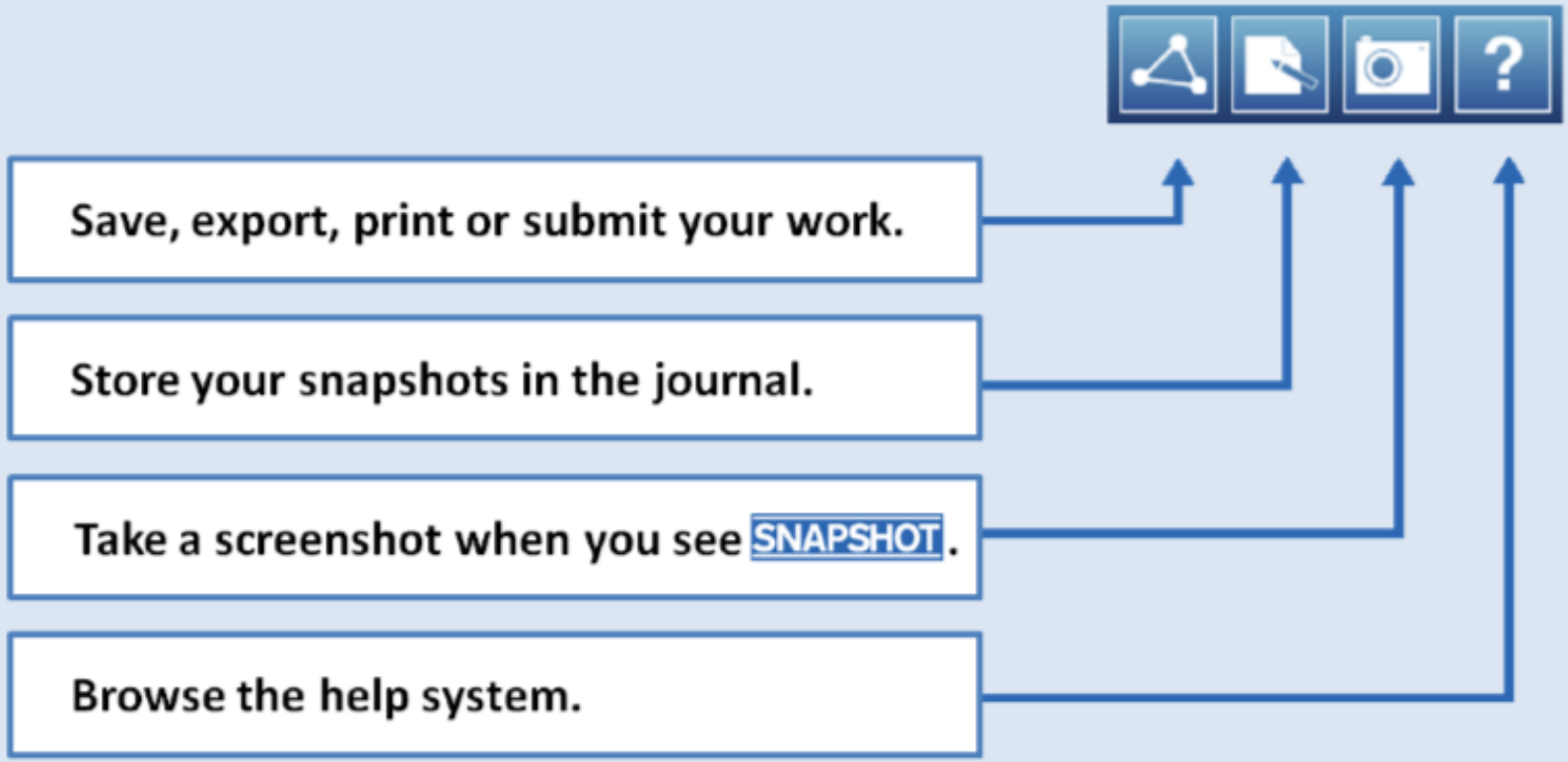
Reaction Rates: Glucose Concentration


Save, export, print or submit your work.
Store your snapshots in the journal.
Take a screenshot when you see SNAPSHOT.
Browse the help system.

