

Name _____	Lab Partner _____
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Reaction Stoichiometry Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

Table A: Stock solution concentrations of HCl, H₃PO₄ and NaOH

[HCl]	M	[H ₃ PO ₄]	M	[NaOH]	M
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1. Show your calculation for the mmol of base and the mmol of acid in mixing experiment 1. Use the same technique for experiments 2-6.

Table B: Temperature data for combinations of NaOH and HCl

Expt #	mL NaOH	mmol NaOH	mL H ₂ O	mL HCl	mmol HCl	Initial T, °C	Final T, °C	ΔT, °C
1	20.		20.	10.				
2	20.		10.	20.				
3	20.		0	30.				

Table C: Temperature data for combinations of NaOH and H₃PO₄

Expt #	mL NaOH	mmol NaOH	mL H ₂ O	mL H ₃ PO ₄	mmol H ₃ PO ₄	Initial T, °C	Final T, °C	ΔT, °C
4	15		30.	15				
5	30.		15	15				
6	45		0	15				

2. Construct a reaction table in millimoles for experiment 1.

	HCl(aq)	+	NaOH(aq)	→	NaCl(aq)	+	H ₂ O (l)
initial							--
change(Δ)							--
final							--

3. What is the limiting reagent in mixing experiment 1?

4. Which experiments from 1-3 have the same change in temperature?

5. For the experiments from 1-3 with the same temperature change, what other parameters are the same? Select all that apply.

mmol HCl total mL solution
mmol NaOH initial concentration of NaOH
mL H₂O initial concentration of HCl

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Solutions and Spectroscopy Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

Table A: Calibration Curve of Cu^{2+} Solutions and Unknown

Stock Cu^{2+} solution concentration _____ M		Wavelength _____ nm				
Solution #	Target volume of Cu^{2+} , mL	Actual volume of Cu^{2+} , mL	Target volume of H_2O , mL	Actual volume of H_2O , mL	$[\text{Cu}^{2+}]$ (calculated)	Absorbance (measured)
1	1.50		6.50			
2	3.00		5.00			
3	4.50		3.50			
4	6.00		2.00			
Equation of Trendline _____			R ² Value _____			
Unknown # _____	Absorbance (measured) _____		$[\text{Cu}^{2+}]$ (calculated) _____ M			

1. What is the concentration of Cu^{2+} in Solution 1 that you prepared? Show your calculations neatly.

2. Would you predict the absorbance of solution 2 to be greater or less than that of solution 1? Why?

3. What is the concentration of Cu^{2+} in your unknown solution?

Show your calculations neatly. Record this concentration in Data Table A.

4. You desire to make a copper(II) solution at the same concentration as the unknown you just determined in Part A. How many grams of $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$ are required to make 25.00 mL of this solution?

Show your calculations neatly. Record the result as the target mass in Data Table B.

Table B: Preparation of a Cu^{2+} Solution from solid $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$

Target $[\text{Cu}^{2+}]$ from Part A, M	Target Mass $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, g	Actual Mass $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, g	Absorbance of Cu^{2+} solution	$[\text{Cu}^{2+}]$ calculated from absorbance, M

5. Comment on how the absorbance of your solution made from solid compares to the unknown solution's absorbance in Part A. Do you expect them to be the same?

Why or why not?

Table C: Preparation of a Cu^{2+} Solution from stock Cu^{2+} solution

Stock Cu^{2+} solution concentration _____ M				
Target $[\text{Cu}^{2+}]$ from Part A, M	Target Volume Cu^{2+} solution, mL	Actual Volume Cu^{2+} solution, mL	Absorbance of Cu^{2+} solution	$[\text{Cu}^{2+}]$ calculated from absorbance, M

6. You desire to make a copper(II) solution at the same concentration as the unknown you determined in Part A. How many mL of the copper(II) stock solution are required to make 25.00 mL of this solution?

Show your calculations neatly. Record the result as the target volume in Data Table C.

7. Comment on how the absorbance of your solution made by dilution of a stock compares to the unknown solution's absorbance in Part A. Do you expect them to be the same?

Why or why not?

