PHYSICAL / INORGANIC CHEMISTRY

DPP

DAILY PRACTICE PROBLEMS

DPP No. 13

Total Marks : 45

Max. Time : 48 min.

Topic : Ionic Equilibrium

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.4	(3 marks, 3 min.)	[12, 12]
Comprehension ('–1' negative marking) Q.5 (i to vii)	(3 marks, 3 min.)	[21, 21]
Subjective Questions ('–1' negative marking) Q.6 to Q.8	(4 marks, 5 min.)	[12, 15]

1. **(a)** Which of the following acids is monoprotic ?

(A) H_2SO_4 (B) $HClO_4$ (C) H_3PO_3 (D) H_3PO_4

(b) The weakest base is :

(A) ClO_4^- (B) HS^- (C) Cl^- (D) NH_3

(c) Which of the following can act both as a Bronsted acid & a Bronsted base ?

(A) HCl (B) H_3PO_4 (C) HCO_3^- (D) O^{2-}

2. **(a)** The ionic product of water at 45 ºC is 4×10^{-14}. What is pH of pure water at this temperature.

[Take : log 2 = 0.3]

(A) 6.7 (B) 7 (C) 7.3 (D) 13.4

(b) For which temperature the pOH of pure water can be greater than 7.

(A) 20 ºC (B) 30 ºC (C) 40 ºC (D) 50 ºC

3. **(a)** For pure water at 10 ºC and 60 ºC , the correct statement is

(A) $pOH_{10^\circ C} = pOH_{60^\circ C}$ (B) $pOH_{10^\circ C} > pOH_{60^\circ C}$ (C) $pOH_{60^\circ C} > pOH_{10^\circ C}$ (D) Can't say

(b) For pure water at 25 ºC and 50 ºC the correct statement is

(A) $pH_{25^\circ C} = pH_{50^\circ C}$ (B) $pH_{25^\circ C} > pH_{50^\circ C}$ (C) $pH_{50^\circ C} > pH_{25^\circ C}$ (D) Can't say

4. **(a)** At – 50ºC autoprotolysis of NH_3 gives $[NH_4^+] = 1 \times 10^{-15}$ M hence, autoprotolysis constant of NH_3 is:

(A) $\sqrt{1 \times 10^{-15}}$ (B) 1×10^{-30} (C) 1×10^{-15} (D) 2×10^{-15}

(b) The self ionization constant for pure formic acid, K = $[HCOOH_2^+][HCOO^-]$ has been estimated as 10^{-6} at room temperature .The density of formic acid is 1.15 g/cm^3. The percentage of formic acid converted to formate ion are :

(A) 0.002 % (B) 0.004 % (C) 0.006 % (D) 0.008 %

5. **Comprehension #**

Relative strengths of conjugate acid base pairs :

	Acid		Conjugate base		
Stronger acid	$HClO_4$, HCl, H_2SO_4, HNO_3	Strong acids 100% dissociated in aqueous solution	ClO_4^-, Cl^-, HSO_4^-, NO_3^-	very weak bases Negligible tendency to be protonated in aqueous solution	Weaker base
	H_3O^+		H_2O		
↑	HSO_4^-, H_3PO_4, HNO_2, HF, CH_3COOH, H_2CO_3, H_2S, NH_4^+, HCN, HCO_3^-, H_2O	Weak acids Exist in solution as a mixture of HA A^-, and H_3O^+	SO_4^{2-}, $H_2PO_4^-$, NO_2^-, F^-, $CH_3CO_2^-$, HCO_3^-, HS^-, NH_3, CN^-, CO_3^{2-}, OH^-	Weak bases Moderate tendency to be protonated in aqueous solution	↓
Weaker acid	NH_3, OH^-, H_2	Very Weak acids Negligible tendency to dissociate.	NH_2^-, O^{2-}, H^-	Strong bases 100% protonated in aqueous solution	Strong base

(i). Account for the acidic properties of nitrous acid in terms of

(i) Arrhenius theory and (ii) Bronsted Lowry theory

(ii). Write a balanced equation for the dissociation of each of the following Bronsted Lowry acids in water.

