

Sample Questions for Chem 002 Final FS08

1. MSDS (the rest listed on review):

- Proper attire – goggles, closed toe shoes, long pants or skirt or lab apron
- Acid Spill – neutralize with sodium bicarbonate
- Bunsen Burners – do not light if flammable biproducts (e.g., H₂ gas) are present
- Phenolphthalein – has a laxative effect when ingested
- Types of radiation (listed below) are stopped by what type of material?
 - alpha – paper or hand
 - beta – aluminum (goes through paper, hand)
 - gamma – lead (goes through paper, hand, aluminum)
 - neutron – concrete (goes through paper, hand, aluminum, lead)

2. Radioactive Decay:

- Balance the following radioactive decay equations:



- Determine the specific decay constant, initial activity and half-life of a radioactive isotope. Given

Time, minutes	Counts/Min	ln (Counts/Min)
0		
2	14472	9.58
3	14328	9.57
4	14248	9.56
5	14095	9.55
6	13920	9.54
10	13359	9.50

- Determine the specific decay constant, k, for this radioactive decay.

$$k = -m \quad m = (y_2 - y_1) / (x_2 - x_1) = (9.58 - 9.50) / (2 - 10) \text{ min} = -0.01$$

$$k = 0.01 \text{ min}^{-1}$$

- Determine the initial activity, A₀.

$$y = mx + b \quad \ln A = -kt + \ln A_0$$

$$9.50 = -(0.01)(10) + \ln A_0$$

$$9.50 = -0.10 + \ln A_0$$

$$9.60 = \ln A_0$$

$$A_0 = e^{\ln A_0} = e^{9.60} = 14764 \text{ counts/min}$$

- Determine the half-life.

$$t_{1/2} = \ln 2 / k = 0.693 / 0.01 \text{ min}^{-1} = 69.3 \text{ min}$$

3. Heat of Neutralization:

A reaction of 100mL of 1.35M HCl and 100mL of 1.76M NaOH is monitored and the following temperatures were recorded: starting temperature = 24.6 °C; and final temperature = 38.8 °C. Calculate the ΔH of this reaction.

Given: C_p of solution (J/K) = 4.13*Volume of solution in mL
 C_p of calorimeter (J/K) = 50
 $\Delta H = (\Delta T \cdot \text{total } C_p) / (\text{mols of solution})$

- a. Determine the change in temperature for the system.

$$\Delta T = T_f - T_i = 38.8 \text{ }^\circ\text{C} - 24.6 \text{ }^\circ\text{C} = 14.2 \text{ }^\circ\text{C}$$

$$\text{Since we calculated } \Delta T, 14.2 \text{ }^\circ\text{C} = 14.2 \text{ K}$$

- b. Determine the C_p of the solution (J/K).

$$C_{p(\text{soln})} = 4.13 \text{ (J/ml}\cdot\text{K)} \times (200 \text{ ml})$$

$$C_{p(\text{soln})} = 826 \text{ J/K}$$

- c. Determine the total C_p of the system.

$$C_{p(\text{sys})} = C_{p(\text{soln})} + C_{p(\text{cal})} =$$

$$C_{p(\text{soln})} = (826 + 50) \text{ J/K} = 876 \text{ J/K}$$

- d. Determine the number of moles of the acid and the base. Which is the limiting reagent?

$$(1.35 \text{ mole / L HCl}) \times (100 \text{ ml}) \times (1 \text{ L / 1000 ml}) = 0.135 \text{ mole HCl}$$

$$(1.76 \text{ mole / L NaOH}) \times (100 \text{ ml}) \times (1 \text{ L / 1000 ml}) = 0.176 \text{ mole NaOH}$$

Since HCl is the limiting reagent, the moles of solution is 0.135 mole.

- e. Determine the change in enthalpy, ΔH , for the reaction.

$$\Delta H = [(14.2 \text{ K}) (876 \text{ J/K})] / (0.135 \text{ mole soln})$$

$$\Delta H = 92,142 \text{ joule / mole}$$

f. If heat transfers from the system (solute) to the surroundings (solvent), then ΔH is negative ($\Delta H < 0$), and the reaction is defined as (endothermic / exothermic) and the temperature of the solvent will go (up / down).

g. If heat transfers from the surroundings (solvent) to the system (solute), then ΔH is positive ($\Delta H > 0$), and the reaction is defined as (endothermic / exothermic) and the temperature of the solvent will go (up / down).

h. The heat of neutralization experiment was an (endothermic / exothermic) reaction .

i. The heat of fusion experiment was an (endothermic / exothermic) reaction.

j. This term means “the techniques that are used to measure enthalpy”: **Calorimetry**

k. This term means “the energy needed to raise the temperature of an object 1° C”: **Heat Capacity**

l. This term means “the energy needed to raise the temperature of one gram of a substance 1° C”: **Specific Heat**

m. The heat capacity is an extrinsic property. What does this mean?

Intrinsic properties are inherent properties usually physical. For example, when a piece of wood is cut, each piece still has the appearance of wood.

Extrinsic properties are dependent upon the amount of an object present. For example, when a small piece of wood is burned it generates less heat, than when a large piece of wood is burned.

4. Antacids: You are given 1.12 M HCl and 1.48 M NaOH. The antacid you use contains 300 mg of CaCO₃ and 100 mg of Al(OH)₃. If the antacid dissolved in 35.0 ml of HCl and was then back titrated with 21.8 ml of NaOH., find the following:

a. The mmoles of HCl used to dissolve the antacid

$$(1.12 \text{ mmole / ml HCl}) \times (35.0 \text{ ml HCl}) = 39.2 \text{ mmole HCl}$$

b. The mmoles of NaOH used to backtitrate

$$(1.48 \text{ mmole / ml NaOH}) \times (21.8 \text{ ml NaOH}) = 32.3 \text{ mmole NaOH}$$

c. The mmoles of antacid used to neutralize the antacid (a.k.a. the excess HCl).

$$\text{Excess HCl} = \text{mmole HCl} - \text{mmole NaOH} = 39.2 - 32.3 = 6.9 \text{ mmole HCl}$$

d. Write the balanced equations for the neutralization of the antacid (Both CaCO₃ and Al(OH)₃).



e. Using the number of mg in the tablet, calculate the mmoles of each component (Both CaCO₃ and Al(OH)₃).

$$300 \text{ mg CaCO}_3 \times (1 \text{ mmole} / 100 \text{ mg CaCO}_3) = 3.00 \text{ mmole CaCO}_3$$

$$100 \text{ mg Al(OH)}_3 \times (1 \text{ mmole} / 78 \text{ mg Al(OH)}_3) = 1.30 \text{ mmole Al(OH)}_3$$

f. Based on the mmoles of each component, calculate the theoretical number of mmoles of HCl that should have been needed to neutralize the antacid.

$$3.00 \text{ mmole CaCO}_3 \times (2 \text{ mmole HCl} / 1 \text{ mmole CaCO}_3) = 6.00 \text{ mmole HCl}$$

$$1.30 \text{ mmole Al(OH)}_3 \times (3 \text{ mmole HCl} / 1 \text{ mmole Al(OH)}_3) = 3.90 \text{ mmole HCl}$$

g. What was the total number of theoretical mmoles of HCl that should have been neutralized?

$$6.00 + 3.90 \text{ mmole HCl} = 9.9 \text{ mmole HCl}$$

h. Compare the theoretical (g.) to the actual (c.). What are possible reasons this discrepancy could have occurred?

$$\text{Actual is } 6.9 \text{ mmole} < \text{Theoretical } 9.9 \text{ mmole}$$

Possible Reasons:

Student may not have performed the titration accurately.

Manufacturer may not have quality control standards that ensure the amount of ingredients.

Binders and other additives may have interfered with the effectiveness of the antacids.

5. Spectrophotometry: Using a Spectrophotometer (Spec 20), a student recorded below the Percent Transmittance data for the following solutions:

Red Dye Standard (6.30 ppm)
Blue Dye Standard (5.05 ppm)
Purple Unknown

	400 nm	450 nm	500 nm	550 nm	600 nm	650 nm
Red Std	63.5	48.5	23.5	38.6	78.3	98.5
Blue Std	80.5	99.0	82.5	56.5	8.5	72.4
Purple Unk	79.3	72.5	35.5	85.8	45.5	65.3

a. Calculate the Absorbance for each of the %T listed above .

	400 nm	450 nm	500 nm	550 nm	600 nm	650 nm
Red Std	$\log(100/63.5)$ 0.197	0.314	0.629	0.413	0.106	0.007
Blue Std	0.094	0.004	0.084	0.248	1.07	0.140
Purple Unk	0.101	0.140	0.450	0.067	0.342	0.185

b. Determine the following from the data calculated in Part 1 (2 pts):

Red Dye Max. Absorbance = 0.629 at 500 nm (λ Max)

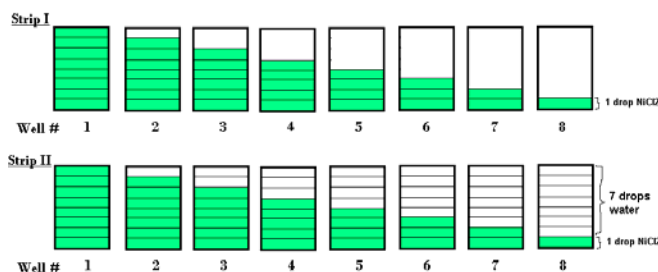
Blue Dye Max. Absorbance = 1.07 at 600 nm (λ Max)

c. Calculate the Absorbance Ratio of the Unknown/Standard at (λ Max).

d. Calculate the Dye Concentration in the Unknown. (Standard Concentrations given above.)

	Abs of Unknown (at λ Max)	Abs of Standard (at λ Max)	Abs Ratio Unk/Std (at λ Max)	Dye Conc. in Unknown
Red in Purple	0.450	0.629	$(0.450/0.629) = 0.715$	$(0.715 \times 6.30) = 4.50$
Blue in Purple	0.342	1.07	$(0.342/1.07) = 0.320$	$(0.320 \times 5.05) = 1.62$

6. Colorimetry: Using the well strips below, the student put the following number of drops in the wells. In strip I, 1-8 drops of red dye standard solution (6.30 ppm) were added as shown in the diagram. In strip II, additional drops of water were added in order to have the same total volume of 8 drops for each well.



Given: The student found that the unknown solution of red dye matched well #5 on Strip II.

- What is changing in the first well strip – concentration or pathlength?
- What is changing in the second well strip – concentration or pathlength?
- Looking from the top how does the intensity compare for Strip 1 to Strip 2?
more intense – the same – less intense
- Using $C_1V_1 = C_2V_2$, what is the approximate concentration in ppm for the unknown?
In Well #5 $6.30\text{ppm} (4 \text{ drops}) = C_2 (8 \text{ drops})$
 $3.15 \text{ ppm} = C_2$

7. Atomic Spectra: Using the Rydberg equation (where $R = 3.29 \times 10^{15}$ Hz) and the speed of light ($C = 2.998 \times 10^8$ m/s):

a. Calculate the expected frequencies in Hertz (s^{-1}) of the radiation emitted by a hydrogen atom for the following electronic transitions.

$$\nu = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

b. Calculate the expected wavelengths in nanometers (nm) of the radiation emitted by a hydrogen atom for the same electronic transitions.

$$C = \lambda\nu$$

c. Label which wavelengths correspond to the Balmer series and which wavelengths correspond to the Lyman series.

Transitions	Frequency (s^{-1})	Wavelength (nm)	Balmer / Lyman
$n_2 = 3$ & $n_1 = 1$	2.92×10^{15}	1.02×10^{-7} m = 102nm	Ultraviolet so Lyman
$n_2 = 2$ & $n_1 = 1$	2.47×10^{15}	1.21×10^{-7} m = 121nm	Ultraviolet so Lyman
$n_2 = 5$ & $n_1 = 2$	6.91×10^{14}	4.34×10^{-7} m = 434nm	Visible so Balmer
$n_2 = 4$ & $n_1 = 2$	6.19×10^{14}	4.84×10^{-7} m = 484nm	Visible so Balmer
$n_2 = 3$ & $n_1 = 2$	4.57×10^{14}	6.56×10^{-7} m = 656nm	Visible so Balmer

d. Why did the Hydrogen spectrum have the fewest lines?

The lines are created when the electrons make transitions from one level to another. Hydrogen has only one electron

e. For the Hydrogen spectra, why was the red line more intense (brighter) than the other lines?

The red line corresponds to a lower energy transition; and, since more electrons are making that transition, it appears more intense.

8. Flame Tests – What color flame is produced by each of the following elements?

- copper – green
- lithium – red
- potassium – purple
- magnesium – white
- sodium – yellow

f. Why did we need the copper wire for the Beilstein reaction?

The copper in the wire reacts with the organohalides to produce a green flame.

9. Gas Laws: Using the ideal gas law calculate the volume of the system.

Given: pressure = 738 mmHg, mass = 0.725 grams, $MW_{\text{butane}} = 58.000 \text{ g/mole}$, $T = 20^\circ\text{C}$, $R = 0.08206 \text{ Latm/molK}$

a. What is the number of moles of butane?

$$0.725\text{g} (1 \text{ mole} / 58.000\text{g}) = 0.0125 \text{ moles of butane}$$

b. What is the pressure in atm?

$$1 \text{ mmHg} = 1 \text{ torr} \qquad 760 \text{ torr} = 1 \text{ atm}$$

$$P = 738 \text{ torr} (1 \text{ atm} / 760 \text{ torr}) = 0.971 \text{ atm}$$

c. What is the temperature in K?

$$T = (20 + 273.15) \text{ K} = 293.15 \text{ K}$$

d. What is the volume of the system?

$$PV = nRT \qquad \text{so } V = nRT / P$$

$$V = (0.0125 \text{ mole}) (0.08206 \text{ L atm} / \text{mole K}) (293.15 \text{ K}) / (0.971 \text{ atm})$$

$$V = 0.309 \text{ L}$$

e. What would the volume be at STP?

$$V = (0.0125 \text{ mole}) (0.08206 \text{ L atm} / \text{mole K}) (273.15 \text{ K}) / (1 \text{ atm})$$

$$V = 0.280 \text{ L}$$

or $P_1V_1 / T_1 = P_2V_2 / T_2$

$$V_2 = P_1V_1T_2 / P_2T_1$$

$$V_2 = (0.971 \text{ atm}) (0.309 \text{ L}) (273.15 \text{ K}) / (1 \text{ atm}) (293.15 \text{ K})$$

$$V_2 = 0.280 \text{ L}$$

10. Gas Chromatography:

For peak A, the retention time is 120 mm, the baseline width is 60 mm, and the height is 30 mm. For peak B, the retention time is 200 mm, the baseline width is 40 mm, and the height is 30 mm.

a. For each peak, calculate the number of theoretical plates, N, where $N = 16 (t_R / w_b)^2$.

$$\begin{aligned} N(P_A) &= 16(120\text{mm} / 60\text{mm})^2 \\ &= 64 \end{aligned}$$

$$\begin{aligned} N(P_B) &= 16(200\text{mm} / 40\text{mm})^2 \\ &= 400 \end{aligned}$$

b. For each peak, calculate the area. This has been simplified to the equation for the area of a triangle, where $A = \frac{1}{2} (\text{base})(\text{height})$.

$$\begin{aligned} A(P_A) &= \frac{1}{2} (60\text{mm}) (30 \text{ mm}) \\ &= 900 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} A(P_B) &= \frac{1}{2} (40\text{mm}) (30\text{mm}) \\ &= 600 \text{ mm}^2 \end{aligned}$$

c. How do you determine the efficiency of the systems? theoretical plates or Areas?

d. Which peak, corresponds to the most efficient elution through the column? P_A P_B

e. Using the peak areas, calculate the composition of (ratio of) the mixture A B.

$$\%A = [900 \text{ mm}^2 / (900 \text{ mm}^2 + 600 \text{ mm}^2)] \times 100 = 60\%$$

$$\%B = [600 \text{ mm}^2 / (900 \text{ mm}^2 + 600 \text{ mm}^2)] \times 100 = 40\%$$

f. How does the elution (travel time) change when you lengthen the column?

