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EXPERIMENT 23
Lab Report Guidelines

Listed below are some guidelines for completing the lab report for Experiment 23:

General

- For each part, follow the procedure outlined in the lab manual. Observe all safety rules, including wearing goggles, during all parts of this experiment.
- Arrange all information neatly and clearly in the lab notebook. This includes:
    - Chemical equation for each equilibrium system studied.
    - Relevant data and observations for each stress applied to the system and its effect.
    - Interpretation of results.
- The interpretation of results should include a clear and coherent paragraph that summarizes observations and their effects on the equilibrium system studied in context of concepts studied in this course. The interpretation of results for part 1 of the experiment is done as an example for you to follow for the remaining parts.

Interpretation of results for Part 1:

$$\underset{\text{yellow}}{2\ CrO_4^{2-}} + 2\ H_3O^+ \leftrightarrow \underset{\text{orange}}{Cr_2O_7^{2-}} + 3\ H_2O$$

When H_2SO_4 is added to the mixture, the $[H_3O^+]$ is increased, shifting the equilibrium forward and producing dichromate ion ($Cr_2O_7^{2-}$). As a result, the solution color changes to orange. When NaOH is added to the mixture, the resulting OH^- reacts with H_3O^+ and decreases its concentration. As a result, the equilibrium shifts in reverse, producing chromate ion (CrO_4^{2-}). As a result, the solution color changes to yellow.

Part 4: Application of Equilibrium to Solubility:

a) Describe which tube (1 or 2) produces more precipitate, and interpret the difference in terms of Le Chaterlier's principle. Note that oxalic acid ($H_2C_2O_4$) is a weak acid that ionizes partially, while potassium oxalate ($K_2C_2O_4$) is a soluble salt that dissociates completely. Interpret your results based on the equilibrium for the formation of the precipitate, shown below:

$$Ca^{2+} + C_2O_4^{2-} \rightleftharpoons CaC_2O_4\ (s)$$

b) Describe what happens after addition of HCl to the equilibria in (tube 3) and interpret your results based on the two equilibria shown below:

$$Ca^{2+} + C_2O_4^{2-} \rightleftharpoons CaC_2O_4\ (s)$$

$$H_3O^+ + C_2O_4^{2-} \rightleftharpoons HC_2O_4^- + H_2O$$

c) Describe what happens after addition of NH_3 to the equilibria (tubes 4 & 5) and interpret your results based on the equilibria below:

$$Ca^{2+} + 2\ OH^- \rightleftharpoons Ca(OH)_2\ (s)$$

$$H_3O^+ + NH_3 \rightleftharpoons NH_4^+ + H_2O$$

Questions: No questions required for this lab.

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EXPERIMENT 24
Lab Report Guidelines

Listed below are some guidelines for completing the lab report for Experiment 24:

Part 1: Absorbance Measurements:

- Prepare the 7 solutions listed in Table 24-1 of lab manual.
- Record the absorbance of the 7 solutions, as directed in the lab manual, and tabulate as described in table in top of page 24-9 of lab manual.
- Measure all solutions as accurately as possible, using burets to dispense each. Remember that buret has uncertainty of 0.01 mL. Mix each solution as described in the lab manual.

Part 2: Determining the Mole Ratio of the Complex:

- Determine the mole fraction of Fe^{3+} ion in each solution by using equation (12) in lab manual.
- Plot the absorbance vs. the mole fraction of Fe^{3+} for the seven solutions.
- Draw a smooth curve through the points you have plotted, and determine the mole fraction of Fe^{3+} and SCN^{-} where the maximum value for absorbance occurs.
- Clearly indicate the mole ratio of Fe^{3+} to SCN^{-} in your lab notebook.

Part 3: Calculating the Equilibrium Constant for the Reaction:

- The calculations below are performed for tubes 2, 4 and 6 only.
- Before starting the calculations, write a net ionic equation showing the equilibrium reaction of Fe^{3+} and SCN^{-} ions to form the complex ion $Fe(SCN)^{2+}$.
- In the directions below, the initial concentrations of reactants are designated by a 0 subscript and the equilibrium concentrations of all species are designated by an "eq" subscript.
- Now calculate the following quantities in the sequence given:
  1. Calculate the equilibrium concentration of the complex ion formed, $[Fe(SCN)^{2+}]_{eq}$, by using equation (11) in lab manual and values of 4700 $M^{-1}cm^{-1}$ for molar absorptivity (ϵ) and a cell path length (b) of 1.00 cm.
  2. Calculate the initial concentrations of each ion before reaction, $[Fe^{3+}]_0$ and $[SCN^-]_0$, for solution 2, 4 and 6, using the initial concentration of each solution (0.00200 M) and the initial and final volumes of each.
  3. Calculate the equilibrium concentration of each reactant ion, by using the relationships given below:

$$[Fe^{3+}]_{eq} = [Fe^{3+}]_0 - [Fe(SCN)^{2+}]_{eq}$$

$$[SCN^{-}]_{eq} = [SCN^{-}]_0 - [Fe(SCN)^{2+}]_{eq}$$

  4. Substitute the equilibrium concentrations for each species into equation (13) in lab manual and calculate the equilibrium constant (K_{eq}) for each sample (2, 4 and 6).
  5. Calculate the average value for the equilibrium constant for the 3 solutions you calculated.

Questions:

- Briefly explain what the magnitude of the equilibrium constant (K_{eq}) calculated above tell you about the extent of the formation of the complex ion, $Fe(SCN)^{2+}$ in this experiment.

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EXPERIMENT 25
Lab Report Guidelines

Listed below are some guidelines for completing the lab report for Experiment 25:

General

- For each step, follow the procedure outlined in the lab manual. Observe all safety rules, including wearing goggles, during all parts of this experiment.
- Arrange all information neatly and clearly in the lab notebook. This includes data, observations and answers to questions.
- Written responses to each question should include coherent sentences that include proper scientific content relevant to the question.

Part 1: Effects of Concentration on Reaction Rates:

- Record the number of seconds required for each solution to change color.
- Describe how the initial concentration of reactant and reaction rate are related.

Part 2: The Influence of the Nature of the Reactants:

- Complete all information requested for each question on page 25-7 of lab manual.

Part 3: The Influence of Surface Area on Reaction Rates:

- Complete all information requested for each question on page 25-8 of lab manual.

Part 4: The Influence of Temperature on Reaction Rates:

- Complete all information requested for each question on page 25-9 of lab manual.

Part 5: Effect of Catalyst on Reaction Rates:

- Complete all information requested for each question on page 25-9 and 25-10 of lab manual.

Part 6: Importance of Mixing Reactants:

- Complete all information requested for each question on page 25-10 of lab manual.

Questions:

- Answer questions 1 and 2 on pages 25-10 and 25-11 of lab manual.

EXPERIMENT 26
Lab Report Guidelines

Listed below are some guidelines for completing the lab report for Experiment 26:

General

- For each step, follow the procedure outlined in the lab manual. Observe all safety rules, including wearing goggles, during all parts of this experiment.
- Arrange all information neatly and clearly in the lab notebook. This includes data, observations and answers to questions.
- Where calculations are involved, include sample calculations with the proper significant digits. Include balanced equations where appropriate.
- Note: when dealing with small volumes of solutions, it is more convenient to do calculations using mmoles instead of moles. (See guide to mmol calculations here).

Part A: Standardization of H_2O_2

- Record data as indicated in table at top of page 26-9 of lab manual.
- Calculate the concentration of H_2O_2 for each trial, as described below, and determine the average value:
    - Determine the volume of $S_2O_3^{2-}$ used to reach the end point.
    - Calculate moles of $S_2O_3^{2-}$ used to reach the end point.
    - Calculate the moles of H_2O_2 used in the reaction by using the stoichiometric relationships in equation (7) on page 26-4 of lab manual.
    - Determine the concentration of H_2O_2 (in M) from the moles of H_2O_2 calculated above and the volume of H_2O_2 used in the titration.

