Estimaing osmolarity by change in volume essay sample

Environment, Water

The volume of a gas at constant pressure increases when the temperature of the gas is raised. This observation was first made by Jacques A. C. Charles in 1787. A quantitative study did not follow, however, until 1802, when Joseph L. Gay' Lussac determined the relationship between the volume of a gas and its temperature.

The relationship between the volume and the temperature of a gas at constant pressure is known as Charles's law. Charles's law states that, at constant pressure, the volume of a given mass of gas is directly proportional to its Kelvin temperature. The law may be expressed mathematically as

V= kT(Eq. 1)

where V is the volume, T is the Kelvin temperature of the gas, and k is a proportionality constant, which is dependent on the mass of gas and the pressure.

If the pressure and the mass of a gas are kept constant, Charles's law may be applied at two different temperatures. In Equation 2

V1 = k andV2 = k (Eq. 2)

T1 T2

V1 and T1 refer to the volume at temperature T1. V2 and T2 refer to the volume at temperature T2. If conditions are chosen so that the proportionality constant is the same at both temperatures, Charles's law may he written

V1 = V2 (Eq. 3)

T1 T2

Charles’s law may be verified by finding the volume occupied by a gas at two different temperatures. If the volume-to-temperature ratios are the same at both temperatures, Charles’s law is verified. The gas you will use in this experiment is air. You will find the volume of air in an Erlenmeyer flask at two different temperatures. First, the air in the flask will be heated to the boiling point of water; the volume of air will be the volume of the flask. Next, the flask will be immersed in cold water without any loss of air, and water will rush into the flask as the gas contracts and occupies a smaller volume. From the volume of the flask and the volume of water pulled into it, the volume of air at the temperature of the ice—water bath can be determined. In the ice-water bath, the air is collected over water. Air and water vapor will be present in the flask. Consequently, the volume of air must be corrected for the volume of water vapor. Then, you will calculate the volume-to-temperature ratio for the volume of the hot, dry air at the temperature of the water in the boiling-water bath and for the volume of cold, dry air at the temperature of the water in the ice-water bath. If these two volume-to-temperature ratios are the same within experimental error, you will have verified Charles’s law. [pic]Fig. 1

PROCEDURE

1. Set up an apparatus for the Charles’s law study like that shown by your TA. Use a 100-mL graduated cylinder to pour about 170—180 mL of water into a 400-mL beaker. Place the beaker on the hot plate.

2. Heat the water to boiling.

3. Fill a pneumatic trough with ice and water. Set the trough aside for use in Step 11.

NOTE: Be sure the Erlenmeyer flask is thoroughly dry. Any water present in the flask will cause a large error in the calculated volume-to-temperature ratio.

4. Dry a 125-mL Erlenmeyer flask by wiping the inner and outer surfaces with a dean, dry towel. Make sure the flask is thoroughly dry.

5. Firmly place a rubber stopper (outfitted with a glass rod, tubing, and clamp) into the top of the Erlenmeyer flask. Make sure that the clamp is firmly attached but that the opening in the rubber tubing is not closed.

Remember the beaker of boiling water and the space directly above the beaker will be hot. The support stand, iron ring, utility clamp, and Erlenmeyer flask will also be hot. Handle with care!

NOTE: Be sure that the pinch clamp is not attached so tightly to the rubber tubing that the rubber tubing is closed.

6. Use a utility clamp to carefully attach the flask to the support rod just above the boiling water. Slowly lower the flask into the beaker containing the

boiling water until the flask is as completely submerged as possible. Do not allow the flask to touch the bottom or the sides of the beaker. See Figure 1.

NOTE: Small amounts of boiling water might have to be added to the beaker during this time to maintain the water level. Your laboratory instructor will give you directions for handling the beaker containing the boiling water to be added.

NOTE: The number appearing in parentheses indicates the line on your Data Sheet on which that data should be entered.

7. Keep the flask in the boiling-water bath for at least 6 min. 8. Insert a thermometer into the boiling-water bath for 3—4 min and measure the temperature of the water. Record this temperature on your Data Sheet (1).

Be careful while removing the hot flask from the boiling water. Do not burn yourself with the steam rising from the boiling water.

9. With care, tightly close the pinch clamp on the rubber tubing, as close to the glass tubing as possible without breaking the glass rod. Use the utility clamp to remove the flask from the boiling water. Quickly invert the flask in the trough of ice water.

10. Keep the flask completely submerged with the glass tubing also submerged and pointing downward. While the end of the tubing is submerged, open the pinch clamp, but do not remove the clamp from that position on the tubing.

11. Keep the flask submerged in the ice-water bath for 4 min. Measure the temperature of the ice water during this time. Record this temperature on your Data Sheet (3).

12. Keep the rubber tubing and pinch clamp submerged and raise the flask until the water level inside the flask is at the same height as the water level in the pneumatic trough.

13. Tightly close the pinch clamp while making sure the pinch clamp is as close to the glass tubing as possible. Remove the flask from the trough.

14. Remove the rubber stopper assembly. Measure the volume of water in the flask to the nearest 1 mL by pouring the water into a dry, 100 mL graduated cylinder. Record this volume on your Data Sheet (2).

15. Completely fill the flask with water to the top of the flask. Open the pinch clamp on the rubber stopper assembly and reinsert the assembly into the flask to the same depth as you did in the beginning. Tighten the pinch clamp and squeeze out the water in the rubber tubing above the clamp.

