For Students

The gas we drink - Carbon dioxide in carbonated beverages

Task description

You will break into groups of 3-5 and each group will carry out in school a number of experimental activities. First, you will study at school and at home the properties of gases and the physical and chemical properties of carbon dioxide. The emphasis will be on gas solubility in liquids and the gas laws. Secondly, you must think of a simple method for determining the amount of carbon dioxide that is contained inside a carbonated beverage. Thirdly you must devise a method for determining the pressure that prevails inside a closed bottle or can containing a carbonated beverage. You will attempt to explain the observed phenomena and account the experimental errors involved. Finally, you will enjoy a demonstration of a carbon dioxide fountain and with your mates will seek the explanation for the operation of the fountain.

Procedure

Phase 1

This phase consists of an introductory lesson, during which under the guidance of the teacher you will revise in class your knowledge about gases, the atmospheric pressure, and gas laws, including the ideal-gas law. Particular emphasis will be placed on carbon dioxide and its properties. In addition you will perform simple experiments that contribute to studying and understanding the properties of gases, for instance: blowing with a straw into a glass containing limewater in order to detect the presence of carbon dioxide in breadth; comparison of similar in size balloons filled with different gases (air, argon, and carbon dioxide); measurement of pH of various carbonated beverages.

Your teacher will break your class into groups of 3-5. Each group is assigned the task to bring to school for the next lesson one or more bottled carbonated beverages. The bottles should be made of glass and have the same content (e.g. 330 mL). In addition, you will

Developers: **Georgios Tsaparlis & Constantinos Kampourakis**
Institution: Department of Chemistry, University of Ioannina
Country: Greece

be assigned the task to study further at home alone or working in their group about:

(i) the physical and chemical properties of carbon dioxide,

(ii) the solubility of gases in liquids and factors affecting it;

(iii) experimental methods for collecting and measuring the volume of a gas.

Phase 2

Working in your group, you will perform in the lab a number of preliminary experiments. Open bottled carbonated beverages, observe carbon dioxide escaping, and suggest an explanation. In addition, using two bottles with the same carbonated beverage, one having been kept in the fridge, the other in a warm place, and by attaching on the bottle's neck a stopper with a tube passing though it, observe and try to explain the amount of bubbles that escape from the tube's end into a container with water. In this way, you will study the effect of temperature on the solubility of gases in liquids.

Following this, each of group will have the task to build an appropriate experimental set-up for collecting and measuring the volume of carbon dioxide that is contained in a carbonated beverage. For this purpose, you will use materials from the school lab. You will discuss within your group and suggest an experimental set up. Your teacher will comment on the proposals and will suggest ways for improvements. After the teacher approves the experimental set up, you will start the activity.

Phase 3

Each group will perform its own experiment, using your own bottled beverage. Record your measurement and report it to the rest of the class. The findings from different bottled beverages are collected in Table 1. The following questions aim at testing understanding of the issues that are relevant to the above activities.

Developers: **Georgios Tsaparlis & Constantinos Kampourakis**
Institution: Department of Chemistry, University of Ioannina
Country: Greece

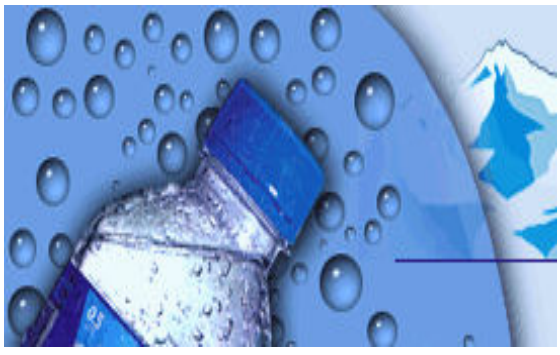
Table 1

Carbon dioxide content (% v/v) of five different carbonated beverages.

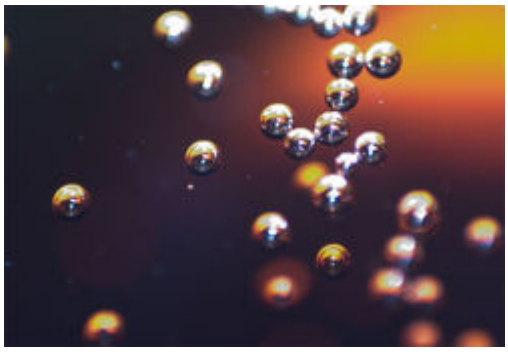
1	Coca-cola			
2	Orange			
3	Sprite			
4	Soda water			
5	Carbonated water			

Questions

1. What factors affect the solubility of a gas in a liquid?
2. Some kind of fish requires more dissolved oxygen in water than other kind. Salmon, for example, is found only in northern seas, where water's temperature is under 15^{o}C. Explain this observation in relation to oxygen's solubility in water.
3. In lakes that are at high altitudes, life seldom appears in the water. There is no fish in these lakes. Explain this observation.
4. In water tanks with cultivated fish, water is sometimes not renewed properly, and in summertime a number of fish die. Explain this observation.
5. Carbon dioxide is an approved food additive in the European Union, and its code number is E290. For what purpose is carbon dioxide added to carbonated beverages?
6. Compare the pH of a carbonated beverage immediately after you open it, and then after having collected the contained carbon dioxide.
7. In carbonated beverages gaseous carbon dioxide is dissolved, Sometimes, we refer to these beverages as containing carbonic acid. What is the relation of carbonic acid to carbon dioxide?



Picture 2 – Bottled carbonated water.



Picture 3 – Carbon dioxide bubbles moving toward the surface of the liquid. (wikipedia.org/wiki/Carbonation)

Developers: Georgios Tsaparlis & Constantinos Kampourakis
Institution: Department of Chemistry, University of Ioannina
Country: Greece

Phases 4

Working always in groups, you must devise a way to measure the gas pressure inside an unopened canned beverage. You will have one short period (45 minutes) to plan your strategy, and one extended period (75 minutes) to complete your investigation in the laboratory. You may use any of the standard equipment in the lab.

This phase is based on

Hans de Grys, *Determining the pressure inside an unopened carbonated beverage* Journal of Chemical Education, Vol. 84, No. 7, 1117-1119.

Phase 5

In this phase there will be a revision of all the activities, the findings, and their interpretation. You will discuss errors entering the various proposed and executed methods. Finally, the teacher will carry out a demonstration of a *carbon-dioxide fountain,* and, with your mates, you will seek the explanation for the phenomenon.

Developers: Georgios Tsaparlis & Constantinos Kampourakis
Institution: Department of Chemistry, University of Ioannina
Country: Greece