

Four Clear Liquids, No Labels

Investigation question: Four clear, colorless liquids arrive in bottles marked only A, B, C and D. Which measurements can name each one, and when is one measurement not enough?

Evidence-based mystery

Groups of 3

1 session

Setup 5 · Activity 38 · Cleanup 7 min

MS-PS1-2 · practice

Name _____

Group _____

Date _____

Your role today

- ☐ **Measurer:** Pours exactly 20.0 mL into the graduated cylinder, reads the bottom of the curved surface at eye level, and transfers the liquid to the tared cup on the balance.
- ☐ **Tester:** Runs the mixing test (5 mL unknown plus 5 mL water in a capped vial, swirl, wait one minute) and the drop test on the paper towel, and calls out what is seen.
- ☐ **Recorder and checker:** Writes every mass and observation on the sheet as it is read, computes each density, flags any value that does not match a partner's expectation, and leads the matching against the reference table.

Safety

- 70% isopropyl alcohol is flammable: no flames, hot plates or heat sources anywhere in the room during this lab. Keep bottles capped when not pouring and keep volumes small.
- Wear goggles throughout. Alcohol stings badly in the eyes; if it splashes, rinse at the eyewash for 15 minutes and tell the teacher.
- Never taste or sniff an unknown. Identification is by measurement only; wafting is not used in this lab.
- Oil and alcohol spills make floors slippery. Wipe spills at once with paper towels and tell the teacher about anything on the floor.
- Alcohol vapor can irritate; keep the room ventilated and cap the alcohol bottle between uses.
- Wash hands at the end. Dispose of small volumes of alcohol and salt water down the sink with plenty of water; collect the oil in the waste cup provided, not the sink.

Procedure

1. Put on goggles. Label four cups A, B, C and D. Place cup A on the balance and press tare so it reads 0.0 g; if your balance cannot tare, record the empty cup's mass instead.
2. Pour liquid A into the graduated cylinder to exactly 20.0 mL. Read the bottom of the curved surface with your eye level with the mark. Add or remove drops with a dropper until it is right.
3. Pour the 20.0 mL into cup A on the balance and record the mass to 0.1 g. Compute density = mass ÷ 20.0 mL and write it in the table. Pour the liquid back into bottle A.
4. Repeat steps 2 and 3 for a second trial of liquid A, then average the two densities. Do the same two trials for B, C and D, rinsing and drying the cylinder between liquids (a quick rinse with the next liquid is better than water for the oil).

5. Mixing test: put about 5 mL of liquid A in a vial, add about 5 mL of tap water, cap it, swirl gently for ten seconds, and stand it up. After one minute record whether you see one layer or two, and if two, which liquid is on top. Repeat for B, C and D in separate vials.
6. Drop test: put one drop of each liquid on a paper towel in a labeled spot. After five minutes record what is left: nothing, a damp spot, a greasy translucent spot that does not dry, or a white residue.
7. Sketch each vial from the mixing test in the drawing box, labeling the layers.
8. Match: for each liquid, find every reference-table entry within 0.05 g/mL of your average density. If more than one entry fits, use the mixing test and the drop test to choose. Write the identity and the two pieces of evidence in the identification table.
9. Return the liquids to their bottles, put the oil waste in the waste cup, rinse the vials and cylinder, wipe the bench, and wash hands. Answer the analysis questions on your own.

Record your observations

Lab 1 recording sheet: Four clear liquids, no labels

Record every mass as you read it. Compute each density before moving to the next liquid so you can catch a mistake while the liquid is still in front of you. Density = mass ÷ volume; since you always use 20.0 mL, divide each mass by 20.0.

Density measurements (20.0 mL each time)

Liquid	Trial 1 mass (g)	Trial 1 density (g/mL)	Trial 2 mass (g)	Trial 2 density (g/mL)	Average density (g/mL)
A					
B					
C					
D					

Mixing test and drop test

Liquid	Layers with water after 1 min (one or two)	If two layers, which is on top?	Drop on paper after 5 min (nothing / damp / greasy / white residue)
A			
B			
C			
D			

Reference table: known liquids at room temperature (rounded values)

Known liquid	Density (g/mL)	Mixes with water?	Drop on paper after 5 min
Mineral oil	0.85	No, floats on top	Greasy spot that does not dry
Isopropyl alcohol, 70%	0.88	Yes, one layer	Nothing; dries fast
Vegetable oil	0.92	No, floats on top	Greasy spot that does not dry
Water	1.00	Yes, one layer	Damp spot, then nothing
Saturated salt water	1.20	Yes, one layer	White residue when dry
Glycerin	1.26	Yes, slowly	Sticky clear film that does not dry

Two of these liquids are not in your set. Your density may differ from the table by up to about 0.05 g/mL because of how the cylinder is read.

-  Sketch the four vials from the mixing test side by side. Label each vial with its letter, draw the layer or layers you saw, and write which liquid you think each layer is.

- Identify each liquid. For each one give the density evidence and a second piece of evidence from the mixing or drop test.

Identity	Density evidence (your value vs. table)	Second evidence (mixing or drop test)
Liquid A		
Liquid B		
Liquid C		
Liquid D		

- Which of your four liquids could not be named by density alone? Name the two reference-table entries it could have been, and say which test decided it.

Analysis questions

3. A group measured 17.6 g for 20.0 mL of one liquid. Calculate its density. Which reference liquids are within 0.05 g/mL of that value, and what single test tells the alcohol from the oils?

4. Why did the procedure use 20.0 mL rather than 5.0 mL for the density measurement? Use the balance's 0.1 g limit in your answer.

5. Water and saturated salt water have different densities, yet the salt water formed one layer with water in the mixing test. Explain why, using the word solubility.

6. Suppose you gently poured your salt water, oil and water into one tall glass. Using your measured densities, predict the layers from top to bottom. Then predict what the glass looks like one minute after stirring it hard.

7. The drop test showed that salt water leaves a white residue and alcohol leaves nothing. What does the residue tell you happened to the salt when it dissolved? Why does the alcohol leave nothing?

8. A classmate says 'my density matched the table, so that proves what the liquid is.' Explain why a match is consistent with an identity but not proof of it, and describe one thing you did in this lab, or could do, to be more certain.
