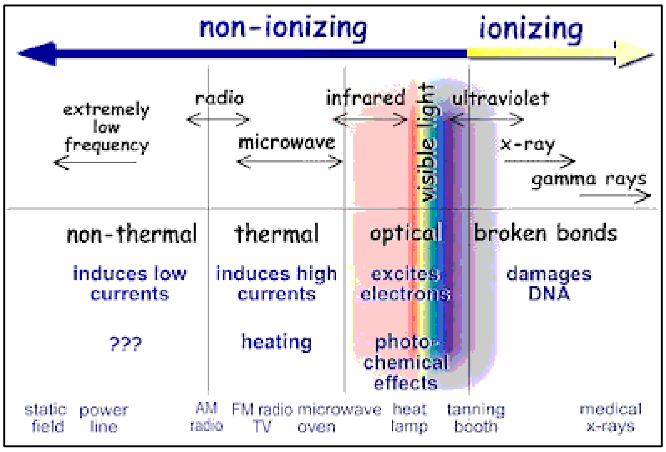
NUCLEAR CHEMISTRY

Name:_______________________________________Period:______Date:_______

Part I: RADIATION

1) ________________________________= a general term for any type of energy that emanates or radiates outward in all directions

2) ______________________________________ (ER) = radiation moving at the speed of light, ranging from high-energy gamma rays to low energy radio waves; includes visible light



3) __________________________________= particles or ER emitted from a nucleus during radioactive decay

4) __________________________________ = radiation with sufficient energy to ionize atoms or molecules (_________________ energy ER)

- detaches electrons from atoms or molecules, ionizing them
- Ex: Alpha and beta particles, gamma rays
- Damages ____________ molecules in cells!!

5) ____ = radiation with insufficient energy to ionize atoms or molecules (________________________ energy ER)

Part II: NUCLEAR RADIATION

1) The atom- A quick review:

a) ___________________= smallest particle of an element that retains the chemical properties of that element (atoms are the building blocks of matter)

- Composed of a densely packed central region (_________________) containing protons and neutrons with electrons outside the nucleus.

b) electron charge =_____; proton charge = _______; neutron charge = _____________

2) Chemical Reactions vs. Nuclear Reactions:

a) _________________________________– atoms change by sharing, gaining or losing valence electrons, but the nucleus is unchanged

- Ex: $Ba(NO_3)_2$ + 2NaCl → $2NaNO_3$ + $BaCl_2$

b) ________________________________ – atoms change by particles (protons/neutrons) in the nucleus changing

- Remember that the number of protons in an atom defines the element, so a change in _________________results in a change in the atom.
- Ex:

Comparison of Chemical & Nuclear Reactions	
CHEMICAL REACTIONS	*NUCLEAR REACTIONS*
• Occur when __________are broken and formed	• Occur when __________combine, split, and emit radiation
• Involve ______________valence electrons	• Can involve protons, neutrons, and electrons
• Associated with *SMALL* ____________changes	• Associated with LARGE ____________changes
• Atoms ______________the same identity although they might gain, lose, or share electrons, and form new substances	• Atoms of one element are often ____________ into atoms of another element
• Temperature, pressure, concentration, and catalysts affect reaction rates	• Temperature, pressure, concentration, and catalysts __________________normally affect reaction rates

3) Background Information:

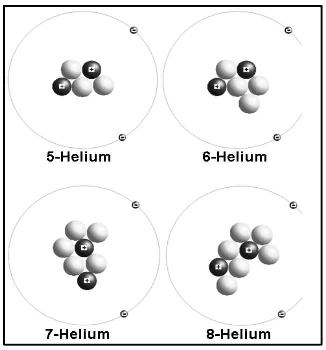
a) Henri Becquerel (1896) "accidentally" discovered that uranium emitted _____________________
   - Becquerel was studying minerals that emit light (phosphoresce) after being exposed to sunlight
   - Discovered by chance that uranium salts produced ________________________ emissions that darkened photographic plates.

b) _____________________________(1867-1934) studied radioactivity and completed much of the pioneering work on nuclear changes

   - ________________________won 2 Nobel Prizes
     - o the first, shared with her husband Pierre Curie and Becquerel for discovering radioactivity
     - o (1898) the second for discovering the radioactive elements radium and polonium

4) Isotopes of atoms with unstable nuclei are called ______________________________.

5) _________________________________= atoms of the same element having different numbers of NEUTRONS and, therefore, a different mass number



6) Unstable nuclei emit ______________________ to attain *more stable* atomic configurations in a process called radioactive decay.

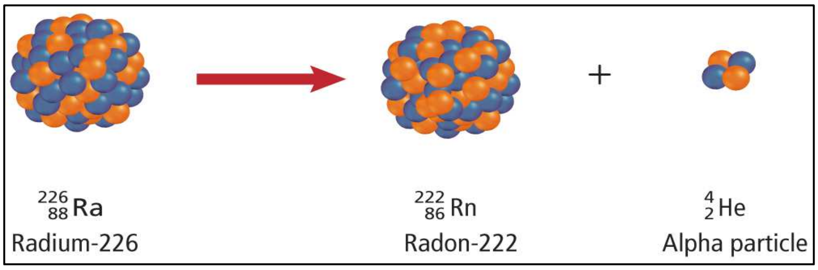
7) ____= the spontaneous break-down of a nucleus into a slightly lighter nucleus, accompanied by the emission of nuclear radiation (alpha, beta, gamma)

8) **3 types of nuclear radiation.**

1) ______________________________ **(α)**= helium nucleus ($^{4}_{2}\mathrm{He}$)

