

Topic : Ionic Equilibrium

Type of Questions

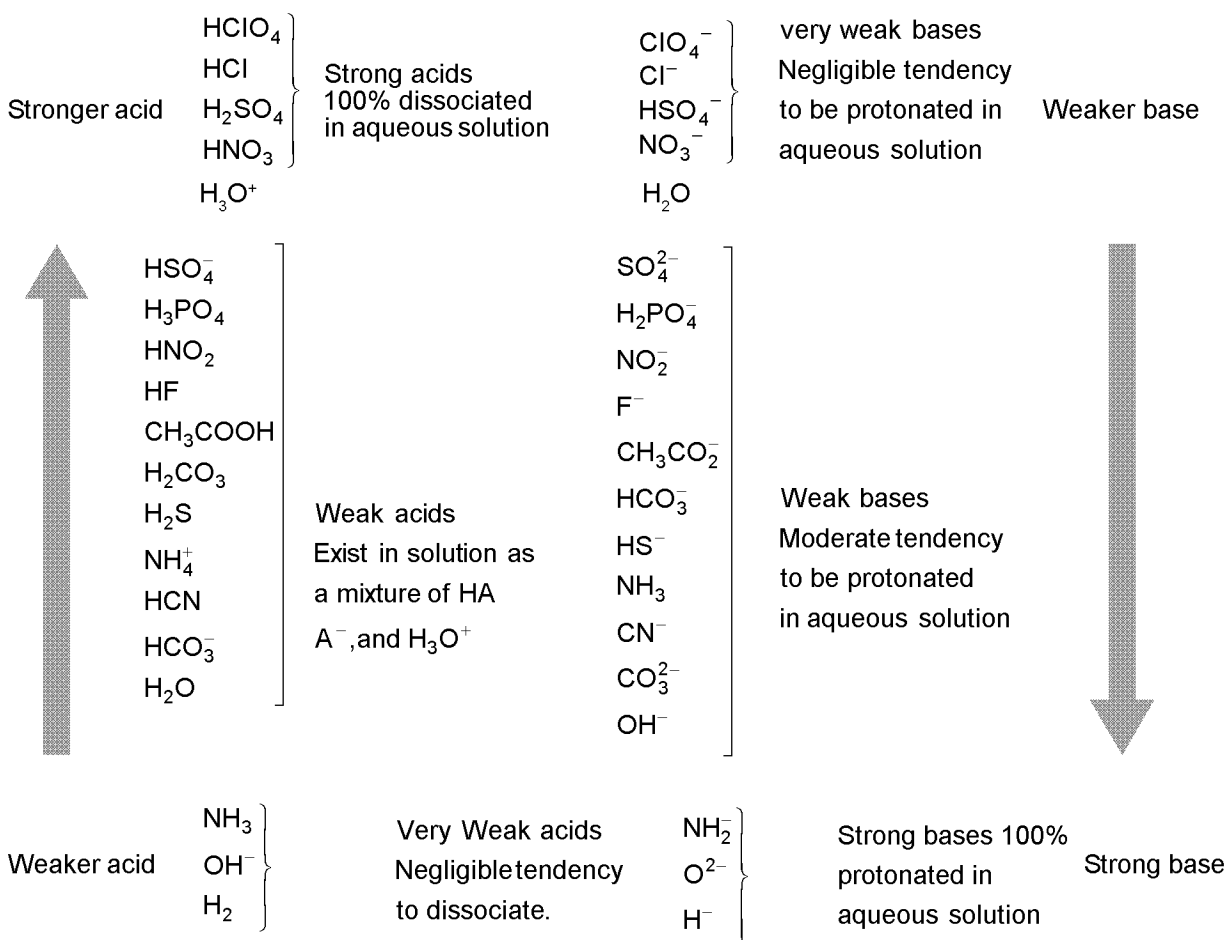
M.M., Min.

