WKS 15-3
Acid/Base Equilibrium: K_a & K_b

Name Answer Key
Period _____ Date_____

1) For each of the following reactions, finish the reactions if needed, then use the K_a values in Chart H to predict whether the equilibrium lies to the left or to the right. To help explain your decision, label substances as "weaker acid", "stronger acid", "weaker base"....

a) $H_2S\ (aq) + CO_3^{2-}\ (aq) \rightleftharpoons HS^-\ (aq) + HCO_3^-\ (aq)$ **(left , right)**

stronger acid stronger base weaker base weaker acid

b) $NH_4^+\ (aq) + Br^-\ (aq) \rightleftharpoons NH_3\ (aq) + HBr\ (aq)$ **(left , right)**

weaker acid weaker base stronger base stronger acid

c) $HNO_2\ (aq) + HPO_4^{2-}\ (aq) \rightleftharpoons NO_2^-\ (aq) + H_2PO_4^-\ (aq)$ **(left , right)**

stronger acid stronger base weaker base weaker acid

d) $C_6H_5OH\ (aq) + CH_3COO^-\ (aq) \rightleftharpoons C_6H_5O^-\ (aq) + CH_3COOH\ (aq)$ **(left , right)**

K_a of $C_6H_5OH = 1.3 \times 10^{-10}$

weaker acid weaker base stronger base stronger acid

2) H_3PO_4 which contains three hydrogen atoms per molecule is a weak acid, whereas HCl, which contains only one hydrogen atom per molecule, is a strong acid. Explain why.
Strengths of acids depend on how easily the acid loses an H^+. The H–Cl bond is more polar than the O–H bond in H_3PO_4, so it is a stronger acid. The number of H's has no effect.

3) Based on the information given in Chart H, rank the acids HF, H_2S, HNO_3 and CH_3COOH from strongest to weakest, then identify the following:

Ranking: Strongest acid HNO_3 > HF > CH_3COOH > H_2S weakest acid

a) strongest acid: HNO_3

b) weakest acid: H_2S

c) strongest conjugate base produced by the acids listed: HS^-

d) weakest conjugate base produced by the acids listed: NO_3^-

4) Explain why the conjugate base of a strong acid is a *very* weak base and the conjugate acid of a strong base is a *very* weak acid.
A strong acid has a weak bond to the H^+, so easily loses it. The base thus has no tendency to bond to the H^+ since the bond formed would be weak and easily broken. A strong base forms a strong bond to the H^+, so the bond is too strong for the conjugate acid formed to lose it, and it would be quickly gained back if lost.

5) A 0.015 M solution of hydrogen cyanide (HCN, otherwise known as cyanic acid) has a hydronium ion (H_3O^+) concentration equal to 3.05×10^{-6} M. Complete the reaction, then write the K_a expression for HCN and determine its value.

	$HCN\ (aq)$	+	$H_2O\ (l)$	⇌	$CN^-\ (aq)$	+	$H_3O^+\ (aq)$
Initial:	0.015	–			0		0
Change:	-3.05×10^{-6}	–			$+3.05\times10^{-6}$		$+3.05\times10^{-6}$
Equil:	0.015	–			3.05×10^{-6}		3.05×10^{-6}

$$K_a = \frac{[CN^-][H_3O^+]}{[HCN]} = \frac{(3.05\times10^{-6})^2}{0.015} = \boxed{6.2\times10^{-10}}$$

6) A 0.035 M solution of benzoic acid, C_6H_5COOH, has a hydronium ion (H_3O^+) concentration equal to 1.45×10^{-3} M. Complete the reaction, then write the K_a expression for HCN and determine its value.

	$C_6H_5COOH\ (aq)$	+	$H_2O\ (l)$	⇌	$C_6H_5COO^-\ (aq)$	+	$H_3O^+\ (aq)$
Initial:	0.035	–			0		0
Change:	-1.45×10^{-3}	–			$+1.45\times10^{-3}$		$+1.45\times10^{-3}$
Equil:	0.03355	–			1.45×10^{-3}		1.45×10^{-3}

$$K_a = \frac{[C_6H_5COO^-][H_3O^+]}{[C_6H_5COOH]} = \frac{(1.45\times10^{-3})^2}{0.03355} = \boxed{6.3\times10^{-5}}$$

7) A 0.025 M solution of hydroxylamine (NH_2OH) has a hydroxide ion concentration equal to 1.66×10^{-5} M. Complete the reaction (this is not ionic—the H^+ from H_2O becomes attached to the N), then write the K_b for this weak base and determine its value.

	$NH_2OH\ (aq)$	+	$H_2O\ (l)$	⇌	$NH_3OH^+\ (aq)$	+	$OH^-\ (aq)$
Initial:	0.025	–			0		0
Change:	-1.66×10^{-5}	–			$+1.66\times10^{-5}$		$+1.66\times10^{-5}$
Equil:	0.025	–			1.66×10^{-5}		1.66×10^{-5}

$$K_b = \frac{[NH_3OH^+][OH^-]}{[NH_2OH]} = \frac{(1.66\times10^{-5})^2}{0.025} = \boxed{1.1\times10^{-8}}$$

8) A 0.20 M solution of ethylamine ($CH_3CH_2NH_2$) has a hydroxide ion concentration equal to 0.0103 M. Complete the reaction, then write the K_b for this weak base and determine its value.

	$CH_3CH_2NH_2\ (aq)$	+	$H_2O\ (l)$	⇌	$CH_3CH_2NH_3^+\ (aq)$	+	$OH^-\ (aq)$
Initial:	0.20	–			0		0
Change:	-0.0103	–			$+0.0103$		$+0.0103$
Equil:	0.1897	–			0.0103		0.0103

$$K_b = \frac{[CH_3CH_2NH_3^+][OH^-]}{[CH_3CH_2NH_2]} = \frac{(0.0103)^2}{0.1897} = \boxed{5.6\times10^{-4}}$$