PHYSICS 3204
WORKSHEET #7 TRANSMUTATION

Transmutations - the changing of one element into another.

Radioactivity - the spontaneous disintegration of atomic nuclei through the emission of radiation or particles.

Unstable nuclei change to more stable nuclei by releasing emissions.

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.
- Certain isotopes are therefore unstable and will radioactively decay.

Radioactive reaction types

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.
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General eq'n:

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

Example:

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

Types of Beta decay:

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:

$$ {}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e(\beta^-) + {}^{0}_{0}\bar{\nu} $$

Example:

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

β$^+$ decay (positron emission)

- The *parent* nucleus emits a positron (e^+) as a proton decays to a neutron.
- Another particle is also emitted and is called a neutrino (^{0}V).
- The *daughter* nucleus has 1 less proton than its *parent*.

General eq'n:

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

Example:

$$ {}^{22}_{11}Na \rightarrow {}^{22}_{10}Ne + {}^{0}_{1}e(\beta^+) + {}^{0}_{0}\nu $$

Electron capture

- The *parent* nucleus absorbs one of its own electrons into its nucleus, causing a proton to change into a neutron.
- A neutrino (^{0}V) is also emitted, along with a photon (γ) as a higher orbital electron drops to the lower level.

General eq'n:

$$ {}^{A}_{Z}X + {}^{0}_{-1}e \rightarrow {}^{A}_{Z-1}Y + {}^{0}_{0}v + \gamma $$

Example:

$$ {}^{7}_{4}Be + {}^{0}_{-1}e \rightarrow {}^{7}_{3}Li + {}^{0}_{0}v + \gamma $$

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)

$$ {}^{60}_{28}Ni^{*} \rightarrow {}^{60}_{28}Ni + \gamma $$

Insert Table 18.3

PART A: MULTIPLE CHOICE

1. 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) Beta positive Decay
   (D) Gamma Decay

2. 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 $

3. 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 $

4. 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

5. Which completes the nuclear reaction shown?

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}Ba + ? + 3\,^{1}_{0}n$$

(A) $^{92}_{35}Br$
(B) $^{94}_{35}Br$
(C) $^{92}_{36}Kr$
(D) $^{94}_{36}Kr$

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

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

7. 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) $^{212}_{81}Tl$

8. Complete the following nuclear reaction ?

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

(A) α
(B) β^-
(C) β^+
(D) γ

9. If a β+ particle is emitted from an unstable nucleus, what happens to the atomic number of the nucleus?

(A) Decreases by 1
(B) Decreases by 2
(C) Increases by 1
(D) Increases by 2

10. Complete the nuclear reaction $^{16}_{8}O + ^{1}_{0}n \rightarrow ? + ^{4}_{2}He$

(A) $^{12}_{6}C$

(B) $^{13}_{6}C$

(C) $^{12}_{8}C$

(D) $^{13}_{8}C$

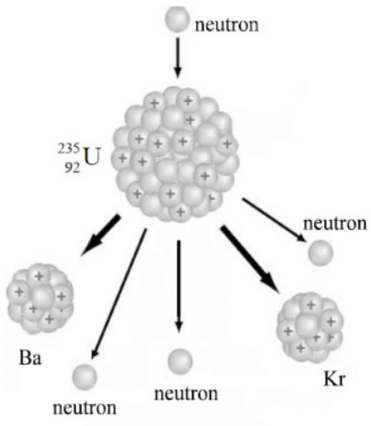
11. The diagram below illustrates part of a typical chain reaction for Uranium-235. Which nuclear equation describes the chain reaction?

(A) $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{144}_{56}Ba + ^{89}_{36}Kr + 3\,^{1}_{0}n$

(B) $^{1}_{0}p + ^{235}_{92}U \rightarrow ^{144}_{56}Ba + ^{89}_{36}Kr + 3\,^{1}_{0}n$

(C) $^{235}_{92}U \rightarrow ^{144}_{56}Ba + ^{89}_{36}Kr + 4\,^{1}_{0}n$

(D) $4\,^{1}_{0}n + ^{235}_{92}U \rightarrow ^{144}_{56}Ba + ^{89}_{36}Kr$



12 Which type of decay emits a helium nucleus?

(A) α

(B) β^{-}

(C) β^{+}

(D) γ

13. 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

14. Which decay is illustrated by the reaction below?

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

(A) α

(B) β^{-}

(C) β^{+}

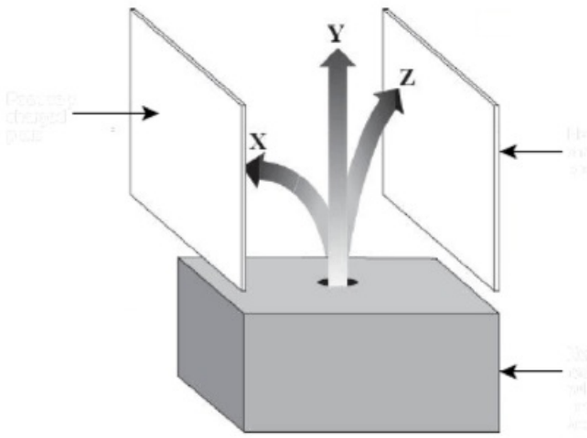
(D) γ

15. What is missing in the nuclear decay process below?

$$^{90}_{39}Y \rightarrow ^{90}_{38}Sr + ?$$

(A) Photon and alpha particle
(B) Photon and neutrino
(C) Positron and alpha particle
(D) Positron and neutrino

16. What types of radiation are passing through the electric field in the diagram below?



	X	Y	Z
(A)	alpha	beta	gamma
(B)	alpha	gamma	beta
(C)	beta	alpha	gamma
(D)	beta	gamma	alpha

17. Which represents the alpha decay of thorium 228?

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

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

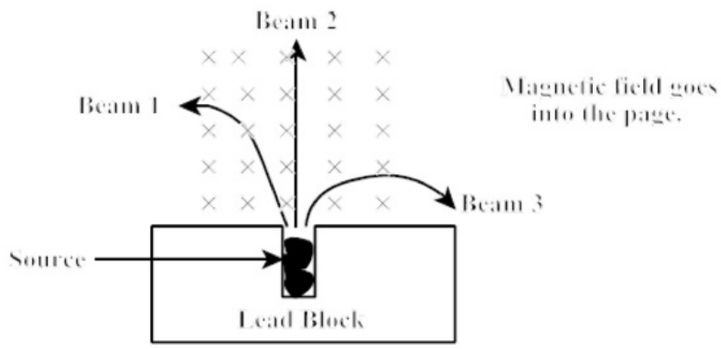
(C) $^{228}_{90}Th \rightarrow ^{228}_{91}Pa + \alpha$

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

18. Which radioactive emission has the greatest penetrating power?

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

19. The diagram below shows how three types of radiation emitted from a radioactive source are affected by a magnetic field. What type of radiation is emitted by each beam?



	beam 1	beam 2	beam 3
(A)	alpha	beta	gamma
(B)	alpha	gamma	beta
(C)	beta	alpha	gamma
(D)	beta	gamma	alpha

20. 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) $^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + \beta^-$

21. 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) $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

22. What is the missing product in the reaction below?

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{56}Ba + ? + 3{}^{1}_{o}n$$

(A) $^{89}_{36}Kr$

(B) $^{91}_{36}Kr$

(C) $^{89}_{34}Kr$

(D) $^{91}_{34}Kr$