Worksheet #1 : Radioactivity

Chemical reactions involve changing one substance into another substance by rearranging atoms. However, during a chemical reaction atoms of one element cannot change into atoms of another element. The reason this change cannot occur is that chemical reactions only involve an atom's electrons - the nucleus remains unchanged.

Recall that an atom's identity is based on its number of protons. Since protons are in the nucleus and chemical reactions do not involve the nucleus, the atom remains unchanged. However, there are some reactions that do involve changes in the nucleus. These are called nuclear reactions and do change one atom of an element into an atom of a different element.

1. Fill in the table below as a review. **You will need your periodic table for this!** Remember the atomic number (or # of protons) determines the element. If you have four protons and seven neutrons you have beryllium. The same is true if you have four protons and six neutrons...you still have beryllium.

Isotope	Total Protons (Atomic #)	Total Neutrons (Mass # - Atomic #)	Mass Number*	Total Electrons Outside Nucleus	Format for Nuclear Equation
K-40	19	21	40	19	$^{40}_{19}K$
Li-6	3	3	6	3	$^{6}_{3}Li$
He-3	2	1	3	2	
~~I~~ I-131	53	78	131	53	$^{131}_{53}I$
Sr-90	38	52	90	38	$^{90}_{38}Sr$

***NOTE: Do NOT use the mass numbers from your periodic table.**

Radioactivity is when a substance spontaneously emits radiation. Radioactive atoms (or radioisotopes) emit radiation because their nuclei are unstable. Unstable nuclei lose energy by emitting radiation in a spontaneous process called radioactive decay. Unstable radioactive atoms undergo radioactive decay until they form stable nonradioactive atoms. There are several types of radiation emitted during radioactive decay.

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.

2. Complete the following table.

Name	Charge	Mass	Greek Symbol	Equation Symbol	Identity
ALPHA	+2	4 amu	α	$^{4}_{2}He$	
BETA	-1	0	β	$^{0}_{-1}e$	
GAMMA	0	0	γ	$^{0}_{0}\gamma$	Energy

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.)

3. Write the nuclear equations for the following radioactive decay series. Use the periodic table in your book.

uranium-235 emits an alpha _____

thorium-231 emits a beta and a gamma _____

protactinium-231 emits an alpha and a gamma _____

actinium-227 emits a beta _____

Th-227 emits an alpha and a gamma _____

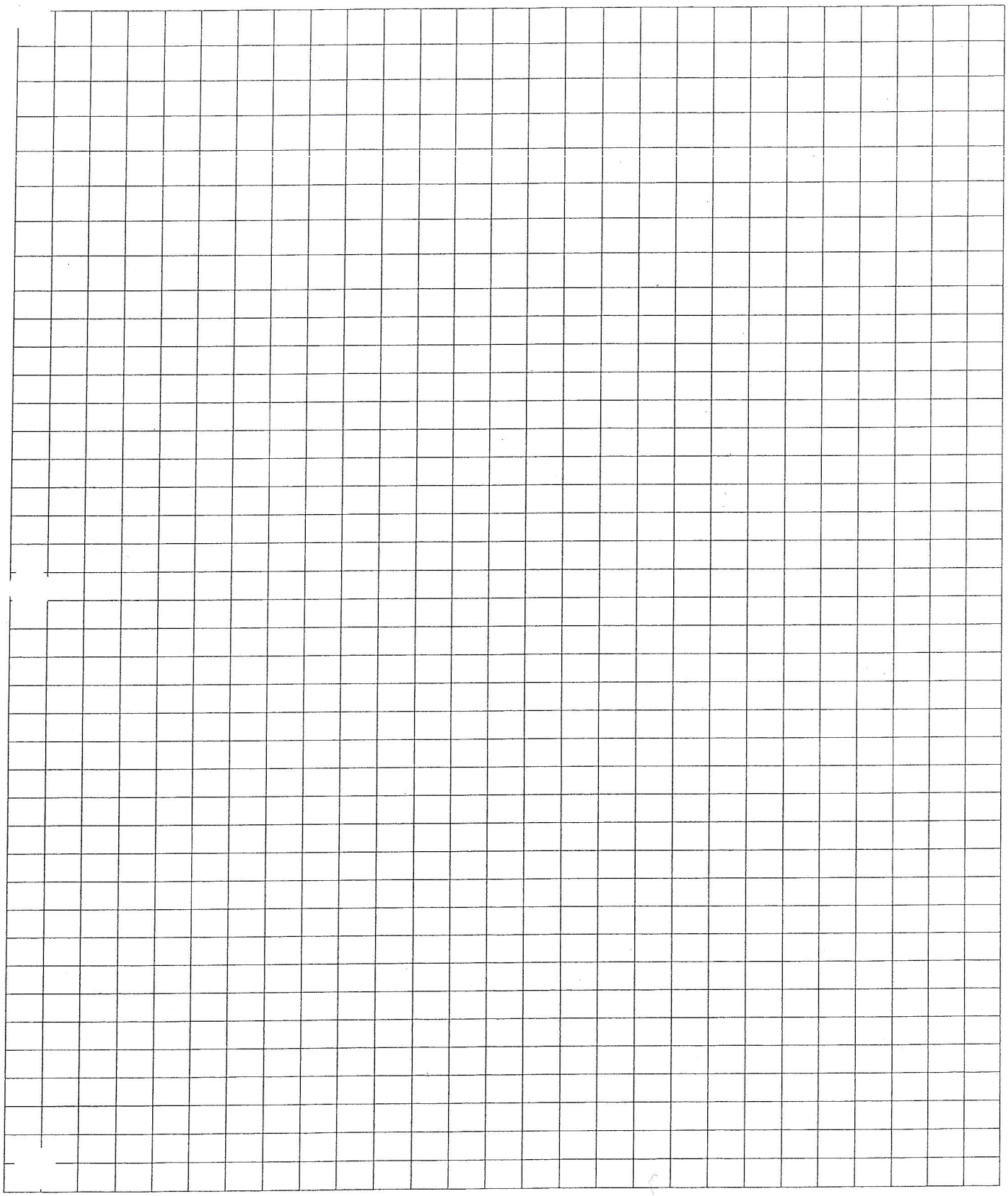
Ra-223 emits an alpha _____

Rn-219 emits an alpha _____

Po-215 emits an alpha and a gamma _____

4. Using a full sheet of graph paper, graph this U-238 decay series(refer to figure 25 on pg. 441). Have atomic number on the x-axis and mass number on the y-axis. Instead of dots make a circle and write the symbol for the element inside the circle. Connect the points as you make the graph, writing α, β or γ on the line to indicate the mode of decay. Make sure your graph has an appropriate title and covers at least half of the page.

Decay Series for U-235 Graph



Atomic Number