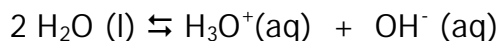


1999 Exam #2 – Chem 36 Exam Questions w/Answers

1. The autoionization constant of water (K_w) is 1.139×10^{-15} at $0.00\text{ }^\circ\text{C}$ and 9.614×10^{-14} at $60.00\text{ }^\circ\text{C}$.



- a. Calculate the enthalpy change (ΔH) for the autoionization of water.

$$\Delta H = 55.95 \text{ kJ/mol}$$

- b. $K_w = 1.0 \times 10^{-14}$ at $25.^\circ\text{C}$. Calculate the standard molar free energy change (ΔG°) for the autoionization of water at $25.^\circ\text{C}$.

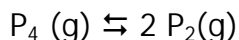
$$\Delta G^\circ = 80. \text{ kJ/mol}$$

- c. What is the pH of pure water at $0\text{ }^\circ\text{C}$ and at $60\text{ }^\circ\text{C}$?

$$\text{At } 0^\circ\text{C: pH}=7.47$$

$$\text{At } 60^\circ\text{C: pH}=6.51$$

2. At $T=1200\text{ }^\circ\text{C}$, the reaction



has an equilibrium constant $K = 0.612$.

- a. Suppose the initial partial pressures of P_4 and P_2 are both 2.00 atm . Will the reaction proceed to the right or to the left as equilibrium is approached? (Note: you must show your work to receive full credit!)

Reaction will proceed to the *left* (making more P_4)

- b. Calculate the partial pressure of P_2 at equilibrium.

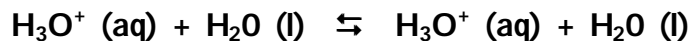
$$P_{\text{P}_2} = 1.21 \text{ atm}$$

- c. If the volume of the system is then increased, will the partial pressure of P_2 increase or decrease? Explain, briefly.

P_{P_2} will *increase* (shift to side with more moles of gas)

3. The strongest acid that can exist in a solvent is the conjugate acid formed from the autoionization of that solvent. So, for example, the strongest acid that can exist in water is the hydronium ion (H_3O^+).

a. Write the acid dissociation equilibrium reaction for H_3O^+ , the equilibrium constant (K_a) expression, and calculate the numerical value of K_a .



$$K_a = \frac{[\text{H}_3\text{O}^+]}{[\text{H}_3\text{O}^+]} = 1$$

b. The approximate K_a values for HCl and HNO_3 are given on the table attached to this exam. In water, which of these acids is stronger? Explain.

Both acids are leveled to the strength of H_3O^+

c. What is the strongest acid that can exist in a solution of *liquid ammonia*?



d. What fraction of Acetic Acid will be undissociated in a *liquid ammonia* solution? (DO NOT do a calculation for this!)

Acetic Acid will be 100% dissociated in liquid ammonia

4. As you all recall from lab, Aspirin is a weak acid (acetylsalicylic acid). When a 0.150 M solution of this acid is prepared, it has a pH of 4.69.

a. Calculate the K_a for acetylsalicylic acid.

$$K_a = 2.8 \times 10^{-9}$$

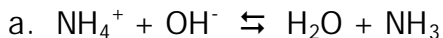
b. Calculate K_b for the acetylsalicylate ion.

$$K_b = 3.6 \times 10^{-6}$$

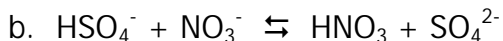
c. Calculate the pH of a 0.150 M solution of sodium acetylsalicylate.

$$\text{pH} = 10.87$$

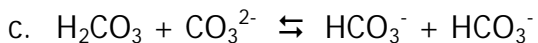
5. Predict the direction favored in each of the following acid-base reactions. That is, for each reaction, indicate the direction (forward or reverse) that the reaction will tend towards. You may wish to make use of the K_a and K_b values tabulated for you on the formula page handed out with this exam.



Forward

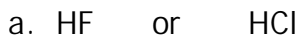


Reverse

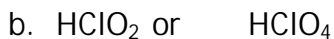


Forward

6. Circle the member of each of the following pairs that is the stronger acid and briefly explain your choice (based on molecular structure/bonding considerations).



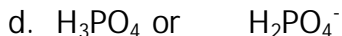
HCl (Fluorine is so much smaller than Cl, that H-F bond strength is greater than H-Cl bond strength)



HClO_4 (more electron-withdrawing oxygens to weaken H-Cl bond)



$\text{CH}_3\text{CHClCOOH}$ (electron-withdrawing Cl is closer to H-O bond)



H_3PO_4 (harder for a negatively charged species to give up a positively charged species)

Extra Credit!!!

At 40 °C and 1.00 atm pressure, a gaseous monoprotic acid has a density of 1.05 g/L. After 1.85 g of this gas is dissolved in water and diluted to 450.0 mL, the pH is measured to be 5.01. Determine the K_a of this acid and use the provided table of K_a -values to identify it.

The mystery acid is: HCN (hydrocyanic acid)