Equilibrium Practice 3: **Acids and Bases** ANSWERS

4. (a) acid: HNO_2 conjugate base: NO_2^-
base: HCO_3^- conjugate acid: H_2CO_3

(b) acid: HF conjugate base: F^-
base: NH_3 conjugate acid: NH_4^+

7. (a) strong acid

$HBr(aq) \rightarrow H^+(aq) + Br^-(aq)$

$[H^+] = 0.050$ mol/L

$$\begin{aligned} pH &= -\log [H^+] \\ &= -\log (0.050) \\ &= 1.3010... \end{aligned}$$

Therefore, the pH of the solution is 1.30

(b) weak base

	$C_6H_5NH_2(aq)$	+	$H_2O(l)$	$\rightleftharpoons$	$C_6H_5NH_3^+(aq)$	+	$OH^-(aq)$
I	0.050		—		0		~0
C	–x		—		+x		+x
E	0.050–x		—		x		x

$$K_b = \frac{[C_6H_5NH_3^+(aq)]\,[OH^-(aq)]}{[C_6H_5NH_2(aq)]}$$

$$4.1\times10^{-10} = \frac{(x)(x)}{0.050-x}$$

$$4.1\times10^{-10} = \frac{x^2}{0.050-x}$$

$$4.1\times10^{-10} = \frac{x^2}{0.050}$$ small K_a ; assume 0.050–x =0.050

$2.05\times10^{-11} = x^2$ {multiply by 0.050}

$4.5276...\times10^{-6} = x$ {square root}

$[OH^-]_{eq}$ = x mol/L
= $4.5276...\times10^{-6}$ mol/L

$K_w = [H^+(aq)]\,[OH^-(aq)]$

$$[H^+(aq)] = \frac{K_w}{[OH^-(aq)]}$$

$$= \frac{1.0\times10^{-14}}{4.5276...\times10^{-6}}$$

$$= 2.2086...\times10^{-9} \text{ mol/L}$$

$$\begin{aligned} pH &= -\log [H^+] \\ &= -\log (2.2086...\times10^{-9}) \\ &= 8.6558... \end{aligned}$$

Therefore the pH of the solution is 8.66.

(c) strong base

$LiOH(aq) \rightarrow Li^+(aq) + OH^-(aq)$

$[OH^-]$ = 0.050 mol/L

$$[H^+(aq)] = \frac{K_w}{[OH^-(aq)]}$$

$$= \frac{1.0\times10^{-14}}{0.050}$$

$$= 2\times10^{-13} \text{ mol/L}$$

$$\begin{aligned} pH &= -\log [H^+] \\ &= -\log (2\times10^{-13}) \\ &= 12.6989... \end{aligned}$$

Therefore the pH of the solution is 12.70.

(d) weak acid

	$C_6H_5COOH(aq)$ $\rightleftharpoons$	$C_6H_5COO^-$	+ $H^+(aq)$
I	0.050	0	~0
C	–x	+x	+x
E	0.050–x	x	x

$$K_a = \frac{[C_6H_5COO^-(aq)]\,[H^+(aq)]}{[C_6H_5COOH(aq)]}$$

$$6.3\times10^{-5} = \frac{(x)(x)}{0.050-x}$$

$$6.3\times10^{-5} = \frac{x^2}{0.050-x}$$

$$6.3\times10^{-5} = \frac{x^2}{0.050} \qquad \text{(small } K_a\text{ ; assume } 0.050-x = 0.050\text{)}$$

$$3.15\times10^{-6} = x^2 \qquad \{\text{multiply by } 0.050\}$$

$$1.7748...\times10^{-3} = x \qquad \{\text{square root}\}$$

$$[H^+]_{eq} = x \text{ mol/L}$$
$$= 1.7748...\times10^{-3} \text{ mol/L}$$

$$pH = -\log[H^+]$$
$$= -\log(1.7748...\times10^{-3})$$
$$= 2.7508...$$

Therefore, the pH of the solution is 2.75.

(e) weak base

	$NH_3(aq)$	+	$H_2O(l)$	$\rightleftharpoons$	$NH_4^+(aq)$	+	$OH^-(aq)$
I	0.050		—		0		~0
C	–x		—		+x		+x
E	0.050–x		—		x		x

$$K_b = \frac{[NH_4^+(aq)]\,[OH^-(aq)]}{[NH_3(aq)]}$$

$$1.8\times10^{-5} = \frac{(x)(x)}{0.050-x}$$

$$1.8\times10^{-5} = \frac{x^2}{0.050-x}$$

$$1.8\times10^{-5} = \frac{x^2}{0.050} \qquad \text{(small } K_b\text{ ; assume } 0.050-x = 0.050\}$$

$$9\times10^{-7} = x^2 \qquad \{\text{multiply by } 0.050\}$$

$$9.4868...\times10^{-4} = x \qquad \{\text{square root}\}$$

$$[OH^-]_{eq} = x \text{ mol/L}$$
$$= 9.4868...\times10^{-4} \text{ mol/L}$$

$$K_w = [H^+(aq)]\,[OH^-(aq)]$$

$$[H^+(aq)] = \frac{K_w}{[OH^-(aq)]}$$

$$= \frac{1.0\times10^{-14}}{9.4868...\times10^{-4}}$$

$$= 1.05409...\times10^{-11} \text{ mol/L}$$

$$pH = -\log [H^+]$$
$$= -\log (1.05409...\times10^{-11})$$
$$= 10.9771...$$

Therefore the pH of the solution is 10.98.

(f) strong base

$Ba(OH)_2(aq) \rightarrow Ba^{2+}(aq) + 2\ OH^-(aq)$

$[OH^-] = 2(0.050\ mol/L) = 0.10\ mol/L$

$$[H^+(aq)] = \frac{K_w}{[OH^-(aq)]}$$

$$= \frac{1.0\times10^{-14}}{0.10}$$

$$= 1\times10^{-13}\ mol/L$$

$$pH = -\log[H^+]$$
$$= -\log(1\times10^{-13})$$
$$= 13$$

Therefore the pH of the solution is 13.00.

(g) weak acid

	HCN(aq)	⇌	H^+	+	CN^-(aq)
I	0.050		~0		0
C	–x		+x		+x
E	0.050–x		x		x

$$K_a = \frac{[H^+(aq)][CN^-(aq)]}{[HCN(aq)]}$$

$$6.2\times10^{-10} = \frac{(x)(x)}{0.050-x}$$

$$6.2\times10^{-10} = \frac{x^2}{0.050-x}$$

$$6.2\times10^{-10} = \frac{x^2}{0.050}$$ (small K_a ; assume 0.050–x =0.050)

$3.1\times10^{-11} = x^2$ {multiply by 0.050}

$5.5677...\times10^{-6} = x$ {square root}

$$[H^+]_{eq} = x \text{ mol/L}$$
$$= 5.5677... \times 10^{-6} \text{ mol/L}$$

$$pH = -\log [H^+]$$
$$= -\log (5.5677... \times 10^{-6})$$
$$= 5.2543...$$

Therefore, the pH of the solution is 5.25.