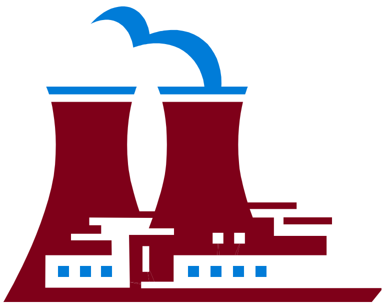
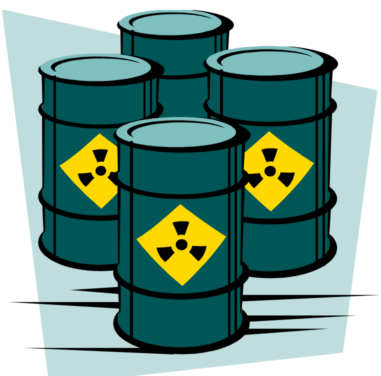
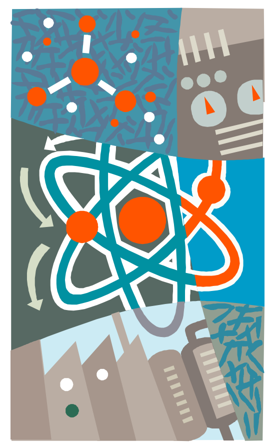
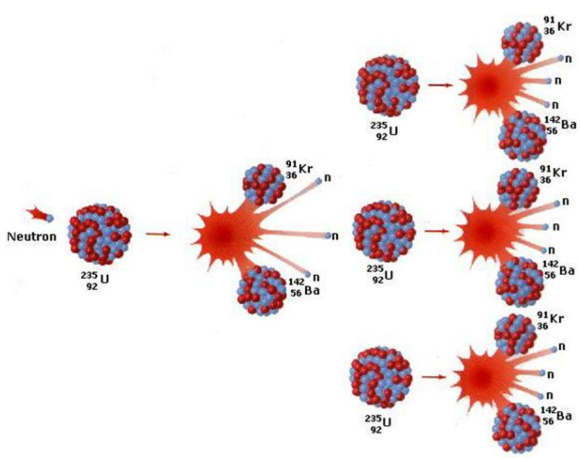
Nuclear Chemistry









Name ____

What will students know and be able to do by the end of this instructional unit?

1. Define transmutation
2. Define natural transmutation
3. List 3 types of natural transmutation
4. Write decay equations for alpha decay, beta decay, and positron emission
5. Describe the difference and similarities between nuclear and chemical reaction
6. Find the missing reactant or product in a nuclear equation
7. Define radioisotope
8. Construct a "Belt of Stability" graph
9. Use the "Belt of Stability" graph to understand the concept of Stable Nuclei
10. Use table N to find selected radioisotopes, their decay modes and their half-life values
11. Calculate the initial amount, the fraction remaining, or the half-life of a radioactive isotope, given two of the three variables.
12. Define transmutation
13. Define artificial transmutation
14. List 2 types of artificial transmutation
15. Describe the difference and similarities between fission and fusion
16. Describe the differences between the reaction in a nuclear bomb and the reaction in a nuclear power plant
17. List benefits of nuclear energy, nuclear reactions and radioactivity
18. List risks involved with nuclear energy, nuclear reactions and radioactivity

Key Subject Competencies

1. Explain what it means for an atom to be radioactive.
2. Explain why some atoms are radioactive.
3. Explain what a transmutation is.
4. Describe what alpha particles, beta particles, and gamma rays are.
5. Describe the behavior of alpha particles, beta particles, and gamma rays as they pass through an electric/magnetic field.
6. Explain what the difference is between natural and artificial transmutation/radioactivity.
7. Explain how to complete a nuclear equation when one of the particles is missing.
8. Describe what Half-Life is.
9. Calculate the "initial amount", "fraction remaining", or "half-life" of a radioactive isotope, when given two of these three variables.
10. Compare and contrast fission and fusion reactions.
11. Describe how a nuclear reactor/explosion produces energy.
12. Describe how the amount of energy released in a nuclear reaction differs from the amount of energy released in a chemical reaction.
13. Describe some beneficial uses of radioactive isotopes that do not involve energy. (example: in medicine and science research)

Vocabulary:

Alpha particle
Artificial transmutation
Beta particle
Fission
Fusion
Gamma ray
Half-life
Radioisotope
Tracer
Natural Transmutation

Answer the following as True or False. Be prepared to discuss each.

