PHYSICAL / INORGANIC CHEMISTRY

DPP

DAILY PRACTICE PROBLEMS

DPP No. 16

Total Marks : 45

Max. Time : 54 min.

Topic : Ionic Equilibrium

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.3	(3 marks, 3 min.)	[9, 9]
Subjective Questions ('–1' negative marking) Q.4 to Q.12	(4 marks, 5 min.)	[36, 45]

1. **(a)** pH of a strong acid is 3 , On dilution its pH changes to 4. How many times the dilution takes place ?
(A) 10 times (B) 100 times (C) 1000 times (D) 10000 times

(b) Calculate the change in pH when a 0.1 M solution of CH_3COOH in water at 25ºC is diluted to a final concentration of 0.01 M. [$K_a = 1.85 \times 10^{-5}$]
(A) +0.5 (B) +0.4 (C) +0.7 (D) +0.6

2. At 25ºC , the dissociation constants of CH_3COOH and NH_4OH in an aqueous solution are almost the same. The pH of a solution of 0.01 N CH_3COOH is 4 at 25ºC. The pH of 0.01 N NH_4OH solution at the same temperature would be :
(A) 4 (B) 3 (C) 10 (D) 11

3. Which of the following increases with dilution at a given temperature?
(A) pH of 10^{-3}M acetic acid solution (B) pH of 10^{-3} M aniline solution
(C) degree of dissociation of 10^{-3}M acetic acid (D) degree of dissociation of 10^{-3}M aniline

4. Does the pH of solution increases, decreases or remain same when you
(a) add NH_4Cl(s) to 100 ml of 0.1 M NH_3?
(b) add sodium acetate(s) to 50 ml of 0.015 M acetic acid?
(c) add NaCl(s) to 25 ml of 0.1 M NaOH?

5. When 0.100 mol of NH_3 is dissolved in sufficient water to make 1.00 L of solution, the solution is found to have a hydroxide ion concentration of 1.2×10^{-3} M.
(a) What is the pH of the solution ?
(b) What will be the pH of the solution after 0.100 mol of NaOH is added to it ?
(c) Calculate K_b for ammonia .
(d) How will NaOH added to the solution affect the extent of dissociation of ammonia ?

6. **(a)** How much water must be added to 300 mL of a 0.2 M solution of CH_3COOH for the degree of dissociation of the acid to double ? (Assume K_a of acetic acid is of order of 10^{-5} M)

(b) What is the pH of a 1M solution of acetic acid ? To what volume must one litre of this solution be diluted so that the pH of the resulting solution will be twice the original value? Given : $K_a = 2 \times 10^{-5}$.

7. Saccharin ($K_a = 2 \times 10^{-12}$) is a weak acid represented by formula HSac. A 4×10^{-4} mole amount of saccharin is dissolved in 200 cm^3 solution of pH 3 . Assuming no change in volume, calculate the concentration of Sac^- ions in the resulting solution at equilibrium.

8. What is the pH of 0.01 M H_2S solution ? $K_{a1} = 9 \times 10^{-8}$, $K_{a2} = 1.2 \times 10^{-13}$.

9. Find the concentration of (i) hydrogen oxalate ion [$HC_2O_4^-$] and (ii) oxalate ion [$C_2O_4^{2-}$] in a solution 1.00 M with respect to $H_2C_2O_4$.$K_1 = 3.6 \times 10^{-3}$, $K_2 = 6.4 \times 10^{-7}$.

10. Calculate (i) [H^+], (ii) [$H_2PO_4^-$], (iii) [HPO_4^{2-}], and (iv) [PO_4^{3-}] in a 0.15 M solution of phosphoric acid, H_3PO_4. $K_1 = 7.5 \times 10^{-3}$, $K_2 = 6.2 \times 10^{-8}$, $K_3 = 3.6 \times 10^{-13}$.

11. H_2SO_3, sulfurous acid, is a weak acid capable of providing two H^+ ions. $K_{a1} = 0.02$, $K_{a2} = 6 \times 10^{-6}$.
(i) What is pH of a 0.4 M solution of H_2SO_3 ?
(ii) What is the equilibrium concentration of the sulfite ion, SO_3^{2-}, in the 0.4 M solution of H_2SO_3 ?

12. Hydrazine, N_2H_4, can interact with water in two stages.
$N_2H_4(aq) + H_2O(l) \rightleftharpoons N_2H_5^+(aq) + OH^-(aq)$ $K_{b1} = 8.1 \times 10^{-7}$
$N_2H_5^+(aq) + H_2O(l) \rightleftharpoons N_2H_6^{2+}(aq) + OH^-(aq)$ $K_{b2} = 9 \times 10^{-16}$
(i) What are the concentrations of OH^-, $N_2H_5^+$ and $N_2H_6^{2+}$ in a 0.010 M aqueous solution of hydrazine ?
(ii) What is pOH of the 0.010 M solution of hydrazine?

