## AP Chemistry

General Hints for Lab Essay

## Error Analysis

- Specifically, state if the error will cause the results to be too high, too low, or remain unchanged [the variable has no effect on the results]. Use mathematical equations to back up your statements!
- Writing the mathematical equation for required calculations may help determine how an error will affect results.
- Be aware there are quantities you measure, such an initial temperature and final temperature or initial pressure and final pressure, etc. versus terms you calculate using what you measured such as $\Delta T$ or $\Delta P$.


## Using Concepts to Explain Observations or Data

- Think about intermolecular forces (H-bonding, dipole-dipole, LDF)
- Think about types of solids: ionic, molecular, network solid, atomic solid
- Think about bonding: coulombs law, bond energy
- Think about solubility and like dissolves like


## Design an Experiment

- THINK SCIENTIFIC METHOD!
o materials-lab equipment and reagents-be complete in your list and don't create equipment that doesn't exist!
o procedure-"heat to constant mass", "rinse the buret with the solution before titrating", "calibrate the pH meter", "bake the crucible to remove water trapped in the pores of the porcelain", "meniscus at eye level" etc.
o results-data tables and graphs-the "whats" that happened
o conclusions-WHY the "whats" happened-not a restatement of the data or yield-must use sound scientific principles
o If a PERCENT anything is asked for-don't forget to show the "multiply by 100 " step in your calculations-you lose a point if you don't!
o If something like enthalpy or freezing point is asked for [rather than the change in...] be sure and use the correct SIGN!
- do not use terms such as "determine the amount" instead use measure the volume or measure the massremember you measure initial and final quantities and CALCULATE changes in those quantities
- use mathematical equations for required calculations to determine all the data required


## CALORIMETRY

Calorimetry is used to determine the heat released or absorbed in a chemical reaction. The calorimeters shown here can determine the heat of a solution reaction at constant (atmospheric) pressure. The calorimeter is a double styrofoam cup fitted with a plastic top in which there is a hole for a thermometer. Key techniques for obtaining accurate results are starting with a dry calorimeter, measuring solution volumes precisely, and determining change in temperature accurately.


Information to know about calorimetry:

- Heat capacity $(\mathrm{C})=$ the amount of heat necessary to raise the temperature of an object by one degree Celsius or Kelvin, $\mathrm{J} /{ }^{\circ} \mathrm{C}$ or $\mathrm{J} / \mathrm{K}$.
- The heat capacity of 1 mol of a substance is called its molar heat capacity. joules per mole per degree, $\mathrm{J} / \mathrm{mol}{ }^{\circ}{ }^{\circ} \mathrm{C}$ or $\mathrm{J} / \mathrm{mol} \cdot \mathrm{K}$.
- Specific heat,(s or lower case c) also known as specific heat capacity, is defined as the amount of heat necessary to raise the temperature of 1.00 g of a substance by one degree. Units are joules per gram per degree, $\mathrm{J} / \mathrm{g} \cdot{ }^{\circ} \mathrm{C}$ or $\mathrm{J} / \mathrm{g} \cdot \mathrm{K}$. You often use the specific heat capacity in analyzing gathered data then convert to molar heat capacity.
- Note that heat capacity applies to objects, while molar and specific heat capacities apply to substances.

The device used to measure heat flow between systems and surroundings is called a calorimeter.
Assumptions often made during calorimetry:

1. Assume the density of the dilute solutions is the same for water. $=1.0 \mathrm{~g} / \mathrm{mL}$
2. Assume the specific heat of the solutions is the same as that for water. $=4.184 \mathrm{~J} / \mathrm{g}^{\circ} \mathrm{C}$
3. Assume the solutions react in their stochiometric amounts.
4. Assume there is no loss of heat to the surroundings.

OF COURSE, EACH OF THESE ASSUMPTIONS INTRODUCES ERROR. BE ABLE TO


$$
\mathrm{q}=\mathrm{C}_{\mathrm{p}} \cdot \mathrm{~m} \cdot \Delta \mathrm{t} \quad\left(\mathrm{C}_{\mathrm{p}}=4.18 \mathrm{~J} / \mathrm{g}^{\circ} \mathrm{C}\right)
$$

$$
\mathrm{q}_{\mathrm{p}}=(\mathrm{m})(\mathrm{s})(\Delta \mathrm{t}), \mathrm{q}_{\mathrm{p}}=\Delta \mathrm{H}
$$

It's not unusual to determine the $\Delta \mathrm{H}$ for a reaction using specific heat constants and masses in grams and then convert to molar enthalpy
Assumptions:

- solutions have the density of water or $1 \mathrm{~g} / \mathrm{mL}$
- solutions have the specific heat of water $4.18 \mathrm{~J} / \mathrm{gC}^{\circ}$
- no heat is lost to the surroundings


## TITRATION

A titration is a laboratory procedure for quantitative analysis. Most titrations are either acid/base or redox. In a titration two reagents are mixed, one with a known concentration \& known volume [or a solid with a known mass] and one with an unknown concentration. There is some way to indicate when the two reagents have reacted essentially completely, and at the end of the titration the unknown solution's concentration can be calculated since you have accurately determined the volume of that solution required to complete the reaction.

