CHEMISTRY 31 EXAM 2
April 19, 2017

NAME_____ LAB SECTION # _____

Some Useful Constants:
R = 8.314 J mol^{-1} K^{-1} 0°C = 273 K
K_w (autoprotolysis constant for H_2O) = 1.0 x 10^{-14}
h = Planck's constant = 6.63 x 10^{-34} J·s; c = speed of light = 3.00 x 10^8 m s^{-1}

A. Multiple Choice/Fill in the Blank Section. Only one correct answer for multiple choice questions. (4 points for each question)

1. In the reaction: Al^{3+} (aq) + $3C_2O_4^{2-}$(aq) ⇌ $Al(C_2O_4)_3^{3-}$ (aq), Al^{3+} is a:
a) Lewis acid but not a Bronsted-Lowry acid b) both a Lewis and a Bronsted-Lowry acid
c) neither a Lewis acid nor a Bronsted-Lowry acid d) a Lewis base only

2. Which of the following salts is acidic?
a) $Mg(OH)_2$ b) $CrCl_3$ c) KClO d) $NaNO_2$
K_a values for related weak acids: HClO (K_a = 3.0 x 10^{-8}); HNO_2 (K_a = 7.1 x 10^{-4})

3. The point in a titration in which an indicator changes color (in response to a change in reactant concentration) is called:
a) the end point b) the equilibrium point c) the equivocate point
d) the equivalence point

4. A precipitation titration is being performed in which Ag^+ is added to a solution. Which of the following conditions will lead to a sharper titration in a precipitation titration?
a) a solution containing multiple anions (e.g. Cl^-, Br^-, and I^-)
b) anions with a larger K_{sp} value
c) a solution with higher anion and Ag^+ concentrations
d) all of the above

5. Ultra-violet light, when absorbed by matter, causes transitions primarily in:
a) molecular rotation states b) molecular vibration states
c) electrons in valence shell states d) nuclear states

6. Infrared radiation is typically given in wavenumbers. A wavenumber of 1830 cm^{-1} corresponds to a wavelength of:
a) 1830 nm b) 1.83 x 10^{10} nm c) 5.46 x 10^7 nm d) 5460 nm

7. In gas chromatography, the analyte that elutes earliest is usually
a) the most volatile b) has the highest boiling point temperature
c) the most polar d) the least polar

8. It is desired to "clean up" biodiesel by removing free fatty acids in the biodiesel by extracting the diesel with water. The biodiesel is a fairly non-polar solvent. Typical free fatty acids have high octanol water partition coefficients (i.e. favor dissolution in non-polar solvents) and are weak acids. To aid the transfer to water, one could.
a) buffer the water to a high pH b) buffer the water to a low pH
c) use a more polar solvent than water

9. List one component of a chromatograph and its purpose: (2 pts each part)
Component _____ Purpose _____

10. How would you expect the aqueous equilibrium reaction, $MgCO_3(s) + H^+ \Leftrightarrow Mg^{2+} + HCO_3^-$ to shift following the addition of some NaCl, assuming the only change is the ionic strength?
a) toward reactants b) toward products c) no change from addition of NaCl

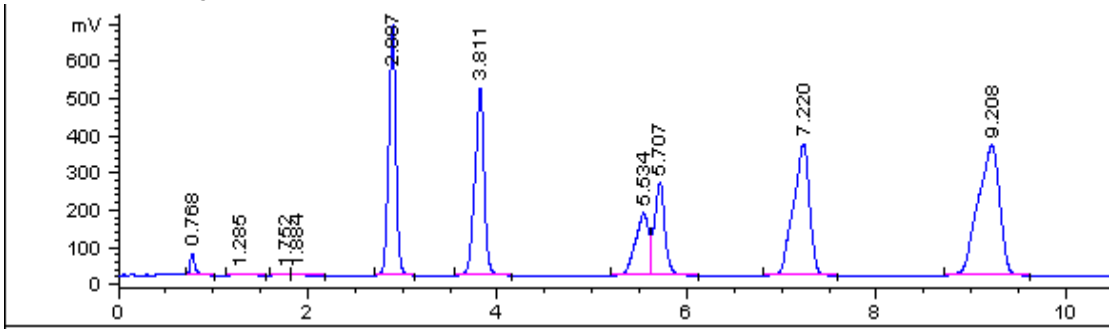
B. Problem Section. Show all needed calculations to receive full credit. The number of points are shown in parentheses. Use the back side of the page if needed.
1. The concentration of iron(III) in a solution can be determined by adding SCN^- to form the colored metal ligand complex, $FeSCN^{2+}$. The K value for $Fe^3 + SCN^- \leftrightarrow FeSCN^{2+}$ is 1050. NaSCN is added to an Fe^{3+} containing sample to create the complex. If after mixing, the concentration of the complex is measured to be 3.1×10^{-4} M (based on absorption of light) and the equilibrium concentration of SCN^- is 0.20 M, calculate the concentration of Fe^{3+} in equilibrium with SCN^- and the complex. (8 pts)

2. Determine the **percent of $CaCO_3$** in a 1.21 g sample that is analyzed using a back titration. In the back titration, $CaCO_3$ reacts with HCl (10.0 mL of 0.500 M) present in excess as follows:

$$CaCO_3(s) + 2HCl \Leftrightarrow CaCl_2(aq) + H_2O + CO_2(g)$$

The solution is heated to remove $CO_2(g)$, and the excess HCl (that which doesn't react with $CaCO_3$) requires 23.2 mL of 0.100 M NaOH. The formula weight of $CaCO_3$ is 100.1 g/mol. (16 pts)

3. The following chromatogram and data table show the separation of linear fatty acids (C18:3, C18:2, C18:1, C16:0, C17:0, and C18:0 – where the first number gives the number of carbons in the fatty acids and number after the colon gives the number of double bonds – all in *cis* isomer). All of the fatty acids have pK_a values of around 4.8. The separation was performed on a C18 (reversed phase) column using HPLC with an eluent of 0.001 M trifluoroacetic acid in water (pH = 3 and 8% by volume) and 92% acetonitrile. W_b in table is the baseline width.



Compound	Retention (min.)	Area	W_b (min.)
Unretained	0.768	NA	NA
C18:3	2.887	3611.5	0.127
C18:2	3.811	3389.3	0.156
C18:1	5.534	1656	0.222
C16:0	5.707	1908.9	0.180
C17:0	7.22	4182.1	0.266
C18:0	9.208	5552.7	0.358

a) Calculate the retention factor (k) of C17:0. (4 pts)

b) Based on the elution order, which compound would be considered the least polar? (4 pts)

c) What is the resolution between the two least well resolved peaks. (4 pts)

Bonus) Switching from 92% acetonitrile to 92% methanol was found to result in smaller retention times for C18:1, C18:2, and C18:3 without affecting the C16:0, C17:0, or C18:0 retention times. Is this a good change? Explain. (3 pts)

4. A compound is known to have a molar absorbtivity of 731 M^{-1} cm^{-1} at a wavelength of 382 nm in water (solvent). A cell with path length of 0.200 cm is filled with the compound and the absorbance is measured to be 0.103. Determine the concentration of the compound. (8 pts)

5. It is desired to determine the solubility of PbI_2 (K_{sp} = 7.9 x 10^{-9}) in a solution containing 0.0120 M CaI_2 with the inclusion of activity in the calculation.
a) Determine the ionic strength of the 0.0120 M CaI_2 solution. (6 pts)

b) Using the following table and the ionic strength from part a), determine the solubility of PbI_2 in the 0.0120 M CaI_2 solution. (10 pts).

Ionic Strength	0.012 M	0.030 M	0.036 M	0.054 M
$\gamma(Pb^{2+})$	0.642	0.523	0.498	0.444
$\gamma(I^-)$	0.890	0.840	0.828	0.801

Hint: Select the γ values using the closest μ value and assume PbI_2 does not provide a significant amount of I^- to the solution. No iterations in this calculation are needed.