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Freezing Point Depression Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

Table A: Measuring the Freezing Point of Stearic Acid

Mass of 30 mL beaker	g
Mass of 30 mL beaker plus stearic acid	g
Mass of stearic acid	g
Measured freezing point of stearic acid (first trial)	°C
Measured freezing point of stearic acid (second trial)	°C
Average measured freezing point to stearic acid	°C

Table B: Freezing Point Depression by a Solute, Lauric Acid

Addition of lauric acid	First	Second
Mass of 30 mL beaker (from Part A)	g	g
Mass of 30 mL beaker and contents	g	g
Mass of 30 mL beaker plus stearic and lauric acids	g	g
Total mass of lauric acid	g	g
Mass of stearic acid	g	g
Colligative molality (m_c) of the solution	m	m
Predicted ΔT_f	°C	°C
Theoretical freezing point of the solution	°C	°C
Measured freezing point of the solution	°C	°C

1. Do you expect the freezing point of this solution from the first addition of lauric acid to be at a higher or lower temperature than that of the pure solvent?

2. Using your measured amounts of stearic acid and lauric acid for the first addition, calculate the colligative molality (m_c) of the resulting solution, the freezing point depression (ΔT_f) this molality should cause and the theoretical freezing point of the solution. Enter your results in Data Table B.

3. How did your measured freezing point compare to your theoretical freezing point for the first addition?

$$\% \text{ error} = ((\text{theoretical value} - \text{actual value}) \times 100\%) / \text{theoretical value}$$

4. Do you expect the freezing point of this solution from the second addition of lauric acid to be at a higher or lower temperature than that of the previous solution?

5. Using your measured amounts of stearic acid and lauric acid for the second addition, calculate the colligative molality (m_c) of the resulting solution, the freezing point depression (ΔT_f) this molality should cause and the theoretical freezing point of the solution. Enter your results in Data Table B.

6. How did your measured freezing point compare to your theoretical freezing point for the second addition?

$$\% \text{ error} = ((\text{theoretical value} - \text{actual value}) \times 100\%) / \text{theoretical value}$$

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Calorimetry Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

Table A: Validating the Assumption about Insulation

	Mass (g)	Temperature (°C)
Cups and cover		N/A
Cups, cover, and cold water		N/A
Cold water		
Cups, cover, and mixture		
Warm water		

1. When the cold and warm water are mixed, do you expect $\Delta T_{\text{cold water}}$ and $\Delta T_{\text{warm water}}$ to have the same value or different values? What about $q_{\text{cold water}}$ and $q_{\text{warm water}}$?

2. Calculate $\Delta T_{\text{cold water}}$, $\Delta T_{\text{warm water}}$, $q_{\text{cold water}}$, and $q_{\text{warm water}}$. Show your work.

$\Delta T_{\text{cold water}}$	°C
$\Delta T_{\text{warm water}}$	°C
$q_{\text{cold water}}$	kJ
$q_{\text{warm water}}$	kJ

3. Confer with your lab partner and instructor. In this experiment, what is the system and what are the surroundings?

4. When the metal and water are mixed, do you expect ΔT_{metal} and ΔT_{water} to be the same or different?

5. When the metal and water are mixed, do you expect q_{metal} and q_{water} to be the same or different?

Table B: Identifying Unknown Metal by Specific Heat

	Mass (g)	Temperature (°C)
Unknown metal # _____		
Cups and cover (from Part A)		N/A
Cups, cover, and cold water		N/A
Cold water		
Mixture of metal and water	N/A	

6. Calculate the specific heat of the metal. Show your work.

7. What is the identity of the metal? Refer to the table below.

Specific Heats of Selected Metals

Metal	s_{metal} , J/g·°C	Metal	s_{metal} , J/g·°C
Al	0.901	Fe	0.449
Cu	0.384	Ni	0.444
Si	0.711	Sn	0.226
Zn	0.389	Mn	1.02

Table C: Identifying Unknown Metal by Specific Heat

	Mass (g)	Temperature (°C)
Cups and cover (from Part A)		N/A
NH ₃ solution	N/A	
Cups, cover and mixed solution		N/A
mixed solution		

8. What is ΔH for this reaction?

Show your work.

9a. Using volume and concentration, how many moles of NH₃ and H₃PO₄ were mixed together?

9b. What is the molar value for ΔH for this reaction? Show your work.

