

## Ionic Equilibrium

## Self Evaluation Test - 9

- The most important buffer in the blood consists of  
[BHU 1981]  
(a)  $HCl$  and  $Cl^{\ominus}$  (b)  $H_2CO_3$  and  $HCO_3^{\ominus}$   
(c)  $H_2CO_3$  and  $Cl^{\ominus}$  (d)  $HCl$  and  $HCO_3^{\ominus}$
- The solubility product of  $AgI$  at  $25^{\circ}C$  is  $1.0 \times 10^{-16} \text{ mol}^2 \text{ L}^{-2}$ . The solubility of  $AgI$  in  $10^{-4} N$  solution of  $KI$  at  $25^{\circ}C$  is approximately (in  $\text{mol l}^{-1}$ )  
[CBSE PMT 2003]  
(a)  $1.0 \times 10^{-8}$  (b)  $1.0 \times 10^{-16}$   
(c)  $1.0 \times 10^{-12}$  (d)  $1.0 \times 10^{-10}$
- The pH of the solution:  $5 \text{ mL}$  of  $\frac{M}{5}$ ,  $HCl$  +  $10 \text{ mL}$  of  $\frac{M}{10}$   $NaOH$  is  
[MH CET 2004]  
(a) 5 (b) 3  
(c) 7 (d) 8
- Given that the dissociation constant for  $H_2O$  is  $K_w = 1 \times 10^{-14} \text{ mole}^2 / \text{litre}^2$ . What is the pH of a  $0.001$  molar  $KOH$  solution [UPSEAT 2000; MP PET 2001]  
(a)  $10^{-11}$  (b)  $10^{-3}$   
(c) 3 (d) 11
- The pH of  $0.1 M$  solution of the following salts increases in the order [Pb. CET 2004]  
(a)  $NaCl < NH_4Cl < NaCN < HCl$   
(b)  $HCl < NH_4Cl < NaCl < NaCN$   
(c)  $NaCN < NH_4Cl < NaCl < HCl$   
(d)  $HCl < NaCl < NaCN < NH_4Cl$
- The degree of hydrolysis in hydrolytic equilibrium  $A^- + H_2O \rightleftharpoons HA + OH^-$  at salt concentration of  $0.001 M$  is ( $K_a = 1 \times 10^{-5}$ ) [UPSEAT 2004]  
(a)  $1 \times 10^{-3}$  (b)  $1 \times 10^{-4}$   
(c)  $5 \times 10^{-4}$  (d)  $1 \times 10^{-6}$
- If  $pK_b$  for fluoride ion at  $25^{\circ}C$  is  $10.83$ , the ionisation constant of hydrofluoric acid in water at this temperature is [IIT 1997]  
(a)  $1.74 \times 10^{-3}$  (b)  $3.52 \times 10^{-3}$   
(c)  $6.75 \times 10^{-4}$  (d)  $5.38 \times 10^{-2}$
- If the hydrogen ion concentration of a given solution is  $5.5 \times 10^{-3} \text{ mol litre}^{-1}$ , the pH of the solution will be [AMU 1985]  
(a) 2.26 (b) 3.40  
(c) 3.75 (d) 2.76
- Henderson's equation is  $pH = pK_a + \log \frac{[\text{salt}]}{[\text{acid}]}$ . If the acid gets half neutralized the value of pH will be : [ $pK_a = 4.30$ ] [RPMT 2000]  
(a) 4.3 (b) 2.15  
(c) 8.60 (d) 7
- The pH of a  $0.01 M$  solution of acetic acid having degree of dissociation  $12.5\%$  is [JIPMER 2000]  
(a) 5.623 (b) 2.903  
(c) 3.723 (d) 4.509
- Which of the following solutions will have pH close to 1.0 [IIT 1992; MP PET 1993; AMU 1999]  
(a)  $100 \text{ ml}$  of  $\frac{M}{10} HCl$  +  $100 \text{ ml}$  of  $\frac{M}{10} NaOH$   
(b)  $55 \text{ ml}$  of  $\frac{M}{10} HCl$  +  $45 \text{ ml}$  of  $\frac{M}{10} NaOH$   
(c)  $10 \text{ ml}$  of  $\frac{M}{10} HCl$  +  $90 \text{ ml}$  of  $\frac{M}{10} NaOH$   
(d)  $75 \text{ ml}$  of  $\frac{M}{5} HCl$  +  $25 \text{ ml}$  of  $\frac{M}{5} NaOH$
- In which of the following solvents will  $AgBr$  have the highest solubility [CBSE PMT 1992]  
(a)  $10^{-3} M NaBr$  (b)  $10^{-3} M NH_4OH$   
(c) Pure water (d)  $10^{-3} M HBr$
- How many grams of  $CaC_2O_4$  will dissolve in distilled water to make one litre of saturated solution ? (Solubility product of  $CaC_2O_4$  is  $2.5 \times 10^{-9} \text{ mole}^2 \text{ litre}^{-2}$  and its molecular weight is 128) [MP PET 1993; MP PMT 2000]  
(a)  $0.0064 \text{ gm}$  (b)  $0.0128 \text{ gm}$