- All nuclear materials remain highly toxic for thousands of years.
- Man-made radiation is more toxic to humans than naturally occurring radiation even if the dose is the same.
- The human body has the capability to repair damaged caused by exposure to radiation.
- In the US, most cases of cancer in humans are known to be caused by man-made radiation.
- I would rather live within a 50 mile radius of a coal-burning plant than a nuclear power plant.
- One of the chief dangers from nuclear power plants is that they can explode like a nuclear bomb.
- It is safer to drive behind a tanker truck carrying gasoline than a truck load of spent nuclear fuel.
- On average, people are exposed to more radiation from nuclear power plants than from radon gas in homes.
- Since the construction of the first nuclear power plant, man-made radiation in known to have resulted in new species of plants and animals.
- The fact that nuclear power plants have elaborate evacuation plans for the surrounding area indicates they are inherently more dangerous than other types of plants.

The Nucleus of an Atom

- nucleus is comprised of ________________________and ____________________
- The number of protons is the _________________________
- The number of __________________ and _____________________ together is the mass.
- Not all atoms of the same element have the same mass due to different numbers of

  _________________________ in those atoms. They are called ________________.

Radioactivity

- It is not uncommon for some nuclides of an element to be____________________, or ___ _________________________.
- We refer to these as ____________________.
- There are several ways radionuclides can _______________into a different nuclide.

- **Alpha Decay**
    - ______________________________

α particle

α decay

- **Beta Decay**
    - ______________________________

β particle

β decay

- **Positron Emission**
    - ______________________________

      ____

Positron

positron emission

- **Gamma Emission**
    - ______________________________

      ____

Gamma

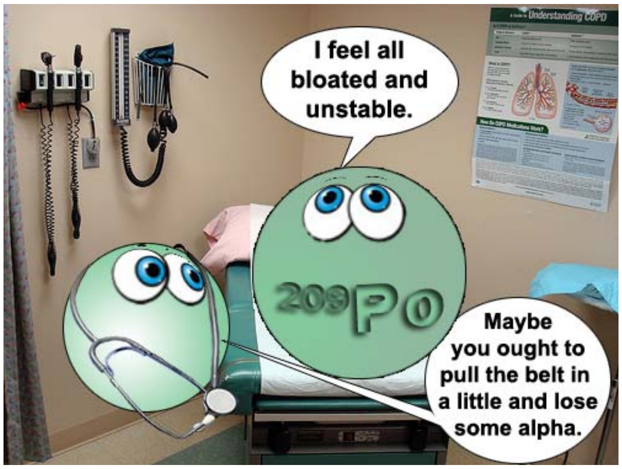
gamma emission

Name ______________________________

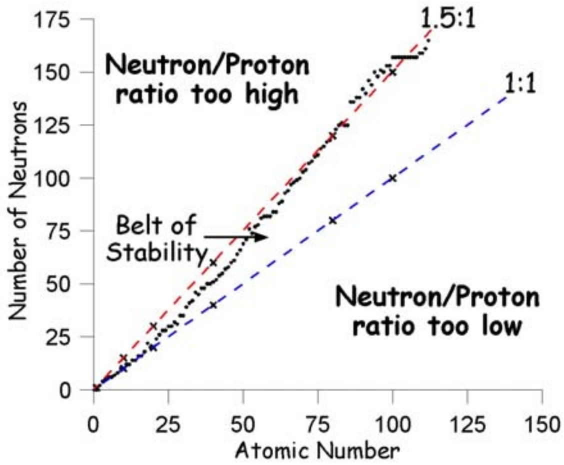
Date _________________ Period _____

What is Radioactivity?

Protons repel each other. The higher the atomic number of an atom is, the greater the repulsion among protons is. This makes the nucleus unstable. Atoms with atomic numbers above 82 have no stable isotopes. Neutrons help to stabilize the nucleus by adding forces of attraction, without increasing the repulsion. Hydrogen is the only element that does not always have neutrons. As the number of protons increases, the number of neutrons needed to keep the nucleus stable increases. The ratio of neutrons to protons in stable nuclei is between 1:1 and 1.5:1, the higher ratio being associated with larger nuclei that have larger repulsive forces. Stable atoms have a ratio of neutrons to protons that falls in the belt of stability.



The box below shows a comparison of neutron to proton ratios for lead–206, a stable isotope, and uranium–235, a radioactive isotope. Lead falls in the belt of stability, while uranium does not.

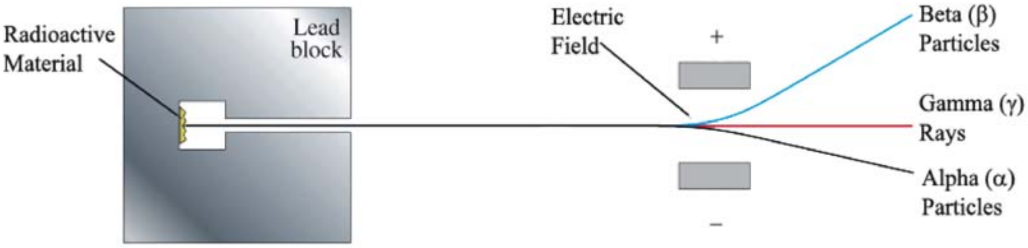


Sample Problems

Look up the atomic number (Z) on the *Periodic Table*. Subtract the atomic number from the mass number (A) to get the number of neutrons (N).