10. Calculate the amount of NH₄H₂PO₄ that you made in Part C in grams.

Table D: Heat of Solution

	Mass (g)	Temperature (°C)
Cups and cover (from Part A)		N/A
Cups, cover, and water		N/A
Water		
Solution	N/A	
Solid $\text{NH}_4\text{H}_2\text{PO}_4$		N/A

11. Confer with your lab partner and instructor. In this experiment, what is the system and what are the surroundings?

12. How would you expect the molar change in enthalpy (ΔH) for this reaction to compare with the heat of neutralization in Part C? (If you would like to check, calculate it now. You will be asked for the value in the WebAssign postlab exercise.)

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Determination of an Equilibrium Constant Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

Table A: Calibration Curve of FeSCN^{2+} Solutions

Solution #	Volume of 0.100 M Fe^{3+} (mL)	Volume of 6.00×10^{-4} M SCN^{-} (mL)	Volume of water (mL)	Total Volume (mL)	$[\text{FeSCN}^{2+}]$ (M)	Absorbance at ~470 nm
Blank	1.00	0.00	7.00	8.00	_____	_____
1A	1.00	1.00	6.00	8.00		
2A	1.00	2.00	5.00	8.00		
3A	1.00	3.00	4.00	8.00		
4A	1.00	4.00	3.00	8.00		
Equation of Trendline _____					R ² Value _____	

1. What is the initial concentration of SCN^{-} in Solution 1A? Show your work; remember to account for dilution. Pay attention to significant figures.

2. Given your result from Question 1, what is the concentration of FeSCN^{2+} in Solution 1A? Enter this concentration in your data table.

3. How does the intensity of the color of the solutions and the absorbance vary with the concentration of the FeSCN^{2+} solution?

Table B: Measuring $[\text{FeSCN}^{2+}]$ in Equilibrium Mixtures

Solution #	Volume of 0.002 M Fe^{3+} (mL)	Volume of 0.002 M SCN^{-} (mL)	Volume of water (mL)	Total Volume (mL)	Initial $[\text{Fe}^{3+}]$ (M)	Initial $[\text{SCN}^{-}]$ (M)	Abs at ~470 nm	Calculated Equilibrium $[\text{FeSCN}^{2+}]$ (M)
1B	2.00	4.00	2.00	8.00				
2B	3.00	4.00	1.00	8.00				
3B	4.00	4.00	0.00	8.00				
4B	4.00	3.00	1.00	8.00				
5B	4.00	2.00	2.00	8.00				

4. Calculate the initial concentration of Fe^{3+} in Solution 1B. Show your work; remember to account for dilution. Enter the concentration in your data table.

5. Calculate the initial concentration of SCN^{-} in Solution 1B. Show your work; remember to account for dilution. Enter the concentration in your data table.

6. Using your calibration curve from Part A and your absorbance data from Part B, what is the equilibrium concentration of FeSCN^{2+} in Solution 1B? Show your work.

7. Construct a reaction table for Solution 1B.

	$\text{Fe}^{3+}(\text{aq})$	+	$\text{SCN}^{-}(\text{aq})$	\rightarrow	$\text{FeSCN}^{2+}(\text{aq})$
initial					
change(Δ)					
equilibri um					

8. From the equilibrium concentrations in the reaction table for Solution 1B, calculate the equilibrium constant for the reaction.

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Mixtures of Acids and Bases Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

Table A: Calculated and Measured pH's of Acid and Base Mixtures

Reaction #	Reagents	Calculated pH	Measured pH
1 Water + Strong Base	10 mL H ₂ O		
	+ 5 mL NaOH		
	+ additional 5 mL NaOH		
	+ additional 5 mL NaOH		
2 Strong Acid + Strong Base	10 mL HCl		
	+ 5 mL NaOH		
	+ additional 5 mL NaOH		
	+ additional 5 mL NaOH		
3 Weak Acid + Strong Base	10 mL NH ₄ Cl		
	+ 5 mL NaOH	to be calculated in lab	
	+ additional 5 mL NaOH	to be calculated in postlab	
	+ additional 5 mL NaOH	to be calculated in postlab	
4 Weak Base + Strong Base	10 mL NaC ₂ H ₃ O ₂		
	+ 5 mL NaOH	to be calculated in lab	
	+ additional 5 mL NaOH	to be calculated in postlab	
	+ additional 5 mL NaOH	to be calculated in postlab	

1. For reaction series 1, water reacting with strong base, compare the pH's you calculated in your prelab to the pH's you measured in Data Table A. Please explain any inconsistencies between your calculated and measured results.