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°C 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°C (B) 30°C (C) 40°C (D) 50°C
3. (a) For pure water at 10°C and 60°C , the correct statement is
 (A) $\text{pOH}_{10^\circ\text{C}} = \text{pOH}_{60^\circ\text{C}}$ (B) $\text{pOH}_{10^\circ\text{C}} > \text{pOH}_{60^\circ\text{C}}$ (C) $\text{pOH}_{60^\circ\text{C}} > \text{pOH}_{10^\circ\text{C}}$ (D) Can't say
- (b) For pure water at 25°C and 50°C the correct statement is
 (A) $\text{pH}_{25^\circ\text{C}} = \text{pH}_{50^\circ\text{C}}$ (B) $\text{pH}_{25^\circ\text{C}} > \text{pH}_{50^\circ\text{C}}$ (C) $\text{pH}_{50^\circ\text{C}} > \text{pH}_{25^\circ\text{C}}$ (D) Can't say
4. (a) At -50°C autoprotolysis of NH_3 gives $[\text{NH}_4^+] = 1 \times 10^{-15}$ 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, $K = [\text{HCOOH}_2^+][\text{HCOO}^-]$ 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 :



- (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) $\text{HF}(\text{aq}) + \text{NO}_3^-(\text{aq}) \rightleftharpoons \text{HNO}_3(\text{aq}) + \text{F}^-(\text{aq})$ (B) $\text{NH}_4^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightleftharpoons \text{HCO}_3^-(\text{aq}) + \text{NH}_3(\text{aq})$
- (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) $\text{H}_2\text{CO}_3(\text{aq}) + \text{HSO}_4^-(\text{aq}) \rightleftharpoons \text{H}_2\text{SO}_4(\text{aq}) + \text{HCO}_3^-(\text{aq})$
(b) $\text{HF}(\text{aq}) + \text{Cl}^-(\text{aq}) \rightleftharpoons \text{HCl}(\text{aq}) + \text{F}^-(\text{aq})$
(c) $\text{HF}(\text{aq}) + \text{NH}_3(\text{aq}) \rightleftharpoons \text{NH}_4^+ + \text{F}^-(\text{aq})$
(d) $\text{HSO}_4^-(\text{aq}) + \text{CN}^-(\text{aq}) \rightleftharpoons \text{HCN}(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$

Reactions proceeding to the right are :

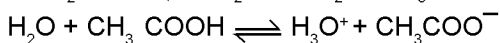
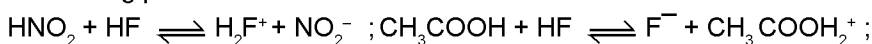
(A) a, b

(B) c, d

(C) a, c

(D) b, d

(vii) If following proceed in forward side :



then increasing order of acid strength is :

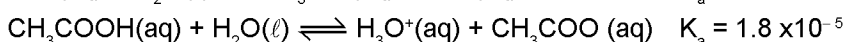
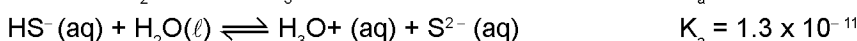
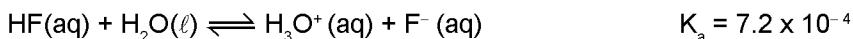
(A) $\text{H}_2\text{O} < \text{CH}_3\text{COOH} < \text{HF} < \text{HNO}_2$

(B) $\text{HNO}_2 < \text{HF} < \text{CH}_3\text{COOH} < \text{H}_2\text{O}$

(C) $\text{HNO}_2 < \text{HF} < \text{H}_2\text{O} < \text{CH}_3\text{COOH}$

(D) $\text{HNO}_2 < \text{CH}_3\text{COOH} < \text{HF} < \text{H}_2\text{O}$

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



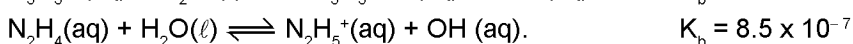
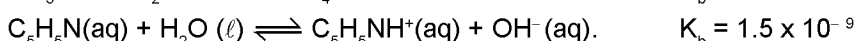
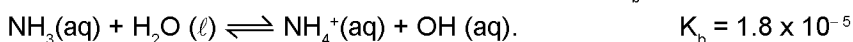
(i) Which is the strongest acid ? Which is the weakest ?