- (c) 0.0032 gm (d) 0.0640 gm
14. The solubility product of  $CuS$ ,  $Ag_2S$ ,  $HgS$  are  $10^{-31}$ ,  $10^{-44}$ ,  $10^{-54}$  respectively. The solubilities of these sulphides are in the order
- (a)  $Ag_2S > CuS > HgS$  (b)  $Ag_2S > HgS > CuS$
- (c)  $HgS > Ag_2S > CuS$  (d)  $CuS > Ag_2S > HgS$
15. The solubility product constant  $K_{sp}$  of  $Mg(OH)_2$  is  $9.0 \times 10^{-12}$ . If a solution is 0.010 M with respect to  $Mg^{2+}$  ion, what is the maximum hydroxide ion concentration which could be present without causing the precipitation of  $Mg(OH)_2$
- (a)  $1.5 \times 10^{-7} M$  (b)  $3.0 \times 10^{-7} M$
- (c)  $1.5 \times 10^{-5} M$  (d)  $3.0 \times 10^{-5} M$
16. If the  $K_b$  value in the hydrolysis reaction  $B^+ + H_2O \rightleftharpoons BOH + H^+$  is  $1.0 \times 10^{-6}$ , then the hydrolysis constant of the salt would be
- (a)  $1.0 \times 10^{-6}$  (b)  $1.0 \times 10^{-7}$
- (c)  $1.0 \times 10^{-8}$  (d)  $1.0 \times 10^{-9}$
17. For a sparingly soluble salt  $A_pB_q$ , the relationship of its solubility product ( $L_s$ ) with its solubility ( $S$ ) is
- [IIT Screening 2001]
- (a)  $L_s = S^{p+q} \cdot p^p \cdot q^q$  (b)  $L_s = S^{p+q} \cdot p^q \cdot q^p$
- (c)  $L_s = S^{pq} \cdot p^p \cdot q^q$  (d)  $L_s = S^{pq} \cdot (p \cdot q)^{p+q}$
18. Arrange  $NH_4^+$ ,  $H_2O$ ,  $H_3O^+$ ,  $HF$  and  $OH^-$  in increasing order of acidic nature [BVP 2003]
- (a)  $H_3O^+ < NH_4^+ < HF < OH^- < H_2O$
- (b)  $NH_4^+ < HF < H_3O^+ < H_2O < OH^-$
- (c)  $OH^- < H_2O < NH_4^+ < HF < H_3O^+$
- (d)  $H_3O^+ > HF > H_2O > NH_4^+ > OH^-$
19. How many grams of  $CaC_2O_4$  (molecular weight = 128) on dissolving in distilled water will give a saturated solution [ $K_{sp}(CaC_2O_4) = 2.5 \times 10^{-9} \text{ mol}^2 \text{ l}^{-2}$ ] [KCET 2003]
- (a) 0.0064 g (b) 0.1280 g
- (c) 0.0128 g (d) 1.2800 g
20. If the concentration of  $CrO_4^{2-}$  ions in a saturated solution of silver chromate is  $2 \times 10^{-4}$ . Solubility product of silver chromate will be
- (a)  $4 \times 10^{-8}$  (b)  $8 \times 10^{-12}$
- (c)  $12 \times 10^{-12}$  (d)  $32 \times 10^{-12}$
21. According to Bronsted-Lowry concept, the correct order of relative strength of bases follows the order
- [Pb. PMT 2001]
- [CBSE PMT 1997]
- (a)  $CH_3COO^- > Cl^- > OH^-$
- (b)  $CH_3COO^- > OH^- > Cl^-$
- (c)  $OH^- > CH_3COO^- > Cl^-$
- (d)  $OH^- > Cl^- > CH_3COO^-$
22.  $H_2SO_4 + OH^- \rightarrow SO_4^{2-} + H_2O$  Which is correct about conjugate acid base pair [JEE Orissa 2004]
- [Pb. PMT 1998]
- (a)  $HSO_4^{2-}$  is conjugate acid of base  $SO_4^{2-}$
- (b)  $HSO_4^-$  is conjugate base of acid  $SO_4^{2-}$
- (c)  $SO_4^-$  is conjugate acid of base  $HSO_4^-$
- (d) None of these
23. Which may be added to one litre of water to act as a buffer
- [JIPMER 2000]
- (a) One mole of  $HC_2H_3O_2$  and 0.5 mole of  $NaOH$
- (b) One mole of  $NH_4Cl$  and one mole of  $HCl$
- (c) One mole of  $NH_4OH$  and one mole of  $NaOH$
- (d) One mole of  $HC_2H_3O_2$  and one mole of  $HCl$
24. Which of the following base is weakest [DCE 2003]
- (a)  $NH_4OH : K_b = 1.6 \times 10^{-6}$
- (b)  $C_6H_5NH_2 : K_b = 3.8 \times 10^{-10}$
- (c)  $C_2H_5NH_2 : K_b = 5.6 \times 10^{-4}$
- (d)  $C_6H_7N : K_b = 6.3 \times 10^{-10}$
25.  $HClO$  is a weak acid. The concentration of  $H^+$  ions in 0.1 M solution of  $HClO$  ( $K_a = 5 \times 10^{-8}$ ) will be equal to
- [CPMT 1993]
- (a)  $7.07 \times 10^{-5} m$  (b)  $5 \times 10^{-9} m$
- (c)  $5 \times 10^{-7} m$  (d)  $7 \times 10^{-4} m$
26. Upto what pH must a solution containing a precipitate of  $Cr(OH)_3$  be adjusted so that all of precipitate dissolves
- (When  $Cr^{3+} = 0.1 \text{ mol/l}$ ,  $K_{sp} = 6 \times 10^{-31}$ ) [MP PET 2003]
- [MP PET 1992; CPMT 1993]
- (a) Upto 4.4 (b) Upto 4.1
- (c) Upto 4.2 (d) Upto 4.0
27.  $NH_4Cl$  is acidic, because [JEE Orissa 2004]