2. For reaction series 2, strong acid reacting with strong base, compare the pH's you calculated in your prelab to the pH's you measured in Data Table A. Please explain any inconsistencies between your calculated and measured results.

3. For reaction series 3, compare the pH you calculated in your prelab for a 0.1 M NH_4Cl solution in Data Table A with the pH you measured. Please explain any inconsistencies between your calculated and measured results.

4a. Construct a reaction table for the mixture of 10.0 mL of 0.1 M NH_4Cl with 5.0 mL of 0.1 M NaOH .

	$\text{NH}_4^+(\text{aq})$	+	$\text{OH}^-(\text{aq})$	\rightarrow	$\text{NH}_3(\text{aq})$	+	$\text{H}_2\text{O}(\text{l})$
initial							---
change(Δ)							---
final							---

4b. Calculate the equilibrium concentrations of NH_4^+ , NH_3 , H_3O^+ and OH^- in the resulting solution.

4c. Calculate the pH of the resulting solution.

4d. How does this compare to the pH you measured? Please explain any inconsistencies.

5. For reaction series 4, compare the pH you calculated in your prelab for a 0.1 M $\text{NaC}_2\text{H}_3\text{O}_2$ solution Data Table A with the pH you measured. Please explain any inconsistencies between your calculated and measured results.

6a. Construct a reaction table for the mixture of 10.0 mL of 0.1 M $\text{NaC}_2\text{H}_3\text{O}_2$ with 5.0 mL of 0.1 M NaOH . Using LeChatelier's principle, explain the effect of OH^- on the reaction of $\text{C}_2\text{H}_3\text{O}_2^-$ with water.

	$\text{C}_2\text{H}_3\text{O}_2^- (\text{aq})$	+	$\text{H}_2\text{O} (\text{l})$	\rightarrow	$\text{HC}_2\text{H}_3\text{O}_2(\text{aq})$	+	$\text{OH}^-(\text{aq})$
initial			--				
change(Δ)			--				
final			--				

6b. Calculate the equilibrium concentrations of $\text{C}_2\text{H}_3\text{O}_2^-$, $\text{HC}_2\text{H}_3\text{O}_2$, H_3O^+ and OH^- in the resulting solution.

6c. Calculate the pH of the resulting solution.

6d. How does this compare to the pH you measured? Please explain any inconsistencies.

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Buffers Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

1. Show your calculation for preparing the 0.60 M $\text{HC}_2\text{H}_3\text{O}_2$ solution from your prelab assignment.

2. Show the calculation of how many grams of $\text{NaC}_2\text{H}_3\text{O}_2 \cdot 3 \text{H}_2\text{O}$ are needed from your prelab assignment.

Table A: pH Data for Acetate Buffers (Direct Method)

Solution #	mL of 0.60 M $\text{HC}_2\text{H}_3\text{O}_2$	mL of 0.60 M $\text{NaC}_2\text{H}_3\text{O}_2$	pH
1A	30	0	
2A	30	10	
3A	0	30	
4A	10	30	
5A	20	20	

3. Explain the order of pH for the five solutions. Consider the relative amounts of acid and base in each.

Table B: pH Data for Acetate Buffers (Indirect Method)

Solution #	mL NaOH added	total mL NaOH added	pH	total mmol NaOH added	Buffer? Y/N
1B	0	0			
2B	4	4			
3B	5	9			
4B	6	15			
5B	10	25			

4. How many mmol of acetic acid are present in your sample 1B? Show your work.

5. How many total mmol of NaOH have you added at this point? (Show your setup.) Enter this amount in Data Table B.

6. Is this solution a buffer solution? Explain your reasoning. Fill in Data Table B with your choice.

7. Will you need to use $\text{Na}_3\text{PO}_4 \cdot 12 \text{H}_2\text{O}$ or $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$ in order to generate the desired pH? Explain your answer. Enter your choice in Data Table C.

8. What mass of the other phosphate compound will you need to add in order to generate the desired pH? Show your work. Enter this amount in Data Table C.