Reaction Rates: Glucose Concentrations

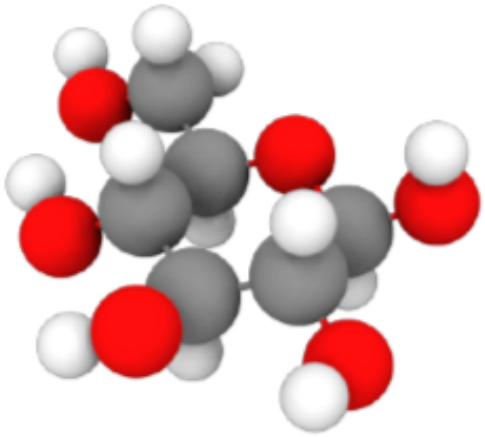
People with diabetes mellitus have persistently elevated concentrations of glucose in their blood. High blood sugar (glucose) levels can damage organs and tissues in the body, so it is important for those with diabetes to monitor and control the concentration of glucose in their blood. Many people use glucose monitors to get quick and accurate readings of their blood glucose level.

In this lab activity, you will discover how a chemical reaction is used to determine the concentration of glucose in different mixtures.

Glucose Monitor

Introduction

- In this lab, you will measure how long it takes for glucose ($C_6H_{12}O_6$) to react with potassium permanganate ($KMnO_4$) in acidic conditions.
- In this reaction, the glucose will donate electrons to the colored permanganate ion (MnO_4^-) which reduces the ion to a colorless manganese ion (Mn^{2+}). The reaction will be performed in an acidic solution.



Glucose Molecule

Half - Reactions

$$\underset{\text{(Purple)}}{MnO_4^-} + 8H^+ + 5e^- \rightarrow \underset{\text{(Colorless)}}{Mn^{2+}} + 4H_2O$$

glucose → oxidized glucose products + electrons

Challenges

- Determine how concentration of glucose in solution affects the time it takes for the chemical reaction to occur.
- Use this relationship to estimate the concentration of an "unknown" glucose solution.

Allow the reaction to occur inside a colorimeter. The colorimeter measures the absorbance (concentration) of MnO_4^- as the reaction occurs.

Prediction

SNAPSHOT

You will react 2 different concentrations of glucose (2% and 8%) with a standard potassium permanganate solution. Which concentration of glucose will react the fastest? Explain your prediction.

The concentration of glucose that will react the fastest is...

This will happen because....

Safety

- Wear safety goggles.
- Wear an apron and protective gloves.
- Potassium permanganate is a strong oxidizing agent, it is a corrosive irritant, and it will stain. Avoid contact with skin and eyes.
- Sulfuric acid is a corrosive irritant. Avoid contact with skin and eyes.
- Follow all lab safety rules.

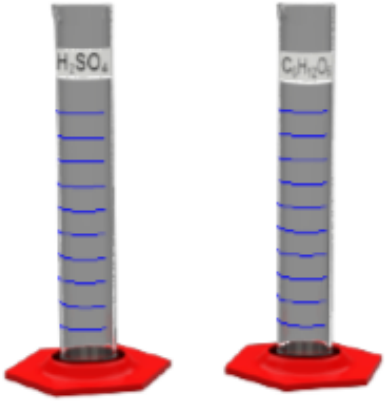
Materials

- Data Collection System
- Colorimeter
- Sensor extension cable
- Glass cuvette with cap (2)
- Test tube in a test tube rack or beaker
- Graduated pipette, 1-mL
- Graduated cylinder, 10-mL (2)
- Beaker for waste, 250-mL
- Non-abrasive cleaning tissue
- Glucose solutions (2%, 8%, unknown)
- 0.01 M Potassium permanganate ($KMnO_4$)
- 1.0 M Sulfuric acid (H_2SO_4)
- Distilled (deionized) water
- Timer

Procedure

1. Use a sensor extension cable to connect a colorimeter to your data collection system.
2. Calibrate the colorimeter using distilled water.
3. Label your graduated cylinders sulfuric acid (H_2SO_4) and glucose ($C_6H_{12}O_6$). You will use the graduated pipette to measure the potassium permanganate ($KMnO_4$).

