

Topic 1.8: Valence Electrons and Ionic Compounds

Worksheet · AP Chemistry

UNIT 1 · ATOMIC STRUCTURE AND PROPERTIES

On ExamFitter.com: [Topic 1.8 Revision Notes](#) · [Topic 1.8 Quiz](#) · [Previous Worksheet: Topic 1.7](#) · [Next Worksheet: Topic 2.1](#) · [Unit 1: All Topics](#) · [AP Chemistry Home](#)

How to Use This Worksheet

Work through the sections in order. Section A checks the ideas, Section B builds fluency with ion charges and formulas, and Section C mixes everything the way an exam would.

Two checks will carry every question: the ion must reach a full outer shell by a plausible route, and the finished formula must be charge-neutral in its lowest ratio.

Do not look at the answer key until you have attempted every question. The key gives full working, so compare your method, not just your final answer.

Section A: Recall and Concepts

A1. Explain, in terms of electron shells, why sodium forms Na^+ rather than Na^{2+} or Na^- .

.....

.....

A2. State the charge of the ion formed by each of these elements, and the rule you used: potassium, barium, bromine, oxygen, aluminium, phosphorus.

.....

.....

A3. Explain why iron can form both Fe^{2+} and Fe^{3+} while zinc forms only Zn^{2+} .

A4. A student writes the formula of the compound of magnesium and chlorine as Mg_2Cl_4 "to balance the atoms". Identify both errors in that formula.

A5. Explain what it means to say that Mg^{2+} and F^- are isoelectronic with neon, and state one property this shared arrangement gives all three species.

Section B: Core Practice

B1. Write the electron configuration of the Mg^{2+} ion, and state how many protons and how many electrons it contains.

B2. Write the formula of the ionic compound formed by calcium and bromine, showing how the charges balance.

B3. Write the formula of the ionic compound formed by potassium and oxygen.

B4. Write the formula of the ionic compound formed by aluminium and sulfur.

.....

.....

B5. An ionic compound has the formula Fe_2O_3 . State the charge on the iron ion, and give the name of the compound including the Roman numeral.

.....

.....

B6. State the ions present, with their charges and relative numbers, in the compound Na_2S .

.....

.....

Section C: Exam Style

C1. Iron forms two chlorides, FeCl_2 and FeCl_3 . (a) State the charge on iron in each compound and name each compound. (b) Write the electron configuration of the iron species in FeCl_3 , and explain in terms of electron removal order why it has that configuration.

.....

.....

C2. Chromium(III) oxide is used as a green pigment. (a) Write the formula of chromium(III) oxide, showing the charge balance. (b) A second oxide contains chromium with a total of +6 charge balancing three oxide ions. State the charge on chromium in this oxide and write its formula.

.....

.....

C3. Barium and nitrogen form an ionic compound. (a) Predict its formula, justifying your answer from the valence electrons of each atom. (b) State how many electrons are transferred, in total, in the formation of one formula unit of the compound from its atoms.

Answer Key

A1. Sodium is $[\text{Ne}] 3s^1$. Losing its single 3s electron exposes the complete neon core beneath, giving Na^+ with a full outer shell. Forming Na^{2+} would require breaking into that full, tightly held $n = 2$ shell, which costs far more energy than the first removal. Forming Na^- would add an electron to the 3s shell, leaving sodium with an unfinished outer shell and no stability gain. The ion that forms is the one that reaches a full shell by the cheapest route.

A2. Potassium: $1+$ (Group 1, one valence electron lost). Barium: $2+$ (Group 2, two lost). Bromine: $1-$ (Group 17, one gained to complete the shell). Oxygen: $2-$ (Group 16, two gained). Aluminium: $3+$ (Group 13, three lost). Phosphorus: $3-$ (Group 15, three gained). In every case the charge is the count of electrons that must move for the atom to reach the nearest full outer shell.