Table C: Data for Phosphate Buffer

pH Assigned	
mass of $\text{Na}_2\text{HPO}_4 \cdot 7\text{H}_2\text{O}$ used	g
other phosphate compound used	
mass used	g
initial measured pH of buffer	
action taken	
final measured pH of buffer	

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Titration Curves Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

Table A: Titration of KHP

Concentration of KHP solution	M
Volume of KHP solution titrated	mL
Concentration of NaOH solution	M
Calculated V_{eq} of NaOH solution	mL

1. From the values in Data Table A, calculate the theoretical equivalence volume (V_{eq}) for your KHP titration. Record this value in Data Table A.

Table C: Titration of Na_2CO_3 with HCl

mL of 0.20 M NaOH added	Calculated pH (From prelab)	Measured pH (From titration curve)	% Difference
0.00			
10.00			
15.00			
20.00			
22.00			

3a. What is the experimental pK_a value for hydrogen phthalate (HP^- or $\text{HC}_8\text{H}_4\text{O}_4^-$) that you found at the midpoint of your KHP titration curve?

3b. The accepted value for the pK_a of HP^- is 5.408. How does this compare to your experimental value? What is their percent difference?

4. How did the endpoint indicated by the phenolphthalein compare to the equivalence point determined by the titration curve?

What conclusion can you make about the need for an indicator in a pH titration?

Table D: Titration of Na_2CO_3

Concentration of Na_2CO_3 solution	M
Volume of Na_2CO_3 solution titrated	mL
Concentration of HCl solution	M
Calculated first V_{eq} of HCl solution	mL
Calculated second V_{eq} of HCl solution	mL

5. From the values in Data Table D, calculate the theoretical first and second equivalence volumes (V_{eq} 's) for your Na_2CO_3 titration.

6b. How do your theoretical and experimental equivalence volumes compare? What are their percent error?

Table F: Calculated vs Measured pH's for Na₂CO₃ Titration

mL of 0.20 M HCl added	Calculated pH (From prelab)	Measured pH (From titration curve)	% Difference (Calculated = actual)
0.00			
5.00			
10.00			
15.00			
20.00			
22.00			

7a. What are the experimental pK_a values for carbonic acid (H₂CO₃) and hydrogen carbonate (HCO₃⁻) that you found at the midpoints of your Na₂CO₃ titration curve?

7b. The accepted values for the pK_a's of H₂CO₃ and HCO₃⁻ are 6.352 and 10.329, respectively. How do these compare to your experimental values? What are their percent error?

8. How did the endpoint indicated by the methyl orange compare to the equivalence points determined by the titration curve? What conclusion can you make about the need for an indicator in a pH titration?

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Solubility Product Constants Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

Table A: Absorbances of Standard Cu^{2+} Solutions

Standard Cu^{2+} Solutions	Absorbance at _____ nm
1: 5.0×10^{-4} M $\text{Cu}(\text{NO}_3)_2$	
2: 1.0×10^{-3} M $\text{Cu}(\text{NO}_3)_2$	
3: 5.0×10^{-3} M $\text{Cu}(\text{NO}_3)_2$	
4: 1.0×10^{-2} M $\text{Cu}(\text{NO}_3)_2$	
Equation of Trendline _____ R^2 Value _____	

Table B: Absorbances of Solutions Saturated with $\text{Cu}(\text{IO}_3)_2$

Cu(IO_3) ₂ Saturated Solutions	Absorbance at _____ nm	[Cu^{2+}]	[IO_3^{1-}]
A: 1.0×10^{-2} M KIO_3		M	M
B: 5.0×10^{-3} M KIO_3		M	M
C: deionized water		M	M
D: 1.0×10^{-3} M $\text{Cu}(\text{NO}_3)_2$		M	M
E: 5.0×10^{-3} M $\text{Cu}(\text{NO}_3)_2$		M	M

- Using the trendline from your calibration curve, calculate the [Cu^{2+}] in each of the solutions A - E. Show one representative calculation neatly. Enter these results in Data Table B.

2. Calculate the $[\text{IO}_3^-]$ in each of the solutions A - E. Remember that for solutions A and B where IO_3^- was originally present, you must account for the initial amount plus any ions that were formed due to the solubility of the solid. Show one representative calculation neatly. Enter these results in Data Table B.

3. Calculate the K_{sp} for each of the solutions A - E. Show one representative calculation neatly. Enter these results in Data Table C.

Table C: Calculated K_{sp} and Solubilities of $\text{Cu}(\text{IO}_3)_2$

$\text{Cu}(\text{IO}_3)_2$ Saturated Solutions	Calculated K_{sp}	Calculated Solubility
A: 1.0×10^{-2} M KIO_3		M
B: 5.0×10^{-3} M KIO_3		M
C: deionized water		M
D: 1.0×10^{-3} M $\text{Cu}(\text{NO}_3)_2$		M
E: 5.0×10^{-3} M $\text{Cu}(\text{NO}_3)_2$		M
Average		-----

4a. Calculate the average of your five K_{sp} values. Enter the result in Data Table C.

4b. The literature value for the K_{sp} of $\text{Cu}(\text{IO}_3)_2$ is 6.85×10^{-8} . How does this compare to your average experimental values?

What is the percent error compared to your average?

$$\% \text{ error} = \frac{\text{experimental} - \text{theoretical}}{\text{theoretical}} \times 100$$

5. Calculate the solubility of $\text{Cu}(\text{IO}_3)_2$ in each of the five solutions. Remember that for solutions D and E where Cu^{2+} was originally present, you must subtract the initial amount from the equilibrium amount to get the amount formed due to the solubility of the solid. Show one representative calculation neatly. Enter these results in Data Table C.

6. Looking at your solubility results for solutions A and B as compared to C, did the solubility increase, decrease or stay about the same in the solutions that originally contained IO_3^- ions?

Does this confirm the common ion effect? If not, can you explain why it does not?

7. Looking at your solubility results for solutions D and E as compared to C, did the solubility increase, decrease or stay about the same in the solutions that originally contained Cu^{2+} ions?

Does this confirm the common ion effect?

If not, can you explain why it does not?

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Electrochemical Cells Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

Complete the following table.

Table A: Cell Potentials vs a Zn^{2+}/Zn (0.1 M) Couple

Half-Cell	Potential Difference, V
Ag^+/Ag (0.1 M)	
Ag^+/Ag (0.1 M) †	
Pb^{2+}/Pb (0.1 M)	
Cu^{2+}/Cu (0.1 M)	

†Leads switched

1. In your first measurement, since the Zn^{2+}/Zn (0.1 M) redox couple is the reference, does your test Ag^+/Ag (0.1 M) redox couple have a more positive or more negative reduction potential than zinc?

2a. Given your response to the first question, which half-cell is the anode?

2b. Select all of the following that are true about your Zn-Ag cell. (*Note: The order of these options may be different in the WebAssign question.*)

- Ag^+ is gaining electrons.
- Ag^+ is getting reduced.
- Ag is getting oxidized.
- Ag is losing electrons.
- Electrons travel toward the Ag half-cell.
- Electrons travel away from the Ag half-cell.
- Zn^{2+} is gaining electrons.
- Zn^{2+} is getting reduced.
- Zn is getting oxidized.
- Zn is losing electrons.
- Electrons travel toward the Zn half-cell.
- Electrons travel away from the Zn half-cell.

3. In your second measurement, how does the voltage differ from the first measurement?

4. Write a net chemical equation for the overall reaction in the Zn-Cu cell (spontaneous, left to right). (Omit states-of-matter from your answer. Use the lowest possible whole number coefficients.)

5a. Predict whether the potential of the cell using the 0.1 M Zn^{2+} solution and the diluted copper solution will be more positive or less positive than the standard potential you measured in Part A.

5b. Select all of the following that are true about your Zn-diluted Cu cell. (*Note: The order of these options may be different in the WebAssign question.*)

- The cell potential, E_{cell} , is greater than the standard cell potential, E_{cell}° .
- The cell potential, E_{cell} , is less than the standard cell potential, E_{cell}° .
- The cell potential, E_{cell} , is equal to the standard cell potential, E_{cell}° .
- The amount of a reactant has been increased so the potential decreases.
- The amount of a reactant has been reduced so the potential decreases.
- The amount of a reactant has been increased so the potential increases.
- The amount of a reactant has been reduced so the potential increases.
- The reaction quotient, Q , is greater than 1.
- The reaction quotient, Q , is less than 1.

Complete the following table.

Table B: Cell Potentials vs a Zn^{2+}/Zn (0.1 M) Couple

Half-Cell	Potential Difference, V
Cu^{2+}/Cu diluted solution	
Cu^{2+}/Cu after addition of KOH	

6. Did the potential shift in the direction you predicted in the previous question?

7. Write a net chemical equation for the reaction that took place when KOH was added. (Remember the solubility rules for precipitation reactions. Omit states-of-matter from your answer. Use the lowest possible whole number coefficients.)