- 2 protons and 2 neutrons bound together emitted from a radioactive nucleus

- Ex: $^{232}_{90}\mathbf{Th} \rightarrow {}^{228}_{88}\mathbf{Ra} + {}^{4}_{2}\mathbf{He}$
- Ex of Alpha Decay:



2) ____________________________**(β)**= electron ($^{0}_{-1}e$)

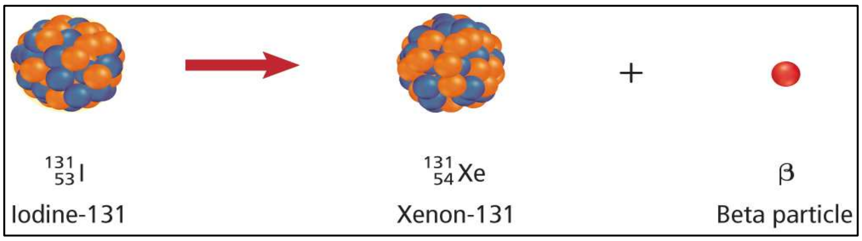
- A neutron is converted into a ________________and an _______________ (beta particle) which is ejected at a high speed

$$^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e$$

- When an atom emits a β particle:
  - ____________________________ will increase by 1 (because the___________ transmutated into an additional ______________________).
  - Ex: decay of the isotope of carbon-14 into nitrogen-14

$$^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}e$$

  - Ex: decay of the isotope of iodine-131 into xenon-131



3) ___________________________(γ) = form of high-energy ER ($^{0}_{0}\gamma$)

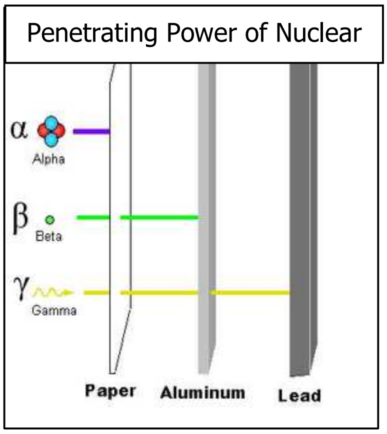
- high energy ER waves emitted from a nucleus as it changes from an excited state to a ground energy state
- gamma does __________ itself cause the transmutation of atoms
  - gamma radiation is often emitted during and simultaneous to, alpha or beta radioactive decay.
  - Ex: $^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He} + 2\gamma$

- ***Write the nuclear symbol.***

Alpha =

Beta =

Gamma =



COMPARING NUCLEAR RADIATION:

Property	**Alpha Particles**	**Beta Particles**	**Gamma Rays**
Nature	Particle consisting of ___ protons and ___ neutrons (Helium Nucleus)	Negatively charged ___________	________________ electromagnetic radiation
Charge	________	_______	_____ Charge
Speed	About __________the speed of light	________________ the speed of light	Speed of light
Mass	___ atomic mass units	0.0005 atomic mass units	_____ mass at rest
Penetrating Power	Relatively ___________ (can be stopped by a piece of paper). Causes harm through ingestion or inhalation!	100 times greater than an alpha particle (can be stopped by a sheet of aluminum foil)	_______________ (can be stopped by several centimeters of lead)
Ionizing Ability	________________	______________	________________

PART III: NUCLEAR STABILITY

1) Except for the emission of gamma radiation, radioactive decay involves the ______________________________________of an element into another element.

2) ____= a change in the identity of a nucleus because of a change in the number of its protons
   - Ex: $^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$

3) Despite the strong electrostatic repulsion forces among _____________________, all protons and neutrons remain bound in the dense nucleus because of the strong nuclear force.

4) The strong _____________________________________ acts on subatomic particles that are extremely close together and overcomes the electrostatic repulsion among protons

5) As atomic number increases, more and more _______________________are needed to produce a strong nuclear force that is sufficient to balance the electrostatic repulsion between protons.

6) To a certain degree the _____________________ of a nucleus can be correlated to its neutron-proton ratio.

   a) Some atoms have too many neutrons to be ____________________ whereas others tend to have too many protons.
   b) All elements with atomic numbers ______________________ than 82 (Lead) are radioactive and decay spontaneously.
   c) Atoms with _______________________________ around 60 are the most stable

IV. BALANCING NUCLEAR EQUATIONS:

1) _____________________________= the number of protons in the nucleus of an atom of an element

2) ____________________________= the total number of protons plus neutrons in the nucleus of an isotope

3) _____________________________________= mass number is written after the name of the element or element's symbol
   - Ex: *element – mass number*

4) ____= element symbols are traditionally preceded by their ____________________ (upper left) and ________________________ (lower left)

   - Ex: $^{mass\ number}_{atomic\ number}\quad element\ symbol$

5) ____= mass number is written after the name of the element or element's symbol

- Ex: *element – mass number*

- Write the nuclear symbol and the hyphen notation for an isotope of uranium with a mass number of 238.

  Nuclear symbol = Hyphen =

- Write the nuclear symbol and the hyphen notation for an isotope of carbon with a mass number of 14.

