Balancing Chemical Equations - Answers

A balanced equation has equal numbers of each type of atom on each side of the equation.

The Law of Conservation of Mass is the rationale for balancing a chemical equation. The law was discovered by Antoine Laurent Lavoisier (1743-94) and this is his formulation of it, translated into English in 1790 from the Traité élémentaire de Chimie (which was published in 1789):

"We may lay it down as an incontestable axiom, that, in all the operations of art and nature, nothing is created; an equal quantity of matter exists both before and after the experiment; the quality and quantity of the elements remain precisely the same; and nothing takes place beyond changes and modifications in the combination of these elements."

A less wordy way to say it might be: "Matter is neither created nor destroyed." Therefore, we must finish our chemical reaction with as many atoms of each element as when we started. Remember this: A balanced equation MUST have EQUAL numbers of EACH type of atom on BOTH sides of the arrow.

An equation is balanced by changing **coefficients** in a somewhat trial-and-error fashion. It is important to note that **ONLY** the **coefficients** can be changed, **NEVER** a **subscript**. Coefficients are whole numbers written in front of a molecule's formula.

Lets look at the following example: $H_2 + O_2 \rightarrow H_2O$

The correct way to balance the above equation is as follows: $2 H_2 + O_2 \rightarrow 2 H_2O$

Note that in order to balance this equation coefficients were placed in front of two formula. The number one is never used as a coefficient. If no coefficient is written, it is understood to be one.

After balancing an equation you should always check to see that there are the same number of each atom on either side of the arrow. If we check our equation above we see that there are 4 hydrogen on the left (2x2=4) and 4 hydrogen on the right (2x2=4); there are 2 oxygen on the left and 2 oxygen on the right (2x1=2).

Two things you CANNOT do when balancing an equation.

You cannot change a subscript. For example, in the following equation you cannot change the oxygen's subscript in water from one to two, as in: H₂ + O₂ → H₂O₂

True, this balances the equation, but you have changed the substances in it. H_2O_2 is a completely different substance from H_2O_2 .

2. You cannot place a coefficient in the middle of a formula. The subscript goes at the beginning of a formula, not in the middle, as in: $H_2 + O_2 \rightarrow H_2O$

There are three rules to follow when balancing chemical equations. They do not work every time, but they do work most times and most people find them helpful.

- 1. If there is an element that is not bonded to any other atom or is diatomic, balance it last.
- For example in the equation: $CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$, oxygen is diatomic. When balancing this equation, balance oxygen last.
- 2. If you are balancing an equation with both hydrogen and oxygen and neither is a diatomic molecule, balance hydrogen last and balance oxygen second to last. For example in the equation: $CO_2 + NH_3 --> OC(NH_2)_2 + H_2O$, both hydrogen and oxygen are used and neither exist as a diatomic molecule. When balancing this equation, balance hydrogen last and oxygen second to last.
 - 3. If you come to the point where you have an odd number of elements on one side of the equation, try doubling the coefficient.

One final note: Make sure that your final set of coefficients is **reduced to the lowest whole number ratio**. Also, you may want to use pencil instead of pen. You will be doing a good deal of erasing at first.

Homework: Balance the following equations.

1.
$$2 H_2 + O_2 \rightarrow 2 H_2O$$

3.
$$S_8 + 12 O_2 \rightarrow 8 SO_3$$

5. **2** HgO
$$\rightarrow$$
 2 Hg + O₂

7.
$$Zn + 2 HCl \rightarrow ZnCl_2 + H_2$$

11.
$$C_{10}H_{16} + 8 Cl_2 \rightarrow 10 C + 16 HCl$$

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

4.
$$2 N_2 + O_2 \rightarrow 2 N_2 O$$

6.
$$6 \text{ CO}_2 + 6 \text{ H}_2 \text{O} \rightarrow \text{ C}_6 \text{H}_{12} \text{O}_6 + 6 \text{ O}_2$$

