Stoichiometry

In this investigation, you will monitor the products of a chemical reaction. You will repeat the reaction several times, varying the relative amounts of the two reactants. (The total number of moles of the two reactants will remain constant.) The purpose of the investigation is to discover which ratio of reactants yields the largest amount of products. Since one of the products of this reaction is heat, you will measure the change in temperature to determine the relative amount of products produced.

Question

By combining varying mole amount ratios of reactants and analyzing their products, what will be the reactant coefficients of a chemical reaction?

Materials

computer system and interface
temperature sensor
4 Styrofoam cups
2 graduated cylinders
500 mL of 0.50 M 5% sodium hypochlorite (NaOCl) (household laundry bleach)
500 mL of 0.50 M potassium iodide solution. (KI)
(Be sure the chemicals and apparatus are at room temperature before beginning.)

Safety Precautions

[CAUTION]: NaOCl is very caustic; handle it with care.

- Be sure to dispose of materials properly.

Procedure

1. Copy the data table below into your notebook. (Note that the "average minimum temperature" for each row will be the same, as all of the reactants will begin at the same temperature.)

2. Connect the computer system with the temperature sensor and create a digits and a graph display of the data.

3. Start the data recording.

Trial #	mL Ratio	Volume of NaOCl used (mL)	Moles of NaOCl used (mol)	Volume of KI used (mL)	Moles of KI used (mol)	Average maximum temperature (°C)	Average minimum temperature (°C)	Change in temperature (°C)
1.	20:80	20		80				
2.	40:60	40		60				
3.	60:40	60		40				
4.	80:20	80		20				

4. Use the graduated cylinder to measure and pour 20 mL of NaOCl into a clean Styrofoam cup.

5. Record the temperature of the 20 mL of NaOCl.

6. Using another graduated cylinder, measure 80 mL of KI and record its temperature.

7. Enter the average of the two temperatures into the Trial #1 row and under the "average minimum temperature" in the table.

8. Pour the KI into the Styrofoam cup with the NaOCl while recording the temperature. Gently stir the mixture with the temperature sensor.

9. After the temperature rises and once the temperature begins to fall, stop recording.

10. Remove the temperature sensor and wipe it clean.

11. Repeat steps 3 to 10 using volume ratios of NaOCl and KI at 40:60, 60:40, and 80:20.

12. Discard the solutions as directed by your teacher. Do not pour anything down the drain. Wash hands thoroughly.

Analysis

1. For each of the volumes listed for both NaOCl and KI calculate the number of moles of each used in the trials (remember that each chemical's concentration is 0.50 M and #moles = molar concentration × volume). Enter these values into the table.

2. For each trial find the maximum temperature attained. Record this under the "average maximum temperature" column.

3. Calculate and record the "change in temperature" by subtracting the average minimum temperature from the average maximum temperature in each row.

4. With which trial number did the temperature rise the most?

5. What was this maximum temperature change?

6. What was the ratio of volume of NaOCl to KI during the maximum change in temperature?

7. What was the ratio of moles of NaOCl to KI during the maximum change in temperature?

Conclusions

8. What are the simplest whole numbers, making use of the maximum temperature mole ratio, that would satisfy the equation xNaOCl + yKI → products + heat? You are not expected to know the coefficients of the products.

9. Which chemical was the limiting reagent?

Applications

10. Other possible reactants you could mix, under your teacher's supervision, with NaOCl might include sodium thiosulfate ($Na_2S_2O_2$) and sodium sulphite (Na_2SO_3).