Common Cents

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Topic

Density of metals

Time

1 hour

Safety

Please click on the safety icon to view the safety precautions.

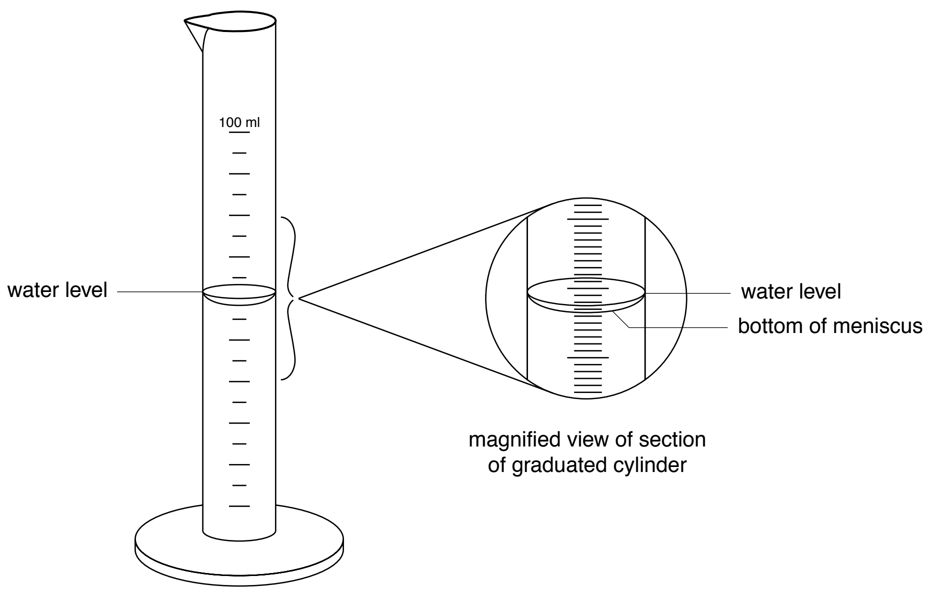
Materials

50 to 100 U.S. pennies minted in 1962 to 1981
50 to 100 U.S. pennies minted in 1982
50 to 100 U.S. pennies minted in 1983 to present
(Most assortments of pennies you get from the bank will contain mainly pennies minted in 1983 to the present. To obtain enough of the older pennies, you may need to sort through $5 to $7 rolls. It is possible to do the experiment using fewer pennies in the older groups, but at least 50 to 100 pennies provide the most accurate results.)
gram balance
100-mL graduated cylinder
water
calculator
towel

Procedure

1. Sort the pennies by date. Make one pile of 50 to 100 pennies dated 1962 to 1981. Make a second pile of 50 to 100 pennies dated 1983 to the present. Put all the 1982 pennies you find in a third pile.
2. Make sure the balance is correctly zeroed. Accurate measurements are very important for the results of this procedure. Find the mass (g) of the first pile of pennies dated 1962 to 1981. Record this figure on the data table.
3. Fill the graduated cylinder about half full of water, and read the volume. Be sure to read the number at the bottom of the curved surface, called the *meniscus,* as shown in the figure. Record the volume (mL) on the data table.
4. Carefully tilt the cylinder slightly, and slide in the pennies that were massed in step 2. Slide the pennies in a few at a time without splashing; losing even a tiny bit of water will throw off the results of this procedure. Read and record the new volume, again reading the number at the bottom of the graduated cylinder.

Data Table							
Mint date of pennies	Mass of pennies (g)	**Volume (mL)**			Density of penny: mass/vol (g/mL)	% Composition copper (density: 8.96 g/mL)	% Composition zinc (density: 7.14 g/mL)
		(1) Water	(2) Water and pennies	(3) Pennies (2–7)			
1962–1981							
1983–present							
1982							



5. Subtract the first volume reading from the second. Record the difference as the volume of the pennies. This method of finding the volume of a solid is called the *water displacement method.*
6. Calculate the density (g/mL) of the pennies by dividing their mass by their volume.
7. Pour the water out of the cylinder while holding the pennies back, and then pour the pennies out onto a towel.
8. Repeat steps 2 to 7 for the pennies dated 1983 to the present.
9. Repeat steps 2 to 7 for the pennies dated 1982.
10. Since 1962, our pennies have been made using a combination of copper and zinc. The densities of these two pure metals are shown below.