  Nuclear symbol = Hyphen =

❖ ***Total atomic numbers and mass numbers must be EQUAL on both sides!***

1. Write a nuclear equation showing the radioactive decay of polonium-218 if the decay produces an alpha particle.

$$^{218}_{84}\mathbf{Po} \rightarrow \_\_\_\_\_\_ + {}^{4}_{2}\mathbf{He}$$

2. What type of nuclear radiation is produced when polonium-212 decays to produce lead-208?

$$^{212}_{84}\mathbf{Po} \rightarrow {}^{208}_{82}\mathbf{Pb} + \_\_\_\_\_\_$$

3. What will decay to produce lead-206 and an alpha particle?

$$\_\_\_\_\_\_ \rightarrow {}^{206}_{82}\mathbf{Pb} + {}^{4}_{2}\mathbf{He}$$

4. Write a nuclear equation showing the radioactive decay of carbon-14 if the decay produces a beta particle.

$$^{14}_{6}\mathbf{C} \rightarrow \_\_\_\_\_\_ + {}^{0}_{-1}\mathbf{e}$$

5. What type of nuclear radiation is produced when potassium-43 decays to produce calcium-43?

$$^{43}_{19}\mathbf{K} \rightarrow \_\_\_\_\_ + {}^{43}_{20}\mathbf{Ca}$$

6. What will decay to produce protactinium-234 and a beta particle?

$$\_\_\_\_\_\_ \rightarrow {}^{234}_{91}\mathbf{Pa} + {}^{0}_{-1}\mathbf{e}$$

Part V: NUCLEAR REACTIONS

1) REMEMBER: ______________________________involve some rearrangement of ______________________________(outside the nucleus)

2) ____ involve changes in particles (protons/neutrons) in an atom's ____________________and thus cause a change in the ______________ itself.

- ***In each type of nuclear reaction a small amount of the ____________of the reactants is converted into _______________! (E= mc^2)***

3) 4 types of nuclear reactions:

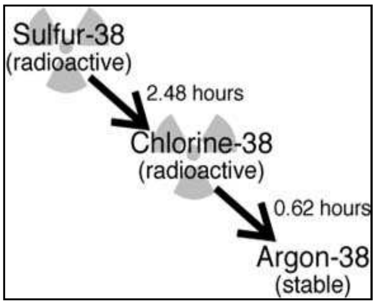
a) _________________________= the spontaneous break-down of a nucleus into a slightly lighter nucleus, accompanied by the emission of nuclear radiation (alpha, beta, or gamma)

- ___________________________________= an isotope with an unstable nucleus that undergoes radioactive decay
  - o All elements with atomic numbers ______________than 82 (Lead) are radioactive and decay spontaneously.

- How long does it take for **ONE** radioactive atom to decay?
  - o ____
  - o The time it takes for a ____________________ of identical radioactive atoms to decay CAN BE determined based on _______________________

- The rate of decay of _________________________ is measured in half-lives.

- _____________________= time needed for decay of one-half the atoms in a *SAMPLE* of radioactive material



- Half-life of polonium-212 = 3 x 10^{-7} seconds
  - o Within 3 x 10^{-7} seconds half of the atoms in a sample of polonium-212 will decay, changing into atoms of a ________________________ element and giving off ____________________________________.

- Half-life of uranium-238 = 4.5 billion years
  - o Within 4.5 billion years half of the atoms in a sample of uranium-238 will decay, changing into atoms of a different element and giving off nuclear radiation.

b) ______________________________________= nucleus is bombarded with alpha particles, protons, neutrons or other particles

- Scientists can change the identity of atoms by hitting them with small particles.
- Ex: An aluminum-27 nucleus is hit by an alpha particle:

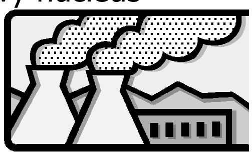
- Ex: A sulfur-32 nucleus is hit by a neutron:

c) ______________________= a very heavy nucleus splits to form medium-weight nuclei

d) ______________________ = the process in which light weight nuclei combine to form a heavier, more stable nucleus

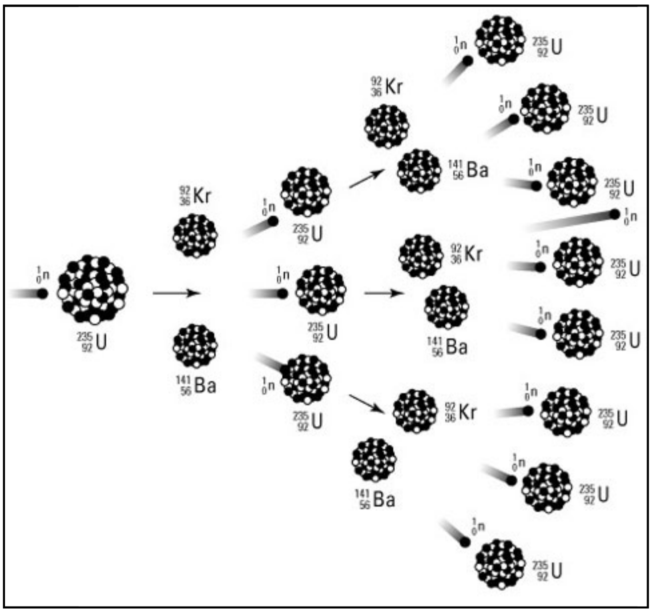
Part VI: FISSION

1) ____= the process in which a very heavy nucleus splits to form medium-weight nuclei



a) A chain reaction occurs→ each nuclear fission produces two or more _____________________, which can in turn cause more nuclear fissions

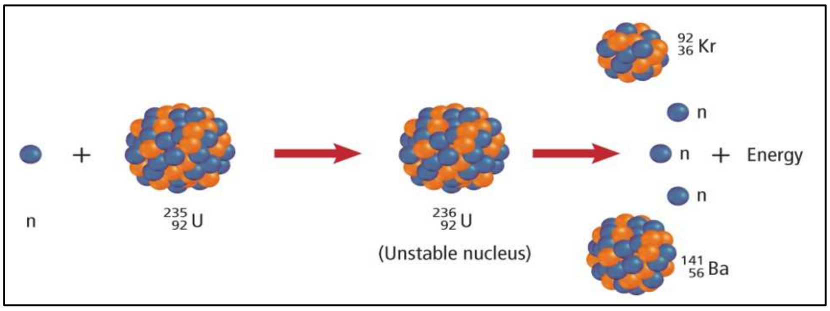
b) ________________________________= in fission reactions, neutrons are emitted; these neutrons can split more nuclei and a chain reaction can occur



c) _________________________________= mass of fissionable material needed to sustain a nuclear chain reaction

d) Fission Reaction Ex: Nuclear power plants (**TMI-**______________________________)

- Use fission to produce electricity by striking uranium-235 with neutrons.



