Name: ____________________________________ **Date:** ________

Chemistry ~ *Ms. Hart* **Class:** Anions or Cations

THE URBAN ASSEMBLY SCHOOL FOR CRIMINAL JUSTICE

Nuclear Chemistry – Study Guide

Radioactive isotopes have many beneficial uses. Radioactive isotopes are used in medicine and industrial chemistry for radioactive dating, tracing chemical and biological processes, industrial measurement, nuclear power, and detection and treatment of diseases. There are inherent risks associated with radioactivity and the use of radioactive isotopes. Risks can include biological exposure, long-term storage and disposal, and nuclear accidents. There are benefits and risks associated with fission and fusion reactions.

- Co-60 is used to treat cancer
- I-131 is used for thyroid treatment / detection
- U-238 is used for geological dating (e.g. rocks)
- C-14 is used for organic dating (e.g. living things)
- Risks associated with any radiation – Can cause damage to DNA which can kill cells or cause mutations.
- Advantages of Nuclear Power – lower greenhouse gases, low cost to produce, more efficient (e.g. more energy produced than fossil fuels because some mass is converted to energy)
- Risks for Nuclear Power – Potential exposure of workers to radiation, disposal of nuclear waste is difficult, risk of meltdown could expose people to radiation or contaminate (e.g. – Chernobyl, Fukoshima)

Spontaneous decay can involve the release of alpha particles, beta particles, positrons, and/or gamma radiation from the nucleus of an unstable isotope. These emissions differ in mass, charge, ionizing power, and penetrating power.

- All radiation particles are found in Table O. Use this to compare the mass and charge of each.
- Alpha particles have the lowest penetrating power, but the highest ionizing power. Gamma Rays have the highest penetrating power, but the lowest ionizing power.

Stability of an isotope is based on the ratio of neutrons and protons in its nucleus. Although most nuclei are stable, some are unstable and spontaneously decay, emitting radiation. Each radioactive isotope has a specific mode and rate of decay (half-life).

- Unstable nuclei tend to be atoms that have much more protons than neutrons, much more neutrons than protons, or an atomic # greater than 83.
- Use Table N to find the decay modes for specific radio isotopes and to find their half lives.
- Be able to solve half life problems. Remember that every half life means that half of the substance decays into a new one (e.g. multiply initial amt. by ½ for each half life that has passed). (Multiply by 2 if you have the remaining amount, and you want to find out how much you started with).

A change in the nucleus of an atom that converts it from one element to another is called transmutation. This can occur naturally or can be induced by the bombardment of the nucleus with high-energy particles.

- Natural transmutation will be an element on its own on the right side of the equation decaying into 2 or more new substances on the left. (Beta, alpha, positron decay)
- Artificial transmutation will have a particle that you are bombarding and element with on the left side of the eqn, (so an element plus a alpha, beta, positron, neutron, etc.).

Energy released in a nuclear reaction (fission or fusion) comes from the fractional amount of mass that is converted into energy. Nuclear changes convert matter into energy. Energy released during nuclear reactions is much greater than the energy released during chemical reactions.

- Fusion is 2 lighter atoms creating one heavier atoms.
- Fission is one heavier atom being bombarded with a neutron to split into 2 lighter atoms + more neutrons which create a chain reaction.
- Both produce much more energy than chemical reactions because some mass is converted into energy.

Nuclear reactions can be represented by equations that include symbols which represent atomic nuclei (with mass number and atomic number), subatomic particles (with mass number and charge), and/or emissions such as gamma radiation.

- To solve for the missing isotope or particle, you need to make sure that the mass and atomic number on the left and right sides of the equation are equal to each other.

Alpha Decay

A nuclear reaction in which an alpha particle (α) is given off as the result of nuclear disintegration.

Alpha Particle

A helium nucleus (atomic number 2, atomic mass 4), referred to by the symbol alpha (α) or $^{4}_{2}He$.

Artificial Transmutation

Bombardment of nuclei by accelerated particles causes nuclei to become unstable and may result in the formation of isotopes or new elements.

Beta Decay

A nuclear reaction in which a beta particle (β) is given off as the result of nuclear disintegration. Beta particles are high-speed electrons.

Beta Particle

A high speed electron (0 atomic mass, −1 charge); referred to by the symbol β or $^{0}_{-1}e$

Fission Reaction

A nuclear reaction in which a heavy nucleus is split into lighter nuclei accompanied by the release of energy. An example is neutron capture, resulting in fission fragments, the liberation of energy, and the release of two or more neutrons. The release of energy is the result of the conversion of mass into energy.

Fusion Reaction

A nuclear reaction in which two lighter nuclei combine to form a heavier nucleus, accompanied by the release of energy.
Since each nucleus carries a positive charge, nuclei repel one another with increasing strength as they are moved closer together. Consequently, for the nuclei to interact, they must have enough kinetic energy to overcome the repulsion. The thermonuclear approach, through the use of very high temperatures, may provide the means for controlled fusion.

Gamma Radiation

Gamma rays (γ) are similar to high energy x-rays.

Half-Life

The time required for one-half of the nuclei of a given sample of a radioactive isotope to disintegrate.

- Nothing changes the half-life of a radioactive isotope.

Isotopes

Atoms with the same atomic number but a different number of neutrons. For a given element, the number of protons in the nucleus remains constant, but the number of neutrons may vary. For example, ^{14}C and ^{12}C are isotopes of carbon.

Mass Number

The number of nucleons (protons and neutrons) in the nucleus of an element; indicated by a supercript, for example, ^{14}C indicates carbon-14.

Natural Transmutation

The production of a new element as a result of changes within the nucleus.

Nuclear Energy

A form of energy that is released in nuclear reactions.

- In nuclear reactions, mass is converted into nuclear energy.
- In conventional chemical reactions, mass is neither gained nor lost; only in nuclear reactions is there a conversion of mass to energy.