Name:

**Nuclear Chemistry**

Date:

Marie Curie was the first woman to be awarded the Nobel Prize. She was awarded this honor for her discoveries and studies of the elements radium and polonium. She later died of aplastic anemia, a blood disease that often results from exposure to large amounts of radiation. It was the exposure to large amounts of radiation that caused Marie Curie’s death, but what is **radiation** and why do certain elements produce it? Radiation is a form of energy and different types of radiation have different amounts of energy and different dangers. We have already talked about isotopes, like C-14 and C-12. The difference between these 2 isotopes is the number of neutrons they have in the nucleus. C-12 has 6 neutrons and C-14 has 8 neutrons. The more neutrons in the nucleus of an atom,

the more unstable the element is. All of the elements that have an atomic number higher than 83 are radioactive. The most stable elements have a ratio of 1 neutron to 1 proton (like C-12). As the ratio increases, like 1.3:1 in C-14, the atom becomes more unstable and will undergo nuclear decay, which is when the nucleus releases a nuclear particle in order to become more stable. These unstable isotopes which undergo radioactive decay are called **radioisotopes**.

1. What is radiation?

2. How are radiation and isotopes linked?

3. What types of isotopes decay?

4. What is released from nuclear decay?

Elements exist in various isotopes in nature, many of which are radioactive in nature, such as carbon-14. C-14 is a radioisotope used to measure the age of fossils and relics (carbon dating). Carbon dating works through the process of C-14 decaying into another element over time. All organisms have some quantity of C-14 as part of their chemical composition. Once an organism dies, the amount of C-14 stops renewing and any existing C-14 begins to decay into N-14. This is nuclear chemistry because it involves a changing nucleus. While the nuclei of all elements can never decompose chemically, they can undergo a nuclear decay. Nuclear decay causes changes in the number of neutrons or protons in the nucleus. Some elements, like uranium, will break down naturally because of the atomic instability. This is called a **natural transmutation** – it is natural because it happens spontaneously. All radioisotopes decay until their nuclei are stable and no longer radioactive.

5. How does C-14 become N-14?

6. Describe natural transmutation.

When radioisotopes undergo nuclear decay, they can release large quantities of energy and always release smaller particles. The particles generated by a decaying nucleus each have a different amount of energy and penetrating power (ability to pass through materials). The following types of radiation are the most common**:** alpha particles, beta particles and gamma rays. **Alpha particles** (42*α* OR 42He) are essentially a helium nuclei composed of 2 neutrons and 2 protons. They are positively charged, the largest radiation particle and slow moving. They can be blocked by only a piece of paper. **Beta particles** (0-1*β* OR 0-1e) are electrons that are created during decay and are emitted from the nucleus. They are negatively charged and have no mass. They are blocked by thin layers of lead. When a Beta particle is released, one of the neutrons in the nucleus mutates and becomes a proton which is reabsorbed. **Gamma radiation** (00*γ*) is pure energy produced when a nucleus decays. It has no mass, no charge, is the smallest radiation particle and has extremely high energy. For this reason, it is able to pass through several centimeters of lead or several meters of concrete. This is the most dangerous form of radiation. Occasionally, nuclear decay can result in the release of a neutron. The neutron (10n) has no charge, but has a mass of 1 and needs to be shielded by several feet of concrete.

7. What is released when isotopes decay?

8. Fill in the following chart with the information in the reading

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name of particle** | **Symbol** | **Charge** | **Mass** | **Penetrating Power**  **(Rank from lowest to highest 1-4)** |
| **Alpha** |  |  |  |  |
| **Beta** |  |  |  |  |
| **Gamma** |  |  |  |  |
| **Neutron** |  |  |  |  |

When an elements nucleus decays and undergoes natural transmutation to become a new element, the strong nuclear forces that holds the particles together is released. But the total mass and total charges of the starting elements and the decay products after transmutation must be equal. For example:

*I-131 undergoes β* decay as a natural transmutation.

131

53I 

0-1e +

131

54Xe *\*\*\*Notice the total mass and charge on both sides of the equation are equal\*\*\**

Uranium undergoes alpha decay

238

92U 

42He +

234

90Th

Calculate the missing particles:

a) 22288Ra 21886Rn +

b) 21483Bi 21081Tl +