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- (a) On hydrolysis  $NH_4Cl$  gives weak base  $NH_4OH$  and strong acid  $HCl$   
 (b) Nitrogen donates a pair of electron  
 (c) It is a salt of weak acid and strong base  
 (d) On hydrolysis  $NH_4Cl$  gives strong base and weak acid
- 28.** A solution of weak acid  $HA$  containing 0.01 moles of acid per litre of solutions has  $pH = 4$ . The percentage degree of ionisation of the acid and the ionisation constant of acid are respectively [UPSEAT 2001]  
 (a) 1%,  $10^{-6}$  (b) 0.01%,  $10^{-4}$   
 (c) 1%,  $10^{-4}$  (d) 0.01%,  $10^{-6}$
- 29.** The  $pH$  of a buffer solution containing 0.2 mole per litre  $CH_3COONa$  and 1.5 mole per litre  $CH_3COOH$  is ( $K_a$  for acetic acid is  $1.8 \times 10^{-5}$ ) [CPMT 2001]  
 (a) 4.87 (b) 5.8  
 (c) 2.4 (d) 9.2
- 30.** 100 mL of 0.04 N  $HCl$  aqueous solution is mixed with 100 mL of 0.02 N  $NaOH$  solution. The  $pH$  of the resulting solution is [UPSEAT 2004]  
 (a) 1.0 (b) 1.7  
 (c) 2.0 (d) 2.3
- 31.** An alcoholic drink substance  $pH = 4.7$  then  $OH^-$  ion concentration of this solution is ( $K_w = 10^{-14} \text{ mol}^2/\text{l}^2$ ) [RPMT 2002]  
 (a)  $3 \times 10^{-10}$  (b)  $5 \times 10^{-10}$   
 (c)  $1 \times 10^{-10}$  (d)  $5 \times 10^{-8}$
- 32.** In its 0.2 M solution, an acid ionises to an extent of 60%. Its hydrogen ion concentration is  
 (a) 0.6 M (b) 0.2 M  
 (c) 0.12 M (d) None of these
- 33.**  $pH$  of 0.1 M  $NH_3$  aqueous solution is ( $K_b = 1.8 \times 10^{-5}$ ) [UPSEAT 2004]  
 (a) 11.13 (b) 12.5  
 (c) 13.42 (d) 11.55
- 34.** 40 mg of pure sodium hydroxide is dissolved in 10 litres of distilled water. The  $pH$  of the solution is [Kerala PMT 2004]  
 (a) 9.0 (b) 10  
 (c) 11 (d) 12  
 (e) 8
- 35.** Solubility of  $PbI_2$  is 0.005 M. Then, the solubility product of  $PbI_2$  is [BVP 2004]  
 (a)  $6.8 \times 10^{-6}$   
 (b)  $6.8 \times 10^6$   
 (c)  $2.2 \times 10^{-9}$   
 (d) None of these
- 36.** A monoprotic acid in a 0.1 M solution ionizes to 0.001%. Its ionisation constant is [MP PET 1985, 88, 99; MP PMT 1988; CPMT 2003]  
 (a)  $1.0 \times 10^{-3}$  (b)  $1.0 \times 10^{-6}$   
 (c)  $1.0 \times 10^{-8}$  (d)  $1.0 \times 10^{-11}$
- 37.** Select the  $pK_a$  value of the strongest acid from the following [KCET 2004]  
 (a) 1.0 (b) 3.0  
 (c) 2.0 (d) 4.5
- 38.** At 90°C, pure water has  $H_3O^+$  ion concentration of  $10^{-6} \text{ mol/L}$ . The  $K_w$  at 90°C is [DCE 2004]  
 (a)  $10^{-6}$  (b)  $10^{-14}$   
 (c)  $10^{-12}$  (d)  $10^{-8}$
- 39.** By adding 20 ml 0.1 N  $HCl$  to 20 ml 0.1 N  $KOH$ , the  $pH$  of the obtained solution will be [CPMT 1975, 86, 93]  
 (a) 0 (b) 7  
 (c) 2 (d) 9