The titrant is the solution of known concentration and is usually placed in the buret. [be sure and state that you rinse the buret with the titrant BEFORE filling the buret with the titrant!] The solution from the buret is added to a flask that contains either a measured volume of a solution or a weighed quantity of solid that has been dissolved. The buret has graduations that are used to read the volume of titrant added to the flask. The point during the reaction where enough titrant has been added to completely react all of the solution being analyzed is called equivalence point. An indicator that changes color at or near the equivalence point is usually added to the solution being analyzed prior to titration. The point during titration where the indicator changes color is called end point. It is important to choose an indicator that has an endpoint at the same pH as your expected equivalence point. To obtain a solution of known concentration the titrant is often standardized.

## Technique

Preparing the Buret:

1. Rinse a clean buret several times with 5 mL portions of distilled water and then the titrant (the solution that will be added to the flask).

2. Allow the titrant to drain through the buret stopcock so that the tip gets rinsed with titrant as well.
3. Discard the rinse solution in a waste beaker. Clamp the buret into place, and fill it with the titrant. Remove air bubbles from the tip of the buret and the stopcock by draining several milliliters of titrant. Dispose of the drained titrant in a waste beaker.

It's amazing how many students miss easy points by not stating any of the highlighted information!!
Preparing the Sample:
If the sample to be titrated is a solution, pipet the desired volume into an Erlenmeyer flask. Record the exact volume transferred. Dilute the sample with a small portion of distilled water (about 10 to 20 mL ). If the sample is a solid, weigh the desired mass, add the solid to an Erlenmeyer flask, and dissolve it in distilled water. Be sure to record the exact mass of sample used. Change in color of a chemical indicator is usually used to signal the endpoint of the titration. If necessary, add a few drops of an appropriate indicator to the solution.

Adding the Titrant:
The rate of addition of titrant is determined by the rate at which the indicator changes color. At the beginning of the titration, titrant may be added quickly since the indicator color disappears rapidly. When the color persists for longer periods of time, add titrant more slowly (a drop or less at a time).

Determining the Endpoint:
Overshooting the endpoint of the titration by adding too much titrant is a common error. The endpoint for this titration is reached when you reach a pale color that persists throughout the solution for several seconds.


Data Required:
$\underline{\text { moles }}$ titrant $=\underline{\text { moles }}$ of substance analyzed @ equivalence point

- mass of DRY substance analyzed OR accurately measured volume of substance analyzed [pipet OR buret]
- initial volume of titrant (substance of known molarity) and final volume of titrant (required to reach end point)
- Molarity of titrant

Hints for Calculations:

- Substance analyzed is liquid:
- Volume of titrant used to reach end point [difference between final and initial volumes]
- $\mathrm{M}_{1} \mathrm{~V}_{1}=\mathrm{M}_{2} \mathrm{~V}_{2} @$ equivalence point
- Moles $=M$ of substance $x$ Liters needed to reach equivalence point
- Substance analyzed is solid:
- mass/FW or molar mass = \# of moles analyzed
- $\mathrm{M}_{\text {titrant }} \mathrm{V}_{\text {titrant }}=$ moles titrant


## GRAVIMETRIC ANALYSIS

One method for determining the amount of a given substance in solution is to form a precipitant that includes the substance. The precipitant is then filtered, and dried to constant mass. This process is called gravimetric analysis. For example if we wanted to determine the amount of chloride ions present in a given solid, we would weigh the solid sample, dissolve the sample in water, add an excess of silver nitrate solution to form the precipitant silver chloride. This precipitant would be filtered, and dried to constant mass. From the mass of silver chloride formed we can determine the moles of silver chloride and the moles of chloride ion in the original sample.
The steps of a Typical Gravimetric Analysis:


## WAYS TO DETERMINE MOLAR MASS

- Remember molar mass = mass of sample in grams $/ \mathrm{mole}$
- Organize answer around calculations-paying special attention to what quantities are measured versus calculated!
a. Freezing point depression:
- $\Delta \mathbf{T}_{\mathbf{f}}=\boldsymbol{i m} \mathbf{k}_{\mathbf{f}}$ (nonelectrolyte $i=1$; is the van't Hoff factor and is equal to the \# of moles of ions released);
- $\mathrm{m}=$ moles of solute $/ \mathrm{kg}$ of solvent;
- molar mass $=\mathrm{g} / \mathrm{mole}$
o data \& constants required:
- FP of pure solvent
- final FP of solution
- kg of solvent
- $k_{\mathrm{f}}=$ known OR determined by data
- grams of solute
o Calculations required:
- $\Delta \mathrm{T}=$ freezing point pure solvent - freezing point of solution
- use $\Delta \mathbf{T}_{\mathrm{f}}=\mathbf{i m} \boldsymbol{k}_{\mathrm{f}}$ to solve for molality
- use molality equation to solve for moles
- use molar mass equation to solve for moles
b. Titration
- $\underline{\text { moles }}$ titrant $=\underline{\text { moles }}$ of substance analyzed @ equivalence point
o data required:
- mass of substance
- initial volume of titrant (substance of known molarity) and final volume of titrant (required to reach end point)
- Molarity of titrant
o Calculations required:
- Substance analyzed is solid:
- $\mathrm{M}_{\text {titrant }} V_{\text {titrant }}=$ moles titrant
- Molar Mass $=\mathrm{g}$ solid analyzed $/ \#$ of moles titrant used