A3. Iron is $[\text{Ar}] 4s^2 3d^6$. Losing the two 4s electrons gives Fe^{2+} ; losing one additional 3d electron gives Fe^{3+} , whose half filled $3d^5$ arrangement is reasonably stable, so both ions are common. Zinc is $[\text{Ar}] 4s^2 3d^{10}$: losing the 4s pair gives Zn^{2+} with a completely full 3d subshell, and removing a third electron would mean breaking into that full, stable subshell, so Zn^{3+} does not form under normal conditions.

A4. First error: ionic formulas balance charge, not atoms; one Mg^{2+} and two Cl^- are neutral, so nothing needs doubling. Second error: ionic subscripts must be the lowest ratio; Mg_2Cl_4 reduces to MgCl_2 . The correct formula is MgCl_2 .

A5. Isoelectronic means having the same number and arrangement of electrons: Mg^{2+} ($12 - 2$), F^- ($9 + 1$) and Ne all have 10 electrons with the configuration $1s^2 2s^2 2p^6$, a completely full outer shell. The shared consequence is stability and chemical unreactivity of the electron arrangement itself: none of the three gains or loses electrons readily compared with their neighbours. (Their sizes still differ, because their proton counts differ: Mg^{2+} is smallest and F^- largest of the three.)

B1. Mg^{2+} : $1s^2 2s^2 2p^6$, i.e. $[\text{Ne}]$. It contains 12 protons (unchanged, it is still magnesium) and 10 electrons.

B2. Ca^{2+} and Br^- . One Ca^{2+} ($+2$) requires two Br^- ($2 \times -1 = -2$) for neutrality: CaBr_2 .

B3. K^+ and O^{2-} . Two K^+ ($2 \times +1 = +2$) balance one O^{2-} (-2): K_2O .

B4. Al^{3+} and S^{2-} . The lowest common multiple of 3 and 2 is 6: two Al^{3+} ($+6$) balance three S^{2-} (-6): Al_2S_3 .

B5. Oxide is O^{2-} , so three oxide ions give -6 in total; two iron ions must give $+6$, so each iron is Fe^{3+} . Name: iron(III) oxide.

B6. Na_2S contains sodium ions and sulfide ions: 2 Na^+ for every 1 S^{2-} , i.e. charges $+2$ and -2 balancing in a 2:1 ratio.

C1. (a) FeCl_2 : two Cl^- give -2 , so iron is Fe^{2+} , iron(II) chloride. FeCl_3 : three Cl^- give -3 , so iron is Fe^{3+} , iron(III) chloride. (b) Fe^{3+} is $[\text{Ar}] 3d^5$. When iron ionizes, the 4s electrons leave first because they

occupy the highest shell, $n = 4$: losing both gives Fe^{2+} , $[\text{Ar}] 3d^6$, and the third electron removed to reach Fe^{3+} comes out of the 3d subshell, leaving the half filled $3d^5$.

C2. (a) Cr^{3+} with O^{2-} : lowest common multiple of 3 and 2 is 6, so two Cr^{3+} (+6) balance three O^{2-} (−6): Cr_2O_3 . (b) If three oxide ions (−6) are balanced by one chromium ion, that ion carries +6, Cr^{6+} , and with a single chromium the formula is CrO_3 . (In practice CrO_3 is a covalent molecular oxide, but the charge arithmetic the question tests is this.)

C3. (a) Barium is Group 2, $[\text{Xe}] 6s^2$: it loses its 2 valence electrons to form Ba^{2+} . Nitrogen is Group 15 with 5 valence electrons: it gains 3 to complete its octet, forming N^{3-} . The lowest common multiple of 2 and 3 is 6, so three Ba^{2+} (+6) balance two N^{3-} (−6): Ba_3N_2 . (b) Each barium atom transfers 2 electrons and there are three of them: 6 electrons transferred in total (and the two nitrogen atoms receive 3 each, also 6, as they must).

Continue Revising

[Topic 1.8 Revision Notes](#)

[Topic 1.8 Quiz: Valence Electrons and Ionic Charge](#)

[Previous Worksheet: Topic 1.7 Periodic Trends](#)

[Next Worksheet: Topic 2.1 Chemical Bonds](#)