Acids, Bases & Buffers

Total mark – 19

Question: 1

1. Phenol, C_6H_5OH, is a powerful disinfectant and antiseptic.

Phenol is a weak Brønsted–Lowry acid.

$$C_6H_5OH(aq) \rightleftharpoons H^+(aq) + C_6H_5O^-(aq) \quad K_a = 1.3 \times 10^{-10} \text{ mol dm}^{-3}$$

Define the following terms:

(i) A Brønsted–Lowry acid,

.....

[1]

(ii) A *weak* acid.

.....

[1]

[Total 2 marks]

1. (i) H^+/proton donor **(1)** 1

(ii) partially dissociates/ionises **(1)** 1

[2]

Question: 2

2. When phenol is mixed with aqueous sodium hydroxide, an acid–base reaction takes place.

$C_6H_5OH(aq)$	+	$OH^-(aq)$	$\rightleftharpoons$	$C_6H_5O^-(aq)$	+	$H_2O(l)$
.....		.....		.....		.....

In the available spaces,

- label one conjugate acid–base pair as **acid 1** and **base 1**,
- label the other conjugate acid–base pair as **acid 2** and **base 2**.

[Total 1 mark]

2. $C_6H_5OH(aq) + OH^-(aq) \rightleftharpoons C_6H_5O^-(aq) + H_2O(l)$

acid 1 base 2 base 1 acid 2 **(1)**

[1]

Question: 3

3. A solution of phenol in water has a concentration of 4.7 g dm^{-3}.

(i) Write an expression for the acid dissociation constant, K_a, of phenol.

[1]

(ii) Calculate the pH of this solution of phenol.

[5]

[Total 6 marks]

3. (i) $K_a = [C_6H_5O^-(aq)]\,[H^+(aq)] / [C_6H_5OH(aq)]$ **(1)** 1

(ii) $M_r\ C_6H_5OH = 94$ **(1)**

$[C_6H_5OH(aq)]$ 4.7/94 = 0.050 mol dm^{-3} **(1)**

$1.3 \times 10^{-10} \approx [H^+(aq)]^2 / 0.050$ mol dm^{-3} **(1)** ('=' sign is acceptable)

$[H^+] = \sqrt{\{(1.3 \times 10^{-10}) \times (0.050)\}} = 2.55 \times 10^{-6}$ mol dm^{-3} **(1)**

pH = –log[H+] = –log 2.55×10^{-6} = 5.59 **(1)**

3 marks: $[H^+]$; pH expression ; calc of pH from $[H^+]$ 5

[6]

Question: 4

4. As part of an investigation, a student needed to prepare a buffer solution with a pH value of 8.71. From the K_a value of phenol, the student thought that a mixture of phenol and sodium phenoxide could be used to prepare this buffer solution.

The student decided to use a 0.200 mol dm^{-3} solution of phenol, mixed with an equal volume of sodium phenoxide.

Use your knowledge of buffer solutions to determine the concentration of sodium phenoxide solution that the student would need to mix with the 0.200 mol dm^{-3} phenol solution.

[Total 3 marks]

4. $[H^+(aq)] = 1.99 \times 10^{-9}$ mol dm^{-3} **(1)**

$[C_6H_5O^-(aq)] = K_a\,[C_6H_5OH(aq)] / [H^+(aq)]$**(1)**

$[C_6H_5O^-(aq)] = 0.13$ mol dm^{-3} **(1)**

Calculation should use half the original concentration of phenol to find the concentration of sodium phenoxide in the buffer. This should then be doubled back up again.

*Do **not** penalise an approach that uses the original concentration of phenol in the expression above.*

[3]

Question: 5

6. 'Superphosphate' fertilisers contain calcium dihydrogenphosphate, $Ca(H_2PO_4)_2$. This compound is one of the world's most important fertilisers. When dissolved in water, $Ca(H_2PO_4)_2$ dissociates forming $H_2PO_4^-$ ions which are easily taken up by plants.

(a) Calcium dihydrogenphosphate, $Ca(H_2PO_4)_2$, is produced by treating rock phosphate, containing $Ca_3(PO_4)_2$, with sulphuric acid, H_2SO_4.

Write a balanced equation for this reaction.

.....

[1]

(b) Aqueous $H_2PO_4^-$ ions can act as a weak acid.

Write an equation to represent the dissociation of the $H_2PO_4^-$ ion.

.....

[1]

(c) The $H_2PO_4^-$ ion can act as either an acid or a base.

(i) State the formula of the conjugate **base** of $H_2PO_4^-$.

.....

[1]

(ii) State the formula of the conjugate **acid** of $H_2PO_4^-$.

.....

[1]

(iii) A solution of calcium dihydrogenphosphate, $Ca(H_2PO_4)_2$, in water acts as a buffer solution.

Suggest, with the aid of equations, how this buffering action takes place.

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.....

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[3]

[Total 7 marks]

6. (a) $Ca_3(PO_4)_2 + 2H_2SO_4 \rightarrow Ca(H_2PO_4)_2 + 2CaSO_4$ **(1)** 1

(b) $H_2PO_4^-(aq) \rightleftharpoons H^+(aq) + HPO_4^{2-}(aq)$ /

$H_2PO_4^-(aq) \rightleftharpoons 2H^+(aq) + PO_4^{3-}(aq)$ **(1)**

(or equivalent with H_2O forming H_3O^+) 1

(c) (i) HPO_4^{2-} **(1)** 1

(ii) H_3PO_4 **(1)** 1

(iii) $H_2PO_4^-$ produced $Ca(H_2PO_4)_2$ or on LHS of an attempted equilibrium equation **(1)**
2 equations/equilibria to shown action of buffer **(1)(1)**
from:
$H_2PO_4^- + H^+ \rightleftharpoons H_3PO_4$ /
$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$/
$H_2PO_4^- + OH^- \rightleftharpoons H_2O + HPO_4^{2-}$ /
$H^+ + OH^- \rightleftharpoons H_2O$ 3

[7]