- The fuel used in nuclear power plants is enriched to contain 3% uranium-235, the amount required to sustain a _____________________________________.
- ________________________________of cadmium or boron are used to control the fission process inside the reactor by absorbing neutrons during the reaction.
- Nuclear reactors produce highly radioactive nuclear __________________ (usually stored in sealed containers that are buried deep underground).

e) Fission Reaction Ex: atomic bombs (the explosion is an example of an ___________________________________chain reaction)

f) Example of a fission reaction of uranium-235:

+ → + + 3 + ENERGY

Reactants:

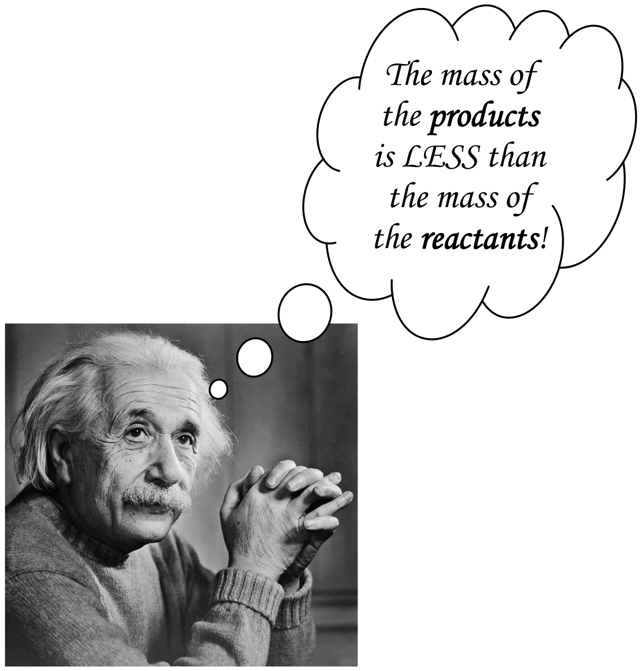
235.043924 amu
\+ 1.008665 amu

Total mass of REACTANTS **236.052589 amu**

Products:

140.914363 amu
91.926270 amu
\+ 3.025995 amu

Total mass of PRODUCTS **235.866628 amu**



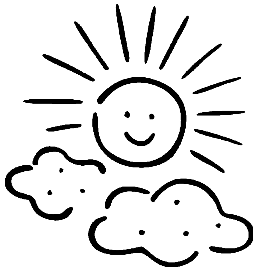
<u>MASS LOSS:</u> 236.052589 amu - 235.866628 amu = <u>0.185961 amu!</u>

g) The mass of the ________________is LESS than the mass of the ________________!

- ✓ ***Why?***
  - ___________________________or missing mass (about 0.2 amu) is converted to a lot of energy!

h) Small amounts of _____________ are converted to HUGE amounts of __________ according to Einstein's formula: _________________

- E = energy
- m= mass
- c = speed of light (3×10^8 m/s)

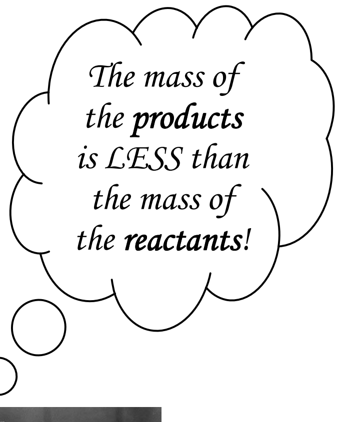


Part VII: FUSION

1) ______________________________________= the process in which light weight nuclei combine to form a heavier, more stable nucleus

- Nuclear fusion produces ________________energy than fission!
- Fusion Reaction Ex: Hydrogen bombs
- Fusion Reaction Ex: fusion powers the ___________and other _____________. The reaction that occur in the sun can be represented as follows (hydrogen isotopes are fused into a helium isotope):

+ ENERGY



Reactants:

2.0140 amu

\+ 3.01605 amu

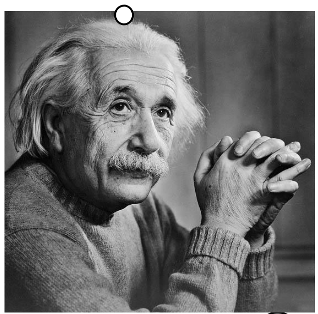
Total mass of REACTANTS **5.03005 amu**

Products:

4.00260 amu

\+ 1.008665 amu

Total mass of PRODUCTS **5.011265 amu**



MASS LOSS: 5.03005 amu - 5.011265 amu = 0.018785 amu!

Where it went→ $E= mc^2$

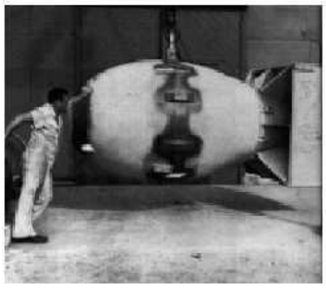
Awesome Energy of Stars and H-bombs!!

Part VIII: 5 BENEFICIAL USES OF RADIATION

1. ______________________radiation- cancer, X-rays, diagnostic tracers
   - Ex: Iodine-131 is used to diagnose the activity of the thyroid gland; treatment of thyroid cancer.
   - Ex: Sodium-24 is used to detect constrictions and obstructions in the circulatory system.
   - Ex: Cobalt-60, phosphorus-32, gallium-67 and cesium-137 are used in the radiation treatment of many cancers.
   - _________________________________:
     - The rapidly dividing cancer-producing cells are most susceptible to radiation damage.
     - Focused radiation beams can shrink or eliminate cancerous tumors while doing less damage to surrounding tissue.
2. ___________________________: weapons
   - WWII: The U.S. Army Air Force received orders to drop these weapons anytime after August 3, 1945. On August 6, "Little Boy" fell on Hiroshima. Three days later, "Fat Man" destroyed Nagasaki.

Little Boy - Hiroshima - 0815, August 6, 1945

Size:	10 ft long
Weight:	8,900 lbs. (132 lbs >90% U-235) (~ 2lbs underwent fission)
Height of blast:	1900 ft.
Yield:	15 - 16 Kt TNT
Casualties	~100,000 immediate deaths ~200,000 total deaths



Fat Man - Nagasaki - 1102, August 9, 1945

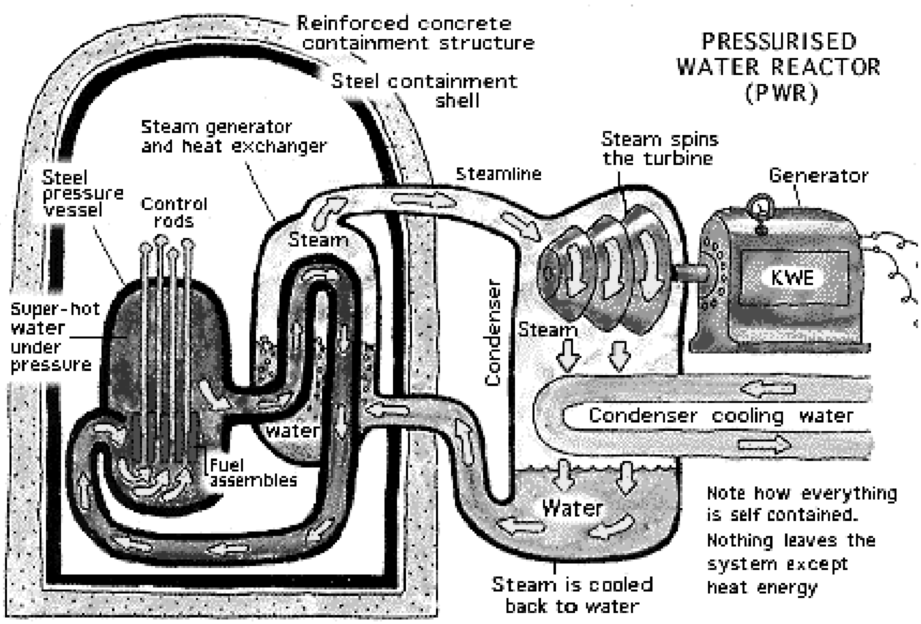
Size:	~10.5 ft long, 5ft. Diameter
Weight:	10,300 lbs., (12 lbs., Pu-239 of which ~2 lbs. underwent fission)
Height of blast:	1650 ft.
Yield:	22 Kt of TNT
Casualties:	~70,000 immediate deaths ~140,000 total deaths

3. _________________________________ "carbon dating"
   - Determines the age of something (rocks, fossils, skeletal remains, etc)
   - Carbon-14 is a beta emitter that decays to nitrogen-14 with a half-life of 5,730 years.
   - In every living thing there is a constant ratio of normal C-12 and radioactive C-14.
   - You can calculate the time needed to change from what is expected to what is actually found.
4. ___________________________: microwaves, sterilize food
5. ______________________________: electricity (TMI-nuclear power plant)

NOTE: the following is NOT on your TEST!! ☺

Part IX: NUCLEAR POWER PLANTS

- The secret to controlling a chain reaction is to control the neutrons.
  - If the **neutrons** can be controlled, then the energy can be released in a **controlled way**. That's what scientists have done with nuclear power plants.
- United States has about **100** nuclear reactors, producing a little more than **20 %** of the country's electricity.
- In France, almost 80 percent of the country's electricity is generated through nuclear fission.
- **How do nuclear power plants make electricity?**



1. **Fuel for nuclear reactors:**
   a) The fuel for nuclear reactors is held in fuel rods.
   b) Fuel rods usually contain mostly non-fissionable uranium-238 and about 3% fissionable uranium-235.
   c) A critical mass of fissionable uranium-235 is present (but not nearly enough for a nuclear explosion).
2. **Energy production:**
   a) A chain reaction fission reaction of uranium-235 occurs in the reactor core.
   b) During the fission of uranium-235 a small amount of mass is converted into a large amount of energy.
   c) The energy generated heats water in the reactor core.
   d) Heated water in the reactor core (under high pressure so it remains a liquid) transfers heat to a second loop of water.
   e) Heated water in the second loop changes to steam.
   f) This steam spins the turbines of giant generators that produce electrical energy (electricity).

3. **Cooling the reactor:**

   a) Steam that has moved past the turbines is cooled by water taken from a nearby body of water.
   b) Cooled steam condenses to liquid water and re-circulates.
   c) So much heat is generated that some must be released into the air through cooling towers.

4. **Facilitating the reaction:**

   a) Moderator = something which slows down high-speed neutrons
   b) Water often acts as the moderator in nuclear reactors.
   c) A moderator slows down high-speed neutrons making them more readily captured by other nuclei.

