CHEMISTRY 31 EXAM 1
March 6, 2017

NAME__________________ LAB SECTION # _________

Some Useful Equations and Constants:

Propagation of uncertainty:

Addition/subtraction:

$y = a + b$ or $y = a - b$

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

multiplication/division:

$y = a \cdot b$ 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: $S = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$

Case 3 t-test: $t_{calc} = \frac{|\bar{d}|\sqrt{n}}{s_d}$

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

F-Test: $F_{calc} = S_1^2/S_2^2$ (where $S_1 > S_2$)

Thermodynamics:

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

The quadratic equation for $ax^2 + bx + c = 0$ is $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

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. An Mg standard is 0.996% by mass. How many grams of solution are needed to deliver 2.00 g of Mg? *(2.00 g Mg)*(100 g sol'n/0.996 g Mg) =*

a) 0.0199 g b) 1.99 g c) 2.01 g **d) 201 g**

3. The number of significant figures in the sum of 13.11 + 0.9 is: *(=14.01)*

a) 1 b) 2 **c) 3** d) 4

4. In a weight loss show, a contestant measures her weight every day for one week. One day the weight was 4 lbs more than any other day's reading, and the contestant wants to discard that one measurement. In order to discard that measurement, she should use a/an:

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

5. A test sample is analyzed for testosterone using a new method. The measured value is 38.11 $\pm$ 0.02 mg/L (second number is standard deviation) while the true value is 27.1 mg/L. It is desired to have % errors under 5% and % relative standard deviations under 2%. We can conclude that the measurement is:

a) precise and accurate
b) precise but not accurate
c) accurate but not precise
d) neither precise nor accurate

6. A bottle containing 200 vitamin tablets with a listed amount of 75 mg of vitamin C (per tablet). Eight tablets are sampled with the vitamin C mass measured. The mean $\pm$ 95% confidence interval is found to be 78 $\pm$ 5 mg. What this means is:

a) all tablets in the bottle will have between 73 and 83 mg of vitamin C
b) all of the tablets will have more than 75 mg of vitamin C
c) there is significantly more vitamin C than listed on the label.
d) a randomly selected tablet will have between 73 and 83 mg of vitamin C 95% of the time

7. The K value for the reaction $\frac{1}{2}H_2(g) + \frac{1}{2} Br_2(g) \leftrightarrow HBr(g)$ is 3.9×10^{-9}. The K value for $2HBr(g) \leftrightarrow H_2(g) + Br_2(g)$ is:

a) 6.6×10^{16}
b) 5.1×10^{8}
c) 2.6×10^{8}
d) -7.8×10^{-9}

8. In which of the following reactions will the entropy increase?

a) $I_2(aq) \leftrightarrow I_2(s)$
b) $I_2(s) + Br_2(aq) \leftrightarrow 2IBr(aq)$
c) $I_2(g) \leftrightarrow I_2(s)$
d) $2I(g) \leftrightarrow I_2(g)$

9. Given that the following reaction: $MgCO_3(s) \Leftrightarrow Mg^{2+} + CO_3^{2-}$ is exothermic, which of the following changes would lead to a shift to the products? Assume the reaction is initially at equilibrium with $MgCO_3(s)$ present.

a) add $MgCO_3(s)$
b) add $MgCl_2(aq)$
c) add water (dilute reaction)
d) increase the temperature

10. A solution is prepared by mixing aqueous solutions of NaF and $Ca(NO_3)_2$. CaF_2 is the only sparingly soluble ion pair that can form (others being highly soluble). Precipitation is expected if:

a) $Q > K_{sp}(CaF_2)$
b) $K_{sp}(CaF_2) = Q$
c) $Q < K_{sp}(CaF_2)$

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. Calculate the molarity (M) of Ca^{2+} in a solution that is 4.8% by mass $CaCl_2$ if the density of the solution is 1.08 g/mL. (8 pts) Atomic weights: Ca 40.08 g/mol; Cl 35.45 g/mol.

$FW(CaCl_2) = 40.08 + 2(35.45)$ g/mol = 110.98 g/mol

*$[Ca^{2+}]$ = (4.8 g $CaCl_2$/100 g sol'n)(1 mol $CaCl_2$/110.98 g $CaCl_2$)(1 mol Ca^{2+}/1 mol $CaCl_2$)**
(1.08 g sol'n/mL sol'n)(1000 mL/1 L)

$[Ca^{2+}]$ = 0.47 M

2. A chemist wants to find the mass and absolute uncertainty in mass of a metal alloy cube. It has a side of length 1.81 ± 0.07 cm and a density of 2.9 ± 0.2 g/cm^3. Be sure to give the answer with the correct number of significant figures. The volume of a cube of length $\ell = \ell^3$. (14 pts)

