

Mass, Volume and the Straight Line: Identifying Three Metals from Data

Learning target: I can calculate density from mass and volume data, graph mass against volume, and use the pattern plus a reference table to identify unknown metals.

Data and graphing About 45 min Individual MS-PS1-2 · practice data analysis independent practice

Name

Date

Period

Directions

A student measured twelve metal pieces: four pieces each of three unknown metals, labeled A, B and C. The numbers are a teaching dataset, invented to be realistic, not measured in a real lab. Volume was found by water displacement in a graduated cylinder that reads to 0.5 mL (1 mL = 1 cm³). Calculate every density, graph all twelve points with a ruler, and show units on every number. Part B uses one more sample and a second property.

You will need: This worksheet, Pencil, Ruler, Calculator

Part A: Three unknown metals, twelve pieces

Mass and volume of twelve metal pieces (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Piece	Mass (g)	Volume (cm³)
A1	10.8	4.0
A2	20.3	7.5
A3	32.3	12.0
A4	41.9	15.5
B1	26.9	3.0
B2	58.1	6.5
B3	89.7	10.0
B4	125.6	14.0
C1	35.6	5.0
C2	57.2	8.0
C3	78.5	11.0
C4	114.1	16.0

Simulated data for teaching. Each metal was cut into four pieces of different sizes before measuring.

Reference table (real rounded values at normal air pressure)

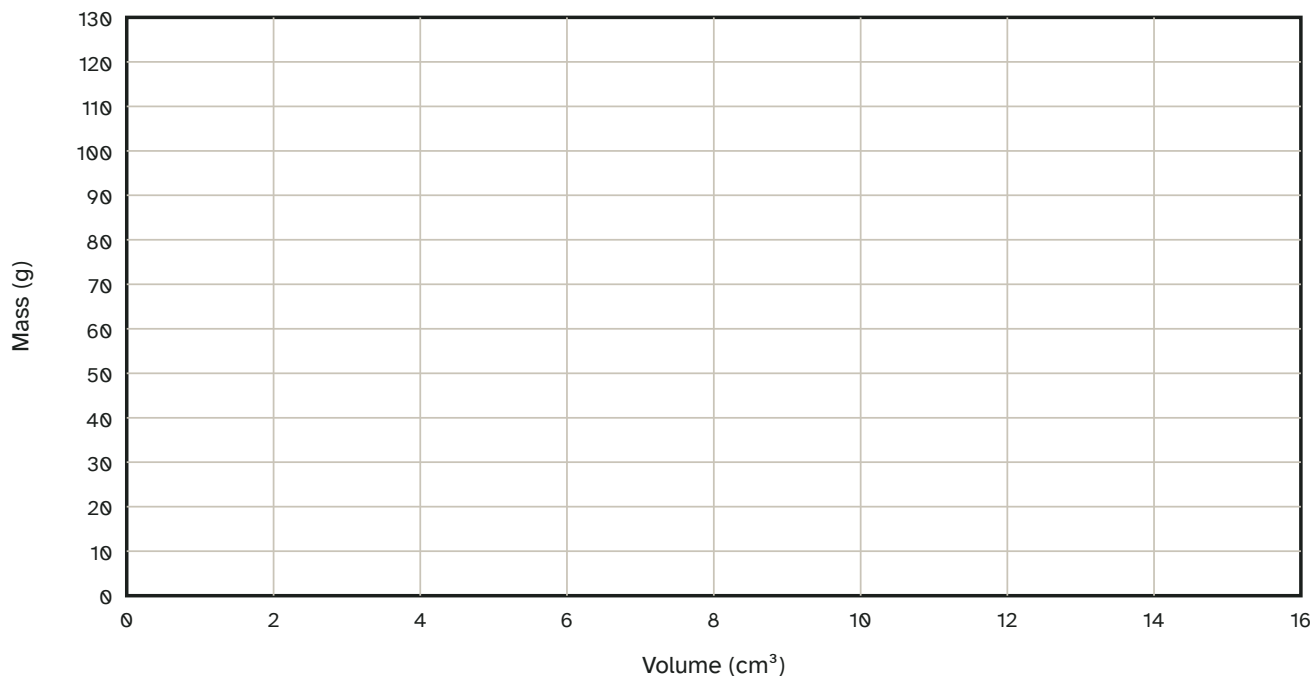
Metal	Density (g/cm ³)	Melting point (°C)
Aluminum	2.7	660
Zinc	7.14	420
Tin	7.29	232
Iron	7.87	1538
Copper	8.96	1085
Silver	10.5	962
Lead	11.3	327

1. Calculate the density of every piece (mass ÷ volume). Write one full calculation below the table.

Density (g/cm ³), to two decimals
A1
A2
A3
A4
B1
B2
B3
B4
C1
C2
C3
C4

2. Find the average density of metal A, metal B and metal C (add the four values and divide by 4). Show the work for one metal.

Mass versus volume for the three metals



3. Describe the three lines on your graph. Which is steepest? What does the steepness of a line tell you about the metal, and why do all three lines pass through (0, 0)?

4. Use your averages from q2 and the reference table to identify metals A, B and C. For each, state the reference value you matched and how far off your average is.

5. Predict the mass of a 20.0 cm³ piece of metal B. Show the calculation, then explain how you could check the prediction on your graph if the axes were extended.

6. Piece A4 (41.9 g) has more mass than piece C1 (35.6 g), yet metal A is much less dense than metal C. Explain how both facts can be true at the same time.

Part B: A fourth sample and a second property

A single small gray piece, sample D, was measured next: mass 29.2 g, volume 4.0 cm³. The student then heated a chip of D in a test tube with a thermometer in the tube while the teacher supervised. The chip stayed solid at 150 °C and at 200 °C, began to melt at about 230 °C, and was completely liquid by 240 °C.

7. Calculate the density of sample D. List every metal in the reference table within 0.3 g/cm³ of your result.

8. The graduated cylinder reads only to the nearest 0.5 mL, so D's true volume could be anywhere from 3.5 to 4.5 cm³. Calculate the lowest and highest density that would give. Which reference metals fall inside that range?

9. Identify sample D. Explain why the density measurement alone could not settle it, what the melting-point result adds, and why the melting-point test would have given the same answer for a chip twice as large.

Keep the division straight

Density is always mass divided by volume, never the other way around. A quick check: for every piece in this dataset the mass number is bigger than the volume number, so every density must come out bigger than 1. If you get a density smaller than 1 for a metal, you divided in the wrong order. Write each calculation as 'mass ÷ volume = density' with units: 10.8 g ÷ 4.0 cm³ = 2.70 g/cm³.

How small a piece can the balance handle?

The classroom balance reads to 0.1 g and the cylinder to 0.5 mL. For metal A (density about 2.7 g/cm³), find the smallest piece whose density you could measure to within 10 percent of the true value. Start by asking how large the volume must be so that a 0.5 mL error is less than 10 percent, then check whether the mass of that piece is large enough for the balance. Explain why a tiny flake gives a bad density even though density is an identifying property.