1. Nov/2022/Paper_41/No.4

   (a) A sample of butanoic acid, $CH_3(CH_2)_2COOH$, is shaken with a mixture of two immiscible solvents, ethoxyethane and water. The solvents form two layers. The butanoic acid is distributed between the two layers, its concentration in ethoxyethane being higher than its concentration in water.

   (i) State what is meant by partition coefficient.

   ....

   .... [1]

   (ii) The partition coefficient, K_{pc}, for butanoic acid between ethoxyethane and water is 3.50.

   A solution of 2.00 g of butanoic acid in $100\,cm^3$ ethoxyethane is added to water. This mixture is left until there is no further change in the concentration of butanoic acid in either solvent. The mass of butanoic acid dissolved in the ethoxyethane layer is now 1.62 g.

   Calculate the volume of water used.

   volume of water used = ... cm^3 [2]

   (b) An aqueous solution of butanoic acid can be used to make a buffer solution.

   (i) Define buffer solution.

   ....

   .... [1]

   (ii) Suggest one organic compound, and one inorganic compound, that can be added to two different samples of aqueous butanoic acid to produce buffer solutions.

   organic compound ....

   inorganic compound ....
   [1]

(c) The solubility of aluminium hydroxide, $Al(OH)_3$, in water is $2.47 \times 10^{-9}\,mol\,dm^{-3}$.

(i) Give the expression for the solubility product, K_{sp}, of aluminium hydroxide.

$K_{sp} =$

[1]

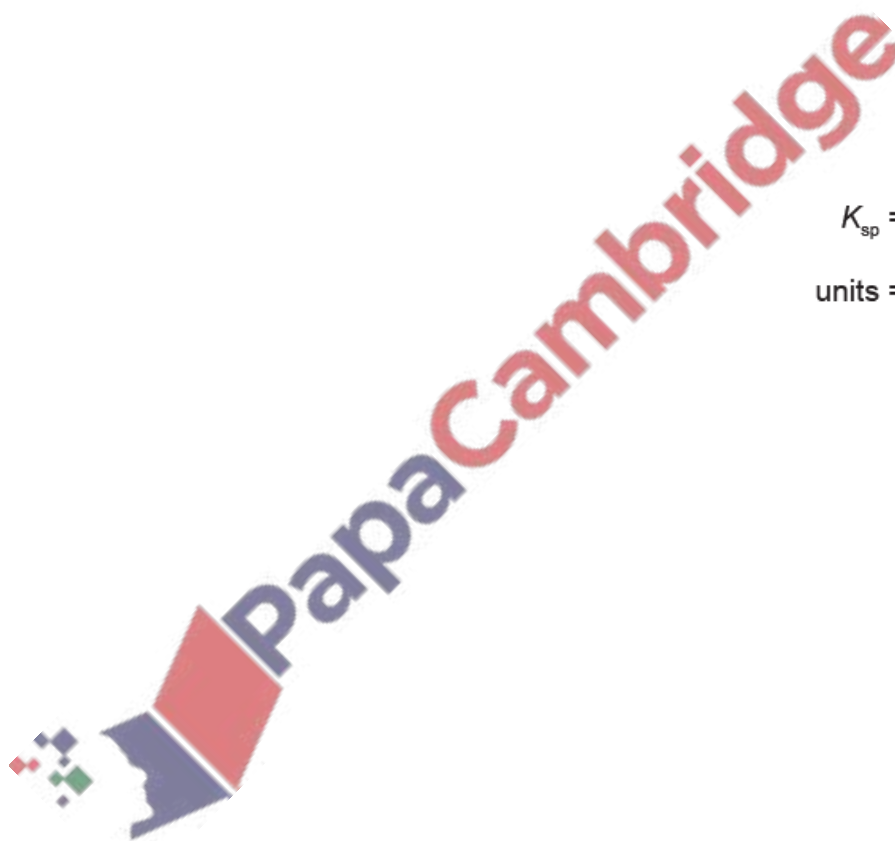(ii) Calculate the numerical value of the K_{sp} of aluminium hydroxide. Include the units of K_{sp} in your answer.

$K_{sp} =$ ....

units = ...

[3]

[Total: 9]

(a) The value of the solubility product, K_{sp}, of iron(III) hydroxide, $Fe(OH)_3$, is given by the following expression.

$$K_{sp} = [Fe^{3+}][OH^-]^3 = 2.0 \times 10^{-39}\,mol^4\,dm^{-12}$$

(i) Calculate the solubility of $Fe(OH)_3$ in water.

solubility = ... $mol\,dm^{-3}$ [1]

(ii) Calculate the solubility of $Fe(OH)_3$ in $0.010\,mol\,dm^{-3}$ barium hydroxide, $Ba(OH)_2(aq)$.

solubility = ... $mol\,dm^{-3}$ [2]

(iii) $Fe(OH)_3$ is less soluble in $Ba(OH)_2(aq)$ than it is in pure water.

Name this effect.

.... [1]

(b) The numerical value of the K_a of HBrO is 2.00×10^{-9}.

X is a solution of HBrO which contains $4.00 \times 10^{-3}\,mol$ of HBrO in $100\,cm^3$ of solution. In this solution the following equilibrium is established in which there are two conjugate acid-base pairs.

$$HBrO + H_2O \rightleftharpoons BrO^- + H_3O^+$$

(i) Define conjugate acid-base pair.

....

.... [1]

(ii) Identify the two conjugate acid-base pairs shown in the equation above.

pair one ....
      acid   base

pair two ....
      acid   base

[1]

(iii)   Calculate the pH of solution **X**. Show all your working.

pH = ... [2]

(iv)   A solution containing 2.00×10^{-3} mol of NaOH is added to solution **X**. A buffer solution is formed.

Calculate the pH of this buffer solution.

pH = ... [1]

[Total: 9]