8.
$$SiCl_4 + 4 H_2O \rightarrow H_4SiO_4 + 4 HCl$$

10. **2**
$$H_{3}PO_{4} \rightarrow H_{4}P_{2}O_{7} + H_{2}O$$

12.
$$CO_2 + 2 NH_3 \rightarrow OC(NH_2)_2 + H_2O$$

- 13. $4 \operatorname{Si}_{2} \operatorname{H}_{3} + 11 \operatorname{O}_{2} \rightarrow 8 \operatorname{SiO}_{2} + 6 \operatorname{H}_{2} \operatorname{O}$
- 15. **4** Fe + **3** $O_2 \rightarrow 2$ Fe₂ O_3
- 17. $2 C_7 H_6 O_7 + 15 O_7 \rightarrow 14 CO_7 + 6 H_7 O_7$
- 19. $4 \text{ FeS}_2 + 11 O_2 \rightarrow 2 \text{ Fe}_2 O_3 + 8 SO_2$
- 21. $\operatorname{Fe_2O_3} + 3 \operatorname{H_2} \rightarrow 2 \operatorname{Fe} + 3 \operatorname{H_2O}$
- 23. $2 K + Br_2 \rightarrow 2 KBr$
- 25. $2 C_2 H_2 + 5 O_2 \rightarrow 4 CO_2 + 2 H_2 O_2$
- 27. **2** $H_2O_2 \rightarrow 2 H_2O + O_2$
- 29. $C_7H_{16} + 11 O_2 \rightarrow 7 CO_2 + 8 H_2O$
- 31. $SiO_2 + 4 HF \rightarrow SiF_4 + 2 H_2O$
- 33. $2 \text{ KClO}_3 \rightarrow 2 \text{ KCl} + 3 \text{ O}_2$
- 35. $4 \text{ KClO}_3 \rightarrow 3 \text{ KClO}_4 + \text{ KCl}$
- 37. $P_4O_{10} + 6 H_2O \rightarrow 4 H_3PO_4$
- 39. $4 \text{ Sb} + 3 \text{ O}_2 \rightarrow \text{ Sb}_4 \text{ O}_6$
- 41. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
- 43. $Fe_2O_3 + 3 CO \rightarrow 2 Fe + 3 CO_2$
- 45. $PCl_5 + 4 H_2O \rightarrow 5 HCl + H_3PO_4$
- 47. $8 \text{ H}_2\text{S} + 8 \text{ Cl}_2 \rightarrow \text{ S}_8 + 16 \text{ HCl}$
- 49. **3** Fe + **4** H₂O \rightarrow Fe₃O₄ + **4** H₂
- 51. Li₂O + H₂O **→ 2** LiOH
- 53. $CaC_2 + 2 H_2O \rightarrow C_2H_2 + Ca(OH)_2$
- 55. 2 $Fe(OH)_3 \rightarrow Fe_2O_3 + 3 H_2O$
- 57. **2** Pb(NO₃)₂ \Rightarrow **2** PbO + **4** NO₂ + O₂
- 59. BaO + H₂O \rightarrow Ba(OH)₂
- 61. $\mathbf{3} \operatorname{Ca} + \mathbf{2} \operatorname{AlCl}_{3} \rightarrow \mathbf{3} \operatorname{CaCl}_{2} + \mathbf{2} \operatorname{Al}$
- 63. 4 NH₃ + 6 NO \rightarrow 5 N₂ + 6 H₂O
- 65. $4 H_3 PO_3 \rightarrow 3 H_3 PO_4 + PH_3$
- 67. $Fe_2O_3 + 3 C \rightarrow 3 CO + 2 Fe$

- 14. 2 Al(OH)₃ + 3 H₂SO₄ \rightarrow Al₂(SO₄)₃ + 6 H₂O
- 16. $Fe_2(SO_4)_3 + 6 KOH \rightarrow 3 K_2SO_4 + 2 Fe(OH)_3$
- 18. $H_2SO_4 + 8 HI \rightarrow H_2S + 4 I_2 + 4 H_2O$
- 20. **2** Al + **3** FeO \rightarrow Al₂O₃ + **3** Fe
- 22. $Na_2CO_3 + 2 HCl \rightarrow 2 NaCl + H_2O + CO_3$
- 24. $P_4 + 5 O_2 \rightarrow 2 P_2 O_5$
- 26. $K_2O + H_2O \rightarrow 2 KOH$
- 28. **4** Al + **3** O₂ \rightarrow **2** Al₂O₃
- 30. **2** Na₂O₂ + **2** H₂O \rightarrow **4** NaOH + O₂
- 32. $C + H_2O \rightarrow CO + H_2$
- 34. $2 \text{ H}_3 \text{AsO}_4 \rightarrow \text{As}_2 \text{O}_5 + 3 \text{ H}_2 \text{O}_4$
- 36. $Al_2(SO_4)_3 + 3 Ca(OH)_2 \rightarrow 2 Al(OH)_3 + 3 CaSO_4$
- 38. $FeCl_3 + 3 NH_4OH \rightarrow Fe(OH)_3 + 3 NH_4Cl$
- 40. 2 $Ca_3(PO_4)_2 + 6 SiO_2 \rightarrow P_4O_{10} + 6 CaSiO_3$
- 42. $N_2O_5 + H_2O \rightarrow 2 HNO_3$
- 44. 2 Al + 6 HCl \rightarrow 2 AlCl₃ + 3 H₂
- 46. $6 \text{ H}_3 \text{BO}_3 \rightarrow \text{H}_4 \text{B}_6 \text{O}_{11} + 7 \text{ H}_2 \text{O}_{12}$
- 48. **3** Mg + $N_2 \rightarrow Mg_3N_2$
- 50. 2 NaOH + Cl₂ → NaCl + NaClO + H₂O
- 52. $H_3PO_4 + 5 HCl \rightarrow PCl_5 + 4 H_2O$
- 54. 2 HCl + $K_2CO_3 \rightarrow 2 KCl + H_2O + CO_3$
- 56. $Ca(ClO_3)_2 \rightarrow CaCl_2 + 3O_2$
- 58. $C_2H_5OH + 2O_2 \rightarrow 2CO + 3H_2O$
- 60. $Xe + 3 F_2 \rightarrow XeF_6$
- 62. $NH_4NO_3 \rightarrow N_2O + 2H_2O$
- 64. $Zn + 2 NaOH + 2 H₂O \rightarrow Na₂Zn(OH)₄ + H₂$
- 66. **2** $C_4H_{10} + 13 O_2 \rightarrow 8 CO_2 + 10 H_2O$
- 68. $Fe_3O_4 + 4 H_2 \rightarrow 3 Fe + 4 H_2O$