Lead–206	*Uranium–235*
A = 206	A = 235
Z = 84	Z = 92
N = A – Z = 122	N = A – Z = 143
N/Z = 122/84 = 1.45	N/Z = 143/92 = 1.55

Radioactivity. Unstable nuclei break apart or decay. Decaying nuclei release high speed particles and energy called radioactive emissions. Radioactive emissions separate in an electric field into three main types: alpha particles which are the same as a helium nucleus and have a positive charge; beta particles which are the same as a negatively charged electron except that they erupt from the nucleus; and gamma rays which are massless, chargeless energy. Sometimes atoms also give off positrons which are the same mass and size as an electron, but have a positive charge.



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Answer the questions below based on your reading and your knowledge of chemistry.

1. Determine whether each of the isotopes below is stable or unstable by first determining the N/Z ratio..

	N/Z	**Stable/Unstable**
a. ^{3}H	______________	______________
b. ^{14}N	______________	______________
c. ^{14}O	______________	______________
d. ^{97}Kr	______________	______________
e. ^{206}Pb	______________	______________

2. Calculate the N/Z ratio for elements with atomic numbers 104 through 109. Are they in the belt of stability? Are they stable? How do you know? What does this show about the belt of stability? ______________________________

____

____

____

3. Why are all elements with atomic numbers above 82 unstable? ______________________________

____

____

4. What is radioactivity? ____

____

____

5. What are three common types of radioactivity given off by unstable atoms? How are they similar? How are they different? ____

____

____

____

Nuclear Stability

- There are no ____
- Tend to decay by ____

Nuclear Equations

- ____
- ____
- ____

Name	**Notation**	**Symbol**

Example 1

Example 2

Example 3

Nuclear Equation Problems

Complete the following nuclear equations and state the type of nuclear decay.

1. $^{210}_{84}Po \rightarrow$ ________ $+ \, ^{4}_{2}He$ ____________________
2. $^{8}_{5}B \rightarrow \, ^{8}_{4}Be +$ ________ ____________________
3. ________ $\rightarrow \, ^{234}_{91}Pa + \, ^{0}_{-1}e + \gamma$ ____________________
4. $^{14}_{6}C \rightarrow$ ________ $+ \, ^{0}_{-1}e$ ____________________
5. _______ $+ \, ^{81}_{37}Rb \rightarrow \, ^{81}_{36}Kr$ + X-ray photon ____________________
6. $^{15}_{8}O \rightarrow \, ^{15}_{7}N +$ _______ ____________________
7. $^{58}_{28}Ni + \, ^{0}_{-1}e \rightarrow$ ________ ____________________
8. $^{226}_{88}Ra \rightarrow \, ^{222}_{86}Rn +$ _______ $+ \gamma$ ____________________

9* $^{1}_{0}n \rightarrow$ ______ $+ \, ^{0}_{-1}e$ ____________________

10. $^{238}_{92}U \rightarrow$ ________ $+ \, ^{4}_{2}He$ ____________________

Complete the following nuclear equations.

