Topic 2: Gases and the Atmosphere

Appendices

Note:
Due to copyright considerations, the following appendices are not available:

Appendix 2.1: Can You Vacuum Pack a Person?

Appendix 2.4: Make Your Own Cartesian Diver

Appendix 2.2: A Historical Timeline of the Measurement of Pressure

Introduction

Your group must create a timeline of the following scientists who helped to develop the measurement of pressure into the concepts that we know today:

Amadeo Avogadro
John Dalton
Galileo Galilei
Joseph Louis Gay-Lussac
Otto von Guericke
Christiaan Huygens
Blaise Pascal
Evangelista Torricelli

Directions

The timeline must be created on poster paper and with markers so that it can be posted and seen easily. Use the biographies that have been supplied to you to get all the necessary information for each scientist. Create the appropriate timeline based on when the scientists made their important discoveries related to gases, and not based on the dates of their birth or their death. Give the poster a catchy title and be original in your presentation of the material on the poster. Remember, this is a group effort, so divide up the labour and be open to suggestions from every member of your group.

Required Information

For each scientist, state the following:

- full name
- date of birth and date of death
- claim to fame related to gases (in three sentences or less)
- age at which the scientist made the "claim to fame" (approximate age is fine, if unclear)
- age at which the person died
- one other interesting piece of information

Assessment

Groups in the class will assess each other's timelines using the activity directions and the Peer-Assessment Rubric provided.

Appendix 2.2: A Historical Timeline of the Measurement of Pressure *(continued)*

Names of Students in Group:

_________________________ _________________________

_________________________ _________________________

Assessed by: ____

Three other groups will assess your timeline based on the directions provided for the activity and on the criteria identified in the rubric below. The three assessment results will be averaged and a mark can be assigned to each member of your group.

When your group is assessing another group, be sure to read each criterion carefully and assign appropriate marks that your group agrees upon.

Peer-Assessment Rubric

Criteria	Rating			
	4	3	2	1
• How engaging is the title of the timeline poster?				
• How well are original materials and sources used and documented in the poster?				
• Are the scientists placed in the proper chronological order on the timeline?*				
• Are all historical dates and ages of persons in the timeline correct?*				
• How well has the person's "claim to fame" related to gases been addressed?				
• How interesting is the "interesting fact" about each scientist to you?				
• How informative, appealing, and effective is the overall poster to a teen audience?				

* Reduce your rating by one level for each significant error of fact.

Overall Mark: ________ / ________

Constructive Comments: ____

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Appendix 2.3: The Drinking Bird

Observation Questions

The following questions could be asked as students observe the drinking bird in action:

1. Observe the drinking bird carefully and describe as many physical properties as possible.
2. How many states of matter are present in the bird system?
3. Draw one cycle of the drinking bird.
4. What causes the liquid to rise in the neck during a cycle?
5. What causes the bird to change position?
6. What is the purpose of the fuzzy head?
7. What is the purpose of the water on the head?
8. Will the bird continue to drink if the cup is removed?
9. What is the bird's energy source?
10. What kind of energy does the bird use?
11. What is the energy receiver?
12. Describe the energy chain.
13. How would you explain the operation of the drinking bird?
14. How many dips does the bird make per minute?
15. How would a breeze affect the rate of dipping?
16. How would direct or indirect sunlight affect the highest rate of dipping of the bird's head?
17. How would relative humidity affect the rate of dipping?
18. List the variables that you think would affect the rate of dipping.
19. How would you set up an experiment to determine which variables would produce the fastest rate of dipping?
20. What must you do to make the bird dip continuously?
21. Under what conditions will the bird fail to operate?
22. Describe the environment necessary for continuous and maximum operation.

The answers to the questions can be found in the background information provided in the Teacher Notes that follow.

Appendix 2.3: The Drinking Bird (Teacher Notes)

The head, neck, and body of the drinking bird are interconnected hollow chambers. These chambers, from which air has been evacuated, contain a volatile liquid and its vapour (a two-phase system). The volatile liquid has a low heat of vaporization, high density and pressure, and a boiling point near normal room temperature. When the fuzzy head of the drinking bird is dry, the temperature is uniform throughout the bird, and the vapour pressure in the top chamber is equal to the vapour pressure in the bottom chamber. The bird is in a state of static equilibrium (that is, it is not working).

