3}}$  mol
- (ii) this is in 30 cm<sup>3</sup> of solution,  
so [NaOH] at finish =  $1.0 \times 10^{-3} / 0.030 = \mathbf{3.3(3) \times 10^{-2}}$  mol dm<sup>-3</sup> ( $\geq 2$  s.f.) ecf from (i) [1]
- (iii)  $[\text{H}^+] = K_w / [\text{OH}^-] = 1 \times 10^{-14} / 3.33 \times 10^{-2} = 3.0 \times 10^{-13}$  mol dm<sup>-3</sup>  
pH =  $-\log_{10}[\text{H}^+] = \mathbf{12.5(2)}$  [1]
- or pOH =  $-\log_{10}(3.33 \times 10^{-2}) = 1.48$   
pH =  $\text{p}K_w - \text{pOH} = 14 - 1.48 = \mathbf{12.5(2)}$  [1]
- (iv) pH / vol curve: start at pH 2.88 (2.9) ecf [1]
- vertical (over at least 2 pH units) portion at V = 10 cm<sup>3</sup> [1]
- levels off at pH  $12.5 \pm 0.3$  ecf [1]
- (v) indicator is thymolphthalein [1]
- 7**
- [Total: 15]