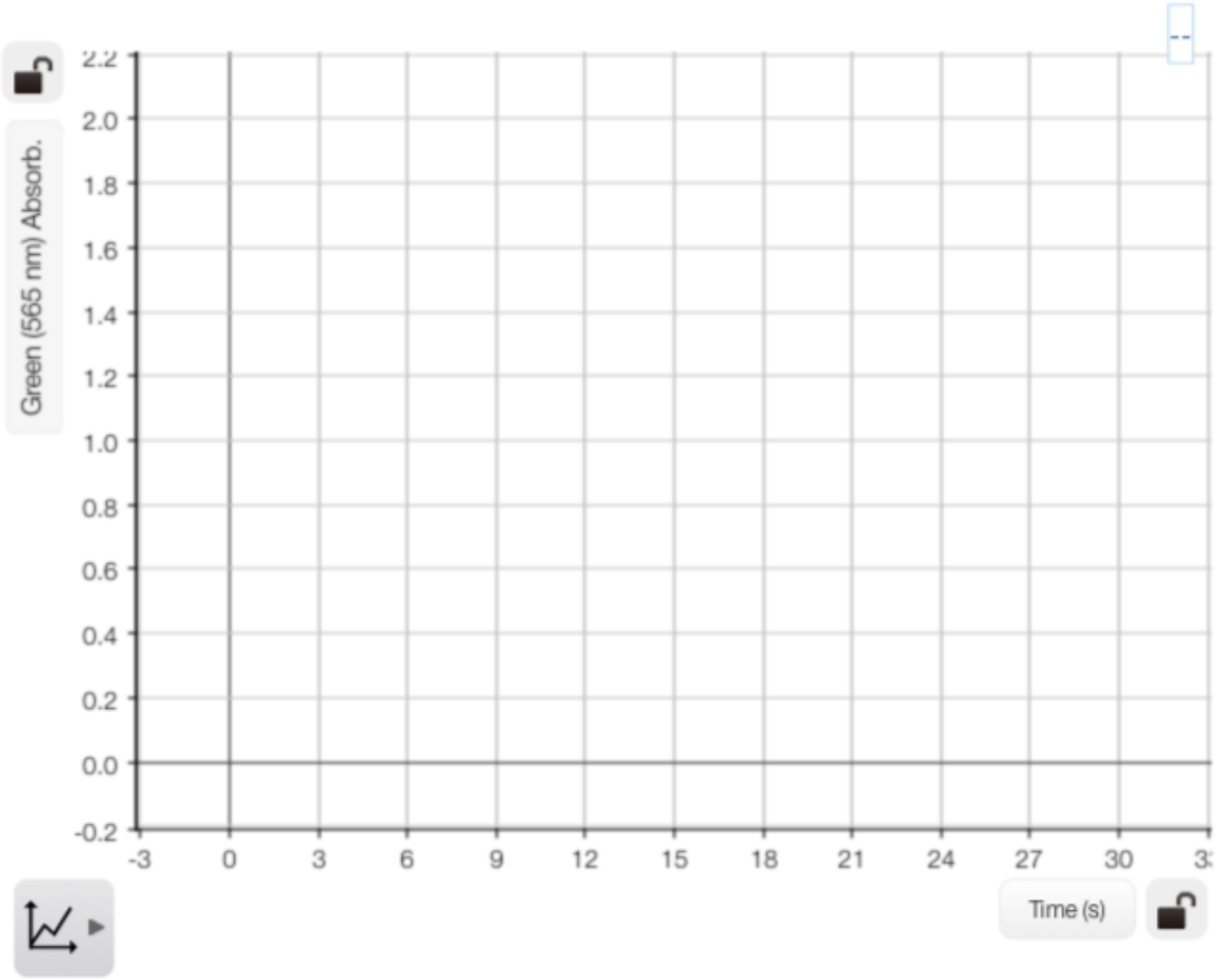
Graduated Pipette



Graduated Cylinders

Procedure

4. Add 5.0 mL of 2% $C_6H_{12}O_6$ to the test tube.
5. Add 2.0 mL of 1.0 M H_2SO_4 to the test tube.
6. The following steps need to be done carefully and quickly. Read and understand the sequence of steps *before* continuing.
    a. Add 1.00 mL of 0.01 M $KMnO_4$ to the test tube and *start a timer*. You have 30 seconds to complete the next four steps.
    b. Swirl the test tube to mix the contents.
    c. Pour the mixture into the cuvette.
    d. Cap the cuvette, place it in the colorimeter, and close the lid.
    e. Start data collection exactly 30 seconds after adding the $KMnO_4$.
7. Continue to the next page to see the data being collected.



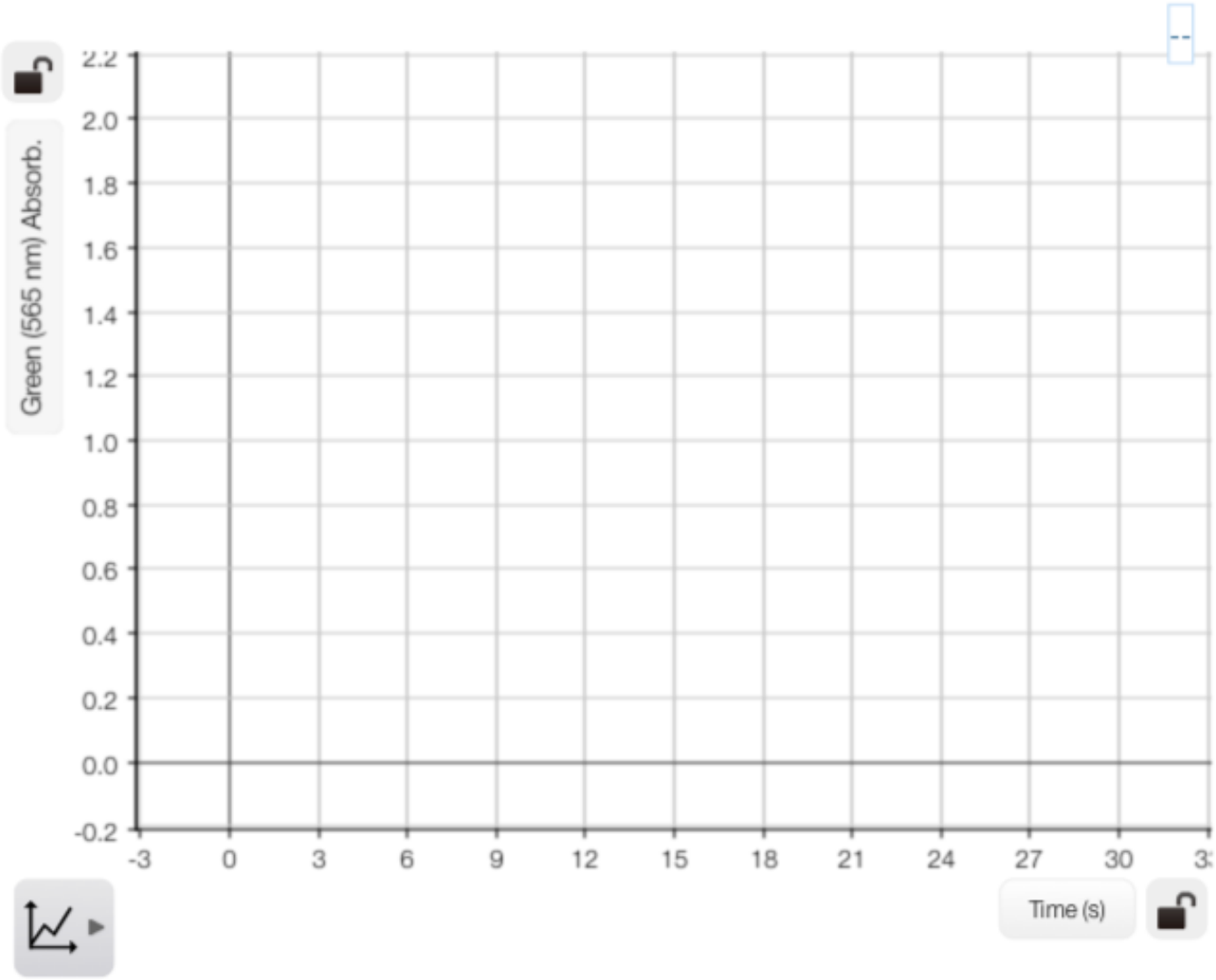
Green (565 nm) Absorb.

0

1.23

8. Look at the data being collected and at the reaction mixture left-over in the test tube. Discuss your observations.

9. Stop collecting data when the absorbance stabilizes.



10. As the reaction occurred, what was the effect on absorbance?

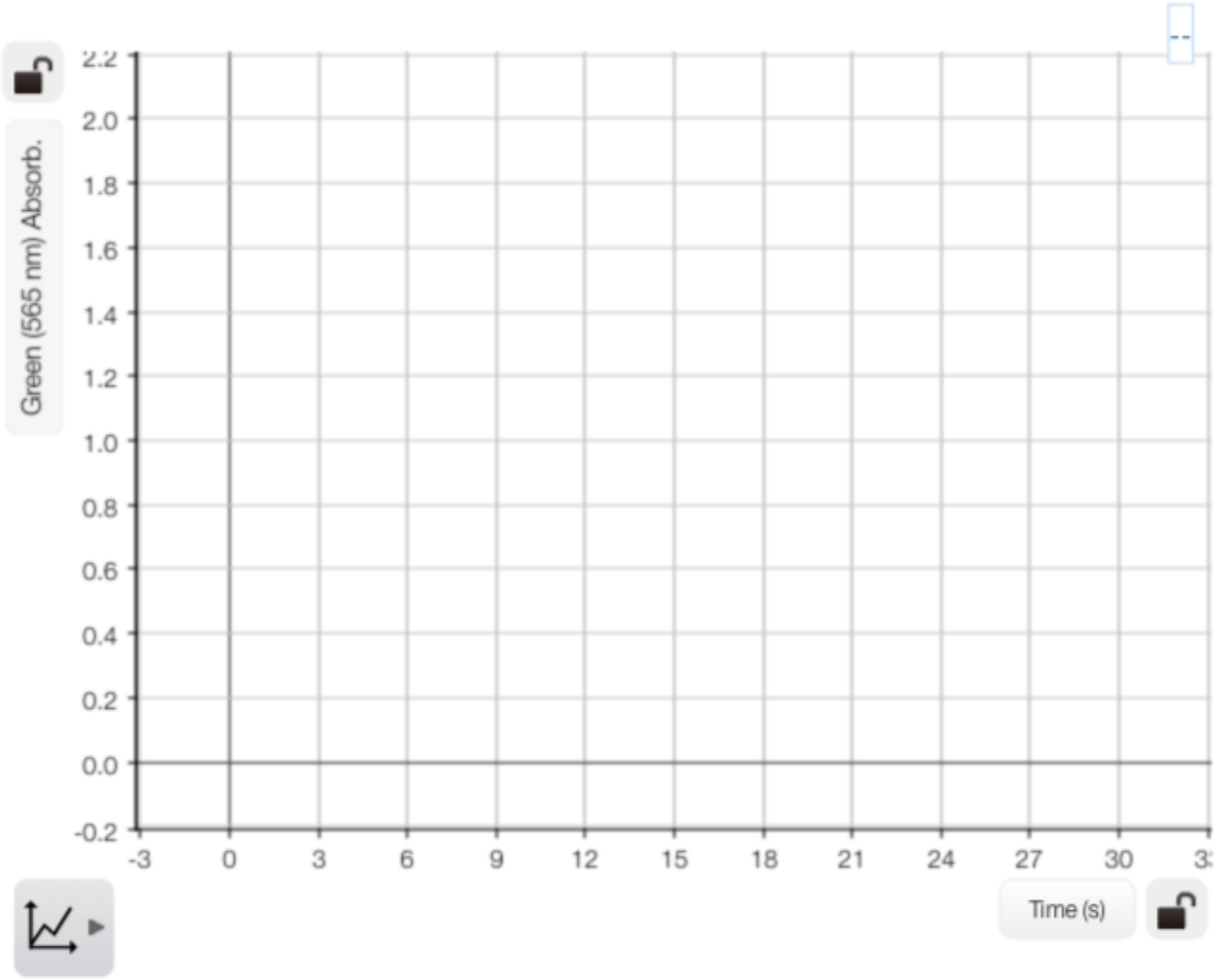
11. What happened to the reaction mixture in the test tube?

10. The absorbance...

11. The reaction mixture in the test tube...

	Glucose Solutions	Reaction Time (s)
	Run 1	Run 1
1	2%	
2	8%	
3	unknown	
4		
5		
6		
7		
8		
9		

12. In the table, record the time it took for the reaction mixture to turn colorless (determine this on the previous page).
13. Clean the cuvette and test tube.
14. Repeat the procedure using 8% $C_6H_{12}O_6$.
    - Add 5.0 mL 8% $C_6H_{12}O_6$
    - Add 2.0 mL H_2SO_4
    - Add 1.00 mL $KMnO_4$
15. Start data collection 30 seconds after mixing, then continue to the next page.



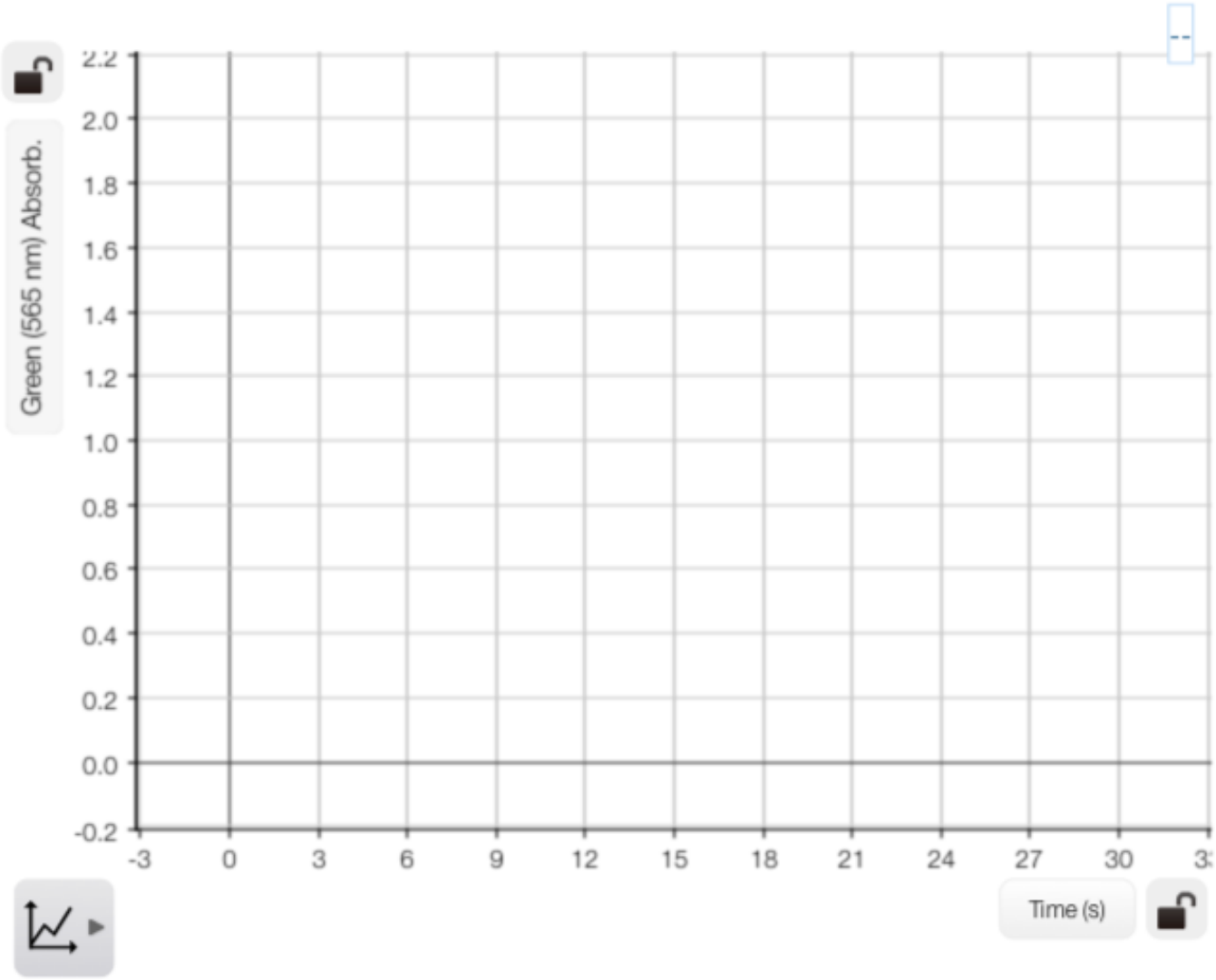
Green (565 nm) Absorb.

0

1.23

16. Examine the data being collected. Discuss how this trial compares to the first trial.

17. Stop collecting data when the absorbance stabilizes.



18. Compare trial 2 with trial 1. Record your observations and explain any differences below.

19. How long did it take the reaction to occur? Record your answer in the table on the next page.

18. In trial 2 (8% glucose)...

	Glucose Solutions	Reaction Time (s)
		Run 1
1	2%	
2	8%	
3	unknown	
4		
5		
6		
7		
8		
9		

