Name: _____ **Date:** _____

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

10.2 Radioactive Decay

SPARK:

Types of Radiation: Alpha, Beta, and Gamma

Three types of radiation have been discovered. The types are called alpha, beta and gamma. **Alpha** rays turned out to be small particles of matter with a charge of +2 and a mass of 4 amu. It has been proved that an alpha particle contains two protons and two neutrons – it is identical to the nucleus of a helium atom. In fact, when an alpha particle slows down and gains two electrons it becomes a helium atom. The Greek letter alpha (α) is used to represent this particle but in equations to keep track of mass and protons we must use ${}^{4}_{2}He$. **Betas** were also found to be particles; they are simply high-speed electrons. We use the Greek letter beta (β), but in equations ${}^{0}_{-1}e$ is used. When a beta slows down it becomes an electron. **Gamma** rays (γ) are not particles; they are high-energy electromagnetic radiation. They are photons (light) with no charge or mass so we simply write ${}^{0}_{0}\gamma$ in our equations.

Example 1: Thorium-232 decays by emitting an alpha and a gamma.

$${}^{232}_{90}Th \rightarrow {}^{4}_{2}He + \gamma + {}^{228}_{88}Ra$$

Example 2: Uranium-239 decays by emitting a beta and a gamma.

$${}^{239}_{92}U \rightarrow {}^{0}_{-1}e + \gamma + {}^{239}_{93}Np$$

NOTE: notice that 92 – [-1] = 93; there is always an increase in the atomic number with beta emission.

In the above examples you should notice that the sum of the masses on the left of the arrow equals the sum of the masses on the right of the arrow and that the sum of the protons on the left equals the sum of the protons on the right.

1. Complete the following table.

Name	Charge	Mass	Greek Symbol	Equation Symbol	Identity
ALPHA					
BETA					
GAMMA					

When an atom undergoes radioactive decay the product nucleus is often unstable and undergoes further decay. This occurs until a stable nucleus is produced. (There is no way for a student to know how an atom will decay. We will always tell you the mode of decay for equations.)

Penetrating Power:

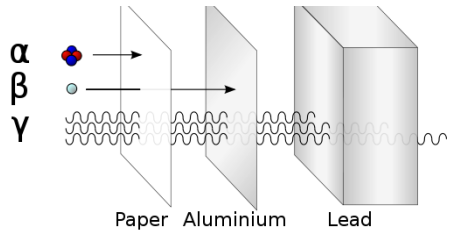
Effects of Radiation on Living Matter

Prolonged exposure to radiation often has detrimental effects on living matter. This is due to radiation's ionizing ability, which can damage the internal functioning of cells. Radiation either ionizes or excites atoms or molecules in living cells, leading to the dissociation of molecules within an organism. The most destructive effect radiation has on living matter is ionizing radiation on DNA. Damage to DNA can cause cellular death, mutagenesis (the process by which genetic information is modified by radiation or chemicals), and genetic transformation. Effects from exposure to radiation include leukemia, birth defects, and many forms of cancer.

Most external radiation is absorbed by the environment; for example, most ultraviolet radiation is absorbed by the ozone layer, preventing deadly levels of ultraviolet radiation to come in contact with the surface of the earth.

Sunburn is an effect of UV radiation damaging skin cells, and prolonged exposure to UV radiation can cause genetic information in skin cells to mutate, leading to skin cancer.

Alpha, beta, and gamma rays also cause damage to living matter, in varying degrees. Alpha particles have a very small absorption range, and thus are usually not harmful to life, unless ingested, due to its high ionizing power. Beta particles are also damaging to DNA, and therefore are often used in radiation therapy to mutate and kill cancer cells. Gamma rays are often considered the most dangerous type of radiation to living matter. Unlike alpha and beta particles, which are charged particles, gamma rays are instead forms of energy. They have large penetrating range and can diffuse through many cells before dissipating, causing widespread damage such as radiation sickness. Because gamma rays have such high penetrating power and can damage living cells to a great extent, they are often used in irradiation, a process used to kill living organisms.



(Courtesy of Ehamberg and Stannered on Wikimedia Commons, available under Creative Commons Attribution 2.5 Generic license.)

*Put alpha, beta, and gamma radiation in order of HIGHEST TO LOWEST penetrating power:

Stability:

The table below indicates the stability of six nuclides.

Stability of Six Nuclides

Nuclide	Stability
C-12	stable
C-14	unstable
N-14	stable
N-16	unstable
O-16	stable
O-19	unstable

What do you notice about unstable elements?

PRACTICE:

1.Which type of radiation would be attracted to the positive electrode in an electric field?

1. $^{0}_{-1}e$ 2. $^{1}_{1}H$ 3. $^{4}_{2}He$ 4. $^{1}_{0}n$

2.Which nuclear reaction is classified as alpha decay?

1. $^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e$
2. $^{42}_{19}K \rightarrow ^{42}_{20}Ca + ^{0}_{-1}e$
3. $^{226}_{88}Ra \rightarrow ^{222}_{86}Rn + ^{4}_{2}He$
4. $^{3}_{1}H \rightarrow ^{0}_{-1}e + ^{3}_{2}He$

3.Gamma rays are emanations that have

1. mass but no charge
2. neither mass nor charge
3. charge but no mass
4. both mass and charge

4.Which of the following particles has the greatest mass?

