Totally Epic AP Chem Review: Lab Review!

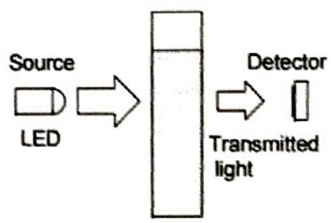
Even if you haven't done the exact experiment being described in a question, you can use your knowledge and skills to account for the observations described.

Lab Question Hints

1. Materials: If they give you a list of equipment, you do NOT have to use all of it!
2. Procedure: Be sure to include important techniques like heating to constant mass, rinsing a precipitate, or rinsing the buret with solution before a titration.
3. Data needed: The data needed are values that can be measured like initial and final temperature. Writing all the mathematical equations needed to do the calculations will help you determine what data is needed.
4. Calculations: A calculation is made using what was measured, like temperature change. Show the set up of mathematical equations required for the calculations. Use sample data when appropriate.
5. Graphs: Be sure to label the axes and other important points on your graph.
6. Error analysis: State whether the quantity will be too high, too low, or no change. Use equations to help you determine what change will occur and to support your answer.

Common Lab Procedure: Colorimetry

Colorimetry: an experimental method to measure reaction rate by using a Colorimeter (or spectrophotometer) to determine the Concentration of solution by analyzing its color intensity.



- Light from an LED light source passes through a Cuvette (tiny container) filled with a solution sample, as shown in the figure to the right.
- Some of the incoming light is absorbed by the solution. As a result, light of a lower intensity strikes a photodiode.
- The colorimeter is set to a wavelength the solution being studied absorbs the most, based on the color of the solution: of course, colorimetry only works if one of your reactants or products is colored. ☺

Beer's Law

$$A = abc$$

A: absorbance

a: molar absorptivity (a proportionality constant that's different for every solution)

b: path length (usually 1.00 cm), c: concentration (measured in molarity)

- Beer's Law is important because it demonstrates that absorbance is directly proportional to concentration (providing the absorbing substance, wavelength, and path length are fixed).
- By measuring the change in absorbance over time, you can use Beer's law to convert absorbance to concentration.
- Graphing [reactant] vs. time, ln[reactant] vs. time, and 1/[reactant] vs time will allow you to determine if the reaction being studied is zero, first, or second order with respect to that reactant.

Errors Associated with Colorimetry	
Error	**Effect on Data**
Cuvette (container) is smudged, cracked or otherwise unclear	Absorbance is too high (transmittance too low); some of the source light is blocked from passing through the solution ⇒ [ ] ↑
Solution is accidently diluted (by extra water present, etc)	Absorbance is too low (transmittance is too high) ⇒ [ ] ↓
Moved wavelength away from maximum absorption setting	Absorbance is too low (transmittance is too high) ⇒ [ ] ↓

Common Lab Procedure: Calorimetry

Calorimetry: technique used to experimentally determine the change in energy of a chemical reaction or phase change by putting it in contact surroundings of known heat capacity.

- ➔ The ~~energy~~ heat change in the water is equal and opposite to the ~~heat~~ energy change by the system!
  - The system can be an object, a phase change, or a chemical reaction.

$$+q_{H_2O} = -q_{system}$$

$$+[\mathrm{mC\Delta T}]_{H_2O} = -[\mathrm{mC\Delta T}]_{system}$$

- → If water bath increases in temperature, it gained energy → chemical reaction or phase change lost energy. $-\Delta H$
- → If water bath decreases in temperature, it lost energy → chemical reaction or phase change gained energy. $+\Delta H$

Coffee cup calorimeter: Styrofoam cups are commonly used as insulators in the high school chemistry lab to measure temperature changes without a loss of energy to the surroundings.

$$q_{calorimeter} = -q_{reaction\ (or\ change)} \text{ (at constant pressure)}$$

$$\Delta H_{rxn} = \frac{-q_{calorimeter}}{mol_{rxn}}$$

- ➔ Here $q_{calorimeter}$ is assumed to be the water in the coffee cup.

Errors Associated with Calorimetry	
Error	**Effect on Data**
Heat is lost to the environment (container not perfectly insulated)	Calculated ΔH_{rxn} is too low, because ΔT (calculated from measurements) does not account for all of heat transferred
Calorimeter (coffee cup) or thermometer absorbs heat	Calculated ΔH_{rxn} is too low, because ΔT (calculated from measurements) does not account for all of heat transferred

$-[mC\Delta T]_{metal} = +[mC\Delta T]_{H_2O}$

$-q_{metal} = q_{H_2O}$

Watch out for masses in calorimetry!

- If there is an object: (for example, a steel cube), use Separate masses of object and water!
- If there is a reaction or phase change: (for example, a salt dissolving in water), Combine masses of water and reactants!

$q_{rxn} = -q_{calor.}$

$= -[mC\Delta T]$

↑ H_2O + chemicals

Common Lab Procedure: Titrations

A substance in a solution of Known concentration (the titrant, usually in a buret) is reacted with another substance in a solution of **unknown** concentration (the **analyte**, usually in a flask or beaker)

- **Equivalence point**: the point at which the moles of each reactant are ***stoichiometrically equal*** to each other in solution: **moles(titrant) = moles(analyte)**
- **End point**: the point of the titration where an indicator changes color

How to Choose an Indicator

- Choose an indicator with pKa of indicator = pH at the equivalence point (of titration)
- **K_a of the indicator** $\approx 1 \times 10^{-pH\ @\ eq\ pt}$
- Indicator is a weak acid where HA and A^- are different colors!
- If pH ≤ pK_a mostly HA (one color), if pH > pK_a mostly A^- (different color)

Quick Reminder: How to Read a Buret

Burets, unlike most glassware, are read from the top down, not the bottom up!

Calculation Hints: Moles of titrant = moles of substance at equivalence point

- If substance analyzed is a solution/liquid:
  - $M_1V_1 = M_2V_2$ @ equivalence point
  - Volume of titrant used to reach end point = difference between initial and final volumes
  - $M_{titrant}V_{titrant\ added}$ = moles of titrant = moles of unknown
- If substance analyzed is a solid:
  - $M_{titrant}V_{titrant\ added}$ = moles of titrant = moles of unknown (@ eq. pt)
  - Molecular weight of unknown = $\frac{\text{mass of solid dissolved}}{\text{moles of unknown}}$

Potential Titration Lab Errors

Error	Cause	Effect
1. Over-titration	Going past equivalence point by adding too much titrant	Calculated moles of titrant and thus calculated moles of analyte are too large.
2. Under-titration	Not reaching equivalence point by adding too little titrant	Calculated moles of titrant and thus calculated moles of analyte are too Small.
3. Water added to titrant (buret)	Buret still wet from rinsing when it is filled with titrant	Actual concentration of titrant is lower than marked, so more volume was added, thus calculated moles of analyte are too large.
4. Water added to analyte (flask)	Flask or beaker is still wet from rinsing when analyte is added	Moles of analyte don't change, so no effect on calculated moles of analyte.

Random Lab Questions!

1. A 50 g sample of a metal is heated to 100°C and then placed in a calorimeter containing 100.0 g of water (c = 4.18 J/g°C) at 20°C. The final temperature of the water is 24°C. Which metal was used?

   a. Lead (c = 0.14 J/g°C)
   b. Copper (c = 0.20 J/g°C)
   (c.) Iron (c = 0.45 J/g°C)
   d. Aluminum (c = 0.89 J/g°C)

   $q_{H_2O} = -q_{metal}$
   $(100)(4)(4) = -(50)C(-76)$
   $1600 = 3800C$
   $C = \frac{16}{38} \approx 0.4$ish

2. Why are solutions of sodium chloride and magnesium nitrate unsuitable for analysis via colorimeter in a Beer-Lambert experiment?

   a. Alkali metals and nitrates are always soluble and thus cannot be precipitated for analysis.
   (b.) Both solutions are colorless, and as a result their absorbance will not vary with the concentration of solution.
   c. Both sodium ions and magnesium ions are too corrosive when dissolved in water.
   d. Neither chloride nor nitrate anions absorb wavelengths in the UV-VIS region of the electromagnetic spectrum.

3. Which of the following indicators would be most suitable for the titration of 0.10 M lactic acid (pK_a = 3.08) with 0.10 M KOH(aq)? WA + SB ⇒ basic @ eq. pt

   a. phenol red (pK_a = 6.9)
   (b.) alizarin blue (pK_a = 10.2)
   c. thymol blue (pK_a = 1.7)
   d. methyl orange (pK_a = 3.4)

Questions 4 – 5 refer to the following.

Inside a calorimeter, 100.0 mL of 1.0 M hydrocyanic acid (HCN), a weak acid, and 100.0 mL of 0.50 M sodium hydroxide are mixed. The temperature of the mixture rises from 21.5°C to 28.5°C. The specific heat of the mixture is approximately 4.2 J/g °C, and the density is identical to that of water.

4. What is the approximate amount of heat released during the reaction?

   a. 1.5 kJ
   b. 2.9 kJ
   (c.) 5.9 kJ
   d. 11.8 kJ

   $q_{cal} = (200)(4)(28.5-21.5)$
   $= (800)(7) = 5600\ J \Rightarrow 5.6\ kJ$

   ↑ mol_{NaOH}

5. If the experiment is repeated for a second time with 100.0 mL of 1.0 M HCN and 100.0 mL of 1.0 M NaOH, what would happen to the values for ΔT and ΔH_{rxn} (relative to the original experimental results)?

	ΔT	ΔH_{rxn}
((A))	Increase	Stay the same
(B)	Increase	Increase
(C)	Decrease	Stay the same
(D)	Stay the same	Increase