20. In the table, record the time it took for the reaction mixture to turn colorless.

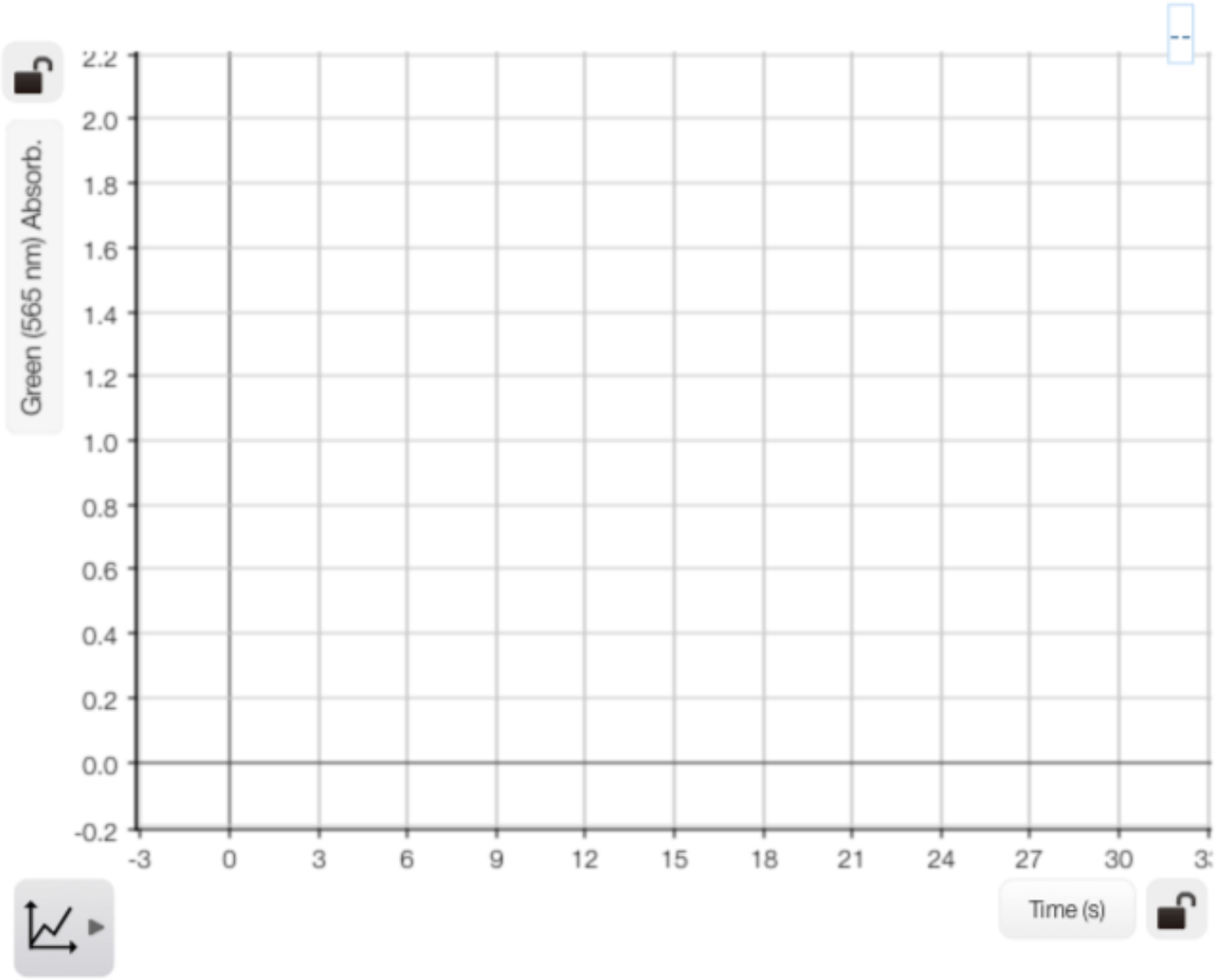
21. Explain how reaction time is related to glucose concentration.

21. The greater the glucose concentration the...

	Glucose Solutions	Reaction Time (s)
	Run 1	Run 1
1	2%	
2	8%	
3	unknown	
4		
5		
6		
7		
8		
9		

Procedure

22. Clean the cuvette and test tube.
23. Repeat the procedure using the unknown $C_6H_{12}O_6$ solution.
    - Add 5.0 mL $C_6H_{12}O_6$
    - Add 2.0 mL H_2SO_4
    - Add 1.00 mL $KMnO_4$
24. Start data collection 30 seconds after mixing, then continue to the next page.



Green (565 nm) Absorb.

0

1.23

25. As you collect data, think about how you might use the data to estimate the percent glucose in this unknown solution.

26. Stop collecting data when the absorbance stabilizes.

	Glucose Solutions	Reaction Time (s)
		Run 1
1	2%	
2	8%	
3	unknown	
4		
5		
6		
7		
8		
9		

27. In the table, record the time it took for the reaction mixture to turn colorless.

28. Estimate the percent of the unknown glucose solution. Explain how you determined your answer.

28. The unknown glucose solution is about....

I determined this by...

Analysis

SNAPSHOT

1. Why did the color change during the experiment?
2. What substance did you monitor the concentration of over time? Was this substance a reactant or a product? How do you know?

1. The color changed because...
2. I monitored the concentration of..., which was a...

   I know this because...

Analysis

3. What happened to the amount of time it took the reaction to occur as the concentration of glucose increased?

Reaction rate, or speed of a reaction, is a measure of how fast or slow a reaction takes place. It is determined by measuring the change in concentration of a reactant or product over time.

4. How did the reaction rate change as the concentration of glucose increased?

3. As the concentration of glucose increased, the time it took the reaction to occur...

4. As the concentration of glucose increased, the reaction rate...

Challenge Revisited

You just finished measuring the concentration of glucose in a mixture of glucose and water. Can the same thing be done with more complex mixtures such as blood or urine? What about in different environmental conditions? What other variables in more complex situations affect the time it takes a reaction to occur?

Your Experiment

- You will design your own experiment to test the effect of another variable on the time it takes glucose to react with potassium permanganate.
- Think of other mixtures, such as blood or urine, that contain glucose and how they are different than the glucose solutions already tested. Could the difference affect the reaction rate? Discuss the questions below with your lab group.
  - Are there other solutes that when mixed with glucose would change the time it takes the reaction to occur?
  - Are there environmental conditions that could cause the rate of the reaction to change?
  - What additional variables could be involved?