1. an alpha particle 2. a proton 3. a beta particle 4. an electron

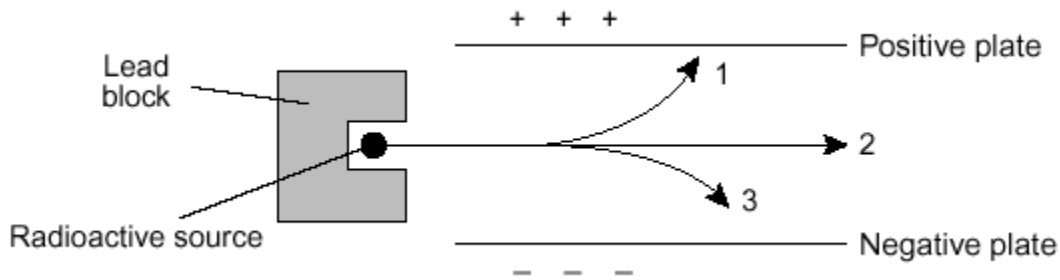
5.Which type of emission has the highest penetrating power?

1. alpha 2. positron 3. beta 4. gamma

6.Which list of particles is in order of *increasing* mass?

1. proton → electron → alpha particle
2. proton → alpha particle → electron
3. electron → proton → alpha particle
4. alpha particle → electron → proton

7.The diagram represents radioactive emanations passing through an electric field.



Which type of emanation is represented by the arrow labeled 1?

1. alpha particle
2. Positron
3. beta particle
4. gamma ray

8. Which equation represents positron decay?

1. $^{87}_{37}Rb \rightarrow {}^{0}_{-1}e + {}^{87}_{38}Sr$
2. $^{227}_{92}U \rightarrow {}^{223}_{90}Th + {}^{4}_{2}He$
3. $^{27}_{13}Al + {}^{4}_{2}He \rightarrow {}^{30}_{15}P + {}^{1}_{0}n$
4. $^{11}_{6}C \rightarrow {}^{0}_{+1}e + {}^{11}_{5}B$

9. Positrons are spontaneously emitted from the nuclei of

1. potassium-37
2. nitrogen-16
3. radium-226
4. thorium-232

10. According to Reference Table *N*, which pair of isotopes spontaneously decays?

1. C-12 and N-14
2. C-14 and N-14 2
3. C-12 and N-16
4.C-14 and N-16

11. Which notation of a radioisotope is correctly paired with the notation of its emission particle?

1. ^{37}Ca and $^{4}_{2}He$
2. ^{235}U and $^{0}_{+1}e$
3. ^{16}N and $^{1}_{1}p$
4. ^{3}H and $^{0}_{-1}e$

12. Which nuclear decay emission consists of energy, only?

1. alpha particle
2. gamma radiation
3. beta particle
4. positron

13. What is the decay mode of ^{37}K?

1. β^-
2. γ
3. β^+
4. α

14. Given the nuclear equation:

$$^{19}_{10}Ne \rightarrow X + {}^{19}_{9}F$$

Which particle is represented by *X*?

(1) alpha (2) neutron (3) beta (4) positron

15. Which equation represents the radioactive decay of ^{226}Ra?

(1) $^{226}_{88}Ra \rightarrow ^{222}_{86}Rn + ^{4}_{2}He$
(2) $^{226}_{88}Ra \rightarrow ^{226}_{89}Ac + ^{0}_{-1}e$
(3) $^{226}_{88}Ra \rightarrow ^{226}_{87}Fr + ^{0}_{+1}e$
(4) $^{226}_{88}Ra \rightarrow ^{225}_{88}Ra + ^{1}_{0}n$

16. Which nuclear decay emission consists of energy, only?

(1) alpha particle (3) gamma radiation
(2) beta particle (4) positron

17. Which list of radioisotopes contains an alpha emitter, a beta emitter, and a positron emitter?

(1) C-14, N-16, P-32
(2) Cs-137, Fr-220, Tc-99
(3) Kr-85, Ne-19, Rn-222
(4) Pu-239, Th-232, U-238

18. According to Reference Table *N*, which pair of isotopes spontaneously decays?

(1) C-12 & N-14 (3) C-14 & N-14
(2) C-12 & N-16 (4) C-14 & N-16

19a. Read and annotate the following article:

What is nuclear energy?

Nuclear energy is a way of creating heat through the fission process of atoms. All power plants convert heat into electricity using steam. At nuclear power plants, the heat to make the steam is created when atoms split apart -- called fission.

It also releases energy in the form of heat. The released neutrons can then repeat the process. This releases even more neutrons and more nuclear energy. The repeating of the process is called a chain reaction. In a nuclear power plant, uranium is the material used in the fission process.

The heat from fission boils water and creates steam to turn a turbine. As the turbine spins, the generator turns and its magnetic field produces electricity. The electricity can then be carried to your home, so you can work on the computer, watch television, play video games, or make toast!
The U.S. Nuclear Regulatory Commission, also called the "NRC," regulates nuclear power plants. We make sure they are safe for people who work there and live nearby, and for the environment.
The NRC also regulates nuclear material that is used in science, medicine and industry. We issue licenses to those who operate power plants or use nuclear material, and we inspect them to make sure they're following our rules.

JUNE 30, 2008 - COVER STORY - The Case For and Against Nuclear Power By MICHAEL TOTTY
Is nuclear power the answer for a warming planet? Or is it too expensive and dangerous to satisfy future energy needs?

Interest in nuclear power is heating up, as the hunt intensifies for "green" alternatives to fossil fuels like coal and natural gas. Even some environmentalists have come on board, citing the severity of the global-warming threat to explain their embrace of the once-maligned power source.

But the issue is far from settled. Proponents insist that nuclear is a necessary alternative in an energy-constrained world. They say that the economics make sense -- and that the public has a warped image of the safety risks, thanks to Three Mile Island, Chernobyl and "The China Syndrome." Opponents, meanwhile, are convinced that the costs are way too high to justify the safety hazards, as well as the increased risks of proliferation.

Has nuclear's time come? The debate rages on.

19b. What is your initial opinion on nuclear power? We will be exploring this more next class!