Sample Exam 2 Summer 2024

Name:_____ **Date:** _____

1. Calculate the pH of a 0.200 M solution of a weak diprotic acid (H_2A). **(6 pts)**

   Ka1 = 1.0×10^{-6}, Ka2 = 2.7×10^{-10}

2. A 20.0 mL sample of a 0.500 M monobasic weak base, methyl amine (CH_3NH_2) is titrated with 0.250M HCl. Kb for the methyl amine is 2.5×10^{-6}. Answer the following questions. **(12 pts)**

a. What is the volume at the equivalence point?

b. What is the pH of the base BEFORE any titrant, HCl, is added?

c. What is the pH after 15.0 mL of HCl is added?

d. What is the pH after 40.0 mL of HCl is added?

e. What is the pH after 50.0 mL of HCl is added

3. Your research advisor wants you to prepare 1.0 L of a 1.0 M buffer solution with a pH of 4.25. You have available 1.00 M $NaC_2H_3O_2$ (sodium acetate) and 1.00 M $HC_2H_3O_2$ (acetic acid) in the lab. What volumes of each should you use to prepare the buffer? (the remaining volume is distilled water) The Ka for acetic acid is 1.8×10^{-5}. **(8 pts)**

4. Determine whether the following salts are acidic, basic or neutral. Write a chemical equation to support your answer. **(10 pts)**

Kb for ammonia 1.8×10^{-5}
Ka for $HC_2H_3O_2$ 1.8×10^{-5}
Ka for HF 6.9×10^{-4}

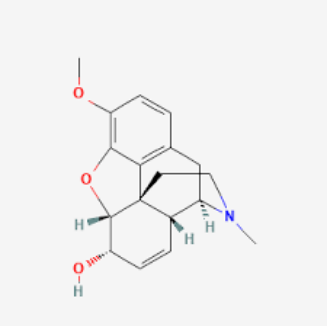
a. $NH_4C_2H_3O_2$

b. NH_4F

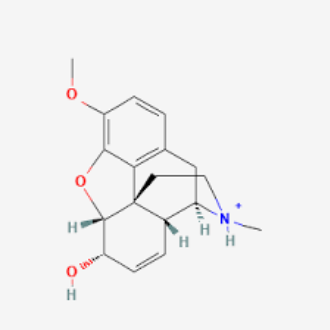
c. KCl

d. $NaC_2H_3O_2$

5. Codeine is a derivative of morphine that can be used as an analgesic. Codeine, monobasic (B) structure shown below, has a pKb of 6.05. Codeine can be sold as a salt with codeine in the conjugate acid form (BH^+). In the lab, 5.0 mg of the conjugate acid of codeine is dissolved in 10.0 mL of water. The molar mass is 299.3 grams/mole. What is the pH of the solution? (**10 pts**)



Codeine, pKb = 6.05



protonated form of codeine (BH^+)

6. The Ksp for magnesium hydroxide is 8.9×10^{-12}. **(12 pts)**

a. What is the concentration of magnesium and hydroxide ions at equilibrium of magnesium hydroxide in water?

b. What is the concentration of magnesium and hydroxide ions at equilibrium if sodium hydroxide is added to water and the pH is 11.00

c. Will a precipitate form when 100.0 mL of 0.0200 M magnesium nitrate is mixed with 10.0 mL of 0.100 M sodium hydroxide. Show your work

7. The synthesis of ammonia gas is shown below: **(10 pts)**

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

G_f° of N_2(g) = 0 kJ/mol **G_f° of H_2**(g) = 0 kJ/mol **G_f° of NH_3** (g) = -16.5 kJ/mol

a. What is the equilibrium constant for the reaction at the at 25.0°? Is the equilibrium reactant or product favored, briefly explain.

b. What is the non-standard Gibb's free energy ΔG, if $[NH_3]$ is 0.100 M, $[N_2]$ is 0.200 M and $[H_2]$ is 0.100M. Which direction will the reaction shift to reach equilibrium?

8. Explain the direction the reaction (shown below) will shift to offset the stress applied. Explain your answer (you do not need to use any math!).(**6 pts)**

$CaCO_3$ (s) ⇌ Ca^{2+} (aq) + CO_3^{2-} (aq)

a. a. 10.0 mL of a 0.100 M sodium carbonate solution is added

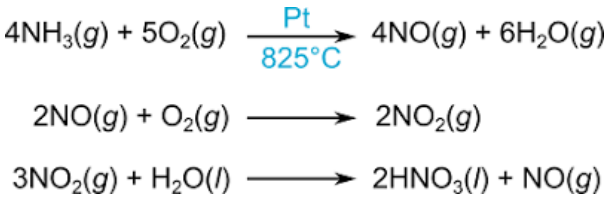
b. b. 10.0 mL of 1.0M hydrochloric acid solution is added

9. Balance the following reactions in acidic solution **(8 pts)**

a. $Cu + \mathbf{NO_3}^{---} \rightarrow Cu^{2+} + NO$

b. $Cr_2O_2^{--7}(aq) + HNO_2(aq) \rightarrow Cr^{3+}(aq) + NO_3^{--}$

10. The process for production of nitric acid is shown below: **(12 pts)**



a. Calculate ΔG°, ΔS° and ΔH° for the first step at 25° C, is the reaction spontaneous?

Molecule	H°f (kJ/mol)	S° (J/mol-K)
$NH_3(g)$	-146.19	192.45
$O_2(g)$	0	205.0
NO(g)	90.3	210.8
H_2O (g)	-241.8	188.8
NO_2 (g)	33.1	240.04

b. Calculate the ΔG° for the second reaction, is this reaction spontaneous at 25.0°C?

c. Is there a thermodynamic reason why the first step is done at a high temperature?

11. Assign oxidation numbers to each species (**6 pts)**

a. $KMnO_4$ K is _____, Mn is _____, O is _____

b. $HClO_4$ H is _____, Cl is _____, O is _____