Part B: Reaction Rate Measurements

- Record all data in a table similar to table included on the bottom of page 26-9 of lab manual.
- Prepare the 6 reaction mixtures outlined in Table 26-2 on page 26-6 of the lab manual. Be sure to measure each solution to the proper significant digits as outlined below:
    - Graduate cylinders (50 and 100 mL)…. ..0.1 mL
    - Graduate cylinder (10 mL)……………. 0.01 mL
    - Buret…………………………………… 0.01 mL

For each mixture,

- Add all reagents (except hydrogen peroxide) to a 250-mL beaker, in the order listed.
- Record the temperature of each mixture after all components have been added, except hydrogen peroxide. The temperature of all mixtures (except #5) should be within 0.5 °C of temperature of mixture 1. Temperatures can be adjusted by cooling or heating in a water bath.
- Measure the hydrogen peroxide using a buret.
- The timer or stopwatch is started after the addition of hydrogen peroxide is complete, with vigorous stirring and stopped when the reaction mixture turns blue.
- When preparing mixture #5, before addition of the hydrogen peroxide, adjust the temperature of the mixture by heating in a water bath until temperature is 10-12°C higher than mixture #1. Then add peroxide and measure time till solution turns blue.

Calculations

- All concentrations can be calculated using the dilution equation and the initial volume and concentration of each reactant the final volume of 150.0 mL.
- Determine the reaction order with respect to each reactant as detailed on pages 26-10 and 26-11 of lab manual. If is suggested that each table on pages 26-10 and 11 be revised as shown below to include the concentration calculations for each step.

Reaction mixture	Time (s)	Reactant Conc. (M)	Calculation

- When calculating $[H_3O^+]$ for reactions 1 and 4 to determine reaction order with respect to $[H_3O^+]$, use the relationship below, and note that the buffer solution contains equal amounts of acetic acid (HAc) and NaAc, but mixture 4 has added amount of HAc that must be considered in addition to the buffer.

$$K_a = \frac{[H_3O^+][Ac^-]}{[HAc]} = 1.8x10^{-5}$$

- To calculate the total concentration of HAc in mixture 4, determine the total amount of HAc in the buffer and the added acid (in mol or mmol) and divide by total volume (in L or mL).
- Determine the reaction order with respect to each reactant using equation (14) in the lab manual and the time and concentration for each reactant.

Questions

- Answer question 1 (all parts) and 2 on pages 26-11 through 26-13 of lab manual. Where appropriate, cite experimental evidence to support your answers.

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EXPERIMENT 27
Lab Report Guidelines

Listed below are some guidelines for completing the lab report for Experiment 27:

General

- For each step, follow the procedure outlined in the lab manual. Observe all safety rules, including wearing goggles, during all parts of this experiment.
- Arrange all information neatly and clearly in the lab notebook. This includes data, observations and answers to questions.
- Where calculations are involved, include sample calculations with the proper significant digits. Include balanced equations where appropriate.
- Note: when dealing with small volumes of solutions, it is more convenient to do calculations using mmoles instead of moles. (See guide to mmol calculations here).

Part 1: Standardization of NaOH with KHP

- Record data as in table similar to one at top of page 27-9 of lab manual.
- Calculate mmol of KHP from mass and formula mass of KHP.
- Determine mmol of NaOH used from the stoichiometric ratios in the balanced equation.
- Determine the concentration of NaOH solution from mmoles and the volume in NaOH (in mL).
- Average the values for the concentration of NaOH and use in Part 2.

Part 2: Titration of Vinegar

- Record all data in a table similar to table included on the top of page 27-10 of lab manual.
- Calculate the mmol of NaOH used in each titration from the volume and concentration of NaOH (average of calculations in Part 1).
- Determine the mmol of acetic acid from the stoichiometric ratios in the balanced equation.
- Determine the mass of acetic acid in each trial using molar mass of 60.0 g/mol for acetic acid.
- Using density of 1.005 g/mL for vinegar, determine the mass % of acetic acid in vinegar.