5. Controlling the reaction:

a) Controlling the neutrons in a reactor allows for control of the nuclear chain reaction.
b) Control rods = rods made of neutron absorbing material (such as boron or cadmium)
c) Control rods are inserted between fuel rods to control the reaction.
d) When all the control rods are pushed all the way into the reactor core, all neutrons are absorbed and the chain reaction stops.

- **Nuclear power plants have CERTAIN ADVANTAGES:**
  - **No fossil fuels** are burned (saving fossil-fuel resources for producing plastics and medicines)
  - **No combustion products** like carbon dioxide and sulfur dioxide to pollute the air and water.

- **PROBLEMS associated with nuclear power plants:**
  1. **Cost**: expensive to build and operate.
     - The electricity that's generated by nuclear power costs about **twice** as much as electricity generated through fossil fuel or hydroelectric plants.
  2. **Supply** of fissionable uranium-235 is limited.
     - Of all the naturally occurring uranium, only about 0.75 percent is U-235. A vast majority is non-fissionable U-238. At current usage levels, we'll be out of naturally occurring U-235 in fewer than 100 years. But there's a limit to the amount of nuclear fuel available in the earth, just as there's a limit to the amount of fossil fuels.
  3. **Accidents** (safety)
  4. **Disposal** of nuclear wastes.

Accidents: Three Mile Island and Chernobyl:

- **Three Mile Island** (1979): A combination of operator error and equipment failure caused a loss of reactor core coolant. The loss of coolant led to a partial meltdown and the release of a small amount of radioactive gas. There was no loss of life or injury to plant personnel or the general population.

- **Chernobyl**, Ukraine (1986): Human error, along with poor reactor design and engineering, contributed to a tremendous overheating of the reactor core, causing it to rupture.
  - Two explosions and a fire resulted, blowing apart the core and scattering nuclear material into the atmosphere. A small amount of this material made its way to Europe and Asia.
  - The area around the plant is ***still*** **uninhabitable**.
  - The reactor has been encased in concrete, and it must remain that way for hundreds of years.
  - Hundreds of people died.
  - Many others felt the effect of radiation poisoning.
    - Instances of thyroid cancer, possibly caused by the release of I-13, have risen dramatically in the towns surrounding Chernobyl.

How do you get rid of this stuff?: NUCLEAR WASTES

- The fission process produces large amounts of radioactive isotopes, and some of the half-lives of radioactive isotopes are rather long.
- Those isotopes are **safe** after **ten half-lives**.
- The wastes are basically buried and guarded at the sites. High-level wastes pose a much larger problem.
  - They're temporarily being stored at the site of generation, with plans to eventually seal the material in glass and then in drums. The material will then be stored underground in Nevada.
- At any rate, the waste must be kept safe and undisturbed for at least **10,000 years**.

Radioactive Decay & Half Life Worksheet

Atoms of the same element with different numbers of neutrons are called **isotopes**. For example, all atoms of the element carbon have 6 protons, but while most carbon atoms have 6 neutrons, some have 7 or 8. Isotopes are named by giving the name of the element followed by the sum of the neutrons and protons in the isotope's nucleus. So a carbon atom with 6 protons and 6 neutrons in its nucleus is called Carbon-12. The carbon atom with 8 neutrons is called Carbon-14. It is interesting to note that Carbon-14 is radioactive while Carbon-12 and Carbon-13 are stable.

Radioactive Decay

When the nucleus of a radioactive isotope gives up its extra energy, that energy is called **ionizing radiation**. Ionizing radiation may take the form of alpha particles, beta particles, or gamma rays. Ionizing radiation is of concern because it may cause adverse health effects. The process of emitting the radiation is called **radioactive decay**. When the nucleus of a radioactive isotope decays, emitting ionizing radiation, the nucleus is altered. It is transformed into another isotope which in many cases is a different element. This new isotope may be stable or unstable. If it is stable, the new isotope is not radioactive. If it is unstable, it also will decay, transforming its nucleus and emitting more ionizing radiation. Several decays may be required before a stable isotope is produced. This sequence is known as a **decay chain** (see Figure 1).

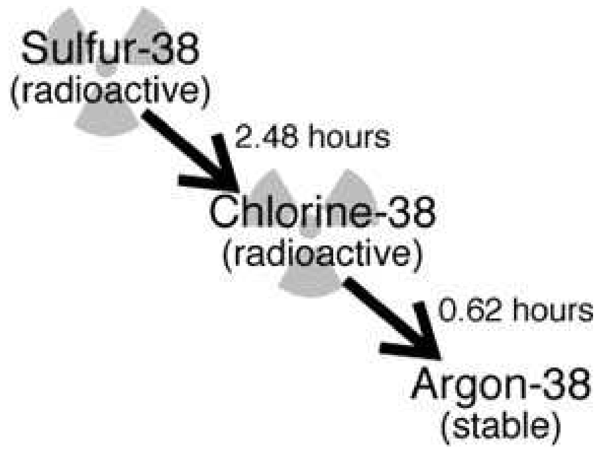


Figure 1. Decay Chain for an Isotope of Sulfur

Decay chains of radioactive isotopes have been studied extensively. Scientists know exactly how many decays are required for each radioactive isotope to become stable. In addition, they know how much energy will be released with each decay.

Half-Life

It is *not* possible to predict exactly when a SINGLE radioactive atom will decay. However, the time required for half of large NUMBER OF IDENTICAL radioactive atoms to decay has been determined. This time is called the half-life. Suppose, for example, a large number of atoms of a radioactive isotope with a half-life of three hours were put in a box. After three hours, one-half of those radioactive atoms would remain. The other half would have been transformed to a different isotope. After three more hours, only half of the remaining radioactive atoms (one quarter of the initial number) would still be unchanged. The concept of half-life is illustrated in Figure 2.

