

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 five 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 |

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

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

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 |

Periodic Table of the Elements

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|--|---------------------------------------|--|--|--|---|--|---------------------------------------|---|---|--|--|--|--|--|--|---|---|---------------------------------------|--|---|--|---|---|---|---|---|---|--|--|---|---|--|--|--|
| 1 H Hydrogen 1.008 | 2 He Helium 4.003 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 Li Lithium 6.941 | 4 Be Beryllium 9.012 | | | | | | | | | | | 5 B Boron 10.811 | 6 C Carbon 12.011 | 7 N Nitrogen 14.007 | 8 O Oxygen 15.999 | 9 F Fluorine 18.998 | 10 Ne Neon 20.180 | | | | | | | | | | | | | | | | | | |
| 11 Na Sodium 22.990 | 12 Mg Magnesium 24.305 | | | | | | | | | | | 13 Al Aluminum 26.982 | 14 Si Silicon 28.086 | 15 P Phosphorus 30.974 | 16 S Sulfur 32.066 | 17 Cl Chlorine 35.453 | 18 Ar Argon 39.948 | | | | | | | | | | | | | | | | | | |
| 19 K Potassium 39.098 | 20 Ca Calcium 40.078 | 21 Sc Scandium 44.956 | 22 Ti Titanium 47.867 | 23 V Vanadium 50.942 | 24 Cr Chromium 51.996 | 25 Mn Manganese 54.938 | 26 Fe Iron 55.845 | 27 Co Cobalt 58.933 | 28 Ni Nickel 58.693 | 29 Cu Copper 63.546 | 30 Zn Zinc 65.38 | 31 Ga Gallium 69.723 | 32 Ge Germanium 72.631 | 33 As Arsenic 74.922 | 34 Se Selenium 78.971 | 35 Br Bromine 79.904 | 36 Kr Krypton 83.798 | | | | | | | | | | | | | | | | | | |
| 37 Rb Rubidium 85.468 | 38 Sr Strontium 87.62 | 39 Y Yttrium 88.906 | 40 Zr Zirconium 91.224 | 41 Nb Niobium 92.906 | 42 Mo Molybdenum 95.95 | 43 Tc Technetium 98.907 | 44 Ru Ruthenium 101.07 | 45 Rh Rhodium 102.906 | 46 Pd Palladium 106.42 | 47 Ag Silver 107.868 | 48 Cd Cadmium 112.414 | 49 In Indium 114.818 | 50 Sn Tin 118.711 | 51 Sb Antimony 121.760 | 52 Te Tellurium 127.6 | 53 I Iodine 126.904 | 54 Xe Xenon 131.294 | | | | | | | | | | | | | | | | | | |
| 55 Cs Cesium 132.905 | 56 Ba Barium 137.328 | 57-71 Lanthanide Series | | 72 Hf Hafnium 178.49 | 73 Ta Tantalum 180.948 | 74 W Tungsten 183.84 | 75 Re Rhenium 186.207 | 76 Os Osmium 190.23 | 77 Ir Iridium 192.227 | 78 Pt Platinum 195.085 | 79 Au Gold 196.967 | 80 Hg Mercury 200.592 | 81 Tl Thallium 204.383 | 82 Pb Lead 207.2 | 83 Bi Bismuth 208.980 | 84 Po Polonium (208.982) | 85 At Astatine 209.987 | 86 Rn Radon 222.018 | | | | | | | | | | | | | | | | | |
| 87 Fr Francium 223.020 | 88 Ra Radium 226.025 | 89-103 Actinide Series | | 104 Rf Rutherfordium (261) | 105 Db Dubnium (262) | 106 Sg Seaborgium (266) | 107 Bh Bohrium (264) | 108 Hs Hassium (269) | 109 Mt Meitnerium (278) | 110 Ds Darmstadtium (281) | 111 Rg Roentgenium (280) | 112 Cn Copernicium (285) | 113 Nh Nihonium (286) | 114 Fl Flerovium (289) | 115 Mc Moscovium (289) | 116 Lv Livermorium (293) | 117 Ts Tennessine (294) | 118 Og Oganesson (294) | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | 57 La Lanthanum 138.905 | 58 Ce Cerium 140.116 | 59 Pr Praseodymium 140.908 | 60 Nd Neodymium 144.243 | 61 Pm Promethium 144.913 | 62 Sm Samarium 150.36 | 63 Eu Europium 151.964 | 64 Gd Gadolinium 157.25 | 65 Tb Terbium 158.925 | 66 Dy Dysprosium 162.500 | 67 Ho Holmium 164.930 | 68 Er Erbium 167.259 | 69 Tm Thulium 168.934 | 70 Yb Ytterbium 173.055 | 71 Lu Lutetium 174.967 | | | |
| | | | | | | | | | | | | | | | | | | 89 Ac Actinium 227.028 | 90 Th Thorium 232.038 | 91 Pa Protactinium 231.036 | 92 U Uranium 238.029 | 93 Np Neptunium 237.048 | 94 Pu Plutonium 244.064 | 95 Am Americium 243.061 | 96 Cm Curium 247.070 | 97 Bk Berkelium 247.070 | 98 Cf Californium 251.080 | 99 Es Einsteinium (254) | 100 Fm Fermium 257.095 | 101 Md Mendelevium 258.1 | 102 No Nobelium 259.101 | 103 Lr Lawrencium (262) | | | |