16. Open the pinch clamp, making sure that the clamp remains in the same position on the tubing Use a dry a 100-mL graduated cylinder to measure the volume of water in the flask, including the water that was in the glass tubing. Record this volume of water to the nearest milliliter on your Data Sheet (4). This volume of water is the volume of the flask.

17. Your instructor should provide you with the barometric pressure. If the pressure is in inches or mm of Hg, record this pressure on your Data Sheet (5). If the pressure is in torr record this pressure on your Data Sheet (6).

CALCULATIONS

Do the following calculations and record the results on your Data Sheet. The numbers in parentheses refer to the numbered lines on the Data Sheet.

1. Find the volume of wet, cold air. Subtract the volume of the water pulled into the flask (2) from the volume of the flask (4). Record this volume on your Data Sheet (8).

2. Convert the barometric pressure to an equivalent pressure in torr, if your pressure reading was made in units other than torr, using Equation 4 or 5.

1 in. of Hg = 25. 4 torr(Eq. 4)

1 mm of Hg = 1 torr(Eq. 5)

Record this pressure on your Data Sheet (6).

3. Find the pressure of the dry, cold air. Subtract the vapor pressure of the water in the ice-water bath from the barometric pressure (6). The vapor pressure of water can be found a data table in the lab, ask your TA. Record the calculated pressure on your Data Sheet (7).

4. Find the volume of dry, cold air. Multiply the volume of the wet, cold air (8) by the pressure of the dry air (7), divided by the barometric pressure (6), using Equation 6.

volume of cold, dry, air, mL = (volume of wet air, mL) (pressure of dry air, torr)(Eq. 6)

barometric pressure, torr

Record this volume on your Data Sheet (9).

5. Convert the temperature of the boiling water and that of the water in the ice-water bath from degrees Celsius to Kelvin, using Equation 7.

K =°C + 273. 2(Eq. 7)

Record the Kelvin temperature of the water in the boiling-water bath on your Data Sheet (10) and the Kelvin temperature of the water in the ice-water bath on your Data Sheet (11).

6. Find the volume-to-temperature ratio for the volume of hot, dry air at the temperature of the water in the boiling-water bath. Divide the volume of hot, dry air (4) by the Kelvin temperature of the boiling water (10). Record this ratio on your Data Sheet (12).

7. Find the volume-to-temperature ratio for the volume of cold, dry air at the temperature of the water in the ice-water bath. Divide the volume of cold, dry air (9) by the Kelvin temperature of the water in the ice-water bath (11). Record this ratio on your Data Sheet (13).

Post-Laboratory Questions Name, Sect.

1Several students performed this experiment without paying adequate attention to the details of the procedure. Briefly explain what effect each of the following procedural changes would have on the size of the volume-to-temperature ratio calculated by the students

(a)One student failed to replenish the boiling water in the boiling-water bath as the flask was being heated. At the end of the 6 min of heating, the boiling water in the bath was only in contact with the lower portion of the flask.

(b)Following the proper heating of the flask in the boiling water, a student removed the flask from the boiling-water bath but only partially immersed the flask in the ice-water bath during the cooling period.

(c)A student neglected to close the pinch clamp before removing the flask from the boiling-water bath and immersing it in the ice-water bath.

(d)One student neglected to measure the volume of the flask before leaving the laboratory. Because the procedure called for a 125-mL Erlenmeyer flask, the student used 125 mL as the volume of the flask.

2. Evaluate your experimental results and briefly explain why they do or do not verify Charles’s law. Data Sheet Name, Sect

| | | Trial 1 | Trial 2 | | 1 | temperature of water in the boiling-water bath, °C | | | | 2 | volume of water pulled into the flask, mL | | | | 3 | temperature of water in the ice-water bath, °C | | | | 4 | volume of flask, mL | | | | 5 | barometric pressure, ___________________ (units) | | | | 6 | barometric pressure, torr | | | | 7 | pressure of dry, cold air, torr | | | | 8 | volume of wet cold air mL | | | | 9 | volume of dry, cold air, mL | | | | 10 | temperature of water in the

boiling-water bath, K | | | | 11 | temperature of water in the ice-water bath, K | | | | 12 | V/T for hot, dry air, mL/K | | | | 13 | V/T for cold, dry air, mL/K | | |

Calculations (Show all your work!!!)

Pre-Lab oratory Assignment

1. Describe the safety precautions you must take when removing the flask from the boiling—water bath.

2. A student doing this experiment collected the following data:

temperature of boiling water99. 7 oC

volume of water pulled into the flask30. 0 mL

temperature of water in ice-water bath 0. 1 °C

volume of flask134. 0 mL

barometric pressure 28. 5 in. Hg

vapor pressure of water at 0. 1oC 4. 6 torr

(a)Find the volume of wet., cold air.

(b)Convert the barometric pressure from inches of Hg to torr

(c)Calculate the pressure of dry, cold air.

(d)Calculate the volume of dry, cold air.

(e)Convert the temperature of the boiling-water bath and that of the ice-water bath from Celsius to Kelvin.

(f)Find the volume-to-temperature ratio for the volume of the hot, dry air at the temperature of the boiling-water bath.

(g)Find the volume-to-temperature ratio for the volume of cold, dry air at the temperature of the ice-water bath. (h)Briefly explain why these values do or do not verify Charles's law.

3. Explain why the pinch clamp must be open when the dry flask is heated in the boiling-water bath in Step 8 of the Procedure