ASSIGN. #1

Radioactivity
Regents Practice

1. Which nuclear emission is negatively charged?
   (1) An alpha particle
   (2) A beta particle
   (3) A neutron
   (4) A positron

2. Positrons and beta particles have
   (1) The same charge and the same mass
   (2) The same charge and different masses
   (3) Different charges and the same mass
   (4) Different charges and different masses

3. Which statement describes the relative masses of two different particles?
   (1) A neutron has less mass than a positron
   (2) A beta particle has less mass than a neutron
   (3) An alpha particle has less mass than a positron
   (4) An alpha particle has less mass than a beta particle

4. Radiation is spontaneously emitted from hydrogen-3 nuclei, but radiation is *not* spontaneously emitted from hydrogen-1 nuclei or hydrogen-2 nuclei. Which hydrogen nuclei are stable?
   (1) Nuclei of H-1 and H-2, only
   (2) Nuclei of H-1 and H-3, only
   (3) Nuclei of H-2 and H-3, only
   (4) Nuclei of H-1, H-2, and H-3

5. Compared to the mass and the penetrating power of an alpha particle, a beta particle has
   (1) Less mass and greater penetrating power
   (2) Less mass and less penetrating power
   (3) More mass and greater penetrating power
   (4) More mass and less penetrating power

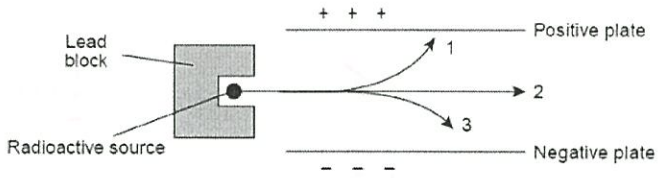
6. Which nuclear emission has the greatest penetrating power?
   (1) Alpha particle
   (2) Beta particle
   (3) Gamma radiation
   (4) Positron

7. Which particle has the greatest mass?
   (1) An alpha particle
   (2) A beta particle
   (3) A neutron
   (4) A positron

8. The nucleus of a radium-226 atom is unstable, which causes the nucleus to spontaneