**Chem 232**
**Exam #2**
**2/15/08**

Name ______________________________

**In-class portion (1-5):**

Pledge:
When you have completed this portion of the exam, please consider the following:

*I affirm that I have neither committed nor witnessed a violation of academic integrity in the completion of this portion of the exam.*

Signed ______________________________

Answer the following on separate sheets of paper. All work must be shown for full credit.

1. (15 pts) Spectrophotometers.
   a) Make a sketch of the Czerny-Turner design for a monochromator. Be sure to include all slit(s), mirror(s), and grating(s). Also show how an incident light beam of more than one wavelength would travel through the monochromator.
   b) What is the purpose of adding the second beam in a double beam spectrometer? Make a block diagram sketch (using labeled boxes to indicate components) that shows the relative positions of the source, monochromator, cuvettes, chopper, mirrors and detector in a double beam spectrometer.
2. (10 pts) A water sample is analyzed for traces of benzene using gas chromatography (GC). Samples and standards are spiked with a fixed amount of toluene as an internal standard. A 1.00-μL spike of a toluene solution is added to 5.00 mL of a 10.00-ppb benzene standard, and the resulting solution is diluted to a final volume of 25.00 mL. Injection of a small amount of this solution into the GC yields peak areas of 252 and 376 for benzene and toluene, respectively. In a second experiment, a 1.00-μL spike of the same toluene solution is added to 5.00 mL of an unknown water sample, and the final solution is again diluted to a final volume of 25.00 mL. GC analysis of this solution gave peak heights of 533 for benzene and 368 for toluene. What is the concentration of benzene in the unknown water sample (in ppb)?
3. (12 pts) The amino acid tyrosine has an absorption peak at 290 nm. After appropriate treatment of a 0.2162-g unknown sample to isolate the tyrosine, the sample volume was 250.0 mL. This solution had an absorbance of 0.118 in a 2.00-cm cell. A sample of pure tyrosine (MW = 181), weighing 126.4 mg, was dissolved in 100.0 mL of solution. A 10.00-mL aliquot of this solution, diluted to 250.0 mL, had an absorbance of 0.473 at 290 nm in a 1.00-cm cell. Calculate the mass percentage of tyrosine in the unknown sample.
4. (18 pts) $Hg_2Br_2$ is a slightly soluble solid which dissociates according to the following reaction:
   $$Hg_2Br_2(s) \leftrightarrow Hg_2^{2+}(aq) + 2\ Br^-(aq)$$
   a) The concentration of $Hg_2^{2+}$ in a saturated solution of $Hg_2Br_2$ at 25°C is found to be $2.44 \times 10^{-8}$ M. Calculate the value of $K_{sp}$ for this salt.
   b) Consider an aqueous mixture of an imaginary metal $X^+(aq)$, which also forms a precipitate with the bromide ion. What is the lowest possible value of $K_{sp}$ for XBr (to 2 sig figs) that would allow you to precipitate 99% of the $Hg_2^{2+}$ with $Br^-$ in a solution of 0.10 M $Hg_2^{2+}$ and 0.20 M $X^+$?
5. (10 pts) In chapter 0 of our text, two students from Bates College undertake an analytical class project. What was their project and how do the different steps they carried out illustrate the general steps in a chemical analysis?

Name ______________________________

**Take-home portion (6-7), due Monday (2/18) at 5:00pm:**

Pledge:
When you have completed this portion of the exam, please consider the following:

> *I affirm that I have neither committed nor witnessed a violation of academic integrity in the completion of this portion of the exam.*

Signed ______________________________

This portion of the exam is open-book. Use any reference material available to you. Where applicable, let a spreadsheet do as much work for you as possible, **then turn in a hard copy of the spreadsheet**. I ask only that you do not consult with another person regarding any of the following questions.

6. (14 pts) The box below shows equilibrium constant data for the reaction of the $Cd^{2+}$ ion with the cyanide anion. ($\beta_1$, $\beta_2$, … refer to *cumulative* formation constants)

| | |
|---|---|
| $K_{sp}$ | $1.0 \times 10^{-8}$ |
| $\log \beta_1$ | 5.48 |
| $\log \beta_2$ | 10.60 |
| $\log \beta_3$ | 15.23 |
| $\log \beta_4$ | 18.78 |

Create a *clearly labeled* spreadsheet and graph to show the concentration of all species in solution as a function of the cyanide concentration. The graph should plot $\log [Cd^{2+}]$, $\log [CdCN^{+}]$, $\log [Cd(CN)_2]$, $\log [Cd(CN)_3^{-}]$, $\log [Cd(CN)_4^{2-}]$, and $\log[Cd]_{total}$ from $\log [CN^{-}]$ values of –8 to –1. Make the $[Cd]_{total}$ line thicker than the rest so that we can easily see the effect of added cyanide on the total cadmium solubility.

Use your spreadsheet and graph to determine the pCN value (to the nearest 0.01) where the total cadmium solubility is at a minimum.

7. (16 pts) The amount of manganese in a steel sample was determined spectroscopically using the method of standard additions. Manganese ion reacts with periodate to form the highly colored permanganate ion:

$$2\ Mn^{2+} + 5\ IO_4^{-} + 3\ H_2O \rightarrow 2\ MnO_4^{-} + 5\ IO_3^{-} + 6\ H^{+}$$

The main points of the procedure are as follows:

1) A standard solution of $Mn^{2+}$ was prepared by dissolving 0.3025 g of $MnSO_4 \cdot H_2O$ in distilled water and diluting to the mark in a 1.00-L volumetric flask.
2) A 0.6879-g sample of steel was dissolved in nitric acid, quantitatively transferred to a 100.0-mL volumetric flask, and diluted to the mark with distilled water.
3) Five 10.00-mL aliquots of the sample solution (from step 2) were added to five separate 50.00-mL volumetric flasks.
4) Standard solution (from step 1) was added to the five flasks in the following volumes: 0.00, 5.00, 10.00, 15.00, and 25.00 mL.
5) An excess of periodate was then added to each of the five flasks, and each was then diluted to the mark with distilled water.
6) Absorbance readings were taken from each of the solutions and the following results were obtained:

| mL added | abs |
|---|---|
| 0.00 | 0.156 |
| 5.00 | 0.318 |
| 10.00 | 0.462 |
| 15.00 | 0.626 |
| 25.00 | 0.998 |

Calculate the weight percent of manganese in the steel sample.