Name Key

CH 222 Quantitative Analysis Test 1 February 11, 2014

Be sure to show units in your numerical work. You must express answers with the correct number of digits!

1. Define "precision" and "accuracy" in scientific analysis, and explain the difference between the two terms. What statistical quantities are used to measure precision and accuracy?

precision: reproducibility of the data – measured by standard deviation

accuracy: agreement with accepted value – measured by % error

2. For solution concentrations, define molarity (M), molality (m), and weight percent. Explain how you would make a 50% NaOH solution.

$$M = \frac{\text{moles solute}}{\text{L solution}}$$

$$m = \frac{\text{moles solute}}{\text{kg solvent}}$$

$$wt\% = \frac{\text{mass solute}}{\text{mass solution}} = \frac{\text{mass solute}}{\text{mass}_{solute} + \text{mass}_{solvent}}$$

Weigh out equal masses of NaOH and water and combine.

3. The density of sea water is 1.035 g/ml. The concentration of $MgCl_2$ in sea water is 0.054 M. How many grams of $MgCl_2$ are in 1.00 kg of sea water?

$$m_{MgCl_2} = M \cdot Vol \cdot MW = M \cdot MW \cdot \frac{m_{solution}}{\rho} \qquad MW = 95.21$$

$$= 0.054 \frac{mmol}{ml}\, 95.21 \frac{mg}{mmol} \frac{1.00\,kg}{1.035\,\frac{kg}{L}} = 49.7\,g \qquad \boxed{50\,g}$$

4. You dissolve 145 mg of $AlCl_3$ in 235 mL of water. For this solution, what is the concentration of chloride ions in ppm?

$$ppm_{Cl} = \frac{m_{Cl}}{m_{solution}} \times 10^6 = \frac{m_{AlCl_3} \cdot \%Cl}{m_{solution}} \times 10^6 \qquad \%Cl = \frac{3\,AW_{Cl}}{AW_{Al} + 3\,AW_{Cl}} = 0.7976$$

assume solution weighs 235 g!

$$\frac{145\,mg\,(0.7976)}{235 \times 10^3\,mg}(10^6) = 49.2\text{ ppm Cl}$$

5. a=8.5±0.2, b=0.123±0.006, c=422±2. Which quantity has the greatest relative error, and why? Compute the value of $a + bc$ with the correct number of significant digits. **Find the propagated error of this value.**

		abs err	rel err
a	8.5	0.2	0.024
b	0.123	.006	0.049 ☆
c	422	2	0.005
bc	51.906	2.5	0.049
a+bc	60.406	2.6	0.042

error in b dominates

error in bc dominates

60.4 ± 2.6

6. Find the mean, standard deviation, standard deviation in the mean, and 95% confidence limits for the following five data: 21.19, 21.22, 21.25, 21.27, 21.34.

$n = 5 \Rightarrow$ 4 degs of freedom

$\bar{x} = 21.25$

$s = 0.05_7$

$t = 2.774$

$\frac{ts}{\sqrt{n}} = 0.07_1$

$\bar{x} \pm \frac{ts}{\sqrt{n}} = 21.25 \pm 0.07$

7. Assume that you have a set of 15 data—each datum in problem 6 appears three times in the set. Repeat the calculation of the statistics for this larger data set, and indicate which values have changed significantly.

$n' = 15 \Rightarrow$ 14 deg of freedom

$\bar{x}' = 21.25$ same as above

$s' = \sqrt{\frac{3(n-1)}{3(n'-1)}}\, s = \sqrt{\frac{12}{14}}\; 0.05_7 = 0.05_3$ slightly smaller

$t' = 2.145$ slightly smaller

$\frac{t's'}{\sqrt{n'}} = 0.02_9$ 21.25 ± 0.03 $\sqrt{15}$ has biggest impact

8. For your results in both problem 6 and problem 7: Is your mean significantly different from the accepted value of 21.19?

21.25 ± 0.07 includes 21.19 not sig diff

21.25 ± 0.03 21.19 not in range sig diff!

9. You have an unknown solid mixture made of sodium chloride and barium chloride. You dissolve 3.000 g of the unknown in 100.0 mls of solution. You treat 50.00 mls of this solution with Na_2SO_4 to precipitate the barium. **Write a balanced reaction for this step.** You obtain 534.3 mg of dry $BaSO_4$. What is the percentage of barium chloride in the original mixture?

$$BaCl_2 + Na_2SO_4 \rightarrow 2\,NaCl + BaSO_4$$

$$Ba^{+2} + SO_4^{-2} \rightarrow BaSO_4$$

$$\%\,BaCl_2 = \frac{m_{BaCl_2}}{m_{sample}} = \frac{m_{BaSO_4}\frac{MW_{BaCl_2}}{MW_{BaSO_4}}}{m_{sample}} = \frac{m_{BaSO_4}\,MW_{BaCl_2}}{m_{sample}\,MW_{BaSO_4}}$$

$\frac{1}{2}$ of weighed sample is treated

$$= \frac{534.3\text{ mg }BaSO_4}{1500\text{ mg sample}}\;\frac{208.23}{233.43} = 31.77\%$$

10. You have a solid unknown containing calcium carbonate, which is insoluble. Your analytical strategy is to dissolve the solid with a **known excess** of HCl, which will destroy the carbonate ion (lots of CO_2 bubbles!) and create a solution of $CaCl_2$ and leftover acid. **Write a balanced reaction for this step!** You will titrate **the leftover HCl** with NaOH to figure out how much $CaCO_3$ was originally present. You dissolve 1.500 g of the solid using 100.00 ml of 0.1000 M HCl. You titrate this solution with 0.1100 M NaOH and get a nice pale pink end point at 42.56 ml. What is the percentage of $CaCO_3$ in the solid sample?

$2\,HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$

10 mmoles$_{HCl}$ → leftover $HCl + NaOH \rightarrow NaCl + H_2O$

total mmole$_{HCl}$ = mmole$_{HCl\ w\ CaCO_3}$ + mmole$_{HCl\ w/\ NaOH\ titration}$

$$mmol_{HCl\ w\ CaCO_3} = mmol_{total} - mmol_{titration}$$

$$= 11 - mL_{NaOH}\, M_{NaOH}$$

$$mmol_{HCl\ w\ CaCO_3} = \frac{2\ HCl}{1\ CaCO_3}\, mmol_{CaCO_3}$$

$$mmol_{CaCO_3} = \frac{1}{2}\, mmol_{HCl\ w\ CaCO_3}$$ substitute

$$\% = \frac{mg_{CaCO_3}}{mg_{sample}} = \frac{mmol_{HCl\ w\ CaCO_3}\, MW_{CaCO_3}}{2\ mg\ sample} = \frac{(mmol_{tot} - mL_{NaOH} M_{NaOH})\, MW_{CaCO_3}}{2\ mg_{sample}}$$

$$= \frac{[10.00\ mmol\ HCl - (42.56)(0.1100)]\ 100.087\ \frac{mg\ CaCO_3}{mmol}}{2\ \frac{mmol\ HCl}{mmol\ CaCO_3}\ 1500\ mg\ sample} = 17.74\%$$