Chemistry 222 **Name**_____
Spring 2021 **80 Points**
Exam 1: Chapters 1-5

Complete five (5) of the following problems. CLEARLY mark the problems you do not want graded. You must show your work to receive credit for problems requiring math. Report your answers with the appropriate number of significant figures.

Do <u>five</u> of problems 1-7. Clearly mark the problems you do not want graded. (16 pts each)

1. A solution was prepared by dissolving 1.795 grams of a solid sample containing an unknown amount of lead in a total of 100.00 mL of solution, which was labeled solution A. Before analysis, 5.00 mL of solution A was pipetted into a 100.00 mL volumetric flask, mixed and diluted to the mark to form solution B. Then 10.00 mL of solution B was pipetted into a 25.00 mL volumetric flask, mixed and diluted to the mark to make solution C. Analysis of solution C determined that it had a lead concentration of 11.2 ppm. What was the percent lead by mass in the original solid sample? You may assume a density of 1.00 g/mL for all solutions.

2. A Standard Reference Material is certified to contain 45.4 ppm of an organic contaminant in soil. You analyze this material to characterize a new method you are developing. Your analysis gives values of 47.8, 47.4, 45.3, 48.1, and 47.2 ppm. Evaluate the results for suspect data and determine whether your results indicate the presence of systematic error in your method at the 95% confidence level. Justify your answer.

3. Acid solutions can be standardized using primary standard sodium carbonate, much like base solutions can be standardized using pure KHP as we did in lab. Below is data from a titration of a sodium carbonate sample with a solution of hydrochloric acid of unknown concentration. In this titration, approximately 25 mL of distilled water was used to dissolve the sodium carbonate that was dispensed from the weighing bottle into an Erlenmeyer flask. What is the molarity of the hydrochloric acid solution with its absolute uncertainty?

Initial mass of weighing bottle and sodium carbonate	32.1834±0.0002 g
Final mass of weighing bottle after sample was removed	30.9651±0.0002 g
Initial buret reading	2.83±0.02 mL
Final buret reading	39.45±0.02 mL
Molar mass of sodium carbonate	105.9885±0.0002 g/mol

4. Complete both parts in a few sentences. (8 pts each part)
   a. Why do systematic (determinate) errors typically have a larger impact on the accuracy of a measurement than random (indeterminate) errors?

   b. You have been tasked with determining the limit of detection for a new instrumental technique for the determination of lead in drinking water. Describe how you would accomplish this task. Include a general description of the samples you would make and measure and how these measurements would be used to determine the LOD.

5. You are working to develop a new method for the determination of the sulfur content in coal. If successful, your method has the potential to be very valuable. To validate your method, you decide to compare it to an established, "Industry Standard" method. The weight percent sulfur of four different coal samples (each containing different amounts of S) was measured by the two different methods. Does your method give results that are consistent with the Industry Standard at the 95% confidence level?

Sample	**1**	**2**	**3**	**4**
Industry Standard Method	1.157	1.538	1.795	2.284
Your Method	1.151	1.534	1.785	2.280

6. You are working to determine the concentration of acetaminophen in an analgesic preparation by absorbance spectrophotometry. You prepare an unknown solution and series of standard solutions and measure the absorbance of each solution at 255 nm. The resulting data is shown below. Assuming a linear relationship between absorbance and concentration, describe how you would determine the 95% confidence interval for the acetaminophen concentration of the unknown. You DO NOT need to do any calculations, just clearly describe how you would go from the raw data to find the 95% confidence interval for the unknown. What key parameters will you calculate along the way? What value do you select for t?

[acetaminophen] (mM)	Absorbance at 255 nm
0.00	0.279
10.37	0.602
20.74	0.896
31.11	1.188
41.48	1.443
Unknown	0.785

7. You have been given the task of teaching a quantitative analysis student, Al Thumbs, the proper preparation and use of a Class A buret for titrations in order to obtain high quality quantitative results. Clearly describe your instructions to this student, include reminders of common pitfalls Al should avoid.

Possibly Useful Information

$m = \frac{m'\left(1-\frac{d_a}{d_w}\right)}{\left(1-\frac{d_a}{d}\right)}$	Density of air = 0.012 g/ml Density of balance weights = 8.0 g/ml
$\mu = \bar{x} \pm \frac{ts}{\sqrt{n}}$	$y = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2/2\sigma^2}$
$e_C = \sqrt{e_A^2 + e_B^2}$	$e_C = C\sqrt{\left(\frac{e_A}{A}\right)^2 + \left(\frac{e_B}{B}\right)^2}$
$t_{calculated} = \frac{\lvert known\ value - \bar{x}\rvert}{s}\sqrt{n}$	$s = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{n-1}}$
$t_{calculated} = \frac{\lvert \bar{x}_1 - \bar{x}_2\rvert}{s_{pooled}}\sqrt{\frac{n_1 n_2}{n_1 + n_2}}$	$s_{pooled} = \sqrt{\frac{s_1^2(n_1-1) + s_2^2(n_2-1)}{n_1 + n_2 - 2}}$
$t_{calculated} = \frac{\bar{d}}{s_d}\sqrt{n}$	$s_d = \sqrt{\frac{\sum_i (d_i - \bar{d})^2}{n-1}}$
$s_x = \frac{s_y}{\lvert m\rvert}\sqrt{\frac{1}{k} + \frac{1}{n} + \frac{(y-\bar{y})^2}{m^2 \sum (x_i - \bar{x})^2}}$	$s_y = \sqrt{\frac{\sum (d_i - \bar{d})^2}{n-2}} = \sqrt{\frac{\sum d_i^2}{n-2}}$
$s_m^2 = \frac{s_y^2 \times n}{D}$	$s_b^2 = \frac{s_y^2 \sum x_i^2}{D}$
$y_{LOD} = y_{blank} + 3s$	$F_{calculated} = \frac{(s_1)^2}{(s_2)^2}$
$Q_{calculated} = \frac{gap}{range}$	$G_{calculated} = \frac{\lvert suspect\ value - \bar{x}\rvert}{s}$

Values of Student's t

Degrees of Freedom	Confidence Level (%)			
	90	95	99.5	99.9
1	6.314	12.706	127.32	636.61
2	2.920	4.303	14.089	31.598
3	2.353	3.182	7.453	12.924
4	2.132	2.776	5.598	8.610
5	2.015	2.571	4.773	6.869
6	1.943	2.447	4.317	5.959
7	1.895	2.365	4.029	5.408
8	1.860	2.306	3.832	5.041
9	1.833	2.262	3.690	4.781
10	1.812	2.228	3.581	4.587
∞	1.645	1.960	2.807	3.291

Values of *Q* for rejection of data

# of Observations	Q (90% Confidence)
4	0.76
5	0.64
6	0.56

Grubbs Test for Outliers

# of Observations	$G_{critical}$ At 95% confidence
4	1.463
5	1.672
6	1.822

Critical Values of F at the 95% Confidence Level

Degrees of freedom for s_2	Degrees of freedom for s_1								
	2	3	4	5	6	7	8	9	10
2	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4
3	9.55	9.28	9.12	9.01	8.94	8.89	8.84	8.81	8.79
4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96
5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74