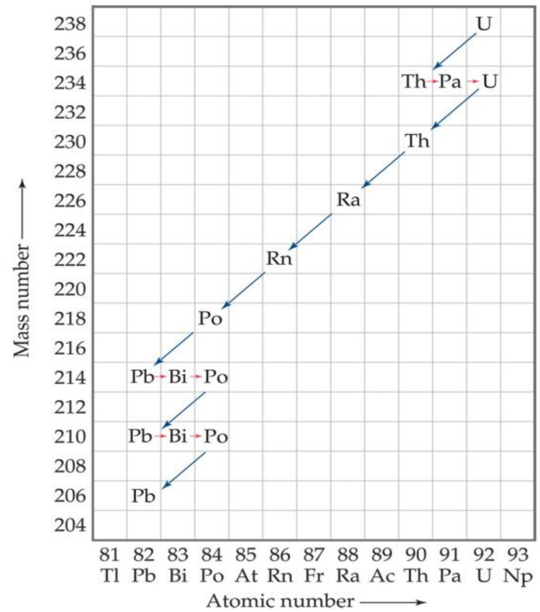
11. $^{9}_{4}Be + \, ^{4}_{2}He \rightarrow$ ______ $+ \, ^{1}_{0}n$
12. _______ $\rightarrow \, ^{239}_{94}Pu + \, ^{0}_{-1}e$
13. $^{66}_{29}Cu \rightarrow \, ^{66}_{30}Zn +$ _______
14. $^{27}_{13}Al +$ _______ $\rightarrow \, ^{30}_{14}Si + \, ^{1}_{1}H$
15. $^{141}_{56}Ba \rightarrow$ _______ $+ \, ^{0}_{-1}e$
16. _______ $+ \, ^{4}_{2}He \rightarrow \, ^{17}_{8}O + \, ^{1}_{1}p$
17. _______ $\rightarrow \, ^{181}_{77}Ir + \, ^{4}_{2}He$
18. $^{241}_{95}Am \rightarrow$ ______ $+ \, ^{237}_{93}Np$
19. _______ $+ \, ^{12}_{6}C \rightarrow \, ^{246}_{98}Cf + 4\, ^{1}_{0}n$
20. $^{18}_{9}F \rightarrow \, ^{17}_{8}O +$ ______
21. $^{2}_{1}H +$ ______ $\rightarrow \, ^{4}_{2}He + \, ^{1}_{0}n + energy$
22. $^{27}_{14}Si \rightarrow \, ^{0}_{-1}e +$ _______
23. _______ $\rightarrow \, ^{4}_{2}He + \, ^{210}_{81}Tl$
24. $^{32}_{15}P \rightarrow$ _______ $+ \, ^{0}_{-1}e$
25. $^{142}_{61}Pm +$ ______ $\rightarrow \, ^{142}_{60}Nd$
26. $^{14}_{7}N +$ ______ $\rightarrow \, ^{14}_{6}C + \, ^{1}_{1}p$
27. $^{13}_{6}C + \, ^{1}_{0}n \rightarrow$ _______
28. $^{239}_{94}Pu + \, ^{4}_{2}He \rightarrow \, ^{1}_{1}H + 2\, ^{1}_{0}n +$ _______

- Large radioactive nuclei ________________

  ____

  by undergoing ________________________nuclear transformation.

- They undergo a ____series of decays until they form a stable nuclide (often a nuclide of lead).
- Example:



Nuclear Fission – Artificial Transmutation

- These reactions are carried out in ____

  and ____.

- Example:

- Bombardment of the radioactive nuclide with a neutron starts the process.

- Neutrons released in the ___________________________________ strike other nuclei,

  causing their ________________________________ and the production of more

  _____________________________________.

- This process continues in what we call a __________________________________.
- Nuclear reactors
  - The reaction is kept in check by the use of __________________________.
  - These block the paths of some neutrons, keeping the system from reaching a dangerous supercritical mass.
  - The end products a highly radioactive and storage is an issue.
- Nuclear Bombs
  - The reaction is not kept in check.
  - There is a rapid release of huge amounts of energy.

Nuclear Fusion – Our Sun

- Fusion would be a superior method of generating power.
  - The good news is that the products of the reaction are not radioactive.
  - The bad news is that in order to achieve fusion, the material must be in the plasma

    state at _______________________________.

Answer the questions below based on your reading and on your knowledge of chemistry.

1. Which type of reaction occurs in a nuclear power plant and in an atomic bomb?
2. Which type of reaction occurs in stars such as the sun?
3. How is fission different than alpha or beta decay?
4. What characteristic of fission makes a chain reaction possible?
5. If fusion releases more energy than fission, why isn't fission used as a source of energy on earth?
6. What is the fuel that runs fusion in stars?
7. Why is fusion only possible with small nuclei?

1. Given the balanced equation representing a reaction:

$$^{27}_{13}Al + ^{4}_{2}He \rightarrow ^{30}_{15}P + ^{1}_{0}n$$

Which type of reaction is represented by this equation?

A) combustion
B) decomposition
C) saponification
D) transmutation

2. Which nuclear equation represents a natural transmutation?

A) $^{9}_{4}Be + ^{1}_{1}H \rightarrow ^{6}_{3}Li + ^{4}_{2}He$
B) $^{27}_{13}Al + ^{4}_{2}He \rightarrow ^{30}_{15}P + ^{1}_{0}n$
C) $^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$
D) $^{235}_{92}U \rightarrow ^{231}_{90}Th + ^{4}_{2}He$

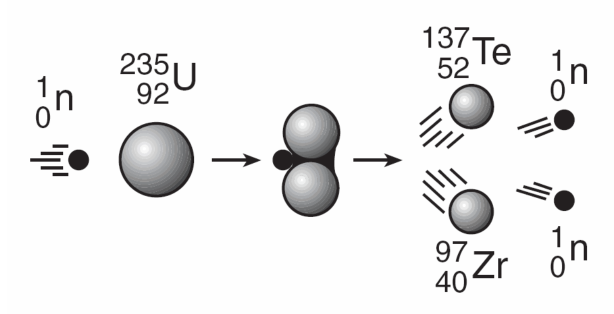
3. Artificial transmutation is brought about by using accelerated particles to bombard an atom's

A) nucleus
B) valence shells
C) occupied sublevels
D) inner principal energy levels

4. What is one benefit associated with a nuclear fission reaction?

A) The products are not radioactive.
B) Stable isotopes are used as reactants.
C) There is no chance of biological exposure.
D) A large amount of energy is produced.