Once the head is wet, the vapour pressure in the top and bottom chambers becomes unequal. When the head is moistened, the water on the surface begins to evaporate, cooling the head area. As the water from the head evaporates, it extracts heat from the top chamber of the bird. (Heat is also absorbed from the surrounding air, but that does not affect the operation of the bird.) As a consequence, the temperature inside the top chamber falls. This cooling reduces the vapour pressure in the head area, causing the gas pressure in the bottom chamber to become greater than that in the top chamber. This pressure difference forces the liquid up the tube and into the head. To summarize, the wet beak leads to

- lowering of the pressure in the top chamber
- a pressure gradient between the two chambers
- elevation of the liquid column

As the evaporation from the head proceeds, the pressure in the top chamber continues to fall and the liquid column continues to rise. The bird becomes top-heavy and tips over, but is stopped before reaching a horizontal level because the liquid in the lower end of the tube becomes higher than that in the bottom chamber. Thus, the rise in the liquid column is arrested by the bird tipping when its centre of gravity, which rises as the liquid column rises, falls outside the stem. At this moment there is a break in the liquid column, and contact is established between the two chambers. Thus, the liquid in the upper chamber returns by gravity to the lower bulb, while, simultaneously, the gas in the lower chamber bubbles up into the head. The vapour pressure and temperature again become uniform throughout the volume of the bird, and it returns to the original vertical position. The cycle repeats since evaporation from the head continues; the bird will continue to dip as long as there is a sufficient difference in temperature between the top and bottom chambers.

From the above description it follows that the drinking bird is a heat engine that converts heat of evaporation into work through rotational motion. The “fuel” for this work happens to be water that undergoes no chemical transformation. Like other heat engines, this machine performs work because of the temperature difference between the heat source and the heat sink. The source in this case, however, is at the ambient temperature and the sink (water on the beak) is at a lower temperature.

Appendix 2.3: The Drinking Bird (Teacher Notes) *(continued)*

Since we live in an energy-conscious age, it is worth reminding students of this distinction between power and energy. The drinking bird illustrates a very interesting relationship between power and energy. The efficiency increases linearly as the column height increases; if the liquid column height is increased by a factor of 2, energy efficiency doubles. The power efficiency, however, does not change. This is because the time it takes to reach the full height is also doubled, since the rate of evaporation is constant. When the height of the column is doubled, both energy output and the time it takes to complete a cycle are doubled, and the power remains constant.

Appendix 2.5: Charles's Law: The Temperature-Volume Relationship in Gases

Introduction

The primary objective of this experiment is to determine the relationship between the temperature and volume of a confined gas. The gas we use will be air, and it will be confined in a syringe. When the temperature of the syringe is changed by placing it in different water baths, a change occurs in the volume of a confined gas. This volume change will be monitored using the gradations on the syringe. It is assumed that pressure will be constant throughout the experiment. Temperature and volume data pairs will be collected during this experiment and then analyzed. From the data and graph, you should be able to determine what kind of mathematical relationship exists between the temperature and volume of the confined gas. Historically, this relationship was first established by Jacques Charles around 1790 and has since been known as Charles's Law.

Materials

- syringe (60 cc)
- modified rubber stopper (size zero)
- 5 beakers (1 L)
- test-tube clamp
- thermometer and clamp
- hot plate
- water
- ice
- ring stand

Procedure

1. Prepare water baths of about 0°C, 20°C (room temperature), 50°C (hot tap water), 80°C, and 95°C. For each water bath, mix varying amounts of hot water from a hot plate, cool water, and ice to obtain a volume of 800 mL in a 1 L beaker. To save time and beakers, several lab groups can use the same set of water baths.
2. Draw out the plunger of the syringe so that the lower portion of its rubber ring is set at the 30 cc mark. To contain this volume of air, cap the tip with the modified rubber stopper.
3. a) Set up the ring stand, test-tube clamp, syringe, thermometer clamp, and thermometer.
   b) Place the syringe and thermometer into the ice-water bath and wait five minutes so that the gas and thermometer will equilibrate to the temperature of the water bath.
   c) Gently press down the plunger a little and release it to reduce some friction between the plunger and the wall of the syringe.
   d) Wait 30 seconds, and then record both the volume and the temperature of the gas in the data table.

Appendix 2.5: Charles's Law: The Temperature-Volume Relationship in Gases *(continued)*

4. Repeat step 3 with water baths of 20°C (room temperature), 50°C, 80°C, and 95°C. Be sure to record the data after each measurement.

Observations		
Volume (cc)	**Temperature (°C)**	**Temperature (K)**

Graph

1. Generate a graph of volume (cc) vs. temperature (°C) from your data. Be sure to include labelled axes, appropriate scales, units, and a title.
2. Extend the curve by extrapolation and identify what temperature is theoretically required to reduce the volume to 0 cc. This Celsius temperature is referred to as *absolute zero* on the Kelvin scale.

