

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

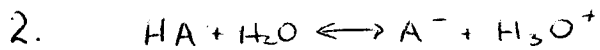
d. let $x = [\text{H}_3\text{O}^+]$, then $[\text{CN}^-] = x$ and $[\text{HCN}] = 0.25\text{M} - x \approx 0.25\text{M}$ if x is small
 $K_a = 4.9 \times 10^{-10} = \frac{x^2}{0.25}$ $x = [\text{H}_3\text{O}^+] = \underline{1.1 \times 10^{-5}\text{M}}$

e. $\text{pH} = -\log [\text{H}_3\text{O}^+] = -\log (1.1 \times 10^{-5}\text{M}) = \underline{4.96}$

f. $[\text{H}_3\text{O}^+][\text{OH}^-] = K_w$ $[\text{OH}^-] = \frac{1.00 \times 10^{-14}}{1.1 \times 10^{-5}\text{M}} = \underline{9.0 \times 10^{-10}\text{M}}$

g. $[\text{HCN}]_{\text{eqm}} = [\text{HCN}]_{\text{initial}} - 1.1 \times 10^{-5}\text{M} = \underline{0.25\text{M}}$

h. % dissociation = $\frac{1.1 \times 10^{-5}\text{M}}{0.25\text{M}} \times 100 = \underline{4.4 \times 10^{-3}\%}$



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

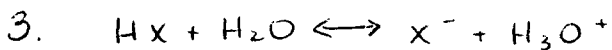
$[\text{H}_3\text{O}^+] = \text{antilog}(-3.45) = 3.55 \times 10^{-4}\text{M}$

$[\text{A}^-] = [\text{H}_3\text{O}^+] = 3.55 \times 10^{-4}\text{M}$

$[\text{HA}] = 0.20\text{M} - 3.55 \times 10^{-4}\text{M} = 0.20\text{M}$

$K_a = \frac{(3.55 \times 10^{-4})^2}{0.20} = \underline{6.3 \times 10^{-7}}$

% dissociation = $\frac{3.55 \times 10^{-4}\text{M}}{0.20\text{M}} \times 100 = \underline{1.8 \times 10^{-1}\%}$



$K_a = \frac{[\text{X}^-][\text{H}_3\text{O}^+]}{[\text{HX}]} = 1.0 \times 10^{-8}$

let $x = [\text{H}_3\text{O}^+]$, then $[\text{X}^-] = x$

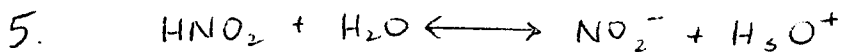
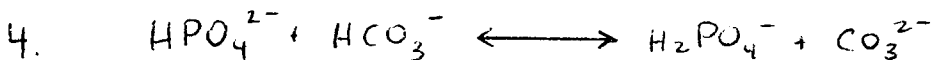
and $[\text{HX}] = 1.0\text{M} - x \approx 1.0\text{M}$ if x is small

$1.0 \times 10^{-8} = \frac{x^2}{1.0}$

$x = [\text{H}_3\text{O}^+] = 1.0 \times 10^{-4}\text{M}$

$\text{pH} = -\log [\text{H}_3\text{O}^+] = -\log (1.0 \times 10^{-4})$

$\underline{\text{pH} = 4.00}$



$K_a = \frac{[\text{NO}_2^-][\text{H}_3\text{O}^+]}{[\text{HNO}_2]} = 4.6 \times 10^{-4}$

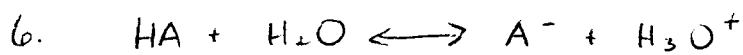
let $x = [\text{H}_3\text{O}^+]$, then $[\text{NO}_2^-] = x$

and $[\text{HNO}_2] = 0.40\text{M} - x$

$\approx 0.40\text{M}$ if x is small

$4.6 \times 10^{-4} = \frac{x^2}{0.40}$

$x = [\text{H}_3\text{O}^+] = \underline{1.4 \times 10^{-2}\text{M}}$



$[H_3O^+] = 4.5 \times 10^{-4} M$

$[A^-] = [H_3O^+] = 4.5 \times 10^{-4} M$

$[HA] = 0.35 - 4.5 \times 10^{-4} M = 0.35 M$

$K_a = \frac{[A^-][H_3O^+]}{[HA]}$

$K_a = \frac{(4.5 \times 10^{-4} M)^2}{0.35} = 5.8 \times 10^{-7}$

this acid is between H_2CO_3 and $Al(H_2O)_6^{3+}$ on the Strengths of Acids table.



