Chemistry 236 -- Quiz 4

Lab Day ____

March 26, 2013 — Least Squares, Probability, and KaleidaGraph

1. (8) Discrete probability distributions are like continuous, except that sums over the possible outcomes replace integrals over the defined range for a continuous probability distribution. We explored this relation through Statistics Problem 23, which dealt with the probability distribution for a single toss of a 6-sided "true" die, having the numbers 1 − 6 on its sides. Give or derive: (a) the probability of getting a 4, (b) the probability of getting an even number, (c) the average value, (d) the variance, and (e) the standard deviation.

   (a) 1/6 (b) 1/2 (c) 7/2 (d) 35/12 (e) $(35/12)^{1/2}$

2. (5) Morely Smartt and Bud Wizer carry out measurements to determine the value of a quantity we will call the Quodacity *Q*, using an instrument and techniques known to have a standard deviation of 0.11 for *single* measurements. Smartt does 100 measurements and obtains the average value 3.6633, while Wizer runs just 4 and gets 3.6418.

   (a) Using the 10% rule, properly state the results of Smartt and Wizer and their uncertainties.

   Smartt: 3.663(11) Wizer: 3.64(6)

   (b) If the true value of *Q* is thought to be 3.6981(7), which result — Smartt's or Wizer's — is the greater cause for "concern"? Be quantitative in your explanation.

   Smartt's value differs from accepted by > 3 σ, which occurs < 0.3% of the time by chance, so is probably indicative of systematic errors in his measurements. Wizer's is within about 1 σ, which is not so unreasonable.

3. (5) In Experiment 2 (Inversion of sucrose), we obtained Arrhenius activation energies from values of the rate constant at T_1 and T_2, using $\ln(k_2/k_1) = E_a/R\,(T_1^{-1} - T_2^{-1})$.

   a. If k_2 has 2.5 % uncertainty and k_1 has 3.5 % uncertainty, what is the % uncertainty in their ratio? 4.3%

   b. Assuming T_1 and T_2 have negligible uncertainty, use these results to give an expression for the uncertainty in E_a, in terms of R, T_1, and T_2.

   $\sigma_{Ea} = \sigma[\ln(k_2/k_1)]\,R\,/\,(T_1^{-1} - T_2^{-1}) = 0.043\ R\,/\,(T_1^{-1} - T_2^{-1})$.

4. (3) You conclude that your thermistor calibration data for a bomb calorimetry setup are adequately represented by a quadratic function of the thermistor readout *t* (in °C) over the calibration range 19-35°C. Write **exactly** what you should enter in the KG Define Fit box to fit your data in a way that you can directly read the uncertainty of calibration at 29°C from the fit results box.

   a + b*(x − 29) + c*(x−29)^2; a=1; b=1; c=1 Then calib. error at 29°C (apparent) is s_a.

5. (5) In using KG to investigate the statistics of random numbers and the uniform probability distribution, we first generated 10^4 random numbers in the default range $0 < x < 1.0$.

   (a) Give the expected number of such random deviates that will fall in the range 0.20 − 0.36. 1600

   (b) What is the standard deviation of this expected bin count? 40

   (c) In another such binning experiment, the expected count is 900. Use the accompanying table to calculate the probability that the actual count will fall in the range 900-950.

   σ = 30 --> t = 5/3 --> probability = 0.452.