(a) H_2SO_4 (b) H_3O^+ (c) HSO_4^-

Also write conjugate base of the acid

(iii). Which of the following reactions proceeds to the right and which proceeds to the left if you mix equal concentrations of reactants and products ?

(A) $HF(aq) + NO_2^-(aq) \rightleftharpoons HNO_2(aq) + F^-(aq)$ (B) $NH_4^+(aq) + CO_3^{2-}(aq) \rightleftharpoons HCO_3^-(aq) + NH_3(aq)$

(iv). What are conjugate base of each of the following Bronsted Lowry acid ?

(a) $HOCl$ (b) HPO_4^{2-} (c) H_2O (d) $CH_3NH_3^+$

(e) H_2CO_3 (f) H_2 (g) H_2O_2 (h) HO_2^-

(v). Which of the following species behave as a strong acids or as strong base in aqueous solutions ?

(a) HNO_2 (b) HNO_3 (c) NH_4^+ (d) Cl^-

(e) H^- (f) O^{2-} (g) H_2SO_4

(vi). Consider following reactions :

(a) $H_2CO_3(aq) + HSO_4^-(aq) \rightleftharpoons H_2SO_4(aq) + HCO_3^-(aq)$

(b) $HF(aq) + Cl^-(aq) \rightleftharpoons HCl(aq) + F^-(aq)$

(c) $HF(aq) + NH_3(aq) \rightleftharpoons NH_4^+ + F^-(aq)$

(d) $HSO_4^-(aq) + CN^-(aq) \rightleftharpoons HCN(aq) + SO_4^{2-}(aq)$

Reactions proceeding to the right are :

(A) a, b (B) c, d (C) a, c (D) b, d

(vii) If following proceed in forward side :

$HNO_2 + HF \rightleftharpoons H_2F^+ + NO_2^-$; $CH_3COOH + HF \rightleftharpoons F^- + CH_3COOH_2^+$;

$H_2O + CH_3COOH \rightleftharpoons H_3O^+ + CH_3COO^-$

then increasing order of acid strength is :

(A) $H_2O < CH_3COOH < HF < HNO_2$ (B) $HNO_2 < HF < CH_3COOH < H_2O$

(C) $HNO_2 < HF < H_2O < CH_3COOH$ (D) $HNO_2 < CH_3COOH < HF < H_2O$

6. Several acids are listed below with their respective equilibrium constants.

$HF(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + F^-(aq)$ $K_a = 7.2 \times 10^{-4}$

$HS^-(aq) + H_2O(\ell) \rightleftharpoons H_3O+(aq) + S^{2-}(aq)$ $K_a = 1.3 \times 10^{-11}$

$CH_3COOH(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + CH_3COO(aq)$ $K_a = 1.8 \times 10^{-5}$

(i) Which is the strongest acid ? Which is the weakest ?

(ii) What is the conjugate base of the acid HF ?

(iii) Which acid has the weakest conjugate base ?

(iv) Which acid has the strongest conjugate base ?

7. Several bases are listed below with their respective K_b values :

$NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH(aq).$ $K_b = 1.8 \times 10^{-5}$

$C_5H_5N(aq) + H_2O(\ell) \rightleftharpoons C_5H_5NH^+(aq) + OH^-(aq).$ $K_b = 1.5 \times 10^{-9}$

$N_2H_4(aq) + H_2O(\ell) \rightleftharpoons N_2H_5^+(aq) + OH(aq).$ $K_b = 8.5 \times 10^{-7}$

(i) Which is the strongest base ? Which is the weakest base.

(ii) What is the conjugate acid of C_5H_5N ?

(iii) Which base has the strongest conjugate acid ? Which has the weakest ?

8. The dissociation constants of HCOOH & CH_3COOH are 2×10^{-4} & 1.6×10^{-5} respectively . Calculate the relative strengths of the acids.

Answer Key

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1. **(a)** (B) **(b)** (A) **(c)** (C) **2.** **(a)** (A) **(b)** (A)

3. **(a)** (B) **(b)** (B) **4.** **(a)** (B) **(b)** (B)

5. **(i)** (i) $HNO_2(aq) \rightleftharpoons H^+(aq) + NO_2^-(aq)$

Since, HNO_2 ionises to give H^+ hence, it is a Arrhenius acid.