The half-life can vary substantially from one isotope to another, ranging from a fraction of a second to billions of years. For example, Iodine-131, an isotope with important medical applications, has a half-life of 8.04 days.

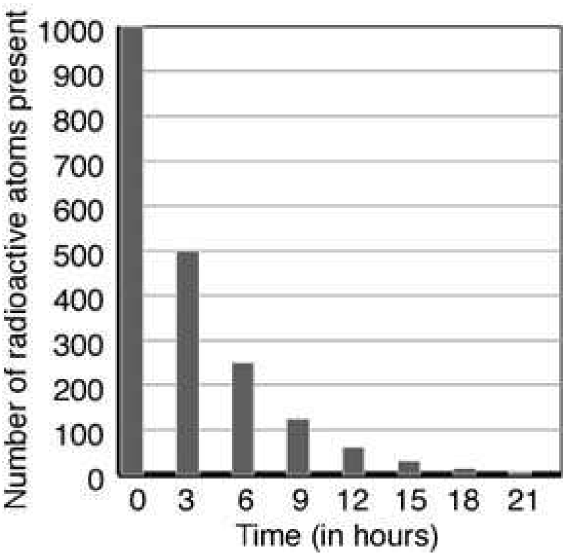


Figure 2. Radioactive Decay of Atoms with a Half-Life of Three Hours.

Calculating Half-life:

1. Suppose we have 100 nuclei of a radioactive isotope. After one half-life, half of the nuclei will have disintegrated, leaving 50 nuclei.
   a. How many nuclei will be left after the second half-life?

   b. How many nuclei would you predict would remain after the third half-life?

2. Element X has a mass of 300g and a ½ life of 10 years. How many grams will remain after 40 years?
   Hint: first determine how many ½ lives is 40 years.

3. Element Z has a mass of 430g. Scientists determined it to have a ½ life of 5 years. How many grams of element Z will remain after 15 years? Show your work.

4. Phosphourous-32 is a radioisotope with a half-life of 14.3 days. If you start with 4 g of phosphorous-32, how many grams will remain after 57.2 days? How many half-lives will have passed?

5. Carbon-14 is a radioisotope with a half-life of 5715 years. Suppose you start with 400 mg of carbon-14. How many half-lives will have passed when 12.5 mg of carbon-14 remains? How much time will have passed when 12.5 mg carbon-14 remains?

6. Astatine-218 is a radioisotope with a half-life of 1.6 seconds. If you start with 10 mg of astatine-218, how many milligrams will remain after 5 half-lives? How much time will have passed after 5 half-lives?

7. Uranium-238 has a half-life of 4.5 billion years (4,500,000,000 years). If you start with 10 mg of uranium-238, how many milligrams will remain after five half-lives? How much time will have passed after five half-lives?

Nuclear Radiation Worksheet

Directions: *Answer the following questions and balance each nuclear equation on the next page.*

1) What is ER?

2) What type of radiation can damage DNA? ___________________________________

3) What is the name of the woman who was a pioneer of nuclear chemistry? __________________

4) What makes the mass of C-12 and C-14 different?

5) Write the hyphen notation for the following: atomic number 11 and mass number 23. ____________

6) Write the nuclear symbol notation for the following: atomic number 11 and mass number 23. _______

7) What are the 3 types of nuclear radiation?

   a) ________________________

   b) ________________________

   c) ________________________

8) What is the **nuclear symbol** for an alpha particle and beta particle?

9) What could stop gamma rays? ____________________ an alpha particle?______________

10) What is the charge of a beta particle? _______________

11) What is the charge of an alpha particle? _____________

12) What type of nuclear radiation has the LARGEST mass? __________

13) What type of nuclear radiation has the SMALLEST mass?_________

14) What type of nuclear (ionizing) radiation can cause the most damage to your DNA? _____________

15) The spontaneous break-down of a nucleus into a slightly lighter nucleus, accompanied by the emission of nuclear radiation is known as ___________________________________

16) *Explain* how are nuclear reactions different from chemical reactions?

Balancing Nuclear Equations Worksheet

1) ${}^{14}_{6}\text{C} \rightarrow {}^{14}_{7}\text{N} +$ ______

2) ______ $\rightarrow {}^{228}_{88}\text{Ra} + {}^{4}_{2}\text{He}$

3) ${}^{228}_{89}\text{Ac} \rightarrow$ ______ $+ {}^{0}_{-1}\text{e}$

4) ______ $\rightarrow {}^{220}_{86}\text{Rn} + {}^{4}_{2}\text{He}$

5) ${}^{234}_{91}\text{Pa} \rightarrow {}^{234}_{92}\text{U} +$ ______

6) ${}^{232}_{90}\text{Th} \rightarrow {}^{228}_{88}\text{Ra} +$ ______

7) ${}^{60}_{27}\text{Co} \rightarrow$ ______ $+ {}^{0}_{-1}\text{e}$

8) ______ $\rightarrow {}^{40}_{20}\text{Ca} + {}^{0}_{-1}\text{e}$

9) ${}^{241}_{95}\text{Am} \rightarrow$ ______ $+ {}^{4}_{2}\text{He}$

10) ${}^{222}_{86}\text{Ra} \rightarrow {}^{218}_{84}\text{Po} +$ ______

11) ${}^{40}_{19}\text{K} \rightarrow {}^{40}_{20}\text{Ca} +$ ______

12) ${}^{237}_{93}\text{Np} \rightarrow$ ______ $+ {}^{4}_{2}\text{He}$

13) ______ $\rightarrow {}^{0}_{-1}\text{e} + {}^{60}_{28}\text{Ni}$

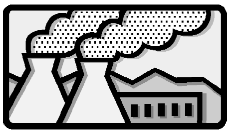
14) ${}^{228}_{88}\text{Ra} \rightarrow$ ______ $+ {}^{228}_{89}\text{Ac}$