5. Given the diagram representing a reaction:



Which phrase best describes this type of reaction and the overall energy change that occurs?

A) nuclear, and energy is released
B) nuclear, and energy is absorbed
C) chemical, and energy is released
D) chemical, and energy is absorbed

6. In which reaction is mass converted to energy by the process of fission?

A) $^{14}{}_{7}N + ^{1}{}_{0}n \rightarrow ^{14}{}_{6}C + ^{1}{}_{1}H$
B) $^{235}{}_{92}U + ^{1}{}_{0}n \rightarrow ^{87}{}_{35}Br + ^{146}{}_{57}La + 3\,^{1}{}_{0}n$
C) $^{226}{}_{88}Ra \rightarrow ^{222}{}_{86}Ra + ^{4}{}_{2}He$
D) $^{2}{}_{1}H + ^{2}{}_{1}H \rightarrow ^{4}{}_{2}He$

7. Which balanced equation represents a fusion reaction?

A) $^{235}{}_{92}U + ^{1}{}_{0}n \rightarrow ^{93}{}_{36}Kr + ^{140}{}_{56}Ba + 3\,^{1}{}_{0}n$
B) $^{2}{}_{1}H + ^{3}{}_{1}H \rightarrow ^{4}{}_{2}He + ^{1}{}_{0}n$
C) $^{14}{}_{7}N + ^{4}{}_{2}He \rightarrow ^{17}{}_{8}O + ^{1}{}_{1}H$
D) $^{226}{}_{88}Ra \rightarrow ^{222}{}_{86}Rn + ^{4}{}_{2}He$

8. Which change takes place in a nuclear fusion reaction?

A) Matter is converted to energy.
B) Energy is converted to matter.
C) Ionic bonds are converted to covalent bonds.
D) Covalent bonds are converted to ionic bonds.

Half Life

Yes, you did this in Earth Science last year.

- The half-life of a radioactive nuclide is the amount of ___________ it takes for ________ of that nuclide to decay into a stable nuclide.

  Example: ____________ → ______________ +

- After _________________________ ½ the ____________ of an original sample of Carbon-14 remains ____________________.
- After _________________________ 5730 years, ________ (half of the half) of an ________________________ of Carbon-14 remains unchanged.
- The half-life of a radioactive nuclide cannot be changed.

1.) What is the half-life of a 100.0 g sample of nitrogen-16 that decays to 12.5 grams in 21.6 seconds?

2.) All isotopes of technetium are radioactive, but they have widely varying half-lives. If an 800.0 gram sample of technetium-99 decays to 100.0 g of technetium-99 in 639,000 years, what is its half-life?

3.) A 208 g sample of sodium-24 decays to 13.0 g of sodium-24 within 60.0 hours. What is the half-life of this radioactive isotope?

4.) If the half-life of iodine-131 is 8.10 days, how long will it take a 50.00 g sample to decay to 6.25 g?

5.) The half-life of hafnium-156 is 0.025 seconds. How long will it take a 560 g sample to decay to one fourth of its original mass?

6.) Chromium-48 has a short half-life of 21.6 hours. How long will it take 360.00 g of chromium-48 to decay to 11.25 g?

7.) Potassium-42 has a half-life of 12.4 hours. How much of an 848 g sample of potassium-42 will be left after 62.0 hours?

8.) Carbon-14 has a half-life of 5730 years. How much of a 144 g sample of carbon-14 will remain after × 104 years?

9.) If the half-life of uranium-235 is 7.04 × 108 years and 12.5 g of uranium-235 remain after 2.82 × 109 years, how much of the radioactive isotope was in the original sample?

- **Benefits of Radioactive Isotopes**
  - Tracers
    - ____

      ____
  - Medical
    - ____

      ____
    - ____

      ____
    - ____

      ____
  - Food ____

    ____
  - Radioactive Dating
    - ____

      ____
    - ____

      ____
  - Nuclear Power
    - ____
- **Risks of Radioactive Isotopes**
  - Biological Damage ______________________________________