(ii) $HNO_2(l) + H_2O(aq) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$

acid 1 base 2 acid 2 base 1

HNO_2 donates a proton hence, it is an acid and changes to NO_2^- (conjugate base). $H_2O(l)$ accepts the proton hence, it is a base and change to H_3O^+ (conjugate acid). Thus HNO_2 is a Bronsted Lowry acid.

(ii) (a) $H_2SO_4 + H_2O \rightleftharpoons H_3O^+ + HSO_4^-$

acid 1 base 2 acid 2 base 1 (conjugatete)

(iii) (A) to the left (B) to the right

Reaction proceed to words the side favoring formation of weak acid and weak base.

(vi) (B) **(vii)** (A)

6. (i) strongest acid,HF; weakest acid HS–. (ii) fluoride F–.

(iii) The strongest acid (HF) has the weakest conjugate base.

(iv) The weakest acid (HS–) has the stongest conjugate base.

7. (i) strongest base, NH_3; weakest base C_5H_5N. (ii) $C_5H_5NH^+$.
(iii) C_5H_5N has the strongest conjugate acid, and NH_3 has the weakest conjugate acid.

8. $\sqrt{12.5}$.

Hints & Solutions

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2. **(a)** At 45ºC
$K_w = 4 \times 10^{-14} = [H^+][OH^-]$. $\Rightarrow$ $[H^+] = 2 \times 10^{-7}$. $\Rightarrow$ pH = 7 – log2 = 6.7.

(b) For H_2O $K_w \propto T$.
$\therefore$ $[H^+] \propto T$.
$\therefore$ $pH \propto \frac{1}{T}$.

4. **(a)** $NH_3 + NH_3 \rightleftharpoons NH_4^+ + NH_2^-$.
in self ionisation of NH_3.
$[NH_4^+] = [NH_2^-]$.
$K_{(Amm)} = [NH_4^+][NH_2^-] = 1 \times 10^{-30}$.

(b) $K = [HCOOH_2^+][HCOO^-] = 10^{-6}$.
$[HCOO^-] = 10^{-3}$ mol/L.
1 liter solution of HCOOH has = 1150 g mass.

moles of (HCOOH) in 1 litre solution = $\frac{1150}{46}$ = 25 mol.

out of 25 mol HCOOH 10^{-3} mol are ionised into $HCOO^-$ ions.

$\therefore$ % dissociation = $\frac{10^{-3}}{25} \times 100 = 0.004\%$.

5.
(i). (i) $HNO_2(aq) \rightleftharpoons H^+(aq) + NO_2^-(aq)$
Since, HNO_2 ionises to give H^+ hence, it is a Arrhenius acid.
(ii) $HNO_2(l) + H_2O(aq) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$
acid 1 base 2 acid 2 base 1
HNO_2 donates a proton hence, it is an acid and changes to NO_2^- (conjugate base). $H_2O(l)$ accepts the proton hence, it is a base and change to H_3O^+ (conjugate acid). Thus HNO_2 is a Bronsted Lowry acid.

(ii) (a) $H_2SO_4 + H_2O \rightleftharpoons H_3O^+ + HSO_4^-$
acid 1 base 2 acid 2 base 1 (conjugatete)

(iii) (A) to the left (B) to the right
Reaction proceed to words the side favoring formation of weak acid and weak base.

(vi) (a) Acid strength $H_2SO_4 > H_2CO_3$.
Basic strength $HCO_3^- > HSO_4^-$.
(b) Acid strength $HCl > HF$.
Basic strength $F^- > Cl^-$.
(c) Acid strength $HF > NH_4^+$
Basic strength $NH_3 > F^-$.
(d) Acid strength $HSO_4^- > HCN$.
Basic strength $CN^- > SO_4^{2-}$.
c and d will move to the right.

8. Relative acidic strength of weak acids = $\sqrt{\frac{K_{a_1}}{K_{a_2}}} = \sqrt{\frac{2 \times 10^{-4}}{1.6 \times 10^{-5}}} = \sqrt{\frac{20}{1.6}} = \sqrt{12.5}$.