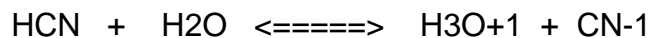


Acid-Base Ka, Kb, pKa & pKb Worksheet Solutions

1. a) 0.50 M HCN Ka for hydrocyanic acid = 4.9×10^{-10}



i	0.50 M	-----	-----
c	-x	+x	+x
e	0.5 - x	x	x

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{CN}^-]}{[\text{HCN}]}$$

$$4.9 \times 10^{-10} = \frac{(x)(x)}{(0.50 - x)}$$

$$2.45 \times 10^{-10} - 4.9 \times 10^{-10}x = x^2$$

$$x^2 + 4.9 \times 10^{-10}x - 2.45 \times 10^{-10} = 0 \quad (\text{solve with the quadratic equation})$$

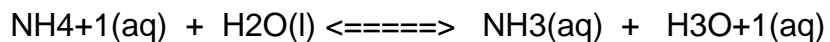
$$x = 1.57 \times 10^{-5} \text{ therefore } [\text{H}_3\text{O}^+] = 1.57 \times 10^{-5} \text{ mole/L}$$

b) $\text{pH} = 4.805$

c) $\frac{1.57 \times 10^{-5} \times 100\%}{0.5} = 0.00314\%$

2. a) First the NH_4NO_3 dissociates into its ions. $\text{NH}_4\text{NO}_3(\text{aq}) \rightarrow \text{NH}_4^+(\text{aq}) + \text{NO}_3^-(\text{aq})$

Then the $\text{NH}_4^+(\text{aq})$ acts like an acid in the water.



i	0.1 M	-----	-----
c	-x	+x	+x
e	0.1 - x	x	x

$$K_a = \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4^+]}$$

$$K_a = 5.6 \times 10^{-10} = x^2 / 0.1 - x$$

$$5.6 \times 10^{-11} - 5.6 \times 10^{-10}x = x^2$$

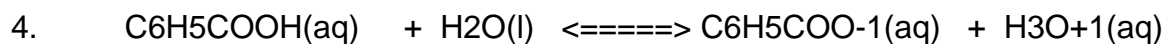
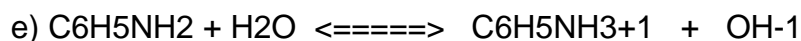
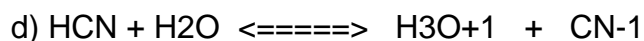
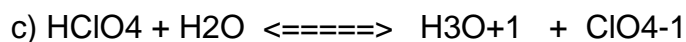
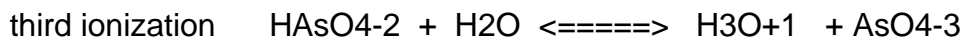
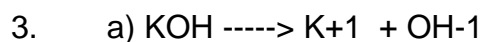
$$x^2 + 5.6 \times 10^{-10}x - 5.6 \times 10^{-11} = 0$$

$$x = 7.48 \times 10^{-6} \text{ therefore } [H_3O^+] = 7.48 \times 10^{-6} \text{ mol/L}$$

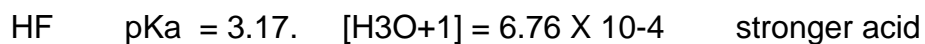
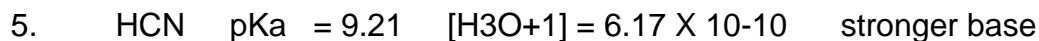
$$b) \text{ pH} = -\log [H_3O^+] = 7.48 \times 10^{-6} \text{ mol/L} = 5.13$$

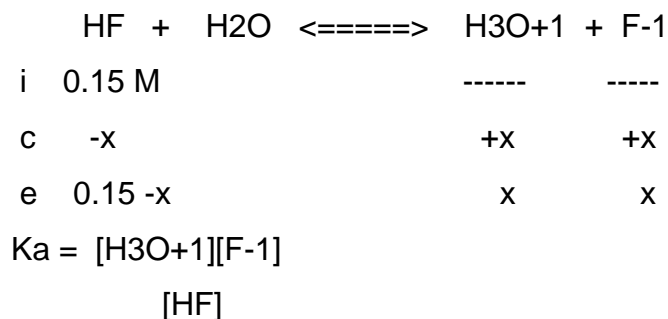
$$c) \text{ pOH} = 14 - \text{pH} = 14 - 5.13 = 8.87$$

$$d) \text{ the \% dissociation is } 7.48 \times 10^{-6} / 0.1 \times 100 \% = 0.0075\%$$