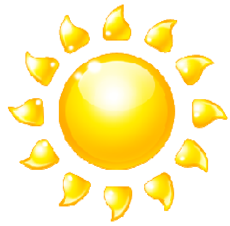
15) ${}^{233}_{92}\text{U} \rightarrow {}^{4}_{2}\text{He} +$ ______

16) ${}^{239}_{92}\text{U} \rightarrow$ ______ $+ {}^{239}_{93}\text{Np}$

17) ______ $\rightarrow {}^{4}_{2}\text{He} + {}^{208}_{82}\text{Pb}$

18) ______ $\rightarrow {}^{32}_{15}\text{P} + {}^{0}_{-1}\text{e}$





1) How long does it take one radioactive atom to decay?

2) ______________________________ is the time needed for decay of one-half the atoms in a *SAMPLE* of radioactive material

3) ______________________is a change in the identity of a nucleus because of a change in the number of its protons

4) List the 4 types of nuclear reactions.
   a) _______________________________________
   b) _______________________________________
   c) _______________________________________
   d) _______________________________________

5) What is the difference between fission and fusion?

6) What type of nuclear reaction takes place at TMI? _________________

7) What type of nuclear reaction takes place at the sun? ________________

8) During fission and fusion reactions, what is the relationship between the MASS of the reactants and products?

   a) WHY?

9) ____________________________ is the missing mass of a nuclear reaction that is converted into energy.

10) Small amounts of mass are converted to HUGE amounts of energy according to Einstein's famous formula. What is this famous formula? __________________

11) ____________________ is the mass of fissionable material needed to sustain a nuclear chain reaction

12) Which would produce the MOST energy from a reaction? **Fission OR Fusion**

13) Explain 3 different areas or fields that radiation is beneficial.

Unit Learning Map (6 days): **Nuclear Chemistry** Mrs. Hostetter

Class: Academic Chemistry B - Grade 11: PA Standard 3.4.A Explain concepts about the structure and properties of matter.

Unit Essential Question(s):

How are nuclear reactions different from chemical reactions?

Optional Instructional Tools:

Guided Notes
Lab Materials: Half life lab

	Concept 1	Concept 2	Concept 3	Concept 4
Concept	Nuclear Equations	Half live		
Lesson Essential Questions:	How do you balance nuclear equations?	How do you solve half life problems?		
Vocabulary:	Radiation Electromagnetic radiation Ionizing radiation Non-ionizing radiation Marie curie Nuclear reactions Isotope Hyphen notation Nuclear symbol notation Transmutation Radioactive isotope Radioactive decay Nuclear radiation Alpha particle Beta particle Gamma ray	Half life Nuclear fission Chain reaction Critical mass Nuclear fusion Nuclear bombardment Mass defect		

Nuclear Chemistry Vocabulary:

1) **Radiation** = a general term for any type of energy that emanates or radiates outward in all directions
2) **Electromagnetic radiation (ER)** = radiation moving at the speed of light, ranging from high-energy gamma rays to low energy radio waves; includes visible light
3) **Ionizing radiation** = radiation with sufficient energy to ionize atoms or molecules (higher energy ER); damages DNA
4) **Non-ionizing radiation** = radiation with insufficient energy to ionize atoms or molecules (lower energy ER)
5) **Marie Curie** = studied radioactivity and completed much of the pioneering work on nuclear changes. Won two Nobel Prizes (the first for discovering radioactivity; the second for discovering the radioactive elements radium and polonium)
6) **Nuclear reactions** = involve changes in particles in an atom's nucleus and thus cause a change in the atom itself
7) **Isotope** = atoms of the same element having different numbers of neutrons and, therefore, a different mass number and atomic mass
8) **Hyphen notation** = (example) U-238
9) **Nuclear notation** = (example)
10) **Transmutation** =change in the identity of a nucleus because of a change in the number of its protons
11) **Radioactive isotope** = an isotope with an unstable nucleus that undergoes radioactive decay
12) **Radioactive decay** = the spontaneous break-down of a nucleus into a slightly lighter nucleus, accompanied by the emission of nuclear radiation
13) **Nuclear radiation** = particles or ER emitted from a nucleus during radioactive decay
14) **Alpha particle** (α)= helium nucleus ( ); 2 protons and 2 neutrons bound together emitted from a radioactive nucleus
15) **Beta particle** (β)= electron( ) ejected at a high speed when a neutron changes into a proton and an electron
16) **Gamma ray** (γ) = form of high-energy ER ( ); often emitted during and simultaneous to, α or β radioactive decay.
17) **Half-life** = time needed for decay of one-half the atoms in a *sample* of radioactive material
18) **Nuclear bombardment** = nucleus is bombarded with alpha particles, protons, neutrons or other particles
19) **Nuclear fission** =process in which a heavy nucleus splits to form medium-weight nuclei; Ex: TMI
20) **Chain reaction** = in fission reactions, neutrons are emitted; these neutrons can split more nuclei and a chain reaction can occur
21) **Critical mass** = mass of fissionable material needed to sustain a nuclear chain reaction
22) **Nuclear fusion** = the process in which light weight nuclei combine to form a heavier, more stable nucleus; Ex: the sun
23) **Nuclear fission** = the process in which a very heavy nucleus splits to form medium-weight nuclei; Ex: TMI (nuclear power plant)
24) **Mass defect** = the missing mass of a nuclear reaction that is converted into energy.