# The Density of Gases

***Objective:*** To determine the density of a gaseous substance

## MATERIALS

- Ohaus Scout Pro® balance (readability 0.01g)
- Conical fl ask (ca. 1 liter)
- Measuring cylinder (ca. 1 liter)
- Vessel containing water
- $CO_2$ , He, $H_2$, or $O_2$ from a cylinder
- Thermometer (room temperature)
- Barometer

## PROCEDURE

1. The conical flask is tared filled with air. Gas is passed into the flask for a few seconds via rubber tubing fitted with a glass tube which reaches the bottom of the vessel.
2. When the display of the balance no longer changes, the gas flow is discontinued and the mass Δm read.
3. The conical flask is then filled with water and volume V determined with a measuring cylinder.
4. The volume can be found more accurately and just as conveniently with the aid of a balance and the assumption that the density of water = 1.00 g/cm$^3$.

## EVALUATION

The gas density is the quotient of the gas and its volume. The gas mass has not been measured directly, but is calculated:

$$m_{gas} = m\text{ (flask with gas)} - m\text{ (flask with air)} + m_{air}$$
$$= \Delta m + m_{air}$$

| | | |
|---|---|---|
| Mass difference between gas and air | $\Delta m$ | in g |
| Mass of air (not measured) | $m_{air}$ | in g |
| Volume of conical flask | v | in dm$^3$ |
| Room Temperature | $\vartheta$ | in C |
| and hence | $T$ | in K |
| Air pressure | $p$ | in mbar |

Under the experimental conditions, the gas density is $\rho_{gas} = \frac{m_{gas}}{V} = \frac{\Delta m + m_{air}}{V}$

and under standard conditions $\rho_{o\,gas} = \frac{\Delta m}{v} \cdot \frac{1013\text{ mbar}}{p} \cdot \frac{T}{273.1K} + \rho_{o\,air}$

where $\rho_{o\,air} = 1.293$ g/dm3

The conical fl ask must be completely dry. The gas cylinders should be at room temperature. Gases which are lighter than air (e.g. hydrogen) can be passed into the inverted conical flask from below.

# Grow Your Own Beast

***Objective:*** To predict, observe, and measure how the Gro-beast undergoes a physical change within a given time frame and to graph the results.

### *NATIONAL STANDARDS*

National Science Standards Alignment: Science as Inquiry, Properties and change of properties in matter
National Math Standards: Measurement Standard

### *BACKGROUND INFORMATION*

The Gro-Beast is made from a polymer that readily absorbs water. Materials of this type are said to be hydrophilic, water loving. Materials with the opposite property are said to be hydrophobic, water fearing.

### *SCIENCE CONCEPTS*

Mass –amount of matter in an object
Weight-measure of force of attraction between two objects due to gravity
SI –International System of Units (Metric System)
Physical Change – doesn't change the identity of the substance
Chemical Change –changes the identity of the substances

### *MATERIALS*

• Gro-beast, plastic container to fit the Gro-beast as it grows
• Graduated cylinder • Ohaus Compact Scale (200g x 0.1g)
• Ruler • Distilled or bottled water • Data sheet • String

### *PROCEDURE*

1. Estimate the mass and length of the Gro-beast. Now measure the mass and length. You may measure the length from head to tail or wingtip to wingtip, whichever is greater.
2. Ask students to estimate how large the Gro-beast will become.
3. Place the Gro-beast in a container of water. Record the mass and length every 10 minutes for 30 minutes. Record the data on the data sheet. (Time may be adjusted according to the needs of the class. Allowing more time between recordings will offer greater variance.)
4. Tell students to give the Gro-beast a name and write a story about its life.
5. Design a bar graph using the data. Y axis is the time and x axis is the mass.

### *ASSESSMENT*

• Write a conclusion about the activity reflecting on what you have learned and how you would change the activity.
• Use the data to complete a graph.
• Teacher and student generated scoring tools or rubrics, questioning, data chart results and graphing.

# Grow Your Own Beast

## Continued

### LITERATURE CONNECTIONS

How Tall, How Short, How Far Away by David A. Adler
Dinosaurs by Kathleen N. Daly
Zack's Alligator by Shirley Mozelle
What Is A Scientist? by Barbara Lehn
How to Think Like a Scientist by Stephen P. Kramer

### EXTENSIONS

Instruct students to:

- Graph their data in a bar/plot graph
- Give their gro-beast a name and write a story about their gro-beast as they watched it grow.
- Research polymers that are used daily both natural and man made.
- Compare and contrast type of dinosaurs.
- Develop an investigation using a gro-beast.
- Measure the volume of the gro-beast.

Contributed by Ruth Ruud, Presidential Awardee for Excellence in Science Teaching, 1993

# The Density of Liquids

***Objective:*** To determine the density of liquids from the measurement of the volume and mass (investigation of the density of various liquids such as water, alcohol, chloroform, hexane, benzine and mineral oil)

## *MATERIALS*

- Measuring cylinders
- Volumetric fl asks
- Pipettes
- Ohaus Scout® Pro balance (readability 0.01g)
- Pycnometers
- Various liquids

## *PROCEDURE*

The glass apparatus such as pycnometer, volumetric fl ask is tared and then fi lled with the liquid under investigation. The mass is noted down.

## *EVALUATION*

The density is determined as the quotient of mass and volume.

$$\rho t = \frac{m}{v}$$

$\rho t$ = density at temperature
m = mass
V = volume
t, $\vartheta$ = temperature of liquid

## *NOTES*

Since the density of liquids is temperature-dependent, the temperature must be specified. For very accurate measurements, a buoyancy correction is necessary. The liquid used for school experiments must not be irritant or poisonous. Carbon tetrachloride, benzene and concentrated alkalis and acids must not be used. Percent errors are normally from temperature and accuracy of the volumetric device, and purity of solution. For example, denatured alcohol has methyl alcohol added. This is an excellent place for students to use standard reference books to check their results. Good technique can give results within 3 signifi cant fi gures.

# Do the Math

***Objective:*** Performing Math Functions with an Electronic Balance )

## *MATERIALS*

- Ohaus Compact Scale (2000g or 5000g capacity recommended)
- Gram cubes measuring one centimeter on each side with a mass of 1 gram each

## *PROCEDURE*

### ADDITION

Place any number of gram cubes on the balance. It will display thatnumber. Add a few more, it will display that number. Use this method to visually demonstrate adding whole numbers.

### SUBTRACTION

As you remove gram cubes, it will display the new total. Use this method to visually demonstrate subtraction of whole numbers.

### NEGATIVE NUMBERS

1. Place the desired number of cubes on the scale and press the On/Zero button. Display should now read 0 while cubes are still on the pan.
2. Remove the cubes. The display should now show a negative number equal to the number of cubes originally placed on the pan.
3. You may now use the scale to visually represent addition of a positive to a negative number by placing cubes back on the scale. EX. Place 10 cubes on scale, press On/ Zero, remove 10 cubes and display should read -10, now introduce addition problems such as -10 + 4 = X. Students place 4 cubes on pan which will then read -6.

## *NOTES/EXTENSION*

- Capacity of scale will determine amount of numbers available to use (2000g capacity = numbers up to 2000)
- Square of cubic numbers - If student assembles a 3 cm square of cubes (9 square cm) and places the 3 square cm assembly on balance, it will read 9g.