Balancing Equations

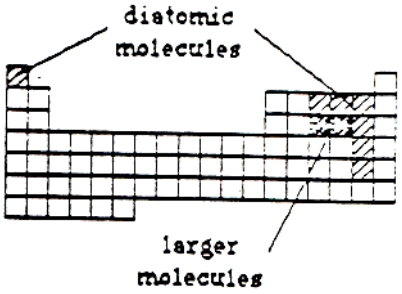
1. Formulas for Elements

Most of the elements exist in the form of atoms. Thus they are represented simply by their symbols. But a few of the elements exist as molecules and are represented by formulas. The major portion of these elements are **diatomic**, meaning that they exist as molecules containing two atoms each. The diatomic elements are:

H_2 O_2 F_2 Br_2 I_2 N_2 Cl_2

Two other elements exist as larger molecules.
Phosphorus has the formula: **P_4**.
Sulfur has the formula: **S_8**.

One can remember these special elements by noticing their positions on the periodic table.



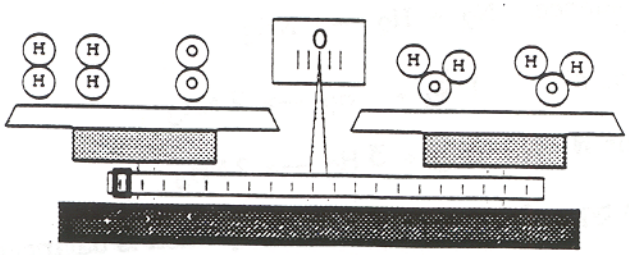
2. Balancing Equations

The law of conservation of matter tells us that there must be the same number of atoms after a chemical reaction as before one. Yet when we write an equation for some reactions, things just don't seem to add up! Like in the equation below:

$$H_2 + O_2 \longrightarrow H_2O$$

The formulas are all correct, so no changes can be made there. Instead we must write in **coefficients** to balance the equation. Coefficients indicate how many of each molecule enters into the reaction. In adding up the atoms on each side, the coefficients act as multipliers. The coefficient times the subscript gives the number of each atom present. With the proper coefficients, this equation now adds up! We have a **balanced equation**.

$$2\ H_2 + 1\ O_2 \longrightarrow 2\ H_2O$$



The rules we will use for balancing equations are listed below. Read them over carefully and study the sample problems to see how they are applied. Then try your hand at balancing the equations at the end of the section.

How to Balance Equations

Balance only **one kind** of **atom** at a time!!!

1. **Start with** an atom that appears only once on each side of the equation. Place a coefficient on each side to balance that atom.
2. **Continue choosing** atoms that need only one new coefficient to become balanced.
3. Balance polyatomic ions as a group.
4. Save hydrogen and oxygen for last.
5. **If you get totally stuck**, try doubling (or tripling, etc.) all the coefficients already entered.

General Rules

1. Don't change any subscripts in formulas.
2. Coefficients must be inserted in front of all of the formulas. Even if they have a value of 1.

Hints and Tips

1. Use a pencil.
2. Coefficients are multipliers. The coefficient times the subscript will give the total number of each kind of atom. Subscripts outside of a parenthesis are multiplied by each subscript inside the parenthesis.
3. The number of similar atoms in different formulas on the same side of the equation must be totaled.
4. You may check your result by taking inventory on each side of the equation. The totals on each side must be the same.
5. The resulting coefficients should be the smallest whole numbers possible. Reduce if necessary.

Sample Problem 1 Balance: $N_2 + H_2 \rightarrow NH_3$

Solution Balance the **N:** $\mathbf{1}\ N_2 + H_2 \rightarrow \mathbf{2}\ NH_3$

Balance the **H:** $1\ N_2 + \mathbf{3}\ H_2 \rightarrow 2\ NH_3$

Since each type of atom "adds up" the equation is balanced!

Sample Problem 2 Balance: $H_3PO_4 + MgCO_3 \rightarrow Mg_3(PO_4)_2 + H_2CO_3$

Solution Balance the **Mg:** $H_3PO_4 + \mathbf{3}\ MgCO_3 \rightarrow \mathbf{1}\ Mg_3(PO_4)_2 + H_2CO_3$

Balance the **P:** $\mathbf{2}\ H_3PO_4 + 3\ MgCO_3 \rightarrow 1\ Mg_3(PO_4)_2 + H_2CO_3$

Balance the **H:** $2\ H_3PO_4 + 3\ MgCO_3 \rightarrow 1\ Mg_3(PO_4)_2 + \mathbf{3}\ H_2CO_3$

Check the **O:** 8-O 9-O = 8-O 9-O

Check the **C:** O-C 3-C = O-C 3-C

The oxygen and carbon "add up" so the equation is balanced!

Sample Problem 3 Balance: $Zn_3Sb_2 + H_2O \rightarrow Zn(OH)_2 + SbH_3$

Solution Balance the **O:** $Zn_3Sb_2 + \mathbf{2}\ H_2O \rightarrow \mathbf{1}\ Zn(OH)_2 + SbH_3$

Balance the **Zn:** **?** $Zn_3Sb_2 + 2\ H_2O \rightarrow 1\ Zn(OH)_2 + SbH_3$ **Oops!**

... We are stuck, so erase all the coefficients and start over with a different atom.