Conclusion

Make a statement about the relationship between the temperature of a gas and its volume. Identify the temperature required to reduce the volume of a gas to 0 cc.

Questions

1. Calculate the percentage error in your Celsius value for absolute zero:

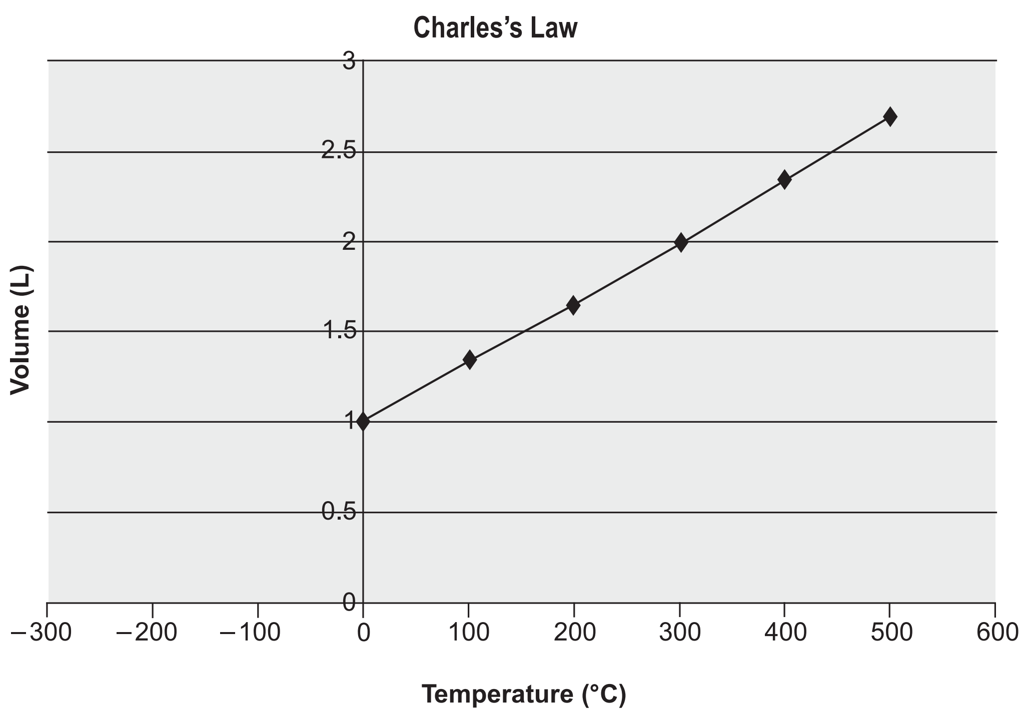
$$\% \text{ error} = \left| \frac{\text{experimental result} + 273}{273} \right| \times 100\%$$

2. Based on the graph that was generated from your data, are temperature and volume directly or inversely related to one another? Explain your answer.
3. Indicate some sources of error.

Appendix 2.6: Charles's Law

Sample Student Data

The following graph is typical of student-generated data for volume versus temperature. It is important, particularly historically, to extrapolate down to a theoretically "absolute" low temperature that implies "no volume," and hence argues for no molecular kinetic activity—that is, an absolute zero (approximately –273°C or 0 K).



Appendix 2.7: Charles's Law Lab

1. Go to the website of The North Carolina School of Science and Mathematics, Distance Learning Technologies, Teachers' Instructional Graphics Educational Resource (TIGER): <http://www.dlt.ncssm.edu/TIGER/chem3.htm>.

   Search the sample simulation links at the website to find one entitled **CharlesLaw.html**. Or, if you prefer, download the executable file marked as **CharlesLaw.exe**.

   a) Explore this simulation.

   b) Fill in the following to make a correct statement.