8. Select all of the following that are true about your Zn-diluted Cu plus KOH cell. (*Note: The order of these options may be different in the WebAssign question.*)

- The cell potential, E_{cell} , increased.
- The cell potential, E_{cell} , decreased.
- The cell potential, E_{cell} , remained the same.
- $[\text{Cu}^{2+}]$ increased.
- $[\text{Cu}^{2+}]$ decreased.
- $[\text{Cu}^{2+}]$ remained the same.
- The amount of a reactant increased so the potential increased.
- The amount of a reactant increased so the potential decreased.
- The amount of a reactant decreased so the potential increased.
- The amount of a reactant decreased so the potential decreased.
- The reaction quotient, Q , increased.
- The reaction quotient, Q , decreased.
- The reaction quotient, Q , remained the same.

Complete the following table.

Table C: Cell Potentials for Ascorbic Acid vs a Cu^{2+}/Cu (0.1 M) Couple

pH	Potential Difference, V
7	
5	

What is the color of lead to copper?

What is the color of lead to graphite?

9. Write a net chemical equation for the overall reaction for this cell (spontaneous, left to right). Use the chemical formulas for dehydroascorbic acid and ascorbic acid. (Omit states-of-matter from your answer. Use the lowest possible whole number coefficients.)

10. Select all of the following that are true about your Cu-ascorbic acid cell. (*Note: The order of these options may be different in the WebAssign question.*)

- When the pH is changed from 7 to 5, the reaction quotient increases.
- When the pH is changed from 7 to 5, the reaction quotient decreases.
- When the pH is changed from 7 to 5, the E_{cell} increases.
- When the pH is changed from 7 to 5, the E_{cell} decreases.
- The reaction quotient, Q , is equal to $([\text{C}_6\text{H}_6\text{O}_6][\text{H}^+]^2)/([\text{Cu}^{2+}][\text{C}_6\text{H}_8\text{O}_6])$.
- The reaction quotient, Q , is equal to $([\text{Cu}^{2+}][\text{C}_6\text{H}_8\text{O}_6])/([\text{C}_6\text{H}_6\text{O}_6][\text{H}^+]^2)$.
- The reaction quotient, Q , is equal to $([\text{C}_6\text{H}_8\text{O}_6])/([\text{Cu}^{2+}][\text{C}_6\text{H}_6\text{O}_6][\text{H}^+]^2)$.

Name _____	Lab Partner _____
TA Name _____	Section _____ Date _____

Chemical Kinetics Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

Data Table A: Determination of Rate Law: $2 \text{I}^- + \text{S}_2\text{O}_8^{2-} \rightarrow \text{I}_2 + 2 \text{SO}_4^{2-}$

Run #	mL of 0.200 M KI	mL of 0.100 M (NH ₄) ₂ S ₂ O ₈	mL of 0.0050 M Na ₂ S ₂ O ₃	mL of 0.2 M KCl	mL of 0.100 M (NH ₄) ₂ SO ₄	Elapsed time (sec)
1	20.0	20.0	10.0	0.0	0.0	
2	10.0	20.0	10.0	10.0	0.0	
3	5.0	20.0	10.0	15.0	0.0	
4	20.0	10.0	10.0	0.0	10.0	
5	20.0	5.0	10.0	0.0	15.0	

1. What are the initial concentrations of iodide, persulfate, and thiosulfate in the first run? Account for dilution and show your work.

2. What is $\Delta[\text{S}_2\text{O}_3^{2-}]$ at the time of the color change in the first run?

3. What is the rate of the reaction in the first run? Show your work.

Table B: Calculations for Determination of Rate Law

Run #	Initial [I ⁻]	Initial [S ₂ O ₈ ²⁻]	Initial [S ₂ O ₃ ²⁻]	Rate	k
1					
2					
3					
4					
5					

4. Inspect the data in Data Table B. What is the order of the reaction with respect to iodide ions? Explain how you arrived at your answer.

5. Inspect the data in Data Table B. What is the order of the reaction with respect to persulfate ions? Explain how you arrived at your answer.

6. Write the rate law for this reaction, showing the proper exponents.

7. Calculate the rate constant for the first run. Include units. Show your work, and record the result in Data Table B.