$$K_a = [C_6H_5COO^-][H_3O^+] / [C_6H_5COOH]$$





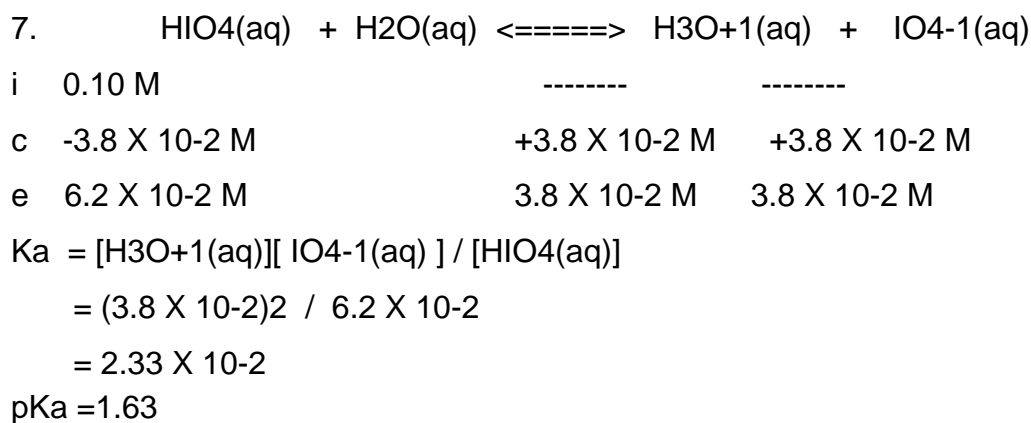
$$5.6 \times 10^{-4} = \frac{(x)(x)}{(0.15 - x)}$$

$$8.4 \times 10^{-5} - 5.6 \times 10^{-4}x = x^2$$

$$x^2 + 5.6 \times 10^{-4}x - 8.4 \times 10^{-5} = 0 \quad (\text{solve with the quadratic equation})$$

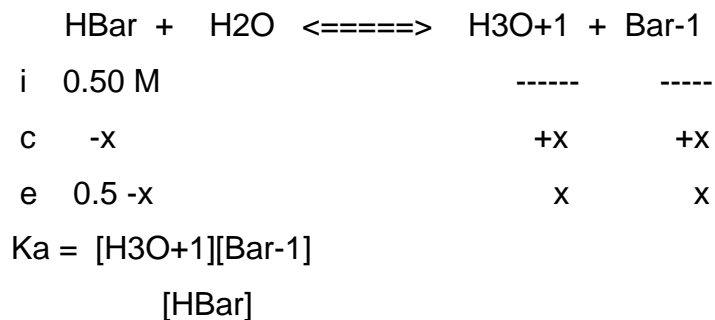
$$x = 8.88 \times 10^{-3} \text{ therefore } [\text{H}_3\text{O}^+] = 8.88 \times 10^{-3} \text{ mole/L}$$

$$\text{pH} = 2.05 \quad \% \text{ ionization} = 5.92\%$$



8. $\text{p}K_a$ for barbituric acid = 4.01

$$K_a = 9.77 \times 10^{-5}$$



$$9.77 \times 10^{-5} = \frac{(x)(x)}{(0.50 - x)}$$

$$4.89 \times 10^{-6} - 9.77 \times 10^{-5}x = x^2$$

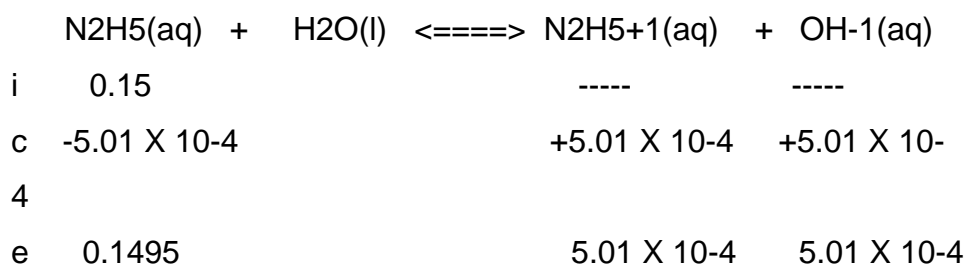
$$x^2 + 9.77 \times 10^{-5}x - 4.89 \times 10^{-6} = 0 \quad (\text{solve with the quadratic equation})$$

$$x = 2.16 \times 10^{-3} \text{ therefore } [\text{H}_3\text{O}^+] = 2.16 \times 10^{-3} \text{ mole/L}$$

$$[\text{H}^+] = 2.16 \times 10^{-3} ; \text{ pH} = 2.67$$

9. $\text{pH} = 10.70$ therefore $\text{pOH} = 3.3$

$$[\text{OH}^-] = 5.01 \times 10^{-4} \text{ M}$$



$$\begin{aligned} K_b &= \frac{[\text{N}_2\text{H}_5^+][\text{OH}^-]}{[\text{N}_2\text{H}_5]} \\ &= \frac{(5.01 \times 10^{-4})^2}{0.1495} \\ &= 1.68 \times 10^{-6} \end{aligned}$$