    ____
  - Long Term Storage ______________________________________

    ____
  - Accidents ____

    ____

1. Given the nuclear equation:

$$^{1}_{1}\text{H} + X \rightarrow {}^{6}_{3}\text{Li} + {}^{4}_{2}\text{He}$$

The particle repr esented by *X* is

A. $^{9}_{4}\text{Li}$
B. $^{9}_{4}\text{Be}$
C. $^{10}_{5}\text{Be}$
D. $^{10}_{6}\text{C}$

2. Which isotope will spontaneously decay and emit particles with a charge of +2?

A. ^{53}Fe C. ^{198}Au
B. ^{137}Cs D. ^{220}Fr

3. Which reaction is an example of natural transmutation?

A. $^{239}_{94}\text{Pu} \rightarrow {}^{235}_{92}\text{U} + {}^{4}_{2}\text{He}$
B. $^{27}_{13}\text{Al} + {}^{4}_{2}\text{He} \rightarrow {}^{30}_{15}\text{P} + {}^{1}_{0}\text{n}$
C. $^{238}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{239}_{94}\text{Pu} + 2\,{}^{0}_{-1}\text{e}$
D. $^{239}_{94}\text{Pu} + {}^{1}_{0}\text{n} \rightarrow {}^{147}_{56}\text{Ba} + {}^{90}_{38}\text{Sr} + 3\,{}^{1}_{0}\text{n}$

4. What is the mass number of an alpha particle?

A. 1 C. 0
B. 2 D. 4

5. Which group of nuclear emissions is listed in order of increasing charge?

A. alpha particle, beta par ticle, gamma radiation
B. gamma radiation, al pha par ticle, beta particle
C. positron, alpha particle, neutron
D. neutron, positron, alpha particle

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

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

7. Positrons ar e spontaneously emitted from the nuclei of

A. potassium-37 C. nitrogen-16
B. radium-226 D. thorium-232

8. Given the nuclear equation:

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

What particle is repres ented by *X*?

A. alpha C. neutron
B. beta D. positron

9. Which nuclear emission has the greatest penetrating power?

A. alpha particle C. gamma radiation
B. beta particle D. positron

10. Which nuclear de cay emission consists of energy, only?

A. alpha particle C. gamma radiation
B. beta particle D. positron

11. If $\frac{1}{8}$ of an original sample of kry pton-74 remains unchanged after 34.5 minutes, what is the half-life of krypton-74?

A. 11.5 min C. 34.5 min
B. 23.0 min D. 46.0 min

12. What is the half-life of sodium-25 if 1.00 gram of a 16.00-gram sample of sodium-25 remains unchanged af ter 237 seconds?

A. 47.4 s C. 79.0 s
B. 59.3 s D. 118 s

13. Atoms of one element are converted to atoms of another element through

A. fermentation C. polymerization
B. oxidation D. transmutation

14. Given the nuclear equation:

$$^{253}_{99}\text{Es} + X \rightarrow {}^{1}_{0}\text{n} + {}^{256}_{101}\text{Md}$$

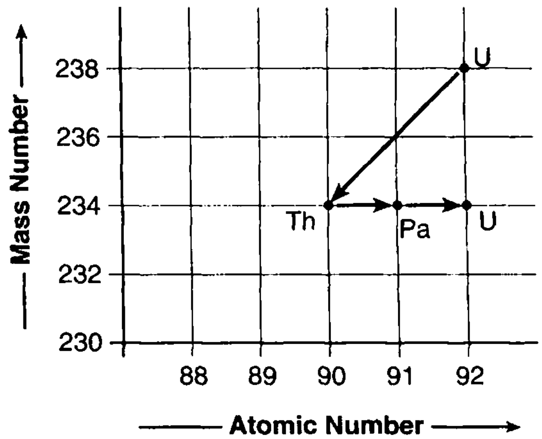
Which particle is repres ented by *X*?

A. $^{4}_{2}\text{He}$ C. $^{1}_{0}\text{n}$
B. $^{0}_{-1}\text{e}$ D. $^{0}_{+1}\text{e}$

15. Which equation repr esents the radioactive decay of $^{226}_{88}\text{Ra}$?

A. $^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$
B. $^{226}_{88}\text{Ra} \rightarrow {}^{226}_{89}\text{Ac} + {}^{0}_{-1}\text{e}$
C. $^{226}_{88}\text{Ra} \rightarrow {}^{226}_{87}\text{Fr} + {}^{0}_{+1}\text{e}$
D. $^{226}_{88}\text{Ra} \rightarrow {}^{225}_{88}\text{Ra} + {}^{1}_{0}\text{n}$

16. The chart below shows the sponta neous nuclear decay of U-238 to Th-234 to Pa-234 to U-234.



What is the correct order of nuclear decay modes f or the change from U-238 to U-2 34?

A. β^- decay, decay, β' decay
B. β^- decay, β^- decay, α decay
C. α decay, α decay, β^- decay
D. α decay, β^- decay, β^- decay

17. Types of nuclear reactions include fission, fusion, and

A. single replacement
B. neutralization
C. oxidation-reduction
D. transmutation

18. Given the fusion reaction:

1 $\quad {}^{2}H + {}^{2}_{1}H \to X$ + energy

Which particle is repres ented by X?

A. ${}^{1}_{1}H$
B. ${}^{3}_{2}He$
C. ${}^{3}_{1}H$
D. ${}^{4}_{2}He$

19. Which nuclear equation represents a natural transmutation?

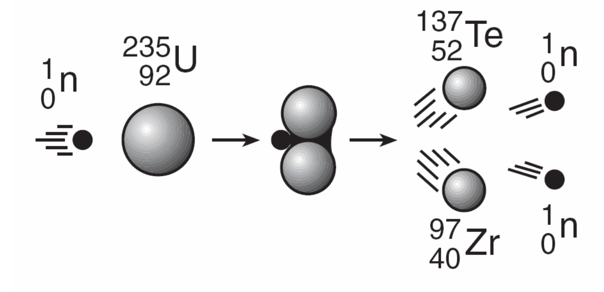
A. ${}^{9}_{4}Be + {}^{1}_{1}H \to {}^{6}_{3}Li + {}^{4}_{2}He$

B. ${}^{27}_{13}Al + {}^{4}_{2}He \to {}^{30}_{15}P + {}^{1}_{0}n$

C. ${}^{14}_{7}N + {}^{4}_{2}He \to {}^{17}_{8}O + {}^{1}_{1}H$

D. ${}^{235}_{92}U \to {}^{231}_{90}Th + {}^{4}_{2}He$

20. Given the diagram representing a reaction:



Which phrase best desc ribes this type of reaction and the overall energy change that occurs?

A. nuclear, and energy is released
B. nuclear, and energy is absorbed
C. chemical, and energy is released
D. chemical, and energy is absorbed

21. Which statement best describes what happens in a fission reaction?

A. Heavy nuclei split into lighter nuclei.
B. Light nuclei form into heavier nuclei.
C. Energy is released and less stable elements are formed.
D. Energy is absorbed and more stable elements are formed.

22. In which reaction is mass converted to energy by the process of fission?

A. ${}^{14}_{7}N + {}^{1}_{0}n \to {}^{14}_{6}C + {}^{1}_{1}H$
B. ${}^{235}_{92}U + {}^{1}_{0}n \to {}^{87}_{35}Br + {}^{146}_{57}La + 3{}^{1}_{0}n$
C. ${}^{226}_{88}Ra \to {}^{222}_{86}Ra + {}^{4}_{2}He$
D. ${}^{2}_{1}H + {}^{2}_{1}H \to {}^{4}_{2}He$

23. Which equation represents a fusion reaction?

A. $H_2O(g) \to H_2O(\ell)$
B. $C(s) + O_2(g) \to CO_2(g)$
C. ${}^{2}_{1}H + {}^{3}_{1}H \to {}^{4}_{2}He + {}^{1}_{0}n$
D. ${}^{235}_{92}U + {}^{1}_{0}n \to {}^{142}_{56}Ba + {}^{91}_{36}Kr + 3{}^{1}_{0}n$

24. Which change takes place in a nuclear fusion reaction?

A. Matter is converted to ener gy.
B. Energy is converted to matter.
C. Ionic bonds are converted to covalent bonds.
D. Covalent bonds are converted to ionic bonds.

25. Nuclear fusion *differs* from nuclear fission because nuclear fusion reactions

A. form heavier isotopes from lighter isotopes
B. form lighter isotopes from heavier isotopes
C. convert mass to energy
D. convert ener gy to mass

26. A nuclear fission reaction and a nuclear fusion reaction are similar because both reactions
    - A. form heavy nuclides from light nuclides
    - B. form light nuclides from heavy nuclides
    - C. release a large amount of energy
    - D. absorb a large amount of energy

27. The energy released by a nuclear reaction results primarily from the
    - A. breaking of bonds between atoms
    - B. formation of bonds between atoms
    - C. conversion of mass into energy
    - D. conversion of energy into mass

28. The amount of energy released from a fission reaction is much greater than the energy released from a chemical reaction because in a fission reaction
    - A. mass is converted into energy
    - B. energy is converted into mass
    - C. ionic bonds are broken
    - D. covalent bonds are broken

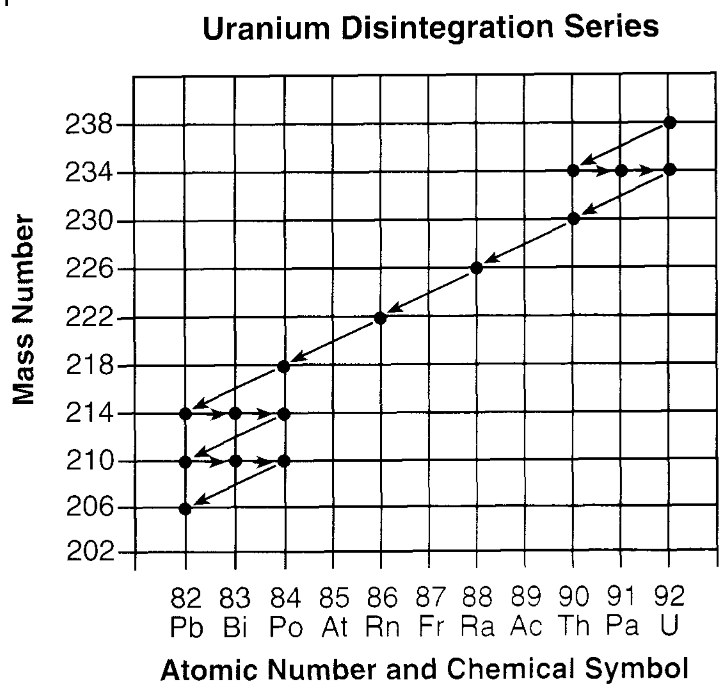
29. Which statement explains why nuclear waste materials may pose a problem?
    - A. They frequently have short half-lives and remain radioactive for brief periods of time.
    - B. They frequently have short half-lives and remain radioactive for extended periods of time.
    - C. They frequently have long half-lives and remain radioactive for brief periods of time.
    - D. They frequently have long half-lives and remain radioactive for extended periods of time.

30. The decay of which radioisotope can be used to estimate the age of the fossilized remains of an insect?
    - A. Rn-222
    - B. I-131
    - C. Co-60
    - D. C-14

31. Which radioisotope is used in medicine to treat thyroid disorders?
    - A. cobalt-60
    - B. iodine-131
    - C. phosphorus-32
    - D. uranium-238

Base your answers to questions **32** and **33** on the information below.

A U-238 atom decays to a Pb-206 atom through a series of steps. Each point on the graph below represents a nuclide and each arrow represents a nuclear decay mode.



32. Based on this graph, what particle is emitted during the nuclear decay of a Po-218 atom?

33. Explain why the U-238 disintegration series ends with the nuclide Pb-206.

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34. Based on Reference Table *N*, what is the fraction of a sample of potassium-42 that will remain unchanged after 62.0 hours?

35. Complete the nuclear equation *below*. Include the symbol, atomic number, and mass number for the missing particle.

$$^{42}_{19}\text{K} \rightarrow \,^{0}_{-1}\text{e} + \_\_\_\_\_\_$$

Lab # __________ **Name ___________________________**

Half Life of an Atom

Introduction:

In any sample of a radioisotope, the individual atoms are decaying in a random fashion. It is impossible to predict which atom is the next to decay, yet statistically you can predict how many atoms will decay in a certain period of time. Scientist measure how much time elapses while half of a given radioactive sample decays. That time is called half life. Half lives of radioactive isotopes vary greatly, from much less than a second to billions of years. A sample of radioisotopes and their half life values can be found in Table N in your reference tables. The half life is a very important factor when choosing a radioactive isotope for a specific application such as a medical tracer.

Purpose:

The class will simulate radioactive decay and half-life using M&Ms and Skittles.

Materials:

Cup containing varying amounts of M&Ms or Skittles
Paper plate
Timer

Procedure :

1. Obtain a cup of candies. Each cup should have approximately 100 candies. Be sure that each candy has a letter on one side. If no letter, you may eat it now. Count the actual number of candies that have a letter. Record this number on the observations sheet.
2. Write down the exact time that you start the experiment (hour, minutes, and seconds) on the observation sheet.
3. Shake the cup containing the candies and dump the candies onto the plate
4. Remove all candies that have the M or S facing down. These will be set aside.
5. All candies with the M or S facing up should be returned to the cup. Record the number of candies with the M or S facing up on your data table as you return them to the cup.
6. Repeat steps #3-6 until there is only 1 candy remaining.
7. Immediately record the time you completed the activity (hour, minutes, and seconds) on the observation sheet.
8. Calculate the number of seconds required to complete the task. Record this on the observation sheet.
9. Divide the number of seconds by the number of half life periods (number of shakes). This will equal the half life of the M&M or Skittle. Record this on your observation sheet.

Vocabulary:

Fusion	Gamma ray	Alpha particle
Fission	Beta particle	Artificial transmutation
Half-life	Radioisotope	Natural Transmutation

Observations: Time Elapsed __________

Shake Number (of half lives)	Number of M or S remaining

Half-life calculations:

(Time elapsed) / (Number of shakes) = (__________) / (__________).
Half life = _____________seconds

Questions:

1. In this experiment, what was the half life of your M&M?
2. Approximately how many candies, by percent, were removed with each shake?
3. Is it possible to predict how many candies will be removed with each shake? Explain.
4. Would combining data from all of the groups be useful? Why?
5. Make a graph plotting M&Ms remaining on the x-axis and number of shakes on the y-axis for your data. Make sure to label the axes and units used for each. Don't forget a title. Connect the data points with a smooth curve.
6. How would you describe the shape of this graph?
7. Will the graph change depending if you started with 100 M&Ms or with 1000 M&Ms? Why?