Ch 15 & 16 Study Guide Key

1. (A) mostly reactants (small K_c)
   (B) mostly products (large K_p)

2. $K_p = K_c(RT)^{\Delta n} = .042\left(.08206 \frac{L\,atm}{mol\,K} \cdot 500K\right)^{-1} = 1.02 \times 10^{-3}$

3. $CoO(s) + H_2(g) \rightleftharpoons Co(s) + H_2O \quad K_{c_1} = 67$

   $Co(s) + CO_2(g) \rightleftharpoons CoO(s) + CO(g) \quad K_{c_2} = 1/490$

   $CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O$

   $K_c = K_{c_1} \cdot K_{c_2}$

   $K_c = 67 \cdot (1/490)$

   $\boxed{K_c = .137}$

4.

	$2NO$	$+ 2H_2$	$\rightleftharpoons N_2$	$+ 2H_2O$
I	.30M	.80M	0	.30M
C	-.238M	-.238M	+.119 M	+.238 M
E	.062M	.562 M	.119 M	.538 M

$K_c = \frac{[N_2][H_2O]^2}{[NO]^2[H_2]^2}$

$K_c = \frac{[.119][.538]^2}{[.062]^2[.562]^2} = \boxed{28.37}$

5. $CO_2 + H_2 \rightleftharpoons CO + H_2O$

(A)

$P = \frac{nRT}{V}$

$P_{CO_2} = \frac{(.2000 mol)(.08206 \frac{L\,atm}{mol\,K})(500K)}{2.000L} = 4.103\ atm$

$P_{H_2} = \frac{(.1000 mol)(.08206 \frac{L\,atm}{mol\,K})(500K)}{2.000L} = 2.052\ atm$

$P_{CO} = 0\ atm$

$P_{H_2O} = \frac{(.1600 mol)(.08206 \frac{L\,atm}{mol\,K})(500K)}{2.000L} = 3.282\ atm$

(B)

	CO_2	$+ H_2$	$\rightleftharpoons CO$	$+ H_2O$
I	4.103	2.052	0	3.282
C	-.2276	-.2276	+.2276	+.2276
E	3.375	1.824	.2276	3.51

(C) $K_p = \frac{P_{CO} \cdot P_{H_2O}}{P_{CO_2} \cdot P_{H_2}} = \frac{(.2276)(.2276)}{(3.375)(1.824)} = \boxed{8.41 \times 10^{-3}}$

6. $SO_2Cl_2 \rightleftharpoons SO_2 + Cl_2$

.108 M .052 M ?

$K_c = .078 = \frac{[SO_2][Cl_2]}{[SO_2Cl_2]}$ $\quad .078 = \frac{[.052][Cl_2]}{[.108]}$

$.162\,M = [Cl_2]$

$P = MRT = (.162\,M)(.08206\frac{L\,atm}{mol\,K})(373\,K) = \boxed{4.96\ atm}$

7. $Br_2 \rightleftharpoons 2Br \quad K_c = 1.04 \times 10^{-3}$

$[Br_2] = .245\,g\,Br_2\left(\frac{1\,mol}{159.80\,g}\right) = \frac{1.53\times10^{-3}\,mol}{.200\,L} = 7.65\times10^{-3}\,M$

$K_c = \frac{[Br]^2}{[Br_2]} \quad 1.04\times10^{-3} = \frac{[Br]^2}{7.65\times10^{-3}}$

$7.96\times10^{-6} = [Br]^2$

$2.82\times10^{-3}\,M = [Br]$

$n = M\cdot V = 2.82\times10^{-3}\,M \cdot .200\,L = 5.64\times10^{-4}\,mol\,Br$

$mass\ Br = 5.64\times10^{-4}\,mol\left(\frac{79.90\,g}{1\,mol}\right) = \boxed{.0451\,g\,Br}$

8. $K_p = .416 = \frac{[NO]^2[Br]}{[NOBr]^2}$

$[Br] = .416\,M$

$P = MRT = .416\,M(.08206\frac{L\,atm}{mol\,K})(373) = \boxed{1.27\ atm}$

9. (A) equilibrium would shift to the left to make more reactants, causing K to decrease. $K = \frac{[products]}{[reactants]}$

(B) equilibrium would shift to the right to make more products, causing K_c to increase

(C) It would depend on which side has more moles: reactants > products - K_c decreases; products > reactants - K_c increases

(D) depends, if its endothermic, K would decrease, exothermic, K increases

(E) Catalysts have no effect on K.

10. (A) $HCOOH(aq) + PO_4^{3-}(aq) \rightleftharpoons HCOO^-(aq) + HPO_4^{2-}(aq)$
acid base c.b. c.a.

(B) $O^{2-}(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + OH^-$
base acid c.a. c.b.

11. HBrO $K_a = 2.5 \times 10^{-9}$
HBr K_a - ↑ large, strong acid

12. $K_w = 1.2 \times 10^{-15} = [H^+][OH^-]$ $[H^+] = [OH^-]$ for a neutral solution

$1.2 \times 10^{-15} = x^2$

$3.46 \times 10^{-8}\ M = x = [H^+] = [OH^-]$

13. Adding NaOH to water would increase OH^- ions, those react with the H^+ ions in water and lowering the overall $[H^+]$.

14.

$[H^+]$	$[OH^-]$	pH	pOH	Acid or Base?
7.5×10^{-3}	1.33×10^{-12}	2.12	11.88	Acid
2.8×10^{-5}	3.6×10^{-10}	4.56	9.44	Acid
5.6×10^{-9}	1.78×10^{-6}	8.25	5.75	Base
5.0×10^{-9}	2.0×10^{-6}	8.30	5.7	Base

15. (A) $pH = -\log[H^+] = -\log[8.5 \times 10^{-4}] = 3.07$ $HBr \rightarrow H^+ + Br^-$

$pOH = 14 - 3.07 = 10.93$

$[OH^-] = 10^{-pOH} = 10^{-10.93} = 1.17 \times 10^{-11}\ M$

(B) $n = 1.52g\ HNO_3 \left(\frac{1\ mol}{63.02g}\right) = .0241\ mol$

$M = .0241\ mol / .575L = .0419\ M$ $HNO_3 \rightarrow H^+ + NO_3^-$

$pH = -\log[.0419] = 1.38$

$pOH = 14 - 1.38 = 12.62$

$[OH^-] = 10^{-12.62} = 2.40 \times 10^{-13}\ M$

15. C. $\underline{HI \rightarrow H^+ + I^-}$ $\quad$ $\underline{HCl \rightarrow H^+ + Cl^-}$

$n = M \cdot V = .100M \cdot .01L$ $\quad$ $n = M \cdot V = .200M \cdot .02L$

$n = 1.0 \times 10^{-3}$ mol H^+ $\quad$ $n = 4.0 \times 10^{-3}$ mol H^+

total moles $= 1.0 \times 10^{-3}$ mol $+ 4.0 \times 10^{-3}$ mol $= 5.0 \times 10^{-3}$ mol H^+

$M_{TOT} = 5.0 \times 10^{-3}$ mol $/ (.01L + .02L) = 1.67 \times 10^{-1}$ M

$pH = -\log[.167] = \boxed{.777}$

$pOH = 14 - .777 = \boxed{13.2}$

$[OH^-] = 10^{-13.2} = \boxed{1.67 \times 10^{-13}\ M}$

16.

	$CH_3CH(OH)COOH$	$\rightleftharpoons$	$CH_3CH(OH)COO^-$	+	H^+
I	.10M		$\emptyset$		$\emptyset$
C	-3.63×10^{-3}		$+3.63 \times 10^{-3}$		$+3.63 \times 10^{-3}$
E	.0964		3.63×10^{-3}		3.63×10^{-3}

$[H^+] = 10^{-2.44} = 3.63 \times 10^{-3} M$

$$K_a = \frac{[H^+][CH_3CH(OH)COO^-]}{[CH_3CH(OH)COOH]} = \frac{[3.63 \times 10^{-3}][3.63 \times 10^{-3}]}{[.0964]}$$

$$= \boxed{1.37 \times 10^{-4}}$$

17. $\%\text{ ionization} = \frac{[H^+]_{eq}}{[HA]_0} \times 100 = 11.0\%$ $\quad$ $[H^+] = .11[.100M] = .011M$

	$ClCH_2COOH$	$\rightleftharpoons$	H^+	+	$ClCH_2COO^-$
I	.100M		$\emptyset$		$\emptyset$
C	$-.011M$		$+.011M$		$+.011M$
E	.089M		.011M		$+.011M$

$$K_a = \frac{[H^+][ClCH_2COO^-]}{[ClCH_2COOH]} = \frac{[.011][.011]}{[.089]} = \boxed{1.36 \times 10^{-3}}$$

18. $pKa = 2.32$

$Ka = 10^{-2.32} = 4.79 \times 10^{-3}$

	$HNC_7H_4SO_3$	$\rightleftharpoons$	H^+	+	$NC_7H_4SO_3^-$
I	.10 M		0		0
C	$-x$		$+x$		$+x$
E	$.10-x$		x		x

$$Ka = 4.79 \times 10^{-3} = \frac{x^2}{(.10-x)} \approx 0$$

$$4.79 \times 10^{-3} = \frac{x^2}{.10}$$

$$4.79 \times 10^{-4} = x^2$$

$$2.19 \times 10^{-2} = x = [H^+]$$

$pH = -\log[2.19 \times 10^{-2}]$

$\boxed{pH = 1.66}$

19.

	H_3N	$\rightleftharpoons$	H^+	+	H_2N^-
I	.400 M		0		0
C	$-x$		$+x$		$+x$
E	$.400-x$		x		x

$$Ka = \frac{[H^+][H_2N^-]}{[H_3N]}$$

$$1.9 \times 10^{-5} = \frac{x^2}{(.400-x)} \approx 0$$

$$1.9 \times 10^{-5} = \frac{x^2}{.400}$$

$$7.6 \times 10^{-5} = x^2$$

$$8.72 \times 10^{-3} M = x = [H^+]$$

$$\%\text{ion.} = \frac{[H^+]_{eq}}{[HA]} \times 100$$

$$= \frac{[8.72 \times 10^{-3}]}{[.400]} \times 100$$

$$= \boxed{2.18\%}$$

20.

	$C_2H_5NH_2$	+ H_2O ⇌	$C_2H_5NH_3^+$	+ OH^-
I	.075M		0	0
C	−x		+x	+x
E	.075 − x		x	x

$$K_b = 6.4 \times 10^{-4} = \frac{[C_2H_5NH_3^+][OH^-]}{[C_2H_5NH_2]}$$

$$6.4 \times 10^{-4} = \frac{x^2}{(.075 - x)} \quad \text{(0)}$$

$$6.4 \times 10^{-4} = \frac{x^2}{.075}$$

$$4.8 \times 10^{-5} = x^2$$

$$6.93 \times 10^{-3} M = x = [OH^-]$$

$pOH = -\log[6.93 \times 10^{-3}]$

$pOH = 2.16$

$pH = 14 - 2.16 = \boxed{11.84}$

21. (A) Since $K_a \cdot K_b = K_w$, you can calculate K_b from K_a

(B)

phenol

$K_a = 2.8 \times 10^{-2}$

$2.8 \times 10^{-2} \cdot K_b = 1.0 \times 10^{-14}$

$\boxed{K_b = 3.6 \times 10^{-13}}$