SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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Student Materials

Learning Sequence Item:

1022

Understanding the Behavior of Gases

May 1996
Adapted by: Jessie M. Jones and Dorothy L. Gabel

Contents

Lab Activities

1. Don’t Flick the Bic
2. Waiting to Exhale
3. Defacing Marble

Readings

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This micro-unit was adapted by **Jessie M. Jones** (Rocky Mount, N. C.) and
Dorothy L. Gabel (Indiana University, Bloomington)

Student Sheet

Science as Inquiry

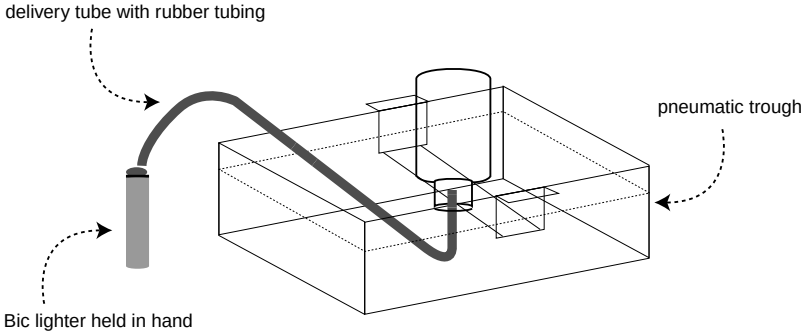
Don't Flick the Bic

What is the volume of a gas if the pressure and temperature change simultaneously?

Overview:

How are the properties of a gas related during a change from one set of conditions to a second set of conditions, such as pressure, temperature, and volume? How can the pressure inside a flask containing butane gas be made equal to the atmospheric pressure. How can the pressure of a dry gas be determined? What is the relationship between °C and K? This activity will answer these questions. *Caution: Butane is a flammable, toxic hydrocarbon. No flames are allowed in the classroom during this activity—follow your teacher's instructions exactly when releasing the butane from the lighter.*

Procedure:



Construct a data table to record measurements of the volume of the flask (mL) the volume of water in the flask after the gas is released (mL), the temperature of the water (°C), barometric pressure (mmHg), and the vapor pressure of the water (mmHg). Why is this necessary? Measure the total volume of water that the flask can hold. Is it 250 mL? Refill the flask with water and cover it with a glass plate. Carefully invert the flask in the trough filled with water. *Use care so as not to get any air bubbles in the flask.* Why?

Hold the free end of the "butane lighter-delivery tube assembly" beneath the mouth of the inverted flask. Why? As you press the release button of the lighter, make sure the bubbles go into the flask. Collect approx. 250 mL of gas. Remove the tubing from the lighter. Raise or lower the flask until the water levels inside and outside are equal. Dispose of the toxic gas by putting the glass plate over the top of the inverted flask, turning it upright and release the gas in the hood. Measure the temperature of the water in the flask, the volume of water remaining in the flask, the barometric pressure and the vapor pressure of water (see Tables 1 and 2) and record in your data table.

Questions:

1. Calculate the following and record in a calculations table: the volume of butane collected temperature of water both in Celsius and Kelvin reading; partial pressure of butane; the volume of butane at STP.

2. Explain in your own words how you arrived at your answer for volume of butane at STP.

3. At 560 mm of pressure and 19°C, a gas, collected over water, occupies a volume of 895 mL. What will the volume of the gas be at 760 mm of pressure and 0°C?

4. A quantity of air at a temperature of 60°C and under a pressure of 110 kPa is found to have a volume of 149 cm^3. What volume will the gas occupy at 0°C and 101.3 kPa

Table 1. Vapor Pressure of Water

Temp. C	Pressure mmHg	Temp. C	Pressure mmHg	Temp. C	Pressure mmHg
0	4.60	24	22.40	42	61.50
2.5	5.50	25	23.80	43	64.80
5	6.50	26	25.20	44	68.30
7.5	7.80	27	26.70	45	71.90
10	9.20	28	28.30	46	75.60
11	9.80	29	30.00	47	79.60
12	10.50	30	31.80	48	83.70
13	11.20	31	33.70	49	88.00
14	12.00	32	35.70	50	92.50
15	12.80	33	37.70	60	149.40
16	13.60	34	39.90	65	187.50
17	14.50	35	42.20	70	233.70
18	15.50	36	44.60	75	289.10
19	16.50	37	47.10	80	355.10
20	17.50	38	49.70	85	433.60
21	18.60	39	52.40	90	525.80
22	19.80	40	55.30	95	633.90
23	21.10	41	58.30	100	760.00

Table 2. Vapor Pressure of Water

Temperature C	Pressure kPa	Temperature C	Pressure kPa
0	0.61	23	2.81
1	0.65	24	2.99
2	0.71	25	3.17
3	0.76	26	3.36
4	0.81	27	3.56
5	0.87	28	3.77
6	0.93	29	4.00
7	1.00	30	4.24
8	1.07	35	5.63
9	1.15	40	7.37
10	1.23	45	9.59
11	1.31	50	12.30
12	1.3:	55	15.73
13	1.49	60	19.86
14	1.60	65	25.00
15	1.71	70	31.16
16	1.81	75	38.54
17	1.43	80	47.34
18	2.07	85	57.81
19	2.20	90	70.00
20	2.33	95	84.51
21	2.49	100	100.10
22	2.64	105	120.80

Science as Inquiry

Waiting to Exhale

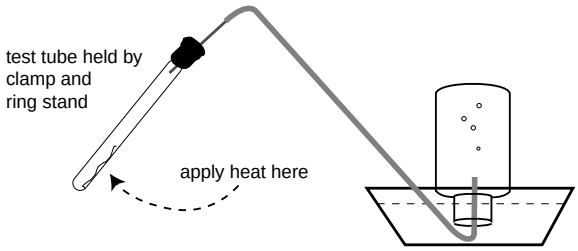
How do pressure and temperature relate to the volume of a gas produced when a solid decomposes?