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Answer Key

DPP No. # 16

1. **(a)** (A) **(b)** (A) **2.** (C) **3.** (A,C,D)

4. (a) pOH will increase so pH decrease (b) $[H^+]$ will decrease so pH increase (c) No change (remains same).

5. (a) pH = 11.08 (b) pH = 13 (c) $K_b = 1.44 \times 10^{-5}$ (d) will suppress it.

6. **(a)** 900 mL. **(b)** 2.37, V = 2.5×10^4 litres. **7.** $[Sac^-] = 4 \times 10^{-12}$ M

8. 4.52. **9.** $[HC_2O_4^-] = 0.06$ M, (ii) $[C_2O_4^{2-}] = 6.4 \times 10^{-7}$ M.

10. (i) $[H^+] = 0.03$ M ; (ii) $[H_2PO_4^-] = 0.03$ M ; (iii) $[HPO_4^{2-}] = 6.2 \times 10^{-8}$, (iv) $[PO_4^{3-}] = 7.44 \times 10^{-19}$

11. (i) pH = 1.1 ; (ii) $[SO_3^{2-}] = K_{a2} = 6 \times 10^{-6}$ M.

12. (i) $[OH^-] = 9 \times 10^{-5}$ M, $[N_2H_5^+] = 9 \times 10^{-5}$; (ii) pOH = 4.04, $[N_2H_6^{2+}] = 9 \times 10^{-16}$.

Hints & Solutions

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DPP No. # 16

1. **(b)** $pH = \frac{1}{2}\{pK_a - \log C\}$

so, $\Delta(pH) = \frac{1}{2}[\log C_i - \log C_f] = \frac{1}{2}\{-1 + 2\} = 0.5$ [pH will increase].

3. Degree of dissocation of WA & WB will increase.
$[H^+]$ in WA and $[OH^-]$ in WB will decrease so pH of WA and pOH of WB will increase.

6. **(a)** Initially degree of dissociation $\alpha = \sqrt{\frac{K_a}{C}}$

Now degree of dissociation, $\alpha_1 = 2\alpha = \sqrt{\frac{4K_a}{C}} = \sqrt{\frac{K_a}{C_1}}$

so $C_1 = \frac{C}{4}$ $\Rightarrow$ Hence we have

$$300 \times 0.2 = V_f \times \frac{0.2}{4} \quad \text{so } V_f = 1200 \text{ ml}$$

Hence water added = 1200 – 300 = 900 ml

(b) $pH = \frac{1}{2}\{pK_a - \log C\} = \frac{1}{2}\{5 - \log 2 - \log 1\} = \frac{4.7}{2} = 2.35.$

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Now on dilution pH will increase degree of dissociation a will also increase so we might not be able to use the approximate formula hence

where $a = \sqrt{\frac{K_a}{C}} = \sqrt{K_a}$

$$K_a = \frac{C_1 \alpha_1^2}{(1-\alpha_1)} = \frac{C\alpha^2}{(1-\alpha)} \qquad \ldots(1)$$

Also we must have $pH_f = 2pH_i$

so $-\log [H^+]_f = -2 \log [H^+]_i$

$\Rightarrow$ $-\log [C_1 \alpha_1] = -2 \log (C\alpha) = -\log \alpha^2$

so $C_1 \alpha_1 = \alpha^2$ ...(2)

From (1) equation $K_a = \frac{C_1 \alpha_1^2}{(1-\alpha_1)} = \frac{(C_1 \alpha_1)\alpha_1}{(1-\alpha_1)} = \frac{\alpha^2 - \alpha_1}{(1-\alpha_1)} = \frac{K_a \cdot \alpha_1}{(1-\alpha_1)}$

Hence $\alpha_1 = \frac{1}{2}$

so we get $2 \times 10^{-5} = \frac{C_1 \times 1/4}{1/2} = \frac{C_1}{2}$

so $C_1 = 4 \times 10^{-5}$

Now $M_1 V_1 = M_2 V_2$ gives $\Rightarrow$ $1 \times 1 = 4 \times 10^{-5} V_f$

so $V_f = 2.5 \times 10^4$ litre

7. Calculation of $[H^+]$ and [HSac] at start

$$[HSac] = \frac{4 \times 10^{-4} \times 1000}{200} = 0.002 \text{ M}$$

The dissociation of HSac is as below

	HSac	H^+	+	Sac^-
At start	0.002	0.001		0
At equi. 0.002-x	0.001 + x	x		

$$\therefore K_a = \frac{[H^+][Sac^-]}{[HSac]} = \frac{(0.01+x)x}{0.002-x} = 2 \times 10^{-12}$$

$x = 4 \times 10^{-12}$ M

$[Sac^-]_{equi.} = 4 \times 10^{-12}$ M.

8. $K_{a_1} >> K_{a_2}$

$[H^+] = [HS^-] = \sqrt{CK_{a_1}} = \sqrt{0.01 \times 9 \times 10^{-8}}$

$[H^+] = 3 \times 10^{-5}$.

pH = 4.52.

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