Further aspects of Equilibria - 2021

1. Nov/2020/Paper_41/No.4

(a) **(i)** Give the mathematical expression for each of the terms pH and K_w.

pH = ...

K_w = ...
[2]

(ii) Calculate the pH of 0.027 mol dm^{-3} NaOH(aq).

pH = ... [1]

(b) The K_a value of chloric(I) acid, HClO, is 3.72×10^{-8} mol dm^{-3}.

Calculate the pH of 0.010 mol dm^{-3} HClO(aq).

pH = ... [1]

(c) Water and octan-1-ol form two layers when mixed.

Ethanamide is more soluble in water than it is in octan-1-ol. When 1.00 g of ethanamide is added to 50.0 cm^3 of water and this is then shaken with 50.0 cm^3 of octan-1-ol, it is found that the water layer contains 0.935 g of ethanamide at equilibrium.

(i) Calculate the partition coefficient, K_{pc}, for ethanamide in water and octan-1-ol.

K_{pc} = ... [1]

(ii) The 50.0 cm^3 of water containing 0.935 g of ethanamide is then shaken with 100.0 cm^3 of pure octan-1-ol under the same conditions.

Calculate the mass of ethanamide that is dissolved in the 100.0 cm^3 of octan-1-ol at equilibrium.

mass of ethanamide = ... g
[2]

[Total: 7]

2. Nov/2020/Paper_42/No.2

(a) Write an expression for the K_a of the weak acid HA in terms of the concentrations of the species involved.

K_a =

[1]

(b) The hydroxylammonium ion, $HONH_3^+$, is a weak acid. A 1.00×10^{-3} mol dm^{-3} solution of hydroxylammonium ions has a pH of 4.41.

(i) Calculate the K_a of $HONH_3^+$.

K_a = ... [2]

(ii) Calculate the pK_a of $HONH_3^+$.

pK_a = ... [1]

(c) The solubility product of manganese(II) hydroxide, $Mn(OH)_2$, in water is 1.1×10^{-11} mol^3 dm^{-9} at 298 K.

Calculate the solubility of $Mn(OH)_2$ in water at 298 K.

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

[Total: 6]

3. March/2020/Paper_42/No.5b

(b) A buffer solution was prepared by dissolving 2.04 g of gallic acid in 250 cm^3 of a solution containing 0.0600 mol dm^{-3} of gallate ions, $C_7H_5O_5^-$.

$$C_7H_6O_5 \rightleftharpoons C_7H_5O_5^- + H^+ \qquad K_a = 3.89 \times 10^{-5}\ mol\ dm^{-3} \text{ at } 298\ K$$

(i) Define the term *buffer solution*.

....

....

.... [2]

(ii) Calculate the pH of this buffer solution.

pH = ... [3]

(iii) Write **two** equations to show how a solution containing gallic acid, $C_7H_6O_5$, and gallate ions, $C_7H_5O_5^-$, acts as a buffer.

....

....

....

.... [2]

4. June/2020/Paper_41/No.6b,6g

(b) (i) The numerical values of K_a for methanoic acid, HCO_2H, and pyruvic acid, CH_3COCO_2H, are given.

acid	K_a
HCO_2H	1.78×10^{-4}
CH_3COCO_2H	4.07×10^{-3}

An equilibrium mixture containing the two acid-base pairs is formed.

$$HCO_2^- + CH_3COCO_2H \rightleftharpoons HCO_2H + CH_3COCO_2^-$$

Use the K_a values to calculate the equilibrium constant, K_{eq}, for this equilibrium.

K_{eq} = ... [1]

(ii) Use your value of K_{eq} to predict the position of this equilibrium. Indicate this by placing a tick (✓) in the appropriate box in the table. Explain your answer.

equilibrium lies to the left	equilibrium lies in the middle	equilibrium lies to the right

....

.... [1]

(iii) Ethanedioic acid, HO_2CCO_2H, has two dissociation constants, K_{a1} and K_{a2}, whose pK_a values are 1.23 and 4.19.

Suggest equations to show the two dissociations that give rise to these pK_a values.

pK_{a1} 1.23 ....

pK_{a2} 4.19 ....

[2]

(iv) State the mathematical relationship between pK_a and the acid dissociation constant K_a.

.... [1]

(g) The ionic product, K_w, for D_2O has a value of $1.35 \times 10^{-15}\,mol^2\,dm^{-6}$ at 298 K.

(i) Write the expression for the K_w of D_2O.

K_w =

[1]

(ii) Calculate the pH of pure, neutral D_2O at 298 K.
Assume $[D^+]$ is equivalent to $[H^+]$ for pH calculations.

pH = ... [2]

5. June/2020/Paper_41/No.8

(a) Explain what is meant by the term *buffer solution*.

....

....

.... [2]

(b) (i) Write an expression for the acid dissociation constant, K_a, for ammonium ions, $NH_4^+(aq)$.

K_a =

[1]

(ii) Write **two** equations to describe how a solution containing ammonium ions, $NH_4^+(aq)$, and ammonia, $NH_3(aq)$, can act as a buffer.

....

.... [2]

(iii) The numerical value of K_a for $NH_4^+(aq)$ is 5.6×10^{-10} at 298 K.
A buffer solution was prepared by adding 0.80 dm^3 of 0.25 $mol\,dm^{-3}$ ammonia, an excess, to 0.20 dm^3 of 0.20 $mol\,dm^{-3}$ hydrochloric acid.

Calculate the pH of the buffer solution formed at 298 K.

pH = ... [3]

[Total: 8]