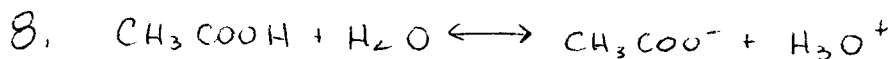
let $x = [H_3O^+]$, then $[CN^-] = x$

and $[HCN] = \frac{1.6 \text{ mols}}{2.0 L} - x \approx 0.80 M$ if x is small

$K_a = \frac{[CN^-][H_3O^+]}{[HCN]} = 4.9 \times 10^{-10}$

$4.9 \times 10^{-10} = \frac{x^2}{0.80}$

$x = [CN^-] = \underline{2.0 \times 10^{-5} M}$



$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]} = 1.8 \times 10^{-5}$

$[H_3O^+] = \text{antilog}(-2.456) = 3.499 \times 10^{-3} M$

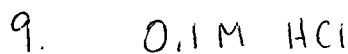
$[CH_3COO^-] = [H_3O^+] = 3.499 \times 10^{-3} M$

$1.8 \times 10^{-5} = \frac{(3.499 \times 10^{-3})^2}{[CH_3COOH]_{\text{initial}} - 3.499 \times 10^{-3} M}$

$[CH_3COOH] = [CH_3COOH]_{\text{initial}} - 3.499 \times 10^{-3} M$

$[CH_3COOH]_{\text{initial}} = 6.8 \times 10^{-1} M$ mols $CH_3COOH = 0.68 M \times 2.00 L = 1.4 \text{ mol}$

mass $CH_3COOH = 1.4 \text{ mol} \times 60.0 g/mol = \underline{82 g}$.



$\frac{1.0 \text{ mL} \times 0.1 M}{100. \text{ mL}} = 1.0 \times 10^{-3} M \text{ HCl}$

pH = 1.0

pH = 3.0

changes by 2.0 pH units.



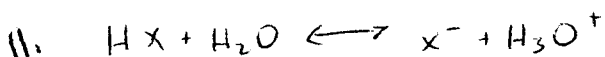
$K_a = \frac{[X^-][H_3O^+]}{[HX]}$

$[H_3O^+] = \text{antilog}(-1.40) = 3.98 \times 10^{-2} M$

$[X^-] = [H_3O^+] = 3.98 \times 10^{-2} M$

$[HX] = 0.18 M - 3.98 \times 10^{-2} M = 0.140 M$

$K_a = \frac{(3.98 \times 10^{-2} M)^2}{0.140 M} = \underline{1.1 \times 10^{-2}}$



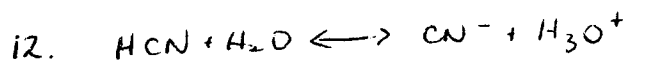
$K_a = \frac{[X^-][H_3O^+]}{[HX]}$

$[H_3O^+] = \text{antilog}(-4.26) = 5.50 \times 10^{-5} M$

$[X^-] = [H_3O^+] = 5.50 \times 10^{-5} M$

$[HX] = 1.0 M - 5.50 \times 10^{-5} M = 1.0 M$

$K_a = \frac{(5.50 \times 10^{-5})^2}{1.0} = \underline{3.0 \times 10^{-9}}$



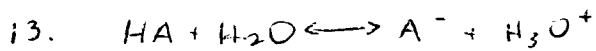
$$K_a = \frac{[\text{CN}^-][\text{H}_3\text{O}^+]}{[\text{HCN}]} = 4.9 \times 10^{-10}$$

let $[\text{H}_3\text{O}^+] = x$, then $[\text{CN}^-] = x$
and $[\text{HCN}] = 0.20\text{M} - x$
 $\approx 0.20\text{M}$ if x is small

$$4.9 \times 10^{-10} = \frac{x^2}{0.20}$$

$$[\text{H}_3\text{O}^+] = x = 9.90 \times 10^{-6}\text{M}$$

$$\% \text{ dissociation} = \frac{9.90 \times 10^{-6}\text{M}}{0.20\text{M}} \times 100 = \underline{4.9 \times 10^{-3} \%}$$



