What Do We Remember?

Please answer the following questions to the best of your ability. Complete as many problems as you can in the time allotted. Do not work through the problems in order; instead, on your first pass through the problems, answer those problems for which you are most confident. When you complete your first pass through the problems, then continue making passes through the problems until you have answers to all problems or run out of time. The order in which you choose to work problems is important, so please make sure this is clear. You are free to ask questions of each other as you work.

1. Is a measurement that yields a result of 6.76 more accurate, more precise, or both more accurate and more precise than a measurement of 6.8? Explain.

   A measurement of 6.76 is more precise, but not more accurate. The number of decimal places in a measurement indicates the absolute uncertainty in that measurment; thus, the uncertainty in 6.76 is ± 0.01 and the uncertainty in 6.8 is ± 0.1. Even if the measurement is precise, a poorly calibrated scale cannot yield an accurate measurement.

2. If a measurement is accurate, is it also precise? If a measurement is precise, is it also accurate? Explain.

   No and no. What makes a measurement accurate is the proper calibration of its scale. What makes a measurement precise is the extent to which the scale is subdivided into smaller units. A perfectly calibrated ruler subdivided into centimeters is less precise than a perfectly calibrated ruler subdivided into millimeters.

3. What factors affect a measurement's accuracy?

   Bias in using an instrument and failure to calibrate an instrument lead to errors in accuracy. Such errors are determinate in that they have a fixed value and a fixed direction.

4. What factors affect a measurement's precision?

   Random variations in the measurements lead to errors in precision. Such errors are indeterminate in that they have neither a fixed value or a fixed direction. Errors in precision appear as noise.

5. We divide chemical reactivity into four distinct types of reactions. What are these four types of reactions? Provide one example that illustrates each type of reaction and provide one example of a reaction that combines two or more of these types of reactions.

   The four types of reactions are acid-base, solubility-precipitation, complex formation-dissociation, and oxidation-reduction; some typical examples, in order, are

$$CH_3COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq)$$

$$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$$

$$Cu^{2+}(aq) + 6NH_3(aq) \rightleftharpoons Cu(NH_3)_6^{2+}(aq)$$

$$2Ag^+(aq) + Cu(s) \rightleftharpoons Cu^{2+}(aq) + 2Ag(s)$$

   An example of a reaction that is both an acid-base reaction and a solubility-precipitation reaction is the dissolution of calcium carbonate in acid

$$CaCO_3(s) + H_3O^+(aq) \rightleftharpoons Ca^{2+}(aq) + HCO_3^-(aq) + H_2O(l)$$

6. What is the Nernst equation?

The Nernst equation relates potential in an oxidation-reduction reaction to the concentrations of the reactants and products, and the reaction's standard state potential.

$$E = E^o - \frac{RT}{nF}\ln Q$$

where Q is the reaction quotient (same form as the equilibrium constant expression), n is the number of electrons, R is the gas constant, T is the temperature (in Kelvin), and F is Faraday's constant.

7. What is the meaning of pH?

   The pH of a solution is given as $-\log[H^+]$, although, more correctly, it is a function of the activity of H^+ instead of its concentration.

8. What is the relationship between transmittance and absorbance?

   The relationship between absorbance, A, and transmittance, T, is $A = -\log T$.

9. What is Beer's law?

   Beer's law is $A = -\epsilon bC$ where ϵ is the molar absorptivity, b is the pathlength light takes through the sample, and C is the molar concentration of the absorbing species.

10. Explain how to prepare an external standards calibration curve and how to use that calibration curve to determine an analyte's concentration in a sample.

    To prepare an external standards calibration curve we first use a standard solution of the analyte to prepare a set of calibration standards with known concentrations of the analyte. We then measure the signal for each solution and plot these signals vs. the analyte's concentration. Next, we use a regression analysis to determine the mathematical relationship between the signal and the analyte's concentration. Finally, we measure the signal for a sample that contains the analyte and use the calibration equation to calculate the concentration of analyte in the sample.