

Name: Key

Chem 2113

Test 1

Fall 2008

Questions are worth 25 points each. OMIT ONE QUESTION by clearly writing OMIT in the space provided for your work. If you fail to mark OMIT on a question I will omit the last question of the test. Show your work and circle your answers for full credit.

1. The molarity of an NaOH solution was determined by titration vs. KHP. Individual titrations gave the following concentrations: 0.1127M, 0.1126M, 0.1132M, 0.1174M and 0.1173M.

Can any of the points be rejected at the 90% confidence interval? If so, which one(s)?

$$\begin{array}{l} 0.1174 > 0.0001 \\ 0.1173 > 0.0001 \\ 0.1132 \\ 0.1127 > 0.0001 \\ 0.1126 > 0.0001 \end{array} \quad \begin{array}{l} \frac{0.0001}{0.0048} = 0.0208 \\ Q_{crit} = 0.642 \end{array} \quad \begin{array}{l} \text{No rejection} \\ (0.0208 \neq 0.642) \end{array}$$

For all remaining points calculate the mean, the standard deviation, the relative standard deviation in ppt, and the confidence interval for μ at the 90% confidence level.

$$\bar{X} = \frac{0.1127M + 0.1126M + 0.1132M + 0.1174M + 0.1173M}{5} = \underline{0.1146M}$$

$$S = \sqrt{\frac{\sum x^2 - \frac{\sum x^2}{N}}{N-1}} = \sqrt{\frac{0.065736 - \frac{(0.5732)^2}{5}}{5-1}} = \underline{0.0025M}$$

$$RSD = \frac{0.00248}{0.11464} * 1000 = \underline{22 ppt}$$

$$CI = 0.1146 \pm \frac{(2.132)(0.00248)}{\sqrt{5}} = 0.1146(\pm 0.0024) \\ = \underline{0.115(\pm 0.002)M}$$

This particular analysis has been performed thousands of times - enough such that the population standard deviation (σ) can be determined. Assuming that σ is equal to 0.0003M for this determination, calculate the 'new' confidence interval for μ at the 90% confidence interval.

$$CI = \bar{X} \pm \frac{Z_{\alpha/2}}{\sqrt{N}} \Rightarrow 0.1146 \pm \frac{(1.645)(0.0003)}{\sqrt{5}} \\ = \underline{0.1146(\pm 0.0002)M}$$

2. In the process of assessing responsibility for an oil spill on Lake Lawtonka, two possible suspects are identified. To differentiate between the two samples of oil the ratio of the concentration for two polyaromatic hydrocarbons is measured using fluorescence spectroscopy. These values are then compared to the sample obtained from Lake Lawtonka:

	<u>Mean</u>	<u>Std. Dev</u>	<u># Samples</u>
Suspect 1	2.31	0.07 ₃	4
Suspect 2	2.67	0.09 ₂	5
Sample	2.45	0.08 ₈	6

Can either (or both) of the suspects be eliminated based on the results of the analysis at the 99% confidence level? [NOTE: Subscripted values are non-significant figures that are provided to decrease the 'round-off' error associated with the calculations]

For Suspect 1:

$$S_{pooled} = \sqrt{\frac{0.07_3^2(4-1) + 0.08_8^2(6-1)}{4+6-2}}$$

$$= 0.08_{27}$$

$$t_{exp} = \frac{|2.31 - 2.45|}{0.08_{27}} \sqrt{\frac{6 \times 4}{6+4}}$$

$$= 2.524$$

$$t_{crit} = 3.355 \text{ (8 dof)}$$

∴ Suspect 1 cannot be eliminated.

For suspect 2

$$S_{pooled} = \sqrt{\frac{0.09_2^2(4) + 0.08_8^2(5)}{5+6-2}}$$

$$= 0.08_{98}$$

$$t_{exp} = \frac{|2.67 - 2.45|}{0.08_{98}} \sqrt{\frac{6 \times 5}{6+5}}$$

$$= 4.046$$

$$t_{crit} = 3.250$$

∴ Suspect 2 can be eliminated.

From the above results, should there be a concern that any combination of the standard deviation values demonstrates a significant difference?

$$\frac{0.09_2^2}{0.08_8^2} = 1.093 ; F_{crit} = 5.19 - \text{no sig. d. ff.}$$

$$\frac{0.09_2^2}{0.07_3^2} = 1.588 ; F_{crit} = 9.12 - \text{no sig. d. ff.}$$

$$\frac{0.08_8^2}{0.07_3^2} = 1.4532 ; F_{crit} = 9.01 - \text{no sig. d. ff.}$$

3. The inside diameter of an open cylindrical tank was measured. The results of four replicate measurements were 5.4, 5.2, 5.5, and 5.2 m. Measurements of the height of the tank yielded 9.9, 9.8, and 9.6 m. Calculate the volume of the tank in m^3 and the standard deviation for this result. [NOTE: volume = $\pi r^2 h$]

$$\text{diameter} = 5.3_{25} \text{ m} ; S = 0.15 \text{ m}$$

$$\text{relative error} = \frac{0.15}{5.3_{25}} = 0.0282$$

$$\text{radius} = \text{dia} / 2, \therefore r = 2.66_{25}$$

Because (2) is an exact number (by definition $r = d/2$)