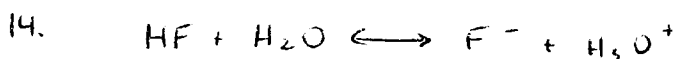
$$K_a = \frac{[\text{A}^-][\text{H}_3\text{O}^+]}{[\text{HA}]}$$

$$K_a = \frac{(2.5 \times 10^{-5})^2}{0.10} = \underline{6.3 \times 10^{-9}}$$

$$[\text{H}_3\text{O}^+] = 0.025\% \times 0.10\text{M} = 2.5 \times 10^{-5}\text{M}$$

$$[\text{A}^-] = [\text{H}_3\text{O}^+] = 2.5 \times 10^{-5}\text{M}$$

$$[\text{HA}] = 0.10\text{M} - 2.5 \times 10^{-5}\text{M} = 0.10\text{M}$$



$$K_a = \frac{[\text{F}^-][\text{H}_3\text{O}^+]}{[\text{HF}]} = 3.5 \times 10^{-4}$$

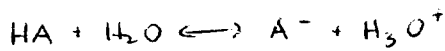
$$3.5 \times 10^{-4} = \frac{x^2}{0.50}$$

$$x = [\text{H}_3\text{O}^+] = 1.32 \times 10^{-2}\text{M}$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+]$$

$$\text{pH} = -\log (1.32 \times 10^{-2}\text{M}) = \underline{1.88}$$

15.



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

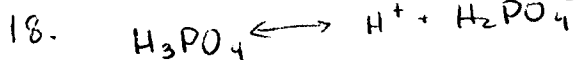
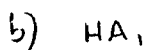
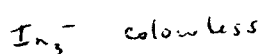
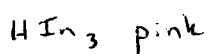
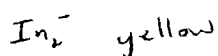
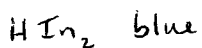
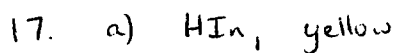
$$K_a = \frac{(2.51 \times 10^{-2})^2}{7.49 \times 10^{-2}} = \underline{8.4 \times 10^{-3}}$$

$$[\text{H}_3\text{O}^+] = \text{antilog}(-1.60) = 2.51 \times 10^{-2}\text{M}$$

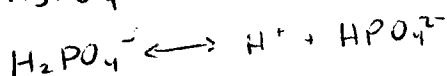
$$[\text{A}^-] = [\text{H}_3\text{O}^+] = 2.51 \times 10^{-2}\text{M}$$

$$[\text{HA}] = 0.10\text{M} - 2.51 \times 10^{-2}\text{M} = 7.49 \times 10^{-2}\text{M}$$

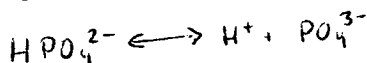
16. $\text{p}K_a = -\log K_a = -\log (1.5 \times 10^{-9}) = \underline{8.82}$



$$K_{a1} = \frac{[\text{H}^+][\text{H}_2\text{PO}_4^-]}{[\text{H}_3\text{PO}_4]} = 7.5 \times 10^{-3}$$

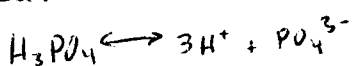


$$K_{a2} = \frac{[\text{H}^+][\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]} = 6.2 \times 10^{-8}$$



$$K_{a3} = \frac{[\text{H}^+][\text{PO}_4^{3-}]}{[\text{HPO}_4^{2-}]} = 2.2 \times 10^{-13}$$

overall:



$$K_T = \frac{[\text{H}^+]^3 [\text{PO}_4^{3-}]}{[\text{H}_3\text{PO}_4]} = K_1 \times K_2 \times K_3 = \underline{1.0 \times 10^{-22}}$$

$$19. [H^+] = \text{antilog}(-7.43) = 3.7 \times 10^{-8} \text{ M}$$

$$[OH^-] = \frac{k_w}{[H^+]} = \frac{1.00 \times 10^{-14}}{3.7 \times 10^{-8}} = \underline{2.7 \times 10^{-7} \text{ M}}$$

20. HCl is a strong acid so $[H_3O^+] = [HCl] = 2.0 \text{ M}$

$$\text{pH} = -\log [H_3O^+] = -\log(2.0) = \underline{-0.30}$$

21. NaOH is highly soluble, so $[OH^-] = 0.15 \text{ M}$

$$\text{pOH} = -\log [OH^-] = -\log(0.15 \text{ M}) = 0.824$$

$$\text{pH} + \text{pOH} = \text{p}K_w \quad \text{p}K_w = 14.000 \text{ at } 25^\circ \text{C}$$

$$\text{pH} = 14.000 - 0.824 = \underline{13.18}$$

22. $\text{Ba(OH)}_2 \rightarrow 2\text{OH}^- \quad [OH^-] = 2 \times 0.025 \text{ M} = 0.050 \text{ M}$

$$\text{pOH} = -\log [OH^-] = 1.301$$

$$\text{pH} = 14.000 - 1.301 = \underline{12.70}$$