Lesson Title	Is Density Intrinsic?
Length of Lesson	90 minutes
Created By	Erin Anderson
Subject	Chemistry
Grade Level	9-12
State Standards	2a., 2c., 2d., 2e.
DOK Level	2 & 3
DOK Application	Distinguish, Investigate, Draw Conclusions
National Standards	B: Physical Science
Graduate Research Element	During the summer months, density stratification can occur in smaller bodies of water (i.e. ponds, lakes, bays). Cooler, oxygen-depleted water accumulates at the bottom and warm oxygen-rich water exists in the upper part of the water column. The two layers do not mix, causing die-off of bottom-dwelling organisms. The lack of oxygen promotes pyritization within bay porewaters.

Student Learning Goal:
Understand that density can be calculated using the equation: ρ (density) = m (mass)/ V (volume)

Understand that density is an intrinsic principal, meaning that density does not always depend on the visual amount of substance present.

State Standards:
2a.Choose the most appropriate SI unit of mass, length or volume of an object
2c. Apply the definition of mass, length, volume, time, density, temperature and pressure.
2d.Use scientific notation in chemical calculations.
2e.Round values to the proper significant digits.

National Standards: B.

- The physical properties of compounds reflect the nature of interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and distances and angles between them.

Materials Needed (supplies, hand-outs, resources):
500 g of metal shot (copper, iron, lead, zinc, or tin will suffice), balances, 100 ml graduated cylinders, 6 watch glasses, packets of plain M&Ms, packets of peanut M&Ms, pennies, nickels, dimes, quarters.

Lesson Performance Task/Assessment:

1. The ability to calculate density is important. Estimating density based on size or weight of an object is not reliable. Students will be asked to calculate the density of different objects: plain M&Ms, peanut M&Ms, pennies, nickels, dimes and quarters. By doing these calculations, students demonstrate their ability to manipulate the density equation:
   ρ (density) = m (mass)/ V (volume)

Mass will be calculated with a scale, and volume will be calculated by dropping the object into a graduated cylinder half-filled with water. Record the change in volume (ml). That value equals the volume of the solid object (cm^3).

2. Students must come to the conclusion that density is an intrinsic property. They will be asked to determine the density of a small piece of metal and a large piece of the same metal. If the densities are the same, density is shown to be an intrinsic property.

Lesson Relevance to Performance Task and Students:
Recollection of the density formula, SI units, significant digits.

Anticipatory Set/Capture Interest:
How many people like to bake? How many of you were denied licking the cookie batter spoon by your parents?

Demonstration: Have 2 eggs: one rotten, one fresh. 2 beakers are filled with water. The fresh egg is dropped into the beaker and sinks to the bottom. The rotten egg is dropped into the second beaker and floats. Ask class why this happens. Explain that when an egg is rotten, microbes are eating the proteins and molecules of the egg and producing sulfide gas through their metabolism and biomass accumulation processes. The gas makes the rotten egg less dense, which is why it floats in water. Don't forget to test all eggs before licking the cookie batter spoon!

Guided Practice:
If needed, a review of the density equation calculations will be conducted.

Independent Practice:
Students will calculate densities for each object (different sizes of metal shot, plain M&Ms, peanut M&Ms, pennies, nickels, dimes, quarters).

Remediation and/or Enrichment:
IEP's will be supported. For remediation, less objects for density calculations will be given. The intrinsic property of density will be the main focus for these students. For enrichment, students will be asked to compare the densities of a plain M&M vs. a peanut M&M. Does surface area affect density? Do you think the peanut affects the density of the larger M&M?

How do the densities of a dime and a penny compare? Is it what you expect?

Check(s) for Understanding:
By determining that density is an intrinsic property, students will have demonstrated that they are capable of proper data acquisition, carrying out proper measurements and manipulating the density equation. Worksheet questions will also be used to determine understanding (file name: discovering density lab procedure.doc).

- Does surface area affect density?
- Does mass affect density?
- If you travelled to the Moon, would the density of your wrist-watch change?

Closure:
Students will be able to take their understanding of density out into the world. You don't need a scale to calculate mass: just water and a graduated cylinder. You don't need a yard stick to measure volume: just water and a graduated cylinder.

Possible Alternate Subject Integrations:
Physics, Math, Earth Science

Teacher Notes:
Make sure students weigh objects before submersing them in water. If the objects are weighed while wet, the mass measurement may not be accurate.

- $cm^3 = ml$

Known Densities:
Copper, 8.92 g/cm^3
Iron, 7.87 g/cm^3
Lead, 11.34 g/cm^3
Zinc, 7.14 g/cm^3
Tin, 7.23 g/cm^3
Penny, 7.18g/cm^3
Nickel, 8.95 g/cm^3
Dime, 8.84 g/cm^3
Quarter, 8.94 g/cm^3
Plain M&M, variable
Peanut M&M, variable

This lesson plan was modified from *17 Effective Activities for New Chemistry Teachers: Fun and easy to run chemistry labs for high school students* by Ian Guch.
http://misterguch.brinkster.net/17.pdf

Invitation to Science Inquiry 2nd edition by Tik L. Liem. 1987. Science Inquiry Enterprises.