69. $4 \text{ FeS} + 7 \text{ O}_2 \rightarrow 2 \text{ Fe}_2 \text{O}_3 + 4 \text{ SO}_2$

71. $4 \text{ NH}_3 + 5 \text{ O}_2 \rightarrow 4 \text{ NO} + 6 \text{ H}_2\text{O}$

73. $4 \text{ Si} + \text{ S}_8 \rightarrow 2 \text{ Si}_2\text{S}_4$

75. $Hg_2CO_3 \rightarrow Hg + HgO + CO_2$

77. $SiC + 2 Cl_2 \rightarrow SiCl_4 + C$

79. $Al_4C_3 + 12 H_2O \rightarrow 3 CH_4 + 4 Al(OH)_3$

81. $V_2O_5 + 6 HCl \rightarrow 2 VOCl_3 + 3 H_2O$

83. $Ag_2S + 4 KCN \rightarrow 2 KAg(CN)_2 + K_2S$

85. $Au_2S_3 + 3 H_2 \rightarrow 2 Au + 3 H_2S$

87. $2 \text{ ClO}_2 + \text{ H}_2\text{O} \rightarrow \text{ HClO}_2 + \text{ HClO}_3$

89. $4 \text{ KO}_2 + 2 \text{ CO}_2 \rightarrow 2 \text{ K}_2 \text{CO}_3 + 3 \text{ O}_2$

91. **2** MgNH₄PO₄ \rightarrow Mg₂P₂O₇ + **2** NH₃ + H₂O

93. $3 O_2 \rightarrow 2 O_3$

95. **2** $Au_2O_3 \rightarrow 4 Au + 3 O_2$

97. $3 \text{ Hg}(OH)_2 + 2 \text{ H}_3PO_4 \rightarrow \text{Hg}_3(PO_4)_2 + 6 \text{ H}_2O$

99. $2 I_4 O_9 \rightarrow 2 I_2 O_6 + 2 I_2 + 3 O_2$ (numerous answers)

70. Pb + 4 Na + 4 C₂H₅Cl \rightarrow Pb(C₂H₅)₄ + 4 NaCl

72. $I_2 + 6 \text{ HNO}_3 \rightarrow 2 \text{ HIO}_3 + 6 \text{ NO}_2 + 3 \text{ H}_2$

74. 2 $C_6H_6 + 15 O_2 \rightarrow 12 CO_2 + 6 H_2O$

76. $C_2H_5OH + 3 O_2 \rightarrow 2 CO_2 + 3 H_2O$

78. **12** HClO₄ + P₄O₁₀ \rightarrow **4** H₃PO₄ + **6** Cl₂O₇

80. $3 \text{ BaCl}_2 + \text{Al}_2(SO_4)_3 \rightarrow 3 \text{ BaSO}_4 + 2 \text{ AlCl}_3$

82. $(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + 4 H_2O$

84. 2 NaHCO₃ \rightarrow Na₂CO₃ + CO₂ + H₂O

86. $Fe_2(C_2O_4)_3 \rightarrow 2 FeC_2O_4 + 2 CO_2$

88. $Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3$

90. **2** As + **6** NaOH \rightarrow **2** Na₃AsO₃ + **3** H₂

92. $MnO_2 + 4 HCl \rightarrow MnCl_2 + 2 H_2O + Cl_2$

94. $Ca(OH)_2 + H_3PO_4 \rightarrow CaHPO_4 + 2 H_2O$

96. $SrBr_2 + (NH_4)_2CO_3 \rightarrow SrCO_3 + 2 NH_4Br$

98. 2 Ca₃(PO₄)₂ + 6 SiO₂ + 10 C \rightarrow 6 CaSiO₃ + P₄ + 10 CO

100. 2 $C_2H_3C1 + 5 O_2 \rightarrow 4 CO_2 + 2 H_2O + 2 HC1$

Extra Credit (10 points!!!): Balance the following. You MUST show all of your work!!!

10 $[Cr(N_2H_4CO)_6]_4[Cr(CN)_6]_3 + 1176 \text{ KMnO}_4 + 1399 \text{ H}_2SO_4 \rightarrow$

 $\mathbf{35}\,\mathrm{K_2Cr_2O_7} + \,\, \mathbf{1176}\,\mathrm{MnSO_4} + \,\, \mathbf{420}\,\mathrm{CO_2} + \,\, \mathbf{660}\,\mathrm{KNO_3} + \,\, \mathbf{223}\,\mathrm{K_2SO_4} + \,\, \mathbf{1879}\,\mathrm{H_2O}$