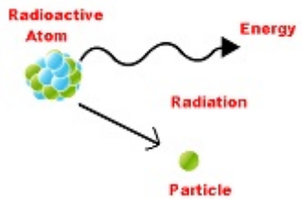
Physics 2204
Unit 3: Work, Power and Energy
Worksheet 12 : Nuclear Stability

Student Name:_____

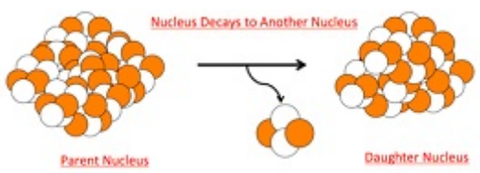
Radioactivity - the spontaneous disintegration of atomic nuclei through the emission of radiation or particles.Unstable nuclei change to more stable nuclei by releasing emissions.In some instances, a new element is formed and in other cases, a new form of the original element, called an isotope, appears.



Nuclear stability:

- The "strong nuclear force" is an attractive force between nucleons which acts only over very short distances.
- It is stronger than the electrical proton-proton repulsion force at nuclear distances.
- The number of neutrons determine the nuclear stability since they can provide the strong nuclear force without increasing the electrical force.

Transmutations - to the changing of one element into another by the process of radioactivity. Particles or energy might be emitted from a parent nucleus resulting in a new element called a daughter nucleus which itself might be unstable and subsequently emit more particles or energy.



Three Types of Natural Transmutation**:**

1) Alpha decay (α)

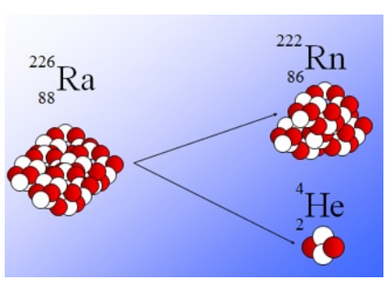
- The *parent* nucleus emits an alpha particle (α), which consists of 2 protons and 2 neutrons.
- The alpha particle, which is equivalent to helium, is often written as ^{4}He (α).
- The new element formed, the *daughter* nucleus, has 4 less nucleons with 2 less protons.
-

General eq'n:

$$ {}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He(\alpha) $$

Example:

$$ {}^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He(\alpha) $$



2) β^- decay (electron emission)

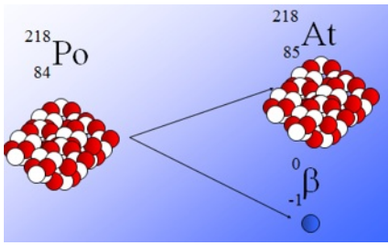
- The *parent* nucleus emits an electron (e^-) as a neutron decays to a proton.
- Another particle is also emitted and is called an antineutrino (${}^0\nabla$). It has neutral charge and appears massless.
- The *daughter* nucleus has 1 more proton than its *parent*.
-

General eq'n:

$${}^A_Z X \rightarrow {}^A_{Z+1} Y + {}^0_{-1} e(\beta^-)$$

Example:

$${}^{218}_{84} Po \rightarrow {}^{218}_{85} At + {}^0_{-1} e(\beta^-)$$



3) Gamma decay (γ)

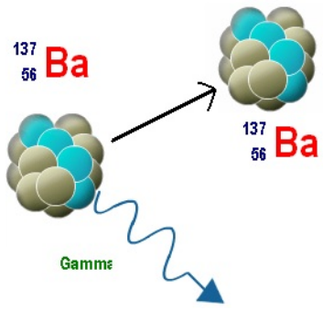
- The *parent* nucleus is in an excited state (*) and gives off a high energy photon or gamma ray (γ) as it drops to a lower energy state.
- It is the nucleus, and not an electron, which is excited and thus the emitted photon is of higher energy and referred to as a gamma ray (γ).

General eq'n:

$${}^A_Z X^* \rightarrow {}^A_Z X + \gamma$$

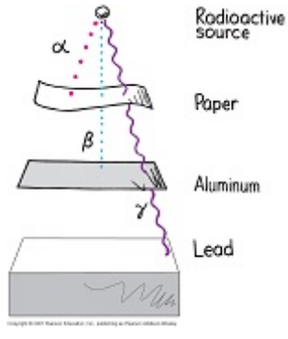
Example: (* indicates excited state of the nuclide)

$${}^{137}_{56} Ni^* \rightarrow {}^{137}_{56} Ni + \gamma$$



Penetrating Ability of Each Radioactive Decay:

A piece of paper can stop alpha rays. Beta particles can be stopped by a sheet of aluminum. Even lead may not stop gamma rays.



Applications Of Radioactivity:

Medicine: medical specialty that involves the use of radioactive isotopes in the diagnosis and treatment of disease.

Energy Industry: Power generation based on the release of the fission energy of uranium

Science: The isotope carbon-14 is used by archeologists to determine age.