# AS Answers and Solutions

(SET -9)

1. (b) Blood consists of  $H_2CO_3 + HCO_3^-$  buffer solution.

2. (c)  $AgI \rightleftharpoons Ag^+_{(s)} + I^-_{(s)} ; K_{sp} = S^2 = 10^{-4} \times S$

$$S = \frac{1.0 \times 10^{-16}}{10^{-4}} = 1 \times 10^{-12} \frac{mol^2}{l^2}$$

3. (c) Milliequivalents of  $HCl = 5 \times \frac{1}{5} = 1$

$$\text{Milliequivalents of } NaOH = 10 \times \frac{1}{10} = 1$$

$$\therefore 5ml \frac{M}{5} HCl = 10ml \frac{M}{5} HCl$$

Hence the solution will be neutral i.e.,  $pH = 7$ .

4. (d)  $pH = 14 - pOH = 14 - 3 = 11$

5. (b)  $HCl$  is strong acid. In its .1M solution,  $[H^+] = 0.1M$  and hence,  $pH = 1$

$NH_4Cl_{(aq)}$  hydrolyses in solution and give acidic solution which is less acidic than .1M  $HCl$ .  $NaCl$  is not hydrolysed in aqueous solutions. Its  $pH = 7$   $NaCN$  undergoes hydrolysis in solution to give alkaline solution. So that  $pH$  increases in the order,  $HCl < NH_4Cl < NaCl < NaCN$

6. (a)  $K_h = \frac{K_w}{K_a} = \frac{10^{-14}}{1 \times 10^{-5}} = 10^{-9}$

$$K_h = \alpha^2 C ; \alpha = \sqrt{\frac{K_h}{C}} = \sqrt{\frac{1 \times 10^{-9}}{.001}} = 1 \times 10^{-3}$$

7. (c)  $K_a \times K_b = K_w$

$$\therefore K_a = \frac{K_w}{K_b} = \frac{10^{-14}}{1.48 \times 10^{-11}} = 6.75 \times 10^{-4}$$