- for a gas with low interaction? **Travel time does not change much.**

- for a gas with high interaction? **Travel time becomes extended.**

g. So what would changing the column length accomplish if the peaks were initially overlapping?

The longer the column, the greater the separation will be.

h. For the gas chromatography, we measured the retention time to the top of the peak. For the paper chromatography, we measured the retention time to the center of the dot. Why did we choose these points?

The peak and the center of the dot correspond to the average amounts.

11. Statistics:

- a. For the following data set (2.10, 3.20, 3.50, 4.90, 4.30, 2.90) find the mean (average).

$$\begin{aligned}x_{\text{bar}} &= (2.10 + 3.20 + 3.50 + 4.90 + 4.30 + 2.90) / 6 \\ &= 20.9 / 6 \\ &= 3.48\end{aligned}$$

- b. For the average of the data set above, calculate the % Error if the expected answer was 3.500.

$$\begin{aligned}\% \text{Error} &= [(3.500 - 3.483) / 3.500] \times 100 \\ &= 0.4857\%\end{aligned}$$

- b. For this data set would you calculate the standard deviation or the standard deviation estimate? Explain why.

You would use the standard deviation estimate because you had a small sample population.

12. People – How did these people contribute to the experiments we did in Chem 2?

- a. Galileo turned his telescope to the heavens and discovered many astronomical phenomena which helped to prove that the earth travels around the sun.
- b. Isaac Newton used prisms to prove white light was composed of colored light.
- c. Pierre and Marie Curie were Nobel laureates who discovered elements Polonium and Radium which were more radioactive than uranium.
- d. Niels Bohr developed the “planetary” model of atom where electrons had fixed orbits.
- e. Max Planck quantized energy and described in mathematically with $E = nh\nu$.
- f. Albert Einstein was famous for his theories of relativity and $E=mc^2$; but he also envisioned particles of light as “photons”.
- g.& h. Robert Bunsen & Gustav Kirchoff figured out that the emission spectrum of elements matched the black solar lines seen by Fraunhofer.
- i. Johann Balmer mathematically described the series of lines in the spectrum for hydrogen.
- j. Ernst Rutherford developed an experiment where they shot α -particles at gold foil. The particles scattered and it was realized the Plum Pudding model of the atom must not be accurate.
- k. Joseph von Fraunhofer studied the solar spectrum to try and improve glass lenses and discovered black lines in the solar spectrum.
- l. Mikhail Tswett developed the first column for liquid chromatography and coined the term chromatography.
- m. Robert Boyle “The Father of Modern Chemistry” was an Irish Chemist who found that at constant temperature $P_1V_1 = P_2V_2$.
- n. Jacques-Alexandre Charles was a French Chemist who found that at constant pressure $V_1 / T_1 = V_2 / T_2$.
- p. Amedeo Avogadro determined the number of atoms per mole; and found that at constant P&T, V is related to n.
- q. Joseph-Louis Gay-Lussac was a French Chemist who found that at constant volume $P_1 / T_1 = P_2 / T_2$.
- r. John Dalton showed that the partial pressure of each gas contributes to the total pressure.
- s. Johannes Diderik van der Waals revised the ideal gas law equation so that it can be used for real gases.
- t. My TA’s name is...

Extra: Ibn Alhazen was the “Father of Optics” who studied light and determined many of its properties.

13. **Dimensional Analysis:** Choose problems from sets 1, 2, 4 or 5 and work them.

14. Scientific Notation & Significant Figures:

- a. Choose problems from sets 1 & 2 and work them.
- b. Review problems from the midterm exam.

****Note:** Most of the questions on the final will be similar to those on review and on quizzes.