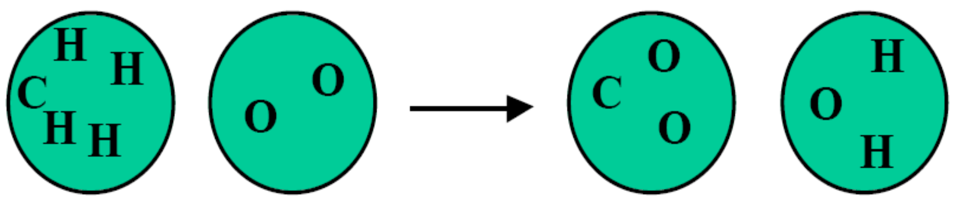
Module 5: Balancing Chemical Equations

Introduction

A chemical reaction is an example of a chemical change and it involves rearrangement of atoms or group of atoms to make new atoms. In this process atoms are neither created nor destroyed, thus satisfying the Law of Conservation of Mass. Only when this law is satisfied can the reaction be used to make quantitative relationships. A **balanced chemical reaction** is a chemical equation that has the same number of atoms of each element involved in the reaction on each side of the equation. Thus, the essence of balancing a chemical reaction is to make sure the Law of Conservation of Mass is satisfied.

Take for example, the reaction between methane and oxygen to form carbon dioxide and water. The equation is given by

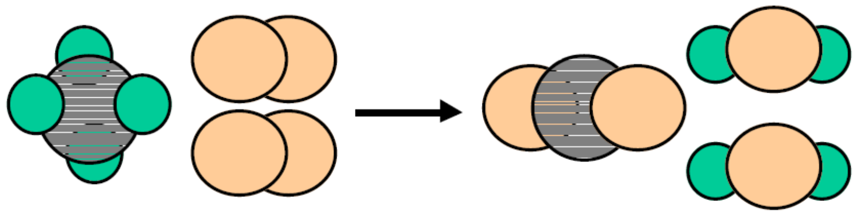
$$CH_4 + O_2 \rightarrow CO_2 + H_2O$$



LHS	**RHS**
C = 1	**C = 1**
H = 4	**H = 2**
O = 2	**O = 3**

Clearly, for this reaction the number of atoms on the left hand side (LHS) is not equal to the number of atoms on the right hand side (RHS). To achieve this, we need to use coefficients in front of the reactants or products. An **equation coefficient** is a number placed to the left of a chemical formula in a chemical equation that changes the amount but not the identity of a substance. By putting 2 in front of O_2 and 2 in front of H_2O, we can make the atoms on the LHS equals that on the RHS as shown below.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$



LHS

C = 1

H = 4

O = 4

RHS

C = 1

H = 4

O = 4

The following must be noted when balancing any chemical reaction.

(a) Do not ever change the chemical formula subscript of the reactants or products when balancing a chemical reaction. For example, in the reaction above it would have been incorrect to change O_2 to O_4 in order to balance the equation. You must leave the chemical formulas just as they are given. The only thing you can do is to place coefficients in front of the chemical formulas.

(b) It is also important to note that an atom may be present as an element, a compound, or an ion.

(c) Coefficients used must give the give the smallest integer to give a balanced chemical equation.

For example, the balance chemical equation between potassium and water to form hydrogen and potassium hydroxide is

$$2K_{(s)} + 2H_2O_{(l)} \rightarrow H_{2(g)} + 2KOH_{(aq)}$$

Not

$$4K_{(s)} + 4H_2O_{(l)} \rightarrow 2H_{2(g)} + 4KOH_{(aq)}$$

The chemical equation below has been balanced using the guided steps below:

___Fe_3O_4 + ____H_2 → _____Fe + _____H_2O

Guided Steps to Balancing a Chemical Reaction

1. Examine the chemical equation and pick one element to balance first.
   Let's balance O first. There are four O atoms on the LHS and only one O atom on the RHS. To balance for O atoms, we put a four in front of H_2O. By placing one and four in front of Fe_3O_4 and H_2O, we have balance for the oxygen on either side. Now there are four O atoms on either side of the equation.

   1 Fe_3O_4 + ____H_2 → _____Fe + **4** H_2O

2. Next pick a second element to balance. Let's balance for Fe, next. This can be achieved by putting a three in front of Fe in the product. Now there are three Fe atoms on either side of the equation.

   1 Fe_3O_4 + ____H_2 → **3** Fe + 4 H_2O

3. Now pick a third element to balance. The only element left to balance is the H. Currently there are eight H atoms on the RHS but only two H atoms on the LHS. To balance for H, we therefore put a four in front of H_2 on the LHS.

$$\underline{1}\ Fe_3O_4 + \underline{\mathbf{4}}\ H_2 \rightarrow \underline{3}\ Fe + \underline{4}\ H_2O$$

4. As a final check on the correctness of the balancing procedure, count atoms on each side of the chemical equation

$$Fe_3O_4 + \mathbf{4}\ H_2 \rightarrow \mathbf{3}\ Fe + \mathbf{4}\ H_2O$$

Atom	LHS	RHS
Fe	1 × 3 = 3	3 × 1 = 3
O	1 × 4 = 4	4 × 1 = 4
H	4 × 2 = 8	4 × 2 = 8

Balancing Chemical Equations – Practice Exercises

Complete these practice exercises on this text document. Submit your work.

Watch lecture video and supplement video on Reactions before doing this lab.

Indicate in the spaced provided next to the equations below whether each of the chemical equations is balanced or unbalanced.