Part 2: Titration of Antacid Tablets

- Record all data in a table similar to table included on page 27-11 of lab manual.
- Determine the mmol of HCl added from the volume and concentration of HCl.
- Determine the mmol of NaOH used to neutralize the excess HCl from the volume and concentration of NaOH solution.
- Determine the mmol of HCl neutralized by the antacid from the difference between mmol of HCl added and mmol of HCl neutralized by NaOH.
- Determine the mmol and mass (mg) of the active ingredient in the antacid table.

Summary

- Compare and report % difference between mass percent of active ingredient in the antacid table calculated in Part 3 and reported by manufacturer.

Questions

- Answer question #3 on page 27-12 of lab manual.

EXPERIMENT 28
Lab Report Guidelines

Listed below are some guidelines for completing the lab report for Experiment 28:

General

- For each step, follow the procedure outlined in the lab manual. Observe all safety rules, including wearing goggles, during all parts of this experiment.
- Arrange all information neatly and clearly in the lab notebook. This includes data, observations and answers to questions.
- Where calculations are involved, include sample calculations with the proper significant digits. Include balanced equations where appropriate.
- Note: when dealing with small volumes of solutions, it is more convenient to do calculations using mmoles instead of moles. (See guide to mmol calculations here).

Part 1: Determination of Molar Mass & K_a Acetic Acid

- Record data as in table similar to one at top of page 28-7 of lab manual.
- Calculate mmol of NaOH from volume and concentration data.
- Determine mmol of acetic acid used from the stoichiometric ratios in the balanced equation.
- Determine the concentration of acetic acid solution (vinegar) from mmoles of acid and the volume of vinegar (in mL). (Note: vinegar is a very dilute solution of acid acid in water; therefore, its density can be assumed to be 1.0 g/mL)
- Calculate the molar mass of the acetic acid using equation (5) in lab manual.
- Using average molar concentration and pH of the acetic acid solutions, calculate the K_a for acetic acid. (Hint: set up ICE table and use molar concentration of acid and pH as data points on the ICE table)

Part 2: Determination of K_a of Acetic Acid by Half-Neutralization Method

- Record all data in a table similar to table included on the bottom of page 28-7 of lab manual.
- Using pH of solution at half-neutralization point, determine the K_a of acetic acid by this method.

Part 3: Determination of Molar Mass & K_a for an Unknown Acid

- Record all data in a table similar to table included on the top of page 28-8 of lab manual.
- Using methods similar to parts 1 and 2, determine the molar mass and K_a for the unknown acid.

Summary

- Compare and report % difference between molar mass of acetic acid determined in part 1 and the literature value.
- Compare and report % difference between K_a for acetic acid determined in part 1 and part 2.

Questions

- No questions required.

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EXPERIMENT 30
Lab Report Guidelines

Listed below are some guidelines for completing the lab report for Experiment 30:

General

- For each step, follow the procedure outlined in the lab manual. Observe all safety rules, including wearing goggles, during all parts of this experiment.
- Arrange all information neatly and clearly in the lab notebook. This includes data, observations and answers to questions.
- Where calculations are involved, include sample calculations with the proper significant digits. Include balanced equations where appropriate.

Part 1: Standardization of Sodium Thiosulfate (Not Required)

Part 2: Molar Solubility of $Ca(IO_3)_2$ in Pure Water

- Record titration data in a table similar to that on bottom of page 30-7 of lab manual.
- For each trial, calculate the $[IO_3^-]$ using (16) in the lab manual.
- Calculate the average $[IO_3^-]$.
- Calculate the molar solubility of $Ca(IO_3)_2$ in pure water.
- Calculate the K_{sp} value for $Ca(IO_3)_2$.

