Formulas of ionic compounds.

To figure out the formula of an ionic compound you need to 1) identify the ions, then 2) create a neutral compound from those ions.

> Example. To write the formula for sodium sulfide requires the following steps:
>
> 1. Recognize that sodium ions are Na^+ and sulfide ions are S^{2-}.
>
> 2. Combine these two ions so that the total charge is zero. In this case, it take two 1+ charges per one 2- charge. Thus the formula for sodium sulfide is Na_2S.

This handout focuses on the second step. The main conceptual issue is that ionic compounds are neutral.

Ions have charge, such as the +1 charge on a sodium ion, Na^+. Ionic compounds, however, are neutral. If you know the ions, you can figure out the formula of an ionic compound by calculating how many of each ion you need to achieve neutrality -- to have the same number of positive charges and negative charges.

People use various mental tricks to figure out how many ions are needed to reach neutrality. After a little practice, you will do many of these "by inspection."

One trick is to "cross multiply." (This is similar to finding the least common denominator when adding fractions.)

> Example. Write the ionic compound between Mg^{2+} and Cl^- (magnesium and chloride ions). The charges are 2+ and 1-. Take 1 of the 2+, 2 of the 1-. The result: $MgCl_2$ (magnesium chloride), which has 2 + charges and 2 - charges.

Caution. Check that your formula is the simplest formula possible (i.e., the empirical formula). This is especially important if you use the cross multiply method.

> Example. Write the ionic compound between Ca^{2+} and O^{2-} (calcium and oxide ions). The charges are 2+ and 2-. Using the cross multiply method, take 2 of the 2+, 2 of the 2-. The result: Ca_2O_2. This is neutral (4 each + and - charges), but it is not the simplest -- or proper -- formula. Simplify to CaO (calcium oxide).

In the problems that follow (see back of page), you are given two ions, and asked to write the formula of the ionic compound that could form between them. Since you are given the ions, including the correct ion charges, all you need to do is to achieve neutrality. You can do these sections in any order; do problems that help you. If you have trouble at first, check yourself as you go. Seek help if necessary.

Problems

A. This section uses imaginary ions. Thus you can work here on neutrality without even having to think about real chemicals. (Real ions rarely have a charge greater than ±3. Imaginary ions, of course, do not have this restriction. Good practice!)

1. A^{+} and R^{2-}	2. A^{+} and T^{3-}	3. E^{3+} and Q^{-}
4. G^{4+} and Q^{-}	5. G^{4+} and R^{2-}	6. D^{2+} and R^{2-}
7. D^{2+} and X^{4-}	8. D^{2+} and T^{3-}	9. D^{2+} and Z^{5-}
10. E^{3+} and R^{2-}	11. G^{4+} and T^{3-}	12. G^{4+} and Z^{5-}

B. This section uses real monatomic ions. Most of these are common ions that you should be able to figure out from the periodic table; however, you are given the ions, including the charge. All you need to do is to achieve neutrality.

13. Na^{+} and S^{2-}	14. Na^{+} and N^{3-}	15. Al^{3+} and Cl^{-}
16. Pb^{4+} and Cl^{-}	17. Pb^{4+} and O^{2-}	18. Ca^{2+} and S^{2-}
19. Al^{3+} and Br^{-}	20. Ca^{2+} and N^{3-}	21. Ca^{2+} and Br^{-}
22. Al^{3+} and S^{2-}	23. Al^{3+} and N^{3-}	24. Mg^{2+} and P^{3-}

C. This section uses real (and common) ions, including both monatomic and polyatomic ions. Note that all the polyatomic ions shown here are ones you should know.

25. Na^{+} and SO_4^{2-}	26. Na^{+} and PO_4^{3-}	27. K^{+} and PO_4^{3-}
28. NH_4^{+} and Br^{-}	29. Mg^{2+} and SO_4^{2-}	30. Al^{3+} and NO_3^{-}
31. Ca^{2+} and CO_3^{2-}	32. Ca^{2+} and PO_4^{3-}	33. Ca^{2+} and NO_3^{-}
34. NH_4^{+} and S^{2-}	35. Pb^{2+} and OH^{-}	36. NH_4^{+} and SO_4^{2-}

Answers

Sect A.

1. A_2R	2. A_3T	3. EQ_3
4. GQ_4	5. GR_2	6. DR
7. D_2X	8. D_3T_2	9. D_5Z_2
10. E_2R_3	11. G_3T_4	12. G_5Z_4

Sect B.

13. Na_2S	14. Na_3N	15. $AlCl_3$
16. $PbCl_4$	17. PbO_2	18. CaS
19. $AlBr_3$	20. Ca_3N_2	21. $CaBr_2$
22. Al_2S_3	23. AlN	24. Mg_3P_2

Sect C.

25. Na_2SO_4	26. Na_3PO_4	27. K_3PO_4
28. NH_4Br	29. $MgSO_4$	30. $Al(NO_3)_3$
31. $CaCO_3$	32. $Ca_3(PO_4)_2$	33. $Ca(NO_3)_2$
34. $(NH_4)_2S$	35. $Pb(OH)_2$	36. $(NH_4)_2SO_4$