1. $FeO + CO \rightarrow Fe + CO_2$ ______balanced______
2. $CH_4 + O_2 \rightarrow H_2O + CO_2$ ____________________
3. $NH_3 + HNO_3 \rightarrow NH_4NO_3$ ____________________
4. $KCl + O_2 \rightarrow KClO_3$ ____________________
5. $Mg + O_2 \rightarrow MgO$ ____________________
6. $NaBr + AgNO_3 \rightarrow AgBr + NaNO_3$ ____________________
7. $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$ ____________________
8. $PCl_3 + H_2 \rightarrow PH_3 + HCl$ ____________________

For each of the following balanced chemical equations below, indicate how many atoms of each element are present on the reactant (LHS) and product (RHS) sides of the chemical reaction.

9. $2Cu + O_2 \rightarrow 2\,CuO$ LHS 2 Cu, 2 O___ RHS 2 Cu, 2 O____

10. $2H_2O \rightarrow 2H_2 + O_2$ LHS________________RHS________________

11. $BaCl_2 + Na_2S \rightarrow BaS + 2NaCl$ LHS_____________RHS______________

12. $2C_3H_8O + 9O_2 \rightarrow 8H_2O + 6CO_2$ LHS___________RHS_____________

13. $N_2 + 3H_2 \rightarrow 2NH_3$ LHS________________RHS________________

14. $4Fe + 3O_2 \rightarrow 2Fe_2O_3$ LHS________________RHS________________

15. $Au_2S_3 + 3H_2 \rightarrow 3H_2S + 2Au$ LHS____________RHS_____________

16. $C_4H_{10}O + 6O_2 \rightarrow 5H_2O + 4CO_2$ LHS____________RHS_____________

Using coefficients only, balance each of the following chemical equations.

17. __2_N_2 + ___3_O_2 $\rightarrow$ ___2_N_2O_3

18. ___NH_3 + ____NO $\rightarrow$ _____N_2 + ____H_2O

19. ___CS_2 + ____O_2 $\rightarrow$ _____CO_2 + ____SO_2

20. ___Mg + ____HBr $\rightarrow$ _____$MgBr_2$ + _____H_2

21. ___Al + ____O_2 $\rightarrow$ _____Al_2O_3

22. ___Na + ____H_2O $\rightarrow$ _____$NaOH$ + _____H_2

23. ___Co + ____$HgCl_2$ $\rightarrow$ _____$CoCl_3$ + _____Hg

24. ___NH_3 + ____O_2 $\rightarrow$ _____N_2O + _____H_2O

25. ___PbO + ____NH_3 $\rightarrow$ _____Pb + _____N_2 + ____H_2O

26. ___$NaHCO_3$ + ____H_2SO_4 $\rightarrow$ _____Na_2SO_4 + ____H_2O + ____CO_2

27. ___TiO_2 + ____Cl_2 + ____C $\rightarrow$ _____$TiCl_4$ + _____CO_2

28. ___NBr_3 + ____$NaOH$ $\rightarrow$ _____N_2 + ____$NaBr$ + ____$HBrO$

29. ___NH_3 + ____O_2 + ____CH_4 $\rightarrow$ _____HCN + _____H_2O

30. ___$KClO_3$ + ____HCl → _____KCl + ____Cl_2 + ____H_2O

31. ___SO_2Cl_2 + ____HI → _____H_2S + ____H_2O + ___HCl + ___I_2

32. ___NO + ____CH_4 → _____HCN + _____H_2O + ____H_2

33. ___C_5H_{12} + ____O_2 → _____CO_2 + _____H_2O

34. ___C_5H_{10} + ____O_2 → _____CO_2 + _____H_2O

35. ___C_5H_8 + ____O_2 → _____CO_2 + _____H_2O

36. ___$C_5H_{10}O$ + ____O_2 → _____CO_2 + _____H_2O

37. ___C_6H_{14} + ____O_2 → _____CO_2 + _____H_2O

38. ___C_6H_{12} + ____O_2 → _____CO_2 + _____H_2O

39. ___C_6H_{10} + ____O_2 → _____CO_2 + _____H_2O

40. ___$C_6H_{10}O_2$ + ____O_2 → _____CO_2 + _____H_2O

41. ___$Ca(OH)_2$ + ____HNO_3 → _____$Ca(NO_3)_2$ + _____H_2O

42. ___$BaCl_2$ + ____$(NH_4)_2SO_4$ → _____$BaSO_4$ + _____NH_4Cl

43. ___$Fe(OH)_3$ + ____H_2SO_4 → _____$Fe_2(SO_4)_3$ + _____H_2O

44. ___Na_3PO_4 + ____$AgNO_3$ → _____$NaNO_3$ + _____Ag_3PO_4

45. ___Al + ____$Sn(NO_3)_2$ → _____$Al(NO_3)_3$ + _____Sn

46. ___$Al(NO_3)_3$ + ____H_2SO_4 → _____$Al_2(SO_4)_3$ + _____HNO_3

47. ___Na_2CO_3 + ____$Mg(NO_3)_2$ → _____$MgCO_3$ + _____$NaNO_3$

48. ___$Ba(C_2H_3O_2)_2$ + ___$(NH_4)_3PO_4$ → ___$Ba_3(PO_4)_2$ + ___$NH_4C_2H_3O_2$

49. ___Fe_2O_3 + ___CO → ___Fe_3O_4 + ___CO_2

50. ___WO_3 + ___H_2 → ___W + ___H_2O