Metal	Density
Copper	8.96 g/mL
Zinc	7.14 g/mL

Using your calculations of the densities of the pennies in the three date groups you have tested, and the known densities of copper and zinc given above, calculate the percentage of copper and zinc in each of the three groups, using the following formula:

Density of pennies = density of copper 2 *x*% + density of zinc 2 (100 1 *x*)%
Density of pennies = 8.96(*x*/100) + 7.14(100)
Density of pennies 2 100 = 8.96*x* + 7.14(1001 *x*)/100
Density of pennies 2 100 = 8.96*x*1 7.14*x* + 714
Density of pennies 2 100 1 714 = (8.96 1 7.14)*x*
Density of pennies 2 100 1 714 = 1.82*x*
Density of pennies 2 100 1 714 = *x*
1.82

Now solve for *x*, which is the percentage of copper in the pennies. Then solve for 1001 *x*, which is the percentage of zinc in the pennies. Record your solutions on the data table. Repeat the calculations for all three groups of pennies tested.

11. Which group of pennies had the greatest density? Which was the least dense? Compare the compositions of the pennies in the three date groups. Which has the most copper? Which has the least?
12. Based on your results, how many different metal compositions do you think are represented by the individual pennies making up the three groups? Why? Is there more than one possible answer?
13. When do you think the composition of the pennies changed?
14. Why do you think the procedure measures groups of pennies instead of just a single penny from each time period tested?
15. Why do you think the United States chose to change the composition of pennies?

What's Going On

The group of pennies dated 1962 to 1981 is the most dense and contains the most copper. The group 1983 to the present is the least dense and contains the least copper. Although the three groups of pennies have three different densities, the individual pennies in the groups actually comprise only two different densities and corresponding compositions of copper and zinc. Pennies minted during 1962 to 1981 are 95% copper and 5% zinc, giving them a density of 8.869 g/mL.

Sometime in 1982, the composition of pennies was changed to copper-plated zinc, and ever since, pennies have been made up of 97.5% zinc and only .025 copper. Since both types of penny were minted during 1982, the density of a group of pennies from that year will vary, depending on how many old-type and how many new-type pennies are in the particular group being measured. Pennies minted during 1983 to the present are all the new type, with a density of 7.19 g/mL. Don't feel bad if you guessed that there are three different compositions corresponding to the three dates tested, since the experiment is set up in a way that might lead you to that conclusion. However, it is worth noting that the different densities of the three groups of pennies could result from any number of combinations of different densities and compositions of metals among the individual pennies making up the groups. The assumption that the pennies in each group are uniform is the kind of assumption that scientists frequently make when they need to measure groups of objects together, because it would be impossible or very inconvenient to measure just one individual object. In this experiment, that assumption works for the groups of pennies from 1962 to 1981 and from 1983 to the present, but breaks down for the pennies from 1982, which actually represent a combination of the two types of pennies in the earlier and later groups.

As explained above, the composition of pennies changed only once during the time period being tested, in 1982. The procedure measures groups of pennies because it would be hard to measure accurately the volume of a single penny with the equipment available to most students. The U.S. government changed the composition of the penny because the price of copper rose to a level that made the amount of copper in one old-style penny worth more than 1 cent.

Connections

Each pure metal has a unique density. Thus, by measuring the mass and volume and calculating the density of any object made up of known metals, you can determine the percentage of each pure metal in its composition. The pennies used in the United States today are composed of different amounts of copper and zinc, depending on the year they were minted. In this experiment you determined the metallic composition of pennies of different dates by calculating their densities.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES