

Chemistry 192
Practice Exam 1
Spring, 2018
Solutions

$$R = 8.3144 \text{ J mol}^{-1} \text{ K}^{-1}$$

$$R = .0821 \text{ L atm mol}^{-1} \text{ K}^{-1}$$

$$R = .08314 \text{ L bar mol}^{-1} \text{ K}^{-1}$$

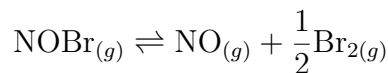
$$N_A = 6.022 \times 10^{23} \text{ molecules mol}^{-1}$$

$$T = t + 273.15$$

$$[\text{H}_3\text{O}^+][\text{OH}^-] = 1.0 \times 10^{-14}$$

Name:

1. The equilibrium degree of dissociation of the gas-phase reaction



at 298. K and a total pressure of 1.00 bar is found to be $\alpha = 0.24$. A gas-phase mixture of NOBr, NO and Br₂ are placed in a container of fixed volume such that [NOBr]=2.53 M, [NO]=0.753 M and [Br₂]=1.57 M. Under these initial conditions, do the necessary calculations and predict whether the reaction will proceed spontaneously to the right or to the left.

Answer:

| | n_{NOBr} | n_{NO} | n_{Br_2} |
|---------|-------------------|-----------------|-------------------|
| initial | n_0 | 0 | 0 |
| change | $-\alpha n_0$ | αn_0 | $\alpha n_0/2$ |
| final | $(1 - \alpha)n_0$ | αn_0 | $\alpha n_0/2$ |

$$n_{\text{tot}} = n_0(1 + \alpha/2)$$

$$K_P = \frac{\left(\frac{\alpha}{1 + \alpha/2}P\right) \left(\frac{\alpha/2}{1 + \alpha/2}P\right)^{1/2}}{\frac{1 - \alpha}{1 + \alpha/2}P} = 0.10$$

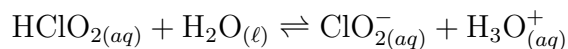
$$K_C = K_P(RT)^{-\Delta n_{\text{gas}}} = (0.10)[(0.08314)(298)]^{-1/2} = 0.020$$

$$Q_C = \frac{[\text{NO}][\text{Br}_2]^{1/2}}{[\text{NOBr}]} = \frac{(0.753)(1.57)^{1/2}}{2.53} = 0.37$$

$$Q_C > K_C \quad \text{to left}$$

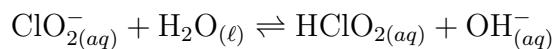
Name:

2. The acid ionization constant of chlorous acid according to the reaction



is $K_a = 1.1 \times 10^{-2}$. Calculate the pH of an aqueous 0.0230 M KClO_2 solution given potassium chlorite is completely soluble in water. Approximations work in the solution to this problem.

Answer:



$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{1.1 \times 10^{-2}} = 9.1 \times 10^{-13}$$

| | $[\text{ClO}_2^-]$ | $[\text{HClO}_2]$ | $[\text{OH}^-]$ |
|-------------|--------------------|-------------------|-----------------|
| initial | 0.0230 M | 0 M | 0 M |
| change | $-y$ M | y M | y M |
| equilibrium | $0.0230 - y$ M | y M | y M |

$$\frac{y^2}{0.0230 - y} \approx \frac{y^2}{0.0230} = 9.1 \times 10^{-13}$$

$$y = [\text{OH}^-] = 1.4 \times 10^{-7}$$

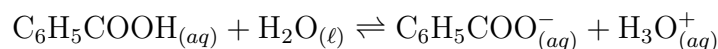
$$\text{pOH} = -\log_{10}(1.4 \times 10^{-7}) = 6.84 \quad \text{pH} = 14.00 - \text{pOH} = 7.16$$

Name:

3. The volume of a buffer solution that is made from 0.00100 moles of benzoic acid ($\text{C}_6\text{H}_5\text{COOH}$) and 0.00200 moles of benzoate anion ($\text{C}_6\text{H}_5\text{COO}^-$) is 0.100 L. Calculate the pH of a solution formed by mixing the buffer with 0.0500 L of 0.0100 M HCl. You are given the acid ionization constant of benzoic acid is 6.3×10^{-5} , and you can assume the standard approximations work for this system.

Answer:

Method 1



$$\text{p}K_a = -\log_{10}(6.3 \times 10^{-5}) = 4.20$$

$$\text{pH} = \text{p}K_a + \log_{10} \frac{[\text{C}_6\text{H}_5\text{COO}^-]}{[\text{C}_6\text{H}_5\text{COOH}]}$$

$$n_{\text{H}_3\text{O}^+} = (0.0100 \text{ mol L}^{-1})(0.0500 \text{ L}) = 5.00 \times 10^{-4} \text{ mol}$$

$$\text{pH} = 4.20 + \log_{10} \frac{\frac{0.00200 - 5.00 \times 10^{-4}}{0.150}}{\frac{0.00100 + 5.00 \times 10^{-4}}{0.150}} = 4.20$$

Method 2, ICE Table

| | $n_{\text{C}_6\text{H}_5\text{COOH}}$ | $n_{\text{C}_6\text{H}_5\text{COO}^-}$ | $n_{\text{H}_3\text{O}^+}$ |
|-------------|---------------------------------------|--|----------------------------|
| initial | 0.00100 | 0.00200 | 0 |
| change | 5.00×10^{-4} | -5.00×10^{-4} | y |
| equilibrium | 0.0015 | 0.0015 | y |

$$\frac{y(0.0015/.150)}{0.0015/.150} = 6.3 \times 10^{-5}$$

$$y = [\text{H}_3\text{O}^+] = 6.3 \times 10^{-5} \text{ M}$$

$$\text{pH} = -\log_{10}(6.3 \times 10^{-5}) = 4.20$$

Name: