

The Mystery Element Cards: Build a Table That Predicts

Investigation question: Given only the properties and atomic masses of fourteen unnamed elements, can your group arrange them into a table that reveals a pattern, and can that table predict elements you were never given?

Evidence-based mystery

Groups of 4

1 session

Setup 5 · Activity 40 · Cleanup 5 min

MS-PS1-1 · practice

Name _____

Group _____

Date _____

Your role today

- ☐ **Card reader:** Reads each card aloud in full before it is placed; keeps the deck in order and makes sure no card is placed on a single clue.
- ☐ **Sorter:** Moves the cards on the desk according to the group's agreed rule, and announces when a card does not fit the rule.
- ☐ **Recorder:** Copies the final arrangement into the grid on the recording sheet and writes the gap predictions with the group's reasoning.
- ☐ **Challenger:** Tests the arrangement: picks any two cards in a column and asks what they share, picks any row and asks whether mass rises along it, and argues for a gap whenever the pattern breaks.

Safety

- No materials beyond paper cards; no chemicals are handled. The water reactions on the cards are described, never demonstrated.
- Do not attempt any of the reactions described on the cards. Sodium, potassium and cesium react dangerously with water and must never be handled by students; this lab uses only their descriptions.

Procedure

1. Spread the 14 cards face up. The card reader reads every card aloud once before anyone sorts. Write down two properties that you think will matter most.
2. First sort: put all 14 cards in a single line in order of increasing atomic mass. Look along the line. Record in q1 any properties that seem to come back again and again.
3. Second sort: now group cards that share the same kind of behavior (how they react with water, what state they are in, how they combine with other elements). Record the sorting rule you used.
4. Build a table: each behavior group becomes a column. Within every column, place cards from lowest mass at the top to highest at the bottom. Then slide the columns so that each row runs from lower mass on the left to higher mass on the right as far as possible.
5. The challenger tests the table: do the cards in each column truly share behavior? Does mass rise along each row? Wherever a row has a card whose mass jumps far above its neighbor in the row above, or

where a column has a large mass gap between two cards, leave an empty space.

- For every empty space, write a prediction card: estimate the missing element's atomic mass by averaging the cards above and below it in the column, and predict two of its properties from its column. Place the prediction card in the gap.
- Copy the finished arrangement, gaps included, into the grid on your recording sheet and complete the gap-prediction table.
- Find the one place where mass order and property order disagree (two neighbors whose masses are reversed). Decide which rule wins and write why in q2.
- Only when the recorder has finished, open the identity envelope. Compare the real elements and masses with your predictions and complete the analysis questions.

Record your observations

Lab 2 recording sheet: The mystery element cards

Teaching dataset — The element names on these cards are invented. The masses and behaviors are rounded versions of real elements, which your teacher will reveal at the end. Do not look anything up until the reveal.

Card set (teacher prints and cuts apart; 14 cards)

Card 1

VEX. Atomic mass 6.9 Da. Soft, silvery metal you could cut with a butter knife. In water it fizzes steadily and does not catch fire. Combines with the gases FLOR, CLO and IOD one atom to one atom. Lightest metal known.

Card 2

RUE. Atomic mass 23.0 Da. Soft, silvery metal. In water it skids about and reacts fast enough to catch fire. Must be stored under oil. Combines with FLOR, CLO and IOD one atom to one atom.

Card 3

PIM. Atomic mass 39.1 Da. Soft, silvery metal. In water it bursts into flame at once. Stored under oil. Combines with FLOR, CLO and IOD one atom to one atom.

Card 4

ZAN. Atomic mass 132.9 Da. Soft, gold-tinted metal that melts in a warm hand. Explodes on contact with water. Stored sealed away from air. Combines with FLOR, CLO and IOD one atom to one atom.

Card 5

HEL. Atomic mass 4.0 Da. Colorless gas, lighter than air. Does not react with water or with anything else known. Glows pale orange-pink in a lit tube. Used to lift balloons.

Card 6

TAM. Atomic mass 20.2 Da. Colorless gas. No known compounds. Glows bright red-orange in a lit tube.

Card 7

NOL. Atomic mass 39.9 Da. Colorless gas. No known compounds. Glows violet in a lit tube. Makes up about one percent of air.

Card 8

KESH. Atomic mass 83.8 Da. Colorless gas. Forms a few compounds only under special laboratory conditions. Used in some bright white lamps.

Card 9

XON. Atomic mass 131.3 Da. Colorless gas, dense. Forms a few compounds with FLOR under special conditions. Used in some car headlights.

Card 10

FLOR. Atomic mass 19.0 Da. Pale yellow gas. The most reactive element known; attacks glass. Combines with VEX, RUE, PIM and ZAN one atom to one atom, and with CAL and BAR two atoms to one.

Card 11

CLO. Atomic mass 35.5 Da. Yellow-green gas with a sharp smell. Very reactive. Combines with VEX, RUE, PIM and ZAN one atom to one atom, and with CAL and BAR two atoms to one.

Card 12

IOD. Atomic mass 126.9 Da. Gray-black shiny solid that turns straight into a purple vapor when gently warmed. Reactive, but less so than CLO. Combines with the soft metals one atom to one atom, and with CAL and BAR two atoms to one.

Card 13

CAL. Atomic mass 40.1 Da. Silvery metal, harder than VEX or RUE. Reacts slowly with water, releasing bubbles. Combines with FLOR, CLO and IOD one atom to two atoms.

Card 14

BAR. Atomic mass 137.3 Da. Silvery metal. Reacts quickly with water. Combines with FLOR, CLO and IOD one atom to two atoms. Its compounds burn with a green flame.

Our arrangement (write the card name in each cell; write GAP where you left a space)

Row	Column A	Column B	Column C	Column D
1				
2				
3				
4				
5				
6				

Gap predictions

Gap location (row, column)	Card above (mass)	Card below (mass)	Predicted mass (average)	Two predicted properties	Real element and mass (after reveal)

1. After the mass-only sort, which behaviors seemed to come back again and again along the line? Name at least two.

2. Where did mass order and behavior order disagree? Which rule did your group let win, and why?

Analysis questions

3. What rule did your group use to decide which cards share a column? Give one example of two cards and the behaviors they share.

4. Pick one of your gaps. Show the calculation for its predicted mass and compare it with the real element's mass from the envelope. How close were you, and why does averaging work here?

5. The cards for RUE and PIM say they combine with CLO one atom to one atom, while CAL combines one atom to two. How did combining ratios help you decide columns even without seeing any atoms?

- 6.** Mendeleev left blank spaces in his 1871 table and predicted three elements that were later found. Explain what makes a blank space a scientific prediction rather than a gap in knowledge, using one of your own gaps as the example.

- 7.** Your table was built from behavior and mass alone. A later discovery, atomic number, gave the real table its order. Based on the place where mass order failed, why might scientists have wanted something better than mass?

- 8.** A new card arrives: a colorless gas, 222 Da, no compounds known. Place it in your table and predict two more of its properties.
