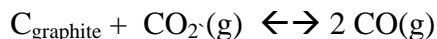


Chapter 14

93) A 1.00 mol sample of CO<sub>2</sub> is heated to 1000. K with excess solid graphite in a container of volume 40.0 L. At 1000. K, K<sub>c</sub> is 2.11x10<sup>-2</sup> for the reaction



a) What is the composition of the equilibrium mixture at 1000. K?

	CO <sub>2</sub>	CO
I	1.00/40.0 L	0
C	-x	+2x
E	0.0250 - x	2x

$$K_c = 2.11 \times 10^{-2} = \frac{[\text{CO}]^2}{[\text{CO}_2]} = \frac{(2x)^2}{0.0250 - x} = \frac{4x^2}{0.0250 - x}$$

0 = 4x<sup>2</sup> + 0.0211x - 0.0005275 solve for x using quadratic equation

$$x = 0.009145$$

$$[\text{CO}] = 0.0183 \quad [\text{CO}_2] = 0.0159$$

b) If the volume of the flask is changed such that [CO<sub>2</sub>] = [CO], what is the volume of the new flask?

If [CO<sub>2</sub>] = [CO] then the following equality must hold true at equilibrium:

$$1.00 \text{ mol} - x = 2x \quad \text{and} \quad x = 0.333$$

This would make it so there where 0.666 mol CO<sub>2</sub> and 0.666 mol CO.

$$K_c = 2.11 \times 10^{-2} = \frac{\left(\frac{0.666M}{xL}\right)^2}{\left(\frac{0.666M}{xL}\right)} = \frac{0.666M}{xL}$$

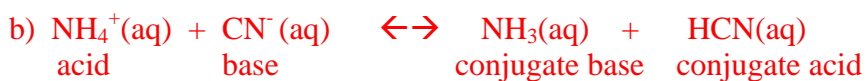
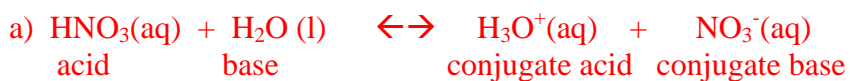
$$x = 31.6 \text{ L}$$

95 i and iii)

- a) right, right
- b) left, left
- c) right, left

## Chapter 16

7)



9) Solution A has 100 times greater  $[\text{H}_3\text{O}^+]$  than solution B

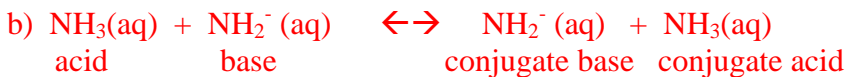
11)



15)



27)



Note in this set of problems,  $\text{HCO}_3^-$  is serving as both a base (eq a) and a base (eq c). If you are perplexed about the fact that  $\text{HCO}_3^-$  decomposes when treated with acid to water and  $\text{CO}_2$ , remember the Alka-Seltzer lab. The Alka-Seltzer is a source of  $\text{HCO}_3^-$ . Vinegar ( $\text{CH}_3\text{COOH}$ ) is an acid.

How could you look at the formula for  $\text{H}_2\text{CO}_3$  and know that it would decompose into  $\text{CO}_2$  and water? I don't think you could from first principles. However, watching the dramatic reaction will help you to remember this fact.

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

$$[\text{H}_3\text{O}^+] = 5.0 \times 10^{-5} \text{ M}$$

47)



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$



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



$$K_b = \frac{[\text{OH}^{-}][\text{HSO}_3^{-}]}{[\text{SO}_3^{-}]}$$



$$K_b = \frac{[\text{OH}^{-}][\text{HPO}_4^{-2}]}{[\text{PO}_4^{-3}]}$$



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



$$K_a = \frac{[\text{H}_3\text{O}^{+}][\text{HSO}_4^{-}]}{[\text{H}_2\text{SO}_4]}$$

49) For these problems, you need to look up the  $K_a$  value in Table 16.2. The large the value of  $K_a$ , the greater dissociation of the acid in water, the greater  $[\text{H}_3\text{O}^{+}]$ , and the more acidic the acid. In each example below, the more acidic acid is boxed.



53) 0.015 M cyanic acid as  $\text{pH} = 2.67$ .       $2.67 = -\log[\text{H}_3\text{O}^{+}]$        $[\text{H}_3\text{O}^{+}] = 2.14 \times 10^{-3}$

$$K_a = \frac{[\text{H}_3\text{O}^{+}][\text{A}^{-}]}{[\text{HA}]} = \frac{(2.14 \times 10^{-3})^2}{1.286 \times 10^{-2}} = 3.58 \times 10^{-4}$$

65)  $0.650 \text{ g aspirin} = 0.650\text{g}/180.16 \text{ g/mol} = 0.00361 \text{ mols}$

$0.00361 \text{ mol}/0.200 \text{ L} = 0.01804 \text{ M}$  and  $K_a = 3.27 \times 10^{-4}$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]} = \frac{x^2}{0.01804 - x} = 3.27 \times 10^{-4}$$

solving quadratic equation  $x = 0.00227$

$\text{pH} = -\log(0.00227) = 2.6$

69)

a)  $\text{H}_2\text{O}(\text{l}) + \text{HNO}_3(\text{aq}) \leftrightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{NO}_3^-(\text{aq})$   $K_a=20$

For a 1 M solution the  $\text{HNO}_3$  would be ~95% dissociated. The reaction favors products.

b)  $\text{H}_3\text{PO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l}) \leftrightarrow \text{H}_2\text{PO}_4^-(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$   $K_a=7.5 \times 10^{-3}$

For a 1 M solution the  $\text{H}_3\text{PO}_4$  would be ~8% dissociated. The reaction favors reactants.

c)  $\text{CN}^-(\text{aq}) + \text{HCl}(\text{aq}) \leftrightarrow \text{Cl}^-(\text{aq}) + \text{HCN}(\text{aq})$

$\text{HCl } K_a=\text{large}$

$\text{CN}^- K_b=2.5 \times 10^{-5}$

$\text{HCN } K_a=4.0 \times 10^{-10}$

$\text{Cl}^- K_b=\text{very small}$

The left side of this equation contains the stronger acid and the stronger base. This means the reaction will lie strongly to products.

d)  $\text{NH}_4^+(\text{aq}) + \text{F}^-(\text{aq}) \leftrightarrow \text{NH}_3(\text{aq}) + \text{HF}(\text{aq})$

$\text{NH}_4^+ K_a=5.6 \times 10^{-10}$

$\text{F}^- K_b=1.4 \times 10^{-11}$

$\text{HF } K_a=7.2 \times 10^{-4}$

$\text{NH}_3 K_b=1.8 \times 10^{-5}$

The right side of this equation contains the stronger acid and the stronger base. This means the reaction will lie strongly to reactants.