

CHEMISTRY 31 EXAM 1
Mar. 2, 2015

NAME _____

LAB SECTION # _____

Some Useful Equations and Constants:

Propagation of uncertainty:

Addition/subtraction:

$$y = a + b \text{ or } y = a - b$$

$$S_y = \sqrt{S_a^2 + S_b^2}$$

multiplication/division:

$$y = a \cdot b \text{ or } y = a / b$$

$$\frac{S_y}{y} = \sqrt{\left(\frac{S_a}{a}\right)^2 + \left(\frac{S_b}{b}\right)^2}$$

Exponents:

$$y = a^n$$

$$\frac{S_y}{y} = n \frac{S_a}{a}$$

Note: n = constant
with no uncertainty

Statistics:

Standard deviation:

$$S = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$$

Grubbs Test: $G_{\text{calculated}} = \frac{|x_{\text{suspect}} - \bar{x}|}{S}$

Thermodynamics:

$$\Delta G = \Delta G^\circ + RT \ln Q \quad \Delta G^\circ = -RT \ln K \text{ (at equilibrium)} \quad R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}, 0^\circ\text{C} = 273.15 \text{ K}$$

A. Multiple Choice/Fill in the Blank Section. Only one correct answer for multiple choice questions. (4 points for each question)

1. Which of the following units is an SI base unit?

- a) centimeter b) minute c) atmosphere d) mole

2. The point in a titration in which an indicator changes color (in response to a change in reactant concentration) is called:

- a) the end point b) the equivalence point c) the half way point
d) the equilibrium point

3. How many significant figures are there in the value 0.00302?

- a) 2 b) 3 c) 4 d) 5

4. A scientist is analyzing water samples for iron concentration. She wants to see if adding nitric acid will help preserve samples. She has collected 20 samples from different lakes and streams. Half of each sample is treated with nitric acid, and then both (with and without nitric acid) are analyzed for iron. What statistical test should be performed to see if there is a significant difference in iron concentration by adding nitric acid?

- a) case 1 t-test b) case 3 t-test c) F-test d) Grubbs test

5. When would you want to use a Z-based-, as opposed to a t-based-, confidence interval?
condition: _____

6. Calibration standards are prepared of known concentration and analyzed by an instrument giving a measure response. When using linear least squares properly to fit the data, response is plotted on the ___ axis and the uncertainty in response should be _____.

7. Given that the following reaction: $\text{MgCO}_3(\text{s}) \rightleftharpoons \text{Mg}^{2+} + \text{CO}_3^{2-}$ is exothermic, which of the following changes would lead to a shift to the products? Assume the reaction is initially at equilibrium with $\text{MgCO}_3(\text{s})$ present.

- a) add $\text{MgCO}_3(\text{s})$ b) add $\text{MgCl}_2(\text{aq})$ c) add water (dilute reaction)
d) increase the temperature

B. Problem Section. Show all needed calculations to receive full credit. The number of points are shown in parentheses. Use the back side of the page if needed.

1. The actinide thorium (Th) reacts with fluoride as: $\text{Th}^{4+} + 4\text{F}^- \Rightarrow \text{ThF}_4$. If 25.0 mL of 0.0246 M Th^{4+} are added to an HF solution,

a) calculate the moles of F^- reacted if the reaction goes to completion. (6 pts)

b) calculate the mass (in g) of a 0.521 wt % aqueous HF solution needed to provide the moles of F^- in a). The formula weight of HF is 20.01 g/mol. (6 pts)

2. It is desired to measure the concentration of CO emitted from cars. Standards ranging from 25 to 500 ppmv are prepared and analyzed by a CO analyzer giving the following equation for the calibration line:

$$\text{response} = m \cdot \text{concentration} + b$$

where $m = 0.950 \text{ mV/ppmv}$ and $b = -12.1 \text{ mV}$

A 6 year-old car gives a response of 194 mV.

a) Calculate the concentration of CO emitted from this car. (6 pts)

b) Is this value reliable (based on where the value falls relative to standards)?
(4 pts)

3. A student has a solution of sulfuric acid, H_2SO_4 , of unknown concentration. She pipets 15.0 ± 0.2 mL of the solution into an Erlenmeyer flask and titrates it with 0.100 ± 0.001 M NaOH which reacts as: $\text{H}_2\text{SO}_4 + 2\text{OH}^- \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}(l)$. The buret delivering the OH^- goes from 0.22 ± 0.04 to 13.91 ± 0.04 mL (initial volume to equivalence point). Calculate the concentration of the sulfuric acid in the unknown solution and its absolute uncertainty (with the correct number of significant figures). (20 pts)

4. A research scientist is investigating a new method to determine the concentrations of carbohydrates in food samples which is faster and has potential to be more precise than the old method. A food sample is analyzed 4 times by the new method. The individual values are listed in the table below:

Sample % carbohydrate

| Analysis 1 | Analysis 2 | Analysis 3 | Analysis 4 |
|------------|------------|------------|------------|
| 18.5 | 19.1 | 19.4 | 18.8 |

a) Using the table below, determine the 95% confidence level for the food sample % carbohydrate giving the correct number of significant figures. (10 pts)

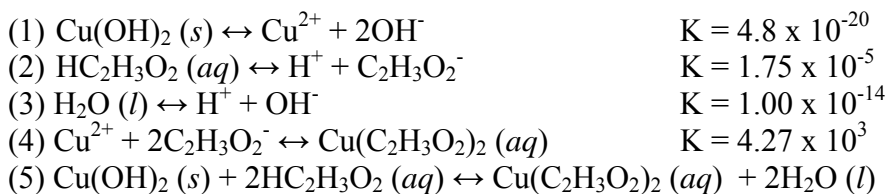
t Table for 95% confidence

| Degrees of freedom | 1 | 2 | 3 | 4 | 5 |
|--------------------|-------|------|------|------|------|
| t value | 12.71 | 4.30 | 3.18 | 2.78 | 2.57 |

b) If the same food sample was analyzed using the old method, which type of test should be used for the above data to **determine if the new method is more precise?** (4 points)

Bonus question (part of #4 on p.3) The scientist needs a 95% confidence of under $\pm 1\%$ (absolute uncertainty in % carbohydrate). What is the minimum number of replicate sample analyses needed to meet this using the new method (assuming the standard deviation for other samples will be roughly the same as calculated above)? (3 pts)

5. Given the equilibrium constants for reactions 1 to 4 (below), determine the K for reaction 5 (8 pts),



a) determine **K** for reaction 5 (9 pts)

b) calculate ΔG° for reaction 1 at 25°C. [See p. 1 for constants] (7 pts)