Your Experiment

SNAPSHOT

Brainstorm a list of 5-10 variables that could affect the time it takes a reaction to occur. Once you have your list, pick which variable you want to study in your experiment.

The following variables may affect the rate of reaction:

Your Experiment

SNAPSHOT

List the **dependent variable, independent variable,** and **controlled variables** in your experiment.

Dependent variable:

Independent variable:

Controlled variables:

Your Experiment

SNAPSHOT

Write your testable **question** below in terms of how the independent variable will affect the dependent variable.

Testable question:

Your Experiment

SNAPSHOT

Predict how the independent variable will affect the dependent variable. Explain your prediction.

Prediction:

Explanation:

Your Experiment

SNAPSHOT

Write your **procedure** below. Consider procedures used earlier in this lab.

Explain how you will conduct the experiment and how to set up the data tables or graphs.

Procedure:

Your Experiment

SNAPSHOT

What **materials** do you need to complete the lab?

What specific **safety** precautions do you need to take?

Materials:

Safety:

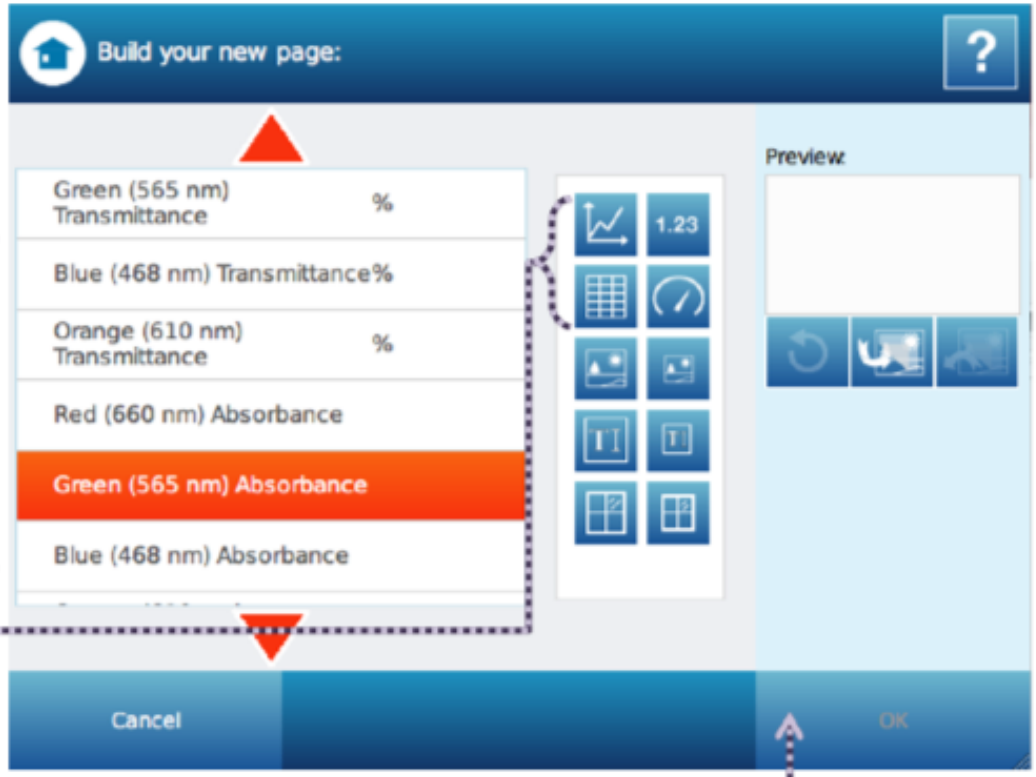
Your Experiment

- Discuss with your teacher how you will conduct the experiment.
- Prepare any materials as needed.
- Follow the procedure your teacher has approved.
- Connect the correct sensors to be used for the experiment.
- Follow the directions on the next slide to set up your data display.

Build Your Data Display

Read all the instructions below before you begin.

1. Select  to build a new page.
2. Select the measurement.
3. Select the data display.
4. Select OK.



Analyze Your Data

SNAPSHOT

Review and analyze the data in your tables or graphs. What does the data show?

Data analysis:

Draw Your Conclusion

SNAPSHOT

What conclusion can you draw based on the results?

My Conclusions:

Make the Connection

SNAPSHOT

Why can reaction rates, such as estimating the concentration of glucose in a patient's blood, be used in medical diagnosis?

Reaction rates can be used to determine the concentration of glucose solutions because...

Congratulations

You have completed the lab.

Please remember to follow your teacher's instructions for cleaning up and submitting your lab.