7.3 NUCLEAR REACTIONS

(Refer to pp. 312-325 in BC Science 10)

- Nuclear fission and fusion are processes that involve extremely large amounts of energy.
  - Fission: the splitting of nuclei
  - Fusion: the joining of nuclei

NUCLEAR FISSION
- Nuclear energy used to produce power comes from fission.
  - nuclear fission: the splitting of one heavy nucleus into two or more smaller nuclei, subatomic particles and energy.
  - A heavy nucleus is usually unstable, due to many positive protons pushing apart.
- When fission occurs:
  1. energy is released
  2. neutrons are released

NUCLEAR REACTIONS VS. CHEMICAL REACTIONS
- Nuclear reactions are different than chemical reactions.
  - In chemical reactions, mass is conserved, and energy changes are relatively small.
    - There are no changes to the nuclei in chemical reactions.
  - nuclear reaction: the process in an atom's nucleus changes by gaining or releasing particles or energy
In nuclear reactions, the actual nuclei of atoms changes. **protons**, **neutrons**, **electrons**, and/or **gamma rays** can be lost or gained.

**small** changes of mass = **huge** changes in energy.

Refer to Table 7.8 on p. 314

NUCLEAR EQUATIONS FOR INDUCED NUCLEAR REACTIONS

- Natural radioactive decay consists of the release of **alpha**, **beta** and **gamma** radiation.
- Scientists can also create nuclear reactions by **bombarding** nuclei with alpha, beta and gamma radiation.

Two ways to write the nuclear equation for induced nuclear reactions:

\[
\begin{align*}
\frac{4}{2}\text{He} + \frac{14}{7}\text{N} &\rightarrow \frac{17}{8}\text{O} + \frac{1}{1}\text{H} \\
\text{Bombarding alpha particle} &\rightarrow \text{Target nitrogen atom} & \text{Oxygen atom} &\rightarrow \text{Hydrogen atom}
\end{align*}
\]

Two ways to write the nuclear equation for induced nuclear reactions:

\[
\begin{align*}
\frac{4}{2}\alpha + \frac{14}{7}\text{N} &\rightarrow \frac{17}{8}\text{O} + \frac{1}{1}\text{p} \\
\text{proton released!} &\rightarrow \text{Or} \\
\frac{4}{2}\text{He} + \frac{14}{7}\text{N} &\rightarrow \frac{17}{8}\text{O} + \frac{1}{1}\text{H}
\end{align*}
\]

RULES FOR WRITING NUCLEAR EQUATIONS

- Same rules as for radioactive decay:
  1. The sum of the mass numbers on each side stays the same.
  2. The sum of the charges on each side of the equation stays the same.

**Complete the Reading Check on p. 315**
NUCLEAR FISSION OF URANIUM-235

• It is much easier to crash a neutral neutron than a positive proton into a nucleus to release energy.
  
  • Nuclear fission of uranium-235 is the main nuclear reaction in both nuclear fission reactors and weapons.
  
  • A neutron, \( ^{0}n \), crashes into an atom of stable uranium-235 to create unstable uranium-236, which then undergoes radioactive decay.
  
  • After several steps, atoms of krypton and barium are formed, along with the release of 3 neutrons and huge quantities of energy.

\[ ^{0}n + ^{235}\text{U} \rightarrow ^{92}\text{Kr} + ^{141}\text{Ba} + 3 ^{0}n + \text{energy} \]

**Complete the Practice Problems on p. 317**

CHAIN REACTIONS

• chain reaction: an ongoing process in which one fission reaction initiates the next reaction.

• Once the nuclear fission reaction has started, it can keep going.
  
  • The neutrons released in the induced reaction can then trigger more reactions on other uranium-235 atoms.
  
  • This chain reaction can quickly get out of control.
    
    • some materials can absorb some neutrons can help to control the chain reaction.
    
    • Nuclear reactors have complex systems to ensure the chain reaction stays at safe levels.
    
    • An uncontrolled chain reaction can result in a violent nuclear explosion.
CANDU REACTORS AND HAZARDOUS WASTES

Canada’s nuclear research into the **safe** use of nuclear reactions has resulted in the creation of CANDU reactors.
- CANDU reactors are found in various countries around the world and use nuclear fission of **uranium-235**.
- Hazardous wastes produced by nuclear reactions are problematic.
  - Some waste products can be **re-used**, some must be stored away from living things and is buried **underground** or stored in **concrete**.
  - It will take 20 half-lives (20,000 of years) before the material is safe.

NUCLEAR FUSION

- **nuclear fusion**: a process in which **two low mass nuclei** join together to make a **more massive nucleus**.
  - In the core of the **sun** and other **stars**, two **hydrogen** nuclei join under tremendous heat and pressure to form a helium nucleus.
  - When the helium atom is formed, huge amounts of energy are released.
    \[
    _2^1H + _3^1H \rightarrow _4^2He + _0^1n + \text{energy}
    \]
  - Scientists **cannot** yet find a safe, manageable method to harness the energy of nuclear fusion.
- Refer to Table 7.11 on p. 321

**Complete p. 325 #1, 2, 6-10**