8. (a)  $[H^+] = 5.5 \times 10^{-3} \text{ mole/litre}$

$$pH = -\log [H^+] ; pH = -\log [5.5 \times 10^{-3}] ; pH = 2.26$$

9. (a)  $pH = pK_a + \log \frac{[\text{Salt}]}{[\text{Acid}]}$

$$pH = 4.3 + \log \frac{1}{\frac{1}{2}} = 4.3 + \log 2 ; pH = 4.3 + 0 = 4.3$$

10. (b)  $[H^+] = C\alpha = 0.01 \times \frac{1.25}{100}$

$$H^+ = 1.25 \times 10^{-3} ; pH = \text{between } 2 \text{ or } 3 = 2.90$$

11. (d) M.eq. of  $HCl = \frac{1}{5} \times 75 = 15$

$$\text{M.eq. of } NaOH = 25 \times \frac{1}{5} = 5$$

$$\text{Total No. of eq.} = 15 - 5 = 10$$

$$\text{Total volume} = 100$$

$$\text{Normality} = \frac{10}{100} = \frac{1}{10}, [H^+] = 10^{-1} M$$

12. (b)  $AgBr$  are not dissolved in  $NaBr$  and  $HBr$  due to common ion effect. And pure water is a neutral solvent. They do not have ions.

13. (a)  $CaC_2O_4$  is a binary electrolyte. Then solubility is

$$S = \sqrt{K_{sp}} = \sqrt{2.5 \times 10^{-9}} \\ = 5 \times 10^{-5} \text{ mole/l.} = 0.0064 \text{ gm/l.}$$

14. (a)

15. (d)  $Mg(OH)_2 \rightleftharpoons Mg^{++} + 2OH^-$

$$K_{sp} = S \times 4S^2$$

$$\frac{K_{sp}}{S \times 4} = S^2 = \frac{9 \times 10^{-12}}{.010 \times 4} = 2.25 \times 10^{-10}$$

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$$S = \sqrt{2.25 \times 10^{-10}} = 1.5 \times 10^{-5} \text{ mol/l}$$

16. (c) For hydrolysis of  $B^+$ ;  $K_H = \frac{K_w}{K_b} = \frac{10^{-14}}{10^{-6}} = 10^{-8}$ .

17. (a)  $A_p B_q \rightleftharpoons pA^{1+} + qB^{p-}$

$$L_s = [A^{q+}]^p [B^{p-}]^q = (p \times S)^p (q \times S)^q = S^{p+q} \cdot p^p \cdot q^q.$$

18. (c)  $H_3O^+ > HF > NH_4^+ > H_2O > OH^-$ .

Acidic nature is decreasing order.

19. (a) Solubility of  $CaC_2O_4 = \sqrt{K_{sp}} = \sqrt{2.5 \times 10^{-9}}$

$$= 5 \times 10^{-5} \text{ mol/L}^{-1}$$

$$= 5 \times 10^{-5} \times 128 = 640 \times 10^{-5} = 0.0064 \text{ g}$$

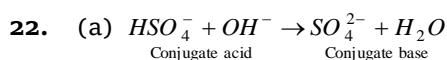
20. (d)  $K_{sp}$  of  $Ag_2CrO_4 = [Ag^+]^2 [CrO_4^{2-}]$

$$CrO_4^{2-} = 2 \times 10^{-4} \text{ then } Ag^+ = 2 \times 2 \times 10^{-4}$$

$$K_{sp} = (4 \times 10^{-4})^2 (2 \times 10^{-4}) = 32 \times 10^{-12}$$

21. (c) Relative strength of bases can be shown by their conjugated acids.

Conjugate acid of  $OH^-$  is  $H_2O$  which is a weak acid conjugate acid of  $CH_3COO^-$  is  $CH_3COOH$  which is stronger than  $H_2O$ . while conjugate acid of  $Cl^-$  is  $HCl$  which is strongest out of there. so the order of relative strength of bases is  $OH^- > CH_3COO^- > Cl^-$ .



23. (a) One mole oxalic acid & 0.5 mole of  $NaOH$  will make.

24. (b) Smallest value of  $K_b$  indicates that aniline ( $C_6H_5NH_2$ ) is the weakest base.