(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 :



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

(ii) What is the conjugate acid of $\text{C}_5\text{H}_5\text{N}$?

(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.

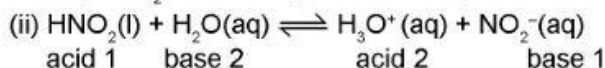
Answer Key

DPP No. # 13

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

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

5. (i) $\text{HNO}_2(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{NO}_2^-(\text{aq})$
Since, HNO_2 ionises to give H^+ hence, it is a Arrhenius acid.



HNO_2 donates a proton hence, it is an acid and changes to NO_2^- (conjugate base). $\text{H}_2\text{O}(\text{l})$ 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) $\text{H}_2\text{SO}_4 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{HSO}_4^-$
acid 1 base 2 acid 2 base 1 (conjugate)

(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 $\text{C}_5\text{H}_5\text{N}$. (ii) $\text{C}_5\text{H}_5\text{NH}^+$.
 (iii) $\text{C}_5\text{H}_5\text{N}$ has the strongest conjugate acid, and NH_3 has the weakest conjugate acid.
8. $\sqrt{12.5}$.

Hints & Solutions

PHYSICAL / INORGANIC CHEMISTRY

DPP No. # 13

2. (a) At 45°C
 $K_w = 4 \times 10^{-14} = [\text{H}^+][\text{OH}^-] \Rightarrow [\text{H}^+] = 2 \times 10^{-7} \Rightarrow \text{pH} = 7 - \log 2 = 6.7.$
- (b) For H_2O $K_w \propto T$.
 $\therefore [\text{H}^+] \propto T$.
 $\therefore \text{pH} \propto \frac{1}{T}$.
4. (a) $\text{NH}_3 + \text{NH}_3 \rightleftharpoons \text{NH}_4^+ + \text{NH}_2^-$
 in self ionisation of NH_3 .
 $[\text{NH}_4^+] = [\text{NH}_2^-]$.
 $K_{(\text{Amm})} = [\text{NH}_4^+][\text{NH}_2^-] = 1 \times 10^{-30}.$
- (b) $K = [\text{HCOOH}_2^+][\text{HCOO}^-] = 10^{-6}$.
 $[\text{HCOO}^-] = 10^{-3} \text{ mol/L}$.
 1 liter solution of HCOOH has = 1150 g mass.
 moles of (HCOOH) in 1 litre solution = $\frac{1150}{46} = 25 \text{ mol}$.
 out of 25 mol HCOOH 10^{-3} mol are ionised into HCOO^- ions.
 $\therefore \% \text{ dissociation} = \frac{10^{-3}}{25} \times 100 = 0.004\%.$
5. (i) (i) $\text{HNO}_2(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{NO}_2^-(\text{aq})$
 Since, HNO_2 ionises to give H^+ hence, it is a Arrhenius acid.
 (ii) $\text{HNO}_2(\text{l}) + \text{H}_2\text{O}(\text{aq}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{NO}_2^-(\text{aq})$
 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). $\text{H}_2\text{O}(\text{l})$ 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) $\text{H}_2\text{SO}_4 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{HSO}_4^-$
 acid 1 base 2 acid 2 base 1 (conjugate)
- (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 $\text{H}_2\text{SO}_4 > \text{H}_2\text{CO}_3$.
 Basic strength $\text{HCO}_3^- > \text{HSO}_4^-$.
- (b) Acid strength $\text{HCl} > \text{HF}$.
 Basic strength $\text{F}^- > \text{Cl}^-$.
- (c) Acid strength $\text{HF} > \text{NH}_4^+$.
 Basic strength $\text{NH}_3 > \text{F}^-$.
- (d) Acid strength $\text{HSO}_4^- > \text{HCN}$.
 Basic strength $\text{CN}^- > \text{SO}_4^{2-}$.

c and d will move to the right.

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