Overview:

How is the volume of a gas at STP determined? How is the pressure of a dry gas determined? How is a bottle prepared for collecting gas? What gas is produced when solid copper carbonate decomposes. You will be able to answer these questions by following the procedure for this lab.

Procedure:

Assemble ring stand, glass tubing bends, stopper and delivery tube, and set up the collection apparatus, complete with water in the trough.



Add 2.20 g of copper (II) carbonate basic, $CuCO_3 \cdot Cu(OH)_2$ to a clean, dry test tube and clamp the test tube at an angle to the ring stand—with the solid spread along the bottom half of the tube. Measure the total volume of two collecting bottles by filling them with water, carefully pouring the water into a graduated cylinder, and then measuring the amount. Create a data table and record this information on it.

Refill the two collecting bottles with water, then cover each with a glass plate. Invert one bottle and place it in the water filled trough over the delivery tube—removing the glass plate under water. *None of the water in the bottle should escape—there should be no air bubbles in the bottle.* Holding the burner in one hand, heat the contents of the test tube gently by moving the flame back and forth beneath the tube.

When the first bottle is filled with gas, slide the glass plate back under the mouth of the first bottle, remove it from the water and place it upright on the table. Immediately invert the second bottle, and place it in the water filled trough over the delivery tube as before. However, this time, heat the tube until no more gas is produced—and immediately turn off the burner and remove the delivery tube when this occurs. Why?

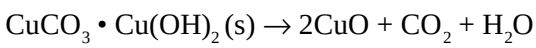
Cover the mouth of the second bottle (still inverted) with the glass plate and remove it from the trough. Using the graduated cylinder, measure the volume of water remaining in the second collecting bottle and record this volume in the data table, along with the temperature, barometric pressure and vapor pressure of the water of the second bottle (see Tables 1 and 2 from Activity 1).

After the collection of CO_2, calculate the volume of CO_2 gas (V_1) collected, the pressure exerted by dry CO_2 gas (P_1), and the volume (V_2) of the CO_2 gas at STP.

Questions:

1. Make the following calculations: the volume of CO_2 gas (V_1) collected in mL; the pressure exerted by dry CO_2 gas in mmHg; the olume (V_2) of the CO_2 gas at STP in mmHg.

2. The balanced equation for the reaction is:



What happens to this water?

3. Suggest some possible sources of error in this lab.

4. A balloon containing 980.0 cm^3 of helium was released on a day when the pressure was 98.8 kPa and the temperature was 28°C. What volume will the helium gas occupy when it rises to a region where the pressure is 94.3 kPa and the temperature is 18°C?

Science as Inquiry

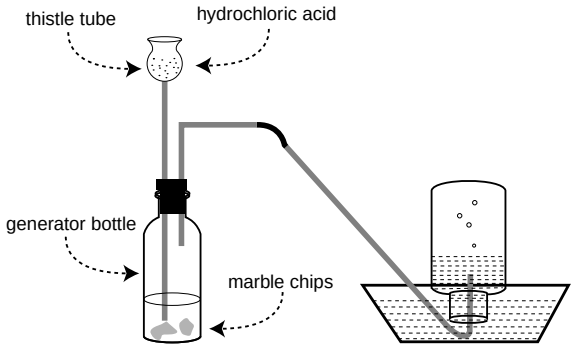
Defacing Marble

What is the volume, at STP, of the gas produced by treating marble chips with hydrochloric acid (HCl) and collecting it under room conditions?

Overview:

A gas, slightly soluble in water, is collected by the water displacement method. How does this affect the volume of the gas collected? How can the volume of this gas be determined at STP? Do this activity to find the answer to these questions.

Procedure:



Set up the collection apparatus and prepare two bottles for the collection of gas by displacement of water method. Measure the total volume of two collecting bottles and record this in a data table.

Add 2 g of marble chips to the generator bottle and then add enough hydrochloric acid (in the thistle tube) to produce some gas. How will you know if gas is produced?

After the first collecting bottle is filled with gas, *immediately* remove and replace the first bottle with the second bottle. When no more gas is produced, cover the second bottle with a glass plate and remove it from the pail. Using a graduated cylinder, measure the volume of water remaining in the second bottle. Record this volume in the data table. Measure and record the temperature of the water in the second bottle, the barometric pressure, and the vapor pressure of the water (see Tables 1 and 2 in Activity 1).

Questions:

1. Calculate the volume of CO_2 gas collected (V_1).

2. Calculate the pressure exerted by dry CO_2 gas.

3. Calculate the volume, $V_{2,}$ of the CO_2 gas at STP.