the relative error is still 0.0282

$$r^2 = 7.0889, \text{ r.e.} = 0.0282 * 2 \left[\text{for an exponent } y = a^x \right] \\ = 0.0563 \left[\frac{S_y}{y} = x \frac{S_a}{a} \right]$$

$$\text{height} = 9.7_{66} ; S = 0.1528$$

$$\text{relative error} = \frac{0.1528}{9.7_{66}} = 0.0156$$

$$\text{For } \pi r^2 h, \text{ r.e.} = \sqrt{0.0563^2 + 0.0156^2} = 0.0585 (= S_y/y)$$

$$\pi * (2.66_{25})^2 * 9.7_{66} = 217.5081 \text{ m}^3 (= y)$$

$$\therefore S_y = 0.0585 * 217.5081 \text{ m}^3 = 12.7242 \text{ m}^3$$

$$\text{Volume} = \underline{\underline{220 (\pm 10) \text{ m}^3}}$$

4. What is the density of 54.3 wt % aqueous NaOH (MW = 40.00) if 17.6 mL of the solution diluted to 2.00 L gives 0.196 M NaOH?

$$\text{mol NaOH} = 2.00 \text{ L} \times 0.196 \frac{\text{mol}}{\text{L}} = 0.392 \text{ mol NaOH}$$

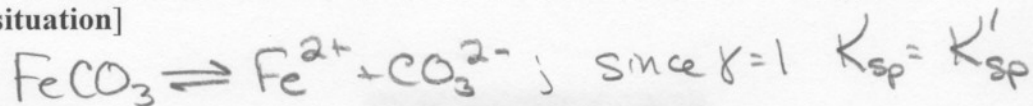
$$\text{mass NaOH} = 0.392 \text{ mol NaOH} \times 40.00 \frac{\text{g}}{\text{mol}} = 15.68 \text{ g NaOH}$$

$$\text{mass sol'n} = 15.68 \text{ g NaOH} \times \frac{100 \text{ g sol'n}}{54.3 \text{ g NaOH}} = 28.88 \text{ g sol'n}$$

$$d_{\text{sol'n}} = \frac{28.88 \text{ g sol'n}}{17.6 \text{ mL sol'n}} = \underline{\underline{1.64 \text{ g/mL}}}$$

5. Consider the dissociation of iron(II) carbonate (FeCO_3 ; $K_{sp} = 2.1 \times 10^{-11}$)

a) Calculate the molar solubility of FeCO_3 in water [HINT - assume $\gamma_i = 1$ for all ions in this situation]



$$K'_{sp} = [\text{Fe}^{2+}][\text{CO}_3^{2-}]$$

$$x^2 = 2.1 \times 10^{-11} \Rightarrow x = \sqrt{2.1 \times 10^{-11}} = \underline{4.6 \times 10^{-6}}$$

b) Calculate the concentration equilibrium constant for FeCO_3 in 0.0010 M NaCl.

$$\text{For } 0.001 \text{ M NaCl } \mu = \frac{C_{\text{Na}^+} z_{\text{Na}^+}^2 + C_{\text{Cl}^-} z_{\text{Cl}^-}^2}{2} = \frac{0.001 \times 1^2 + 0.001 \times 1^2}{2} = 0.001$$

$$\text{For } \mu = 0.001: \gamma_{\text{Fe}^{2+}} = 0.870 \quad \gamma_{\text{CO}_3^{2-}} = 0.868 \quad K'_{sp} = \frac{2.1 \times 10^{-11}}{(0.870)(0.868)} = 2.8 \times 10^{-11}$$

c) Calculate the molar solubility of FeCO_3 in 0.0010 M NaCl.

$$K'_{sp} = [\text{Fe}^{2+}][\text{CO}_3^{2-}]$$

$$x^2 = 2.8 \times 10^{-11}$$

$$x = \underline{5.3 \times 10^{-6} \text{ M}}$$

d) Calculate the molar solubility of FeCO_3 in a solution of 0.00167 M Na_2CO_3 .

$$\mu = \frac{C_{\text{Na}^+} z_{\text{Na}^+}^2 + C_{\text{CO}_3^{2-}} z_{\text{CO}_3^{2-}}^2}{2}$$

$$= \frac{0.00334(1)^2 + 0.00167(2)^2}{2}$$

$$= 0.0050$$

$$K_{sp} = [\text{Fe}^{2+}] \gamma_{\text{Fe}^{2+}} + [\text{CO}_3^{2-}] \gamma_{\text{CO}_3^{2-}}$$

$$[\text{Fe}^{2+}] = \frac{K_{sp}}{\gamma_{\text{Fe}^{2+}} \gamma_{\text{CO}_3^{2-}} [\text{CO}_3^{2-}]}$$

$$= \frac{2.1 \times 10^{-11}}{(0.749)(0.742)(0.00167)} = \underline{2.3 \times 10^{-8} \text{ M}}$$

e) Calculate the percent relative error associated with the facile assumption that the activity would equal the concentration for part (c) of this problem. [HINT: Isn't this the assumption that you used (properly) in part (a) of this problem?]

$$\frac{4.6 \times 10^{-6} - 5.3 \times 10^{-6}}{5.3 \times 10^{-6}} \times 100\% = \underline{\underline{-10\%}}$$