These notes are posted on my site for the following reasons:

- for students to copy in their own hand-writing
  - in order to complete their class notes
  - if student did not have enough time in class
  - if student was away and missed this section
- for assistants and tutors to follow progress of the concepts taught

Photocopied/printed notes can not be used during the Unit Notebook Check in class.

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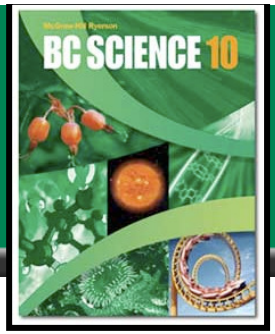
# 4.3 Balancing Chemical Equations




- **Chemical reactions result in chemical changes.**
  - **Chemical changes occur when new substances are created.**
  - **The original substance(s), called reactants, change into new substance(s) called products.**
- **Chemical reactions can be written in different ways.**
  - **A word equation:**
    - **Nitrogen monoxide + oxygen → nitrogen dioxide**
  - **A symbolic equation:**
    - $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$

*State of matter*

*- Letters indicate the state of each compound*

*(aq) = aqueous/dissolved in water*

*(s) = solid*

*(ℓ) = liquid*

*(g) = gas*

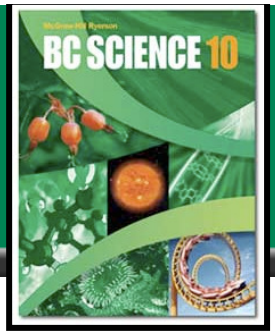
*Coefficients*

*- indicate the ratio of compounds in the reaction*

*- here, there is twice as much NO and $NO_2$ than there is $O_2$*

See pages 202 - 203

# Conservation of Mass in Chemical Change

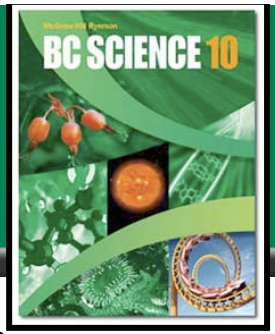



- **Chemical change means new compounds are created.**
  - **BUT no new matter is created or destroyed; atoms are just rearranged.**
  - **All of the matter in the reactants = all of the matter in the products**
  - **John Dalton, 200 years ago, realized that atoms simply rearrange themselves during chemical reactions.**
  - **Number of each atom in reactants = number of each atom in products**
- **The Law of Conservation of Mass**
  - **In chemical reactions, atoms are neither created nor destroyed**
  - **Developed by Antoine Lavoisier and his wife Maire-Anne in the 1700s**
  - **Mass of reactants = Mass of products**

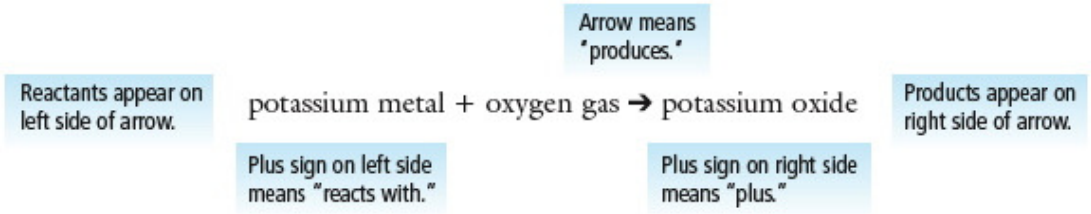
If you could collect and measure all of the exhaust from this car, you would find that mass of reactants (gas + $O_2$) = mass of products (exhaust)!

See pages 204 - 205

# Writing and Balancing Chemical Equations



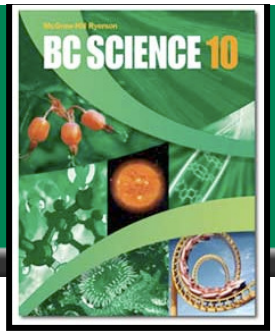

- **The simplest form of chemical equation is a word equation**
  - **Not much information other than the elements/compounds involved**
    - **Potassium metal + oxygen gas → potassium oxide**



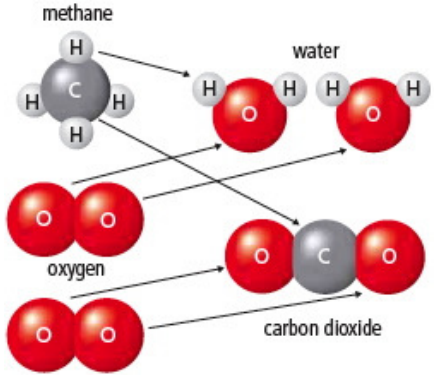

- **A skeleton equation shows the formulas of the elements/compounds**
  - **Shows atoms, but not quantities of atoms**
    - $K_{(s)} + O_{2\ (g)} \rightarrow K_2O_{(s)}$
- **A balanced chemical equation shows all atoms and their quantities**
  - **Balancing ensures that the number of each atom is the same on both sides of the reaction arrow**
  - **Always use the smallest whole number ratio**
    - $4K_{(s)} + O_{2\ (g)} \rightarrow 2K_2O_{(s)}$

See page 206

# Counting Atoms to Balance an Equation




- **Because of the Law of Conservation of Mass, we can count atoms and use math to balance the number of atoms in chemical equations.**
  - **Word equation:** Methane + oxygen → water + carbon dioxide
  - **Skeleton equation:** $CH_{4(g)} + O_{2\,(g)} \rightarrow H_2O_{(\ell)} + CO_{2(g)}$
    - **To balance the compounds, take note of how many atoms of each element occur on each side of the reaction arrow:**




  - **Skeleton equation:** $CH_{4(g)} + O_{2\,(g)} \rightarrow H_2O_{(\ell)} + CO_{2(g)}$

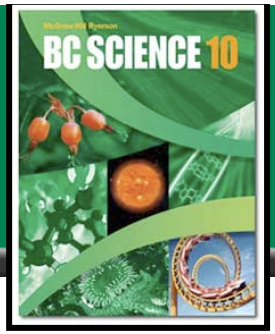
**1 Carbon, 4 Hydrogen, 2 Oxygen → 1 Carbon, 2 Hydrogen, 3 Oxygen**

  - **To balance, attempt to find values that equate atoms on both sides**
  - **Balanced equation:** $CH_{4(g)} + 2O_{2\,(g)} \rightarrow 2H_2O_{(\ell)} + CO_{2(g)}$

**1 Carbon, 4 Hydrogen, (2x2) Oxygen → 1 Carbon, (2x2) Hydrogen, (2x1)+2 Oxygen**

See page 207

# Hints for Writing Word Equations

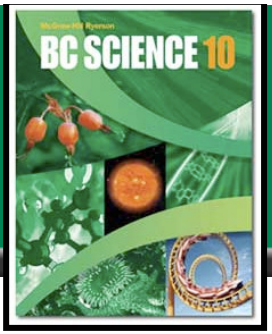



- **Word equations require careful examination to be written correctly.**
  - **The chemical symbol is used for most elements not in a compound**
    - **Be careful of diatomic and polyatomic elements such as $O_2$, $P_4$ and $S_8$**
    - **The "special seven" are all diatomic elements**
      - **$H_2$, $N_2$, $O_2$, $F_2$, $Cl_2$, $Br_2$, $I_2$**
  - **Several common covalent molecules containing hydrogen have common names that do not help in writing chemical formulas**
    - **For example, methane = $CH_4$, glucose = $C_6H_{12}O_6$, Ethane = $C_2H_6$, Ammonia = $NH_3$**

| 1 | | | | | | | | | | | | | | | | | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 + H Hydrogen 1.0 | | | | | | | | | | | | | | | | | 2 0 He Helium 4.0 |
| | | | | | | | | | | | | 14 | 15 | 16 | 17 | | |
| | | | | | | | | | | | | 6 C Carbon 12.0 | 7 3– N Nitrogen 14.0 | 8 2– O Oxygen 16.0 | 9 – F Fluorine 19.0 | | 10 0 Ne Neon 20.2 |
| | | | | | | | | | | | | 14 Si Silicon 28.1 | 15 3– P Phosphorus 31.0 | 16 2– S Sulphur 32.1 | 17 – Cl Chlorine 35.5 | | 18 0 Ar Argon 39.9 |
| | | | | | | | | | | | | 32 4+ Ge Germanium 72.6 | 33 3– As Arsenic 74.9 | 34 2– Se Selenium 79.0 | 35 – Br Bromine 79.9 | | 36 0 Kr Krypton 83.8 |
| | | | | | | | | | | | | 50 4+ 2+ Sn Tin 118.7 | 51 3+ 5+ Sb Antimony 121.8 | 52 2– Te Tellurium 127.6 | 53 – I Iodine 126.9 | | 54 0 Xe Xenon 131.3 |
| | | | | | | | | | | | | 82 2+ 4+ Pb Lead 207.2 | 83 3+ 5+ Bi Bismuth 209.0 | 84 2+ 4+ Po Polonium (209) | 85 – At Astatine (210) | | 86 0 Rn Radon (222) |

See page 208

# Strategies for Balancing Equations

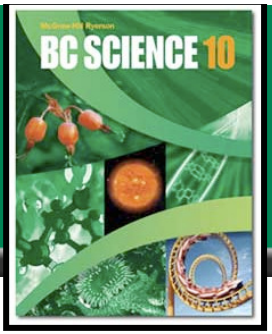



- **Balance chemical equations by following these steps:**
  - Trial and error will work, but can be very inefficient
  - Balance compounds first, elements last
  - Balance one compound at a time
  - Only add coefficients; NEVER change subscripts!
  - If H and O appear in more than one place, attempt to balance them LAST
  - Polyatomic ions (such as $SO_4^{2-}$) can often be balanced as a whole group
  - Always double-check after you think you are finished!
- **Balance the following:**
  - $Fe + Br_2 \rightarrow FeBr_3$
  - $Sn(NO_2)_4 + K_3PO_4 \rightarrow KNO_2 + Sn_3(PO_4)_4$
  - $C_2H6 + O_2 \rightarrow CO_2 + H_2O$

See pages 209 - 211

Take the Section 4.3 Quiz

# Conservation of Mass in Chemical Change




- **Chemical change means new compounds are created.**
  - **BUT no new matter is created or destroyed.**
  - **All of the matter in the reactants = all of the matter in the products**
  - **John Dalton, 200 years ago, realized that atoms simply rearrange themselves during chemicl reactions.**
- **Motion motion motion motion motion motion motion.**
  - **Motion motion motion motion motion motion motion.**
    - **Motion motion motion motion motion motion motion.**

Who is this player?

See pages 8 - 9

Take the Section 8.1 Quiz