   Charles's Law shows the relationship between ______________________ and

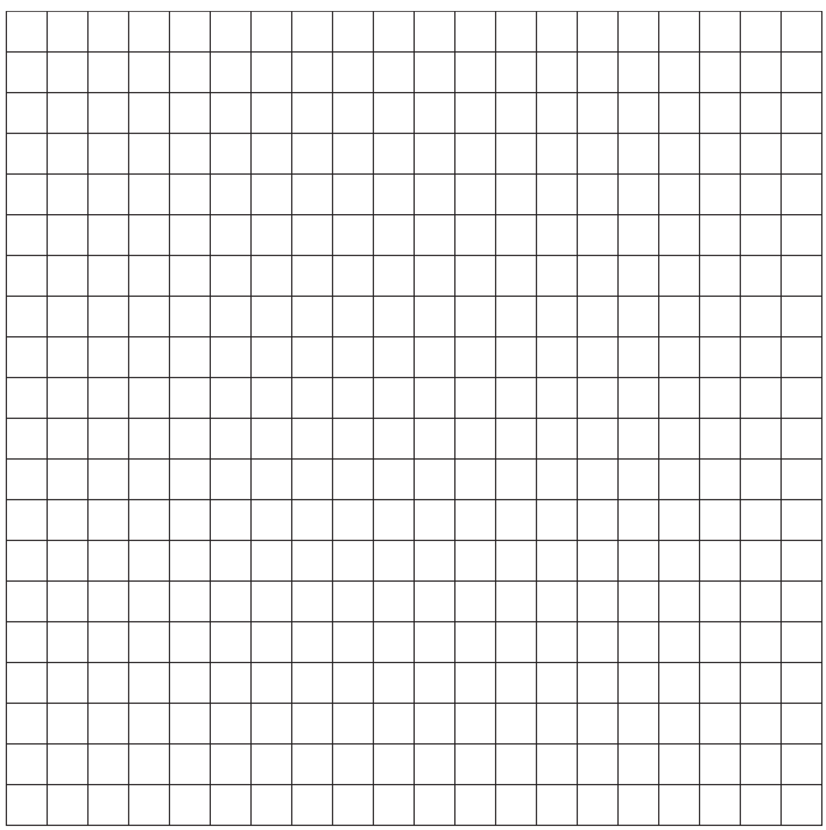
   ______________________ when the ________________________ is constant.

2. Go to the website of Thomas J. Greenbowe, Department of Chemistry, Iowa State University: <http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/gaslaw/charles_law.html>.

   a) Manipulate the simulation to get a set of data.

   b) Graph the data.

Graph



Appendix 2.7: Charles's Law Lab *(continued)*

3. Using the Internet and your own prior knowledge (think about Boyle's Law), fill in the following:

   a) Charles's Law states:

   b) The relationship is directly proportional. Therefore, the equation is:

   c) We can compare a gas when its situation changes by using the formula:

   d) We can also extrapolate the graph to find absolute zero.

   Example:

   A balloon is filled with 3.0 L of helium at 22°C and 760 mmHg. It is then placed outdoors on a hot summer day when the temperature is 31°C. If the pressure remains constant, what will the volume of the balloon be?

Appendix 2.8: Applications of Gases in Our Lives

Research Presentation

Your group will randomly receive one of the following research topics and will present information to the class in the form of a five-minute presentation and a written one-page handout for your classmates.

1. acetylene welding or oxy-fuel gas welding
2. air bags
3. airships
4. anaesthetics
5. hyperbaric chambers
6. propane appliances
7. self-contained underwater breathing apparatus (scuba)

If your selection is not appealing to your group, or if you are having difficulty finding relevant source material (which is unlikely), then you may select your own topic, with the advice of your teacher. Your own selected topic must be approved by the teacher and must be related to an industrial, environmental, or recreational application of gases or the gas laws.

Assessment

Groups in the class will assess each other's presentations and handouts using the Peer-Assessment Rubric provided.

Appendix 2.8: Applications of Gases in Our Lives *(continued)*

Names of Students in Group:

________________________________ ________________________________

________________________________ ________________________________

Assessed by: ____

Please assess your classmates carefully, according to the criteria listed below. Be prepared to justify your ratings if required to do so as an oral follow-up. In addition, leave constructive comments that will aid students in improving their future presentations.

Peer-Assessment Rubric				
Criteria	**Rating**			
	4	**3**	**2**	**1**
Student Presentation				
1. **Preparation:** Class time was used effectively. Group appears ready to present results to class.				
2. **Clarity of Expression:** Presenters speak clearly and with enough volume for everyone to hear clearly.				
3. **Organization:** Concept is presented in a logical, consistent way.				
4. **Information:** Information is accurate, thorough, and current.				
5. **Audience Engagement:** Class is attentive to the presentation.				
6. **Originality:** Something was done in the presentation that made it different from your expectations.				
7. **Presenting with Understanding:** The group clearly understands the material, and can refrain from reciting from a prepared text.				
Student Handout(s)				
8. **Accuracy of Content:** The content is scientifically and technologically accurate.				
9. **Organization of Content:** The content is easy to follow (e.g., it was assembled with a student audience in mind).				
10. **Appearance:** The handout is clearly written, free of grammatical errors, and easy to follow.				

Overall Mark: ____________ **/40** **Mark Scaled to:** ____________ **/20**

(continued)

Appendix 2.8: Applications of Gases in Our Lives *(continued)*

Constructive Comments:

Appendix 2.9: Topic-Review Game

Purpose

To review the learning outcomes and concepts addressed in Topic 2: Gases and the Atmosphere.

Game Instructions

1. Form two groups: Team A and Team B.
2. Team A plays against Team B, so the teams sit opposite each other at a table.
3. Team A and Team B will each receive a separate set of 10 questions.

   (**Note:** Answers are also found on the question sheets, so don't show your opponent the answers.)
4. You will need the following materials:
   - calculator
   - pen/pencil
   - scrap paper
   - your reference sheet with formulas and conversions on it
5. Team A asks Team B a question, selected at random from the assigned set of questions.
6. Students in Team B attempt to answer the question. If they get it right, they get one point. If they get it wrong, they do not get a point, but both teams can help solve the problem until they understand the question. (Remember that you are doing this activity in order to review and to be better prepared for your test.)
7. Team B now asks Team A a question, selected at random from the assigned set of questions.
8. Students in Team A attempt to answer the question. They, too, get a point if they get the right answer, and they must try to understand where they went wrong if they do not get the correct answer.
9. Play continues until all 10 questions from each set of questions have been answered.
10. The team with the most points will receive a bonus mark on the test.
11. Keep a tally sheet of your results and hand it in when the review game ends. Group names must be on the sheet.

Appendix 2.9: Topic-Review Game *(continued)*

Team A	Team B
Q. The most important gases in the environment are oxygen, nitrogen, carbon dioxide, and water vapour. (True or False) **A.** True	**Q.** The gases of our atmosphere are not needed for photosynthetic activity in plants. (True or False) **A.** False
Q. The international agreement called the __________________ Protocol will cut down on the carbon dioxide that goes into the air each year. **A.** Kyoto	**Q.** CEPA stands for The Canadian Environmental ____________________ Act. Its intent is to protect Canada's environment and human health. **A.** Protection
Q. _______________ 's "claim to fame" was that he showed that a vacuum does exist. **A.** Pascal	**Q.** Torricelli's "claim to fame" was that he invented the __________________. **A.** barometer
Q. 738 mmHg = ____________ atm **A.** 0.971 atm	**Q.** 98.7 kPa = ______________ psi **A.** 14.3 psi
Q. 32.0 psi = ___________ atm **A.** 2.18 atm	**Q.** 2.3 atm = ____________kPa **A.** 232.99 kPa
Q. A gas occupies a volume of 458 mL at a pressure of 1.01 kPa. When the pressure is changed, the volume becomes 477 mL. If there has been no change in temperature, what is the new pressure? **A.** 0.970 kPa	**Q.** A gas occupies a volume of 2.45 L at a pressure of 1.03 atm and a temperature of 293 K. What volume will the gas occupy if the pressure changes to 0.980 atm and the temperature remains unchanged? **A.** 2.58 L
Q. A tank of compressed CO_2 has a temperature of 23.6°C and a volume of 31.4 L. The CO_2 is completely transferred into a smaller tank that has a volume of 25.0 L. Assuming none of the CO_2 escapes during the transfer, what is the temperature of the CO_2 in the smaller tank if the temperature is lowered to achieve the same pressure as that in the larger tank? **A.** –36.9°C	**Q.** What will be the volume of a gas sample at 309 K if its volume at 215 K is 3.42 L? Assume that the pressure is constant. **A.** 4.92 L
Q. Seaweed plants release oxygen gas during photosynthesis. A 0.10 mL bubble is released underwater at a pressure of 176 kPa and a temperature of 10°C. What volume will this bubble occupy at the surface, where the temperature is 15°C and the pressure is 101.3 kPa? **A.** 0.18 mL	**Q.** An air-filled balloon has a volume of 225 L at 0.94 atm and 25°C. Soon after, the pressure changes to 0.99 atm and the temperature changes to 0°C. What is the new volume of the balloon? **A.** 196 L
Q. Which scientist stated that the pressure of a gas is inversely proportional to its volume? **A.** Boyle	**Q.** Which scientist stated that the volume of a gas is directly proportional to its temperature? **A.** Charles
Q. What are the final products of the second stage that acetylene welding goes through? **A.** carbon dioxide and water vapour	**Q.** When dealing with anaesthetics, it is important to know that the more ______________ the gas is in the blood the longer it takes to eliminate it from the body. **A.** soluble