Household: Radioactive isotopes are even used in smoke alarms.

Example 1:

A) Name the type of decay.

B)Determine the value of x and y in each nuclear equation where P = parent and D = daughter.

(A) $^{212}_{82}P \rightarrow {}^{212}_{x}D + {}^{0}_{-1}e$	(B) $^{210}_{84}P \rightarrow {}^{y}_{x}D + {}^{4}_{2}He$
(C) $^{227}_{89}P \rightarrow {}^{227}_{90}D + x$	(D) $^{226}_{88}P \rightarrow {}^{y}_{x}P + \gamma$
(E) $^{214}_{83}P \rightarrow {}^{x}_{y}D + {}^{0}_{-1}e$	(F) $^{x}_{y}P \rightarrow {}^{222}_{86}D + {}^{4}_{2}He$
(G) $^{215}_{84}P \rightarrow {}^{211}_{82}D + x$	(H) $^{3}_{1}P \rightarrow x + \gamma$

PART A: MULTIPLE CHOICE

Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided

1. Which of the following occurs in the decay of a radioactive nucleus?

   (A) The nucleus absorbs another nucleus
   (B) The nucleus absorbs at least one form of radiation
   (C) The nucleus always splits into two equal fragments
   (D) The nucleus emits at least one form of radiation

2. During radioactive decay, what does the nucleus disintegrates into?

   (A) A lighter and more stable nucleus
   (B) A lighter and less stable nucleus
   (C) A heavier and more stable nucleus
   (D) A heavier and less stable nucleus

3. What form(s) of radiation are given off during radioactivity?

   (A) Particles
   (B) Energy
   (C) Particles and Energy
   (D) Nothing is given off

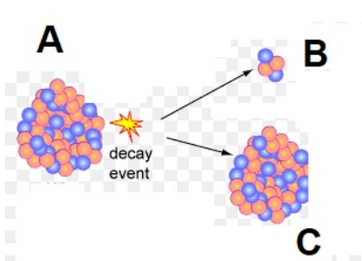
4. What elements on the periodic table is radioactivity mostly confined almost to?

   (A) 10 to 60
   (B) 60 to 92
   (C) 83 to 106
   (D) 92 to 118

5. Which of the following is a natural transmutation?

   (A) Alpha Decay
   (B) Beta Decay
   (C) Gamma Decay
   (D) All of the above

Use the diagram below to answer the following questions 6 and 7:



6. Which of the following represents A?

   (A) Daughter element
   (B) Energy
   (C) Particle
   (D) Parent element

7. Which of the following represents C?

   (A) Daughter element
   (B) Energy
   (C) Particle
   (D) Parent element

8. Which of the following is a helium nucleus with two protons and two neutrons ?

(A) Alpha particle
(B) Beta particle
(C) Gamma ray
(D) Transmutation

9. What is another name for an alpha particle?

(A) An electron
(B) A positron
(C) A helium nucleus
(D) A photon

10. Which transmutation is represented by the equation $^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$?

(A) Alpha Decay
(B) Beta minus Decay
(C) Gamma Decay
(D) None of the above are correct

11. In the following equation for radioactive decay, what are the values of A and Z?

$$^{241}_{95}Am \rightarrow {}^{A}_{Z}X + {}^{4}_{2}He$$

(A) A = 237, Z = 93
(B) A = 237, Z = 91
(C) A = 239, Z = 91
(D) A = 239, Z = 93

12. An atom having 98 protons and 249 neutrons undergoes alpha decay. What are the number of protons and neutrons in the daughter nucleus?

	protons	**neutrons**
(A)	94	251
(B)	96	247
(C)	100	251
(D)	100	249

13. How many neutrons are in the daughter nucleus if $^{235}_{92}U$ undergoes alpha decay?

(A) 90
(B) 141
(C) 143
(D) 231

14. Which isotope is produced when $^{214}_{83}Bi$ decays by emitting an alpha particle?

(A) $^{210}_{79}Au$
(B) $^{212}_{79}Au$
(C) $^{210}_{81}Tl$
(D) $^{212}_{81}Tl$

15. Complete the following nuclear reaction ?

$$^{234}_{90}Th \rightarrow ^{230}_{88}Ra + ?$$

(A) α
(B) β^-
(C) β^+
(D) γ

16. Complete the nuclear reaction $^{16}_{8}O + \rightarrow ? + ^{4}_{2}He$

(A) $^{12}_{6}C$
(B) $^{13}_{6}C$
(C) $^{12}_{8}C$
(D) $^{13}_{8}C$

17. Which type of decay emits a helium nucleus?

(A) α
(B) β^-
(C) β^+
(D) γ

18. Which decay is illustrated by the reaction below?

$$^{238}_{90}Th \rightarrow ^{234}_{88}Ra + ^{4}_{2}He$$

(A) α
(B) β^-
(C) β^+
(D) γ

19. Which represents the alpha decay of thorium 228?

(A) $^{228}_{90}Th \rightarrow ^{227}_{90}Th + \alpha$

(B) $^{228}_{90}Th \rightarrow ^{228}_{90}Ac + \alpha$

(C) $^{228}_{90}Th \rightarrow ^{228}_{91}Pa + \alpha$

(D) $^{228}_{90}Th \rightarrow ^{224}_{88}Ra + \alpha$

20. Which of the following refers to the negatively charged particles emitted from a nucleus at a high speed during a radioactive decay?