Balance the **Sb:** $\mathbf{1}\ Zn_3Sb_2 + H_2O \rightarrow Zn(OH)_2 + \mathbf{2}\ SbH_3$

Balance the **Zn:** $1\ Zn_3Sb_2 + H_2O \rightarrow \mathbf{3}\ Zn(OH)_2 + 2\ SbH_3$

Balance the **O:** $1\ Zn_3Sb_2 + \mathbf{6}\ H_2O \rightarrow 3\ Zn(OH)_2 + 2\ SbH_3$

Check the **H:** O - H 12 - H = 6-H 6-H

The hydrogen "adds up" so the equation is balanced!

Problems

Balance each equation following the rules you learned in class. You may want to transfer these to another sheet of paper so you have more room to solve each problem, but if you do, make sure you copy all subscripts correctly! Use a pencil so that you can cleanly erase if you need to!

1. _____ $CoCl_2$ + _____ Fe → _____ $FeCl_3$ + _____ Co
2. _____ $KClO_3$ → _____ KCl + _____ O_2
3. _____ H_2O + _____ Mg_3N_2 → _____ $Mg(OH)_2$ + _____ NH_3
4. _____ $FeCl_3$ + _____ NaOH → _____ $Fe(OH)_3$ + _____ NaCl
5. _____ H_2O + _____ P_2O_5 → _____ H_3PO_4
6. _____ $NaNO_3$ → _____ $NaNO_2$ + _____ O_2

7. _____ BCl_3 + _____ P_4 + _____ H_2 → _____ BP + _____ HCl

8. _____ H_2S + _____ O_2 → _____ H_2O + _____ SO_2

9. _____ Fe + _____ H_2O → _____ Fe_3O_4 + _____ H_2

10. _____ NH_3 + _____ H_2SO_4 → _____ $(NH_4)_2SO_4$

11. _____ CO_2 + _____ C → _____ CO

12. _____ F_2 + _____ NaOH → _____ NaF + _____ O_2 + _____ H_2O

13. _____ $(NH_4)_2CO_3$ → _____ NH_3 + _____ CO_2 + _____ H_2O

14. _____ Ca_3N_2 + _____ H_2O → _____ $Ca(OH)_2$ + _____ NH_3

15. _____ $Pb(OH)_2$ → _____ PbO + _____ H_2O

16. _____ K_3PO_4 + _____ $MgCl_2$ → _____ $Mg_3(PO_4)_2$ + _____ KCl

17. _____ Al_2O_3 + _____ C + _____ Cl_2 → _____ CO + _____ $AlCl_3$

18. _____ Cl_2 + _____ NaOH → _____ NaCl + _____ NaClO + _____ H_2O

19. _____ Sb + _____ Cl_2 → _____ $SbCl_3$

20. _____ $Ca(HCO_3)_2$ + _____ $Ca(OH)_2$ → _____ $CaCO_3$ + _____ H_2O

21. _____ Al + _____ $CuCl_2$ → _____ Cu + _____ $AlCl_3$

22. _____ H_2SO_4 + _____ $Ba(NO_3)_2$ → _____ $BaSO_4$ + _____ HNO_3

23. _____ NaCl + _____ $Hg_2(NO_3)_2$ → _____ Hg_2Cl_2 + _____ $NaNO_3$

24. _____ P_4 + _____ O_2 → _____ P_2O_5

25. _____ $AlCl_3$ + _____ NaOH → _____ $Al(OH)_3$ + _____ NaCl

26. _____ H_2S + _____ $ZnCl_2$ → _____ ZnS + _____ HCl

27. _____ C_5H_{12} + _____ O_2 → _____ CO_2 + _____ H_2O

28. _____ Na_3PO_4 + _____ $AgNO_3$ → _____ Ag_3PO_4 + _____ $NaNO_3$

29. _____ Na_3PO_4 + _____ $Cu(NO_3)_2$ → _____ $Cu_3(PO_4)_2$ + _____ $NaNO_3$

30. _____ $C_{24}H_{26}$ + _____ O_2 → _____ CO_2 + _____ H_2O

For the remaining equations use the ion table **from the last chapter** to write the formulas for the compounds. For the elements, recall what you learned in the first section **of this chapter**. Then balance as before.

31. copper + silver nitrate → silver + copper (II) nitrate
32. potassium chlorate → potassium chloride + oxygen
33. iron + oxygen → iron (III) oxide
34. hydrogen sulfide + oxygen → water + sulfur (Tip – the compound hydrogen sulfide, not the ion)
35. zinc phosphate + aluminum sulfate → zinc sulfate + aluminum phosphate
36. chlorine + sodium iodide → sodium chloride + iodine
37. calcium + water → calcium hydroxide + hydrogen
38. copper (I) oxide + oxygen → copper (II) oxide
39. hydrogen + sulfur → hydrogen sulfide (Tip – the compound hydrogen sulfide, not the ion)
40. zinc + copper (II) sulfate → zinc sulfate + copper
41. ammonium dichromate + lead (II) chloride →lead (II) dichromate + ammonium chloride
42. calcium carbonate + hydrochloric acid → carbon dioxide + calcium chloride + water
43. nitrogen + oxygen → nitrogen dioxide
44. aluminum + phosphoric acid → aluminum phosphate + hydrogen
45. carbonic acid + potassium hydroxide → potassium carbonate + water
46. sulfur + oyxgen → sulfur trioxide
47. sodium hydroxide + carbon dioxide → sodium carbonate + water