Part 3: Determination of Molar Mass & K_a for an Unknown Acid

- Record titration data in a table similar to that on top of page 30-8 of lab manual.
- For each trial, calculate the $[IO_3^-]$ using (16) in the lab manual.
- Calculate the average $[IO_3^-]$.
- Set up an equilibrium table to show the initial and equilibrium concentrations of all species present at equilibrium.
- Calculate the molar solubility of $Ca(IO_3)_2$ in 0.0100 M KIO_3.

Summary

- Compare the molar solubility of $Ca(IO_3)_2$ in 0.0100 M KIO_3 solution with the molar solubility in pure water, and explain if this difference is consistent with Le Chaterlier's principle.

Questions

- No questions required.

EXPERIMENT 34
Lab Report Guidelines

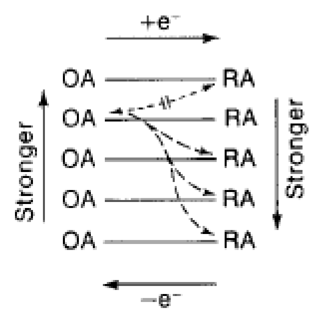
Listed below are some guidelines for completing the lab report for Experiment 34:

General

- For each step, follow the procedure outlined in the lab manual. Observe all safety rules, including wearing goggles, during all parts of this experiment.
- Arrange all information neatly and clearly in the lab notebook. This includes data, observations and answers to questions.

Part 1: Qualitative Redox Series for Metals and Their Ions

- Record your observations for the reaction between each pair of metals.
- Write net ionic equations for any reactions taking place between the metals and metal ions listed on bottom of page 34-7 of the lab manual. If there is no visible evidence of reaction, write NR for "no reaction."
- Determine which metal is the stronger reducing agent for each pair of metals listed on top of page 34-8.
- Construct a redox couple table for iron, copper, zinc, and their ions. Arrange the three metals in a column at the right-hand side, with the strongest reducing agent at the bottom and the weakest at the top. List each metal with its ion (on the left, followed by a slash and the symbol for the metal). See sample table on the right.



Part 2: The Hydrogen Ion/Hydrogen Couple

- Record your observations when you placed iron, copper, and zinc in 6 M HCl. Also, write net ionic equations describing the reactions you observed.
- Place the H^+/H_2 couple in its proper place in the redox couple table you established for the *metal ion/metal* redox couples in part 1 by adding it to the redox couples listed in the table.

Part 3: The Oxidizing Power of Halogens

- Record your observations and write plausible net ionic equations for the reactions of the free halogens with the halide ions, in accordance with your experimental data.
- Construct a redox couple for the halogens and their ions (X_2/X^-), placing the strongest reducing agent at the *bottom* on the *right* of the series, and the strongest oxidizing agent at the *top* and on the *left.*

Part 4: The Fe^{3+}/Fe^{2+} Couple

- Write net ionic equations for the reaction of Fe^{3+} with the halide ions, in accordance with your experimental results. (If there was no evidence of reaction, write "no reaction.")

  Iron(III) ion with iodide ion: ____

  Iron(III) ion with bromide ion: ____

Part 5: The Reaction of Halogens with Metals

- Write net ionic equations describing the results of your experiments on the reaction of Br_2 water and I_2 solution with copper.

Summary

- Construct a redox couple table for all seven couples studied in this experiment. Write "Oxidizing agents" and "Reducing agents" along the proper sides of the table. Indicate the position of the strongest and weakest oxidizing agents and reducing agents by placing "S" and "W" next to the formula for these substances.

Questions

1. In part 1, which is the strongest oxidizing agent between Fe^{2+}, Cu^{2+} or Zn^{2+} ions? Explain your choice.

2. After completing the redox couple table at end of part 3, which is the strongest oxidizing agent in the series? Which is the strongest reducing agent in the series?

3. Based on your results in part 4, the Fe^{3+}/Fe^{2+} couple should be placed between the

   _____________couple and the __________________ couple in the table in part 3.