Mass = d(vol) = $d\ell^3$ *= (2.9 g/cm^3)(1.81 cm)^3 = (2.9 g/cm^3)(5.93 cm^3) = 17.196 g*

d = density

$S_{\ell^3}/\ell^3 = 3(S_\ell/\ell) = 3(0.07/1.81) = 0.116$ *(rel. unc. – but that is all that is needed for next step)*

$S_{mass}/mass = [(S_d/d)^2 + (S_{\ell^3}/\ell^3)^2]^{0.5} = [(0.2/2.9)^2 + (0.116)^2]^{0.5} = 0.135$

$S_{mass} = (0.135)(mass) = (0.135)(17.196\ g) = 2.3\ g$

Mass ± S_{mass} *=* ***17 ± 2 g***

Bonus Question. The uncertainty from which measurement contributed more to the uncertainty in the alloy mass. You must show with a calculation to get credit. (3 pts)

$S_d/d = 0.069$ *vs.* $S_{\ell^3}/\ell^3 = 0.116$ *so* ***length contributes more*** *to the overall uncertainty*

3. A water treatment plant just installed a water fluoridation unit. It wants to make sure that the fluoride concentration exceeds 2.00 ppm less than 1 percent of the time. It takes 20 samples and finds the mean and standard deviation in the fluoride concentration are 1.18 ppm and 0.27 ppm, respectively. Assuming that the measured mean and standard deviation are equivalent to the population mean and standard deviation, calculate the percent of samples that would give a value over 2.00 ppm. (10 pts)

Limit = x = 2.00 ppm, $\mu = 1.18$ *ppm and* $\sigma = 0.27$ *ppm*

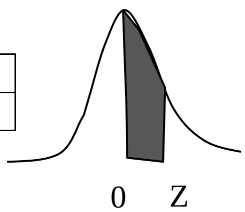
$Z = |x - \mu|/\sigma = (2.00 - 1.18)/0.27 = 3.04 \sim 3$

Probability = fraction of samples = 0.5 – area (this is because 0 to infinity = area of 0.5 and upper limit = 0.5 – table value)

Fraction = 0.500 – 0.499 = 0.001 = ***0.1%***

Z Table

Z	1	1.5	2	2.5	3	3.5
Area (0 to Z)	0.341	0.433	0.477	0.493	0.499	0.4998



Area given in table corresponds to part of Gaussian curve shown to right

4. Arsenic is measured by repeated analysis of a well water sample. The following values are recorded: 23.1, 20.2, 19.7, and 22.3 ppb (parts per billion by weight). (12 pts)
Using the table below, determine:

a) the 95% confidence interval (mean $\pm$ uncertainty) from the good data. Give with correct number of significant figures.

Mean = 21.325 S = 1.63 n = 4 so degrees of freedom = n – 1 = 3

μ = mean $\pm$ $tS/(n)^{0.5}$ = 21.325 $\pm$ $(3.18)(1.63)/(4)^{0.5}$ = 21.33 $\pm$ 2.60 or **21 $\pm$ 3 ppb**

t tables

Degrees of freedom	2	3	4	5
t-value (at 95% level)	4.30	3.18	2.776	2.571

b) If the well water sample was split with part of it being analyzed 3 times by an independent laboratory, what test should be used to determine if there is a significant difference in the mean values?

Case 2 t-test

- *Used when a sample is analyzed multiple times by two methods (or laboratories). Case 3 would be if e.g. 5 different well samples were analyzed by two laboratories.*

5. A scientist is using an instrument to measure the alcohol content in beer. Standards ranging from 2.0% to 8.0 % alcohol are used for calibration giving: response = m*concentration + b where m = 0.45 mV/% alc and b = -0.23 mV. A sample of home brewed beer gives a reading of 2.84 mV. Calculate the % alcohol in the beer. (6 pts)

conc. = (response – b)/m = [2.84 mV – (-0.23 mV)]/(0.45 mV/% alc) = ***6.8%***

6. Given that the K_{sp} for CaF_2 is 3.2×10^{-11}, determine the maximum concentration of F^- (in M) that could be added in the presence of 1.0×10^{-3} M Ca^{2+} (without precipitation of CaF_2). (10 pts)

Precipitation occurs when Q = K_{sp} so no ICE table is needed. Instead, we just need to use $[Ca^{2+}]_o$ for $[Ca^{2+}]$ and solve for $[F^-]$

$3.2 \times 10^{-11} = [Ca^{2+}][F^-]^2 = (0.0010\ M)[F^-]^2$ or $[F^-] = [(3.2 \times 10^{-11})/(0.0010)]^{0.5} =$ **1.8×10^{-4} M**