SCIENCE 10
RADIOACTIVE DECAY

Learning Outcomes:
- I can describe some of the properties of the three types of radiation (alpha, beta and gamma radiation).
- I can complete radioactive equations.

Radioactivity
- the release of **energy** as a result of changes in the **nuclei** of an atom
- scientists discovered that when radioactive energy was given off, the atoms of one type of element were changed into the atoms of **another** type of element
- isotopes that are unstable become stable by losing **energy** by emitting radiation
  - this process of giving off radiation is called **radioactive decay**
  - when an atom of an element **decays**, it usually turns into a **different** type of atom

Types of Radiation
- *TEACHER NOTE: While working at McGill University in Montreal, Ernest Rutherford discovered that there are three common types of radiation*

1. Alpha Radiation
   - a stream of **alpha** particles → called **alpha decay**
   - alpha particle is the same as the nucleus of a **helium** atom ($^{4}_{2}\mathrm{He}$ or $^{4}_{2}\alpha$)
   - because there is only 2 protons and 2 neutrons present, an alpha particle has a charge of **+2**
   - largest and most massive type of radiation
     - relatively **slow** moving
     - does not **penetrate** through other objects → can be stopped by a **sheet of paper**
   - since 2 protons are given off, a different type of **element** is formed with an atomic **number** 2 less than the parent atom
   - Example: $^{208}_{84}\mathrm{Po} \rightarrow {}^{204}_{82}\mathrm{Pb} + {}^{4}_{2}\alpha$

     Daughter Isotope

     Parent Isotope $\longrightarrow {}^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\mathrm{He}$

Practice Problems
a. $^{208}_{84}\mathrm{Po} \rightarrow \mathbf{^{204}_{82}Pb} + {}^{4}_{2}\alpha$
b. $^{231}_{91}\mathrm{Pa} \rightarrow \mathbf{^{227}_{89}Ac} + {}^{4}_{2}\mathrm{He}$
c. $\mathbf{^{225}_{89}Ac} \rightarrow {}^{221}_{87}\mathrm{Fr} + {}^{4}_{2}\alpha$
d. $\mathbf{^{196}_{79}Au} \rightarrow {}^{192}_{77}\mathrm{Ir} + {}^{4}_{2}\alpha$
e. $\mathbf{^{211}_{87}Fr} \rightarrow {}^{207}_{85}\mathrm{At} + {}^{4}_{2}\mathrm{He}$

2. Beta Radiation
   - a beta particle is equal to a high energy **electron** → called **beta decay**
   - written as $\mathbf{{}^{0}_{-1}e}$ **or** $\mathbf{{}^{0}_{-1}\beta}$
   - has a charge of **-1**
   - lightweight and **fast** moving
     - can penetrate more than an alpha particle
     - can be stopped by a sheet of **aluminum foil**
   - the electron comes from the breakdown of a **neutron** → forms an **electron** and a **proton** → increases the atomic number by 1
   - example: $^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}\beta$
     $^{131}_{53}\mathrm{I} \rightarrow {}^{131}_{54}\mathrm{Xe} + {}^{0}_{-1}e$

Practice Problems

a. $^{14}_{6}\mathrm{C} \rightarrow \mathbf{{}^{14}_{7}N} + {}^{0}_{-1}\beta$
b. $^{6}_{2}\mathrm{He} \rightarrow \mathbf{{}^{6}_{3}Li} + {}^{0}_{-1}\beta$
c. $^{24}_{11}\mathrm{Na} \rightarrow \mathbf{{}^{24}_{12}Mg} + {}^{0}_{-1}e$
d. $\mathbf{{}^{201}_{79}Au} \rightarrow {}^{201}_{80}\mathrm{Hg} + {}^{0}_{-1}\beta$
e. $\mathbf{{}^{52}_{26}Fe} \rightarrow {}^{52}_{27}\mathrm{Co} + {}^{0}_{-1}\beta$
f. $\mathbf{{}^{42}_{19}K} \rightarrow {}^{42}_{20}\mathrm{Ca} + {}^{0}_{-1}e$

3. Gamma Radiation
   - a ray of high-energy, **short** wavelength **radiation** → called **gamma decay**
     - results when the nucleus of an atom has too much **energy**
   - written as $\mathbf{{}^{0}_{0}\gamma}$
   - has almost no mass and no charge
     - has great **penetrating** power
     - need thick blocks of **dense** material (lead or concrete) to stop it
   - does not result in the formation of a new atom
   - example: $\mathbf{{}^{60}_{28}Ni^{*}} \rightarrow \mathbf{{}^{60}_{28}Ni} + \mathbf{{}^{0}_{0}\gamma}$ the * means **extra** energy in the nucleus of the isotope
   - gamma decay can result when other types of radioactive decay result in a new atom with too much energy in the nucleus
   - example: $^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th}^{*} + {}^{4}_{2}\alpha$
     then $^{234}_{90}\mathrm{Th}^{*} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{0}_{0}\gamma$