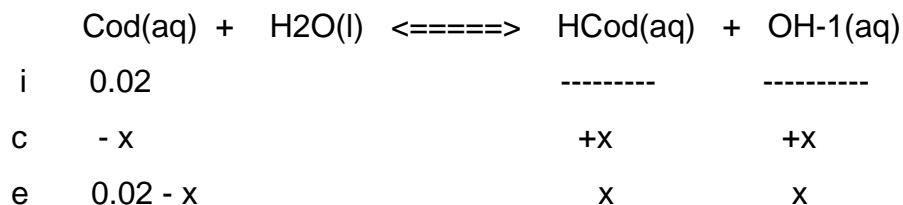
$$\text{p}K_b = 5.77$$

$$\text{p}K_a = 8.23$$

$$K_a = 5.89 \times 10^{-9}$$

10. $\text{p}K_b = 5.79$

$$K_b = 1.62 \times 10^{-6}$$



$$1.62 \times 10^{-6} = \frac{x^2}{(0.02 - x)}$$

$$3.24 \times 10^{-8} - 1.62 \times 10^{-6}x = x^2$$

$$x^2 + 1.62 \times 10^{-6}x - 3.24 \times 10^{-8} = 0$$

$$x = 1.79 \times 10^{-4}$$

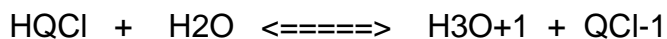
$$\text{therefore } [\text{OH}^-] = 1.79 \times 10^{-4} \text{ M,}$$

so $\text{pOH} = 3.75$ and $\text{pH} = 10.25$

11. pKb for Quinine chloride = 5.48

pKa for its conjugate = 8.52

$$K_a = 3.02 \times 10^{-9}$$



i	0.15 M	-----	-----
c	-x	+x	+x
e	0.15 -x	x	x

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{QCl}^-]}{[\text{HQCl}]}$$

$$3.02 \times 10^{-9} = \frac{(x)(x)}{(0.15 - x)}$$

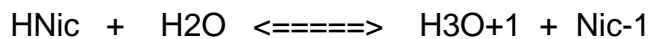
$$4.53 \times 10^{-10} - 3.02 \times 10^{-9}x = x^2$$

$$x^2 + 3.02 \times 10^{-9}x - 4.53 \times 10^{-10} = 0 \quad (\text{solve with the quadratic equation})$$

$$x = 2.13 \times 10^{-5} \text{ therefore } [\text{H}_3\text{O}^+] = 2.13 \times 10^{-5} \text{ mole/L}$$

$$\text{pH} = 4.67$$

12. K_a for nicotinic acid = 1.4×10^{-5}



i	0.01 M	-----	-----
c	-x	+x	+x
e	0.01 -x	x	x

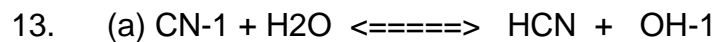
$$K_a = \frac{[\text{H}_3\text{O}^+][\text{Nic}^-]}{[\text{HNic}]}$$

$$1.4 \times 10^{-5} = \frac{(x)(x)}{(0.01 - x)}$$

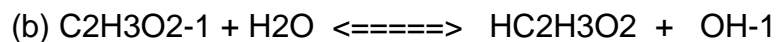
$$1.4 \times 10^{-7} - 1.4 \times 10^{-4}x = x^2$$

$$x^2 + 1.4 \times 10^{-4}x - 1.4 \times 10^{-7} = 0 \quad (\text{solve with the quadratic equation})$$

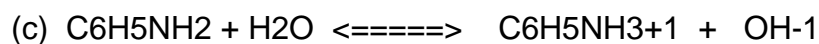
$x = 3.67 \times 10^{-4}$ therefore $[\text{H}_3\text{O}^+] = 3.67 \times 10^{-4} \text{ mole/L}$
 so $\text{pH} = 3.44$



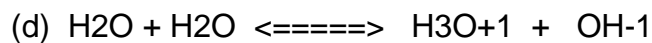
$$K_b = \frac{[\text{HCN}][\text{OH}^-]}{[\text{CN}^-]}$$



$$K_b = \frac{[\text{HC}_2\text{H}_3\text{O}_2][\text{OH}^-]}{[\text{C}_2\text{H}_3\text{O}_2^-]}$$



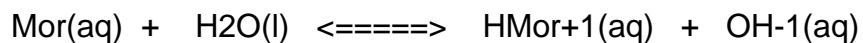
$$K_b = \frac{[\text{C}_6\text{H}_5\text{NH}_3^+][\text{OH}^-]}{[\text{C}_6\text{H}_5\text{NH}_2]}$$



$$K_b = \frac{[\text{H}_3\text{O}^+][\text{OH}^-]}{[\text{H}_2\text{O}]^2}$$

14. $\text{pH} = 10.10$ therefore $\text{pOH} = 3.9$ and

$$[\text{OH}^-] = 1.26 \times 10^{-4} \text{ M}$$



i	0.01	-----	-----
c	-1.26×10^{-4}	$+1.26 \times 10^{-4}$	$+1.26 \times 10^{-4}$
e	9.87×10^{-3}	1.26×10^{-4}	1.26×10^{-4}

$$K_b = \frac{[\text{HMor}^+][\text{OH}^-]}{[\text{Mor}]}$$

Mor

$$= \frac{(1.26 \times 10^{-4})^2}{9.87 \times 10^{-3}}$$

$$= 1.605 \times 10^{-6}$$