The Formula Puzzle

Use periodic trends to predict and revise ionic formulas.

HS-PS1-2 "Construct an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties, and revise, as needed."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline clues about groups and outermost electrons, circle clues about ion charges, and number the three moves in the sodium and fluorine example: electron transfer, charge balance, and formula.

Labels for the Display

1. A museum display has sealed samples of magnesium, calcium, aluminum, oxygen, chlorine, and iodine. Its labels give element names, but not the formulas of compounds these substances might form. To predict a product, look first at the electrons in an atom's outermost energy level, called valence electrons. Atoms often gain or lose electrons to reach a filled outer level. A metal that loses electrons becomes a positive ion; a nonmetal that gains electrons becomes a negative ion. In an ionic compound, the total positive charge and total negative charge balance, even if this requires different numbers of each ion.

2. The periodic table helps visitors read the clues. Magnesium and calcium are in group 2; each has two valence electrons and tends to lose both, forming ions with charges of $^{2+}$. Aluminum is in group 13; it has three valence electrons and commonly forms an ion with a charge of $^{3+}$. Oxygen, in group 16, has six valence electrons and tends to gain two, forming an ion with a charge of $^{2-}$. Chlorine and iodine, in group 17, each have seven valence electrons and tend to gain one, forming ions with charges of $^{-}$. Elements in the same group often react in similar ways.

3. Consider a different pair: sodium, a group 1 metal, and fluorine, a group 17 nonmetal. Sodium's one valence electron can move to fluorine, which needs one electron to fill its outer level. The resulting ions have charges of $^{+}$ and $^{-}$, so one of each balances, giving NaF. That example offers a method, not a universal formula: a different metal may lose two or three electrons, while a different nonmetal may gain two. A product prediction must balance electron changes and ion charges. If a proposed formula leaves unequal total charges, revise the ratio before defending the prediction.

2 ANSWER WITH EVIDENCE

Use the passage

1. A visitor predicts MgO_2 as the product of magnesium and oxygen. Revise the formula and explain why.

2. Predict the compound formula for calcium and iodine. How do their electron changes set the ratio?

3. Predict the compound formula for magnesium and chlorine. Use their periodic-table groups to explain your prediction.

4. A visitor proposes $AlCl_2$ as the product of aluminum and chlorine. Check the charges, then revise the formula.

3 YOUR TURN

Your own words

Write a 4- to 5-sentence label for the product of aluminum reacting with oxygen. Predict its formula, explain the group-based electron changes and ion ratio, and show how you checked or revised a first guess.

The Formula Puzzle

PART 1 · READ AND MARK

Underline clues about groups and outermost electrons, circle clues about ion charges, and number the three moves in the sodium and fluorine example: electron transfer, charge balance, and formula. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	A visitor predicts MgO_2 as the product of magnesium and oxygen. Revise the formula and explain why.	**MgO. Magnesium forms ions with $^{2+}$ charges and oxygen forms ions with $^{2-}$ charges, so one of each balances.**
2	Predict the compound formula for calcium and iodine. How do their electron changes set the ratio?	**CaI_2. Calcium loses two electrons, and each iodine atom gains one, so two iodine ions balance one calcium ion.**
3	Predict the compound formula for magnesium and chlorine. Use their periodic-table groups to explain your prediction.	**$MgCl_2$. Group 2 magnesium forms an ion with a $^{2+}$ charge, while each group 17 chlorine atom forms an ion with a $^{-}$ charge.**
4	A visitor proposes $AlCl_2$ as the product of aluminum and chlorine. Check the charges, then revise the formula.	**$AlCl_2$ has a total charge of $^{+}$. The balanced formula is $AlCl_3$: one aluminum ion with a $^{3+}$ charge balances three chloride ions with $^{-}$ charges.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Aluminum is in group 13, so it tends to lose three outer electrons, while group 16 oxygen tends to gain two. This gives aluminum ions with charges of $^{3+}$ and oxygen ions with charges of $^{2-}$. I first guessed AlO, but its charges do not balance. Two aluminum ions balance three oxygen ions, so the product is Al_2O_3.

Accept explanations based on electron transfer or balanced ion charges. For the open task, the first guess may be correct if the student explicitly checks its charge balance.