(A) Alpha particle
(B) Beta particle
(C) Gamma ray
(D) Transmutation

21. Which shows the beta minus (β^-) de $^{90}_{38}Sr$?

(A) $^{90}_{38}Sr \rightarrow {}^{-1}_{o}e + {}^{89}_{38}Sr$

(B) $^{90}_{38}Sr \rightarrow {}^{0}_{-1}e + {}^{90}_{39}Y$

(C) $^{90}_{38}Sr \rightarrow {}^{-1}_{0}e + {}^{91}_{38}Sr$

(D) $^{90}_{38}Sr \rightarrow {}^{0}_{-1}e + {}^{90}_{37}Rb$

22. Which will complete the nuclear decay reaction shown?

$$^{58}_{29}Cu \rightarrow ? + \gamma$$

(A) $^{54}_{27}Co$

(B) $^{56}_{25}Mn$

(C) $^{57}_{28}Ni$

(D) $^{58}_{29}Cu$

23. Which best describes X in the reaction $^{218}_{84}Po \rightarrow {}^{214}_{82}Pb + X + \gamma$

	Atomic Number	Atomic Mass Number
(A)	2	4
(B)	4	2
(C)	166	432
(D)	432	166

24. Which represents the β^- decay of Thorium 234?

(A) $^{234}_{90}Th \rightarrow {}^{233}_{89}Ac + \beta^-$

(B) $^{234}_{90}Th \rightarrow {}^{234}_{89}Ac + \beta^-$

(C) $^{234}_{90}Th \rightarrow {}^{233}_{91}Pa + \beta^-$

(D) $^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + \beta^-$

25. Which transmutation represents alpha decay?

(A) $^{15}_{8}O \rightarrow {}^{15}_{7} + {}^{0}_{+1}e$

(B) $^{230}_{90}Th \rightarrow {}^{226}_{88}Ra + {}^{4}_{2}He$

(C) $^{227}_{89}Ac \rightarrow {}^{227}_{90}Th + \alpha$

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

26. Which radioactive emission has the greatest penetrating power?

(A) Alpha
(B) Beta negative
(C) Beta positive
(D) Gamma

27. The three types of nuclear radiation with increasing order of penetrating power are

(A) Alpha, beta, gamma
(B) Alpha, gamma, beta
(B) Beta, alpha, gamma
(C) Gamma, beta, alpha

PART B: WRITTEN RESPONSE

1. For each nucleus below, indicate the name and the number of protons and neutrons in the nucleus.

(A) ${}^{2}_{1}X$	(B) ${}^{60}_{27}X$	(C) ${}^{56}_{27}X$

2. Complete the following table:

Symbol	**Z (Atomic Number)**	**A (Atomic Mass)**	**N (Neutrons)**	${}^{A}_{Z}X$
He		4		
	10		10	
	32	67		
		70	40	

3. Each parent nucleus below undergoes alpha decay. Complete the reaction statement and determine the daughter nucleus.

(A) ${}^{8}_{4}Be$ _____

(B) ${}^{226}_{88}Ra$ _____

(C) ${}^{239}_{94}Pu$ _____

4. Each parent nucleus below undergoes beta decay. Complete the reaction statement and determine the daughter nucleus.

(A) $^{19}_{8}O$ _____

(B) $^{212}_{82}Pb$ _____

(C) $^{60}_{27}Co$ _____

5. Fill in the missing particle or atom and identify the type of transmutation in each case

(A) $^{210}_{84}Po \rightarrow \_\_\_\_ + \alpha$ Type:_____

(B) $^{215}_{83}Bi \rightarrow ^{215}_{84}Po + \_\_\_\_$ Type:_____

(C) $^{238}_{92}U \rightarrow ^{234}_{90}T + \_\_\_\_$ Type:_____

(D) $^{218}_{85}At \rightarrow \_\_\_\_ + ^{218}_{86}Rn$ Type:_____

(E) $\_\_\_\_ \rightarrow \gamma + ^{208}_{81}Tl$ Type:_____

(F) $\_\_\_\_ \rightarrow \beta^{-} + ^{211}_{83}Bi$ Type:_____

6. An unstable Thorium-231 nucleus spontaneously emits a beta negative particle and transmutes into a daughter nucleus. Determine the atomic number and mass number of the daughter nucleus and write an equation to show the nuclear decay process.