25. (a)  $[H^+]^2 = C \cdot \alpha = 0.1 \times 5 \times 10^{-8}$

$$H^+ = \sqrt{5 \times 10^{-9}} = 7.07 \times 10^{-5} \text{ M.}$$

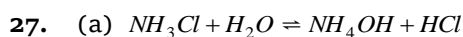
26. (d)  $K_{sp} = [Cr^{3+}][OH^-]^3$

$$[OH^-]^3 = K_{sp} / Cr^{3+} = \frac{6 \times 10^{-31}}{1 \times 10^{-1}} = 6 \times 10^{-30}$$

$$[OH^-] = 1.8 \times 10^{-10}$$

$$pOH = (\log 1.8 + \log 10^{10}) = 10 + 0.25 + 1 = 11.25$$

$$pH = 14 - 11.25 = 2.27$$



$NH_4Cl$  is a salt of weak base & strong acid so solution will be acidic.

28. (a)  $H^+ = C\alpha$

$$\alpha = \frac{H^+}{C} = \frac{10^{-4}}{10^{-2}} = 10^{-6}$$

29. (a)  $pH = -\log K_a + \log \frac{[Salt]}{[Acid]}$

$$= -\log [1.8 \times 10^{-5}] + \log \frac{0.2}{0.1} = 4.87$$

30. (c)  $N_1 V_1 = .04 \times 100 = 4$

$$N_2 V_2 = .02 \times 100 = 2$$

$$N_1 V_1 - N_2 V_2 = N_3 V_3$$

$$4 - 2 = N_3 \times 200, N_3 = 10^{-2} \text{ M}$$

$$pH = \log 10 \frac{1}{H^+} = \log 10 \frac{1}{10^{-2}} = 2.$$

31. (b)  $pH = 4.7$

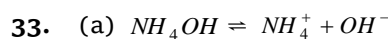
$$pH + pOH = 14; pH = 14 - 4.7; pOH = 9.3$$

$$[OH^-] = \text{Antilog } [-pOH] = \text{Antilog } [-9.3]$$

$$[OH^-] = 5 \times 10^{-10}$$

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32. (c)  $[H^+] = C \cdot \alpha = 0.2 \times 0.60 = 0.12 \text{ M}$



$$K_b = C\alpha^2; \frac{1.8 \times 10^{-5}}{.1} = \alpha^2; \alpha = 1.34 \times 10^{-3}$$

$$[OH^-] = \alpha \cdot C = 1.34 \times 10^{-3} \times .1$$

$$pOH = \log 10 \frac{1}{1.34 \times 10^{-4}}; pOH = 2.87$$

$$pH + pOH = 14; pH + 2.87 = 14$$

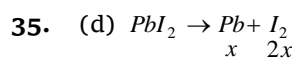
$$pH = 14 - 2.87; pH = 11.13$$

34. (b)  $M = \frac{\text{Solute in 1 litre solution}}{\text{Molecular weight of solute}}$

$$= \frac{40 \times 10^{-3}}{40} \times \frac{1}{10} = 10^{-4} \text{ M}$$

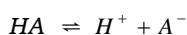
$$pOH = \log 10 \frac{1}{[OH^-]} = \log 10 \frac{1}{10^{-4}} = 4$$

$$pH + pOH = 14; pH + 4 = 14 \Rightarrow pH = 10.$$



$$K_{sp} = 4x^3 = 4(.005)^3 = 4 \times .005 \times .005 = .4 \times 10^{-6}.$$

36. (d)  $\therefore$  Monoprotic acid  $HA$



Ionisation constant = ?

$$\alpha = 0.001\% = \frac{0.001}{100} = 10^{-5}$$

$$K = \frac{\alpha^2}{V} = \frac{[10^{-5}]^2}{10} = 10^{-11}$$

37. (a)  $pK_a \ll$  then strongest acid

$pK_a \gg$  then weak acid

$$pK_a \propto \frac{1}{\text{Acidic strength}}$$

38. (c)  $\underset{10^{-6}}{H_3O^+} \rightarrow \underset{10^{-6}}{H_2O} + \underset{10^{-6}}{H^+}$

$$K_w = [H_2O][H^+] = [10^{-6}][10^{-6}] = 10^{-12}$$

39. (b) Neutralization reaction will take place and form salt of strong acid and strong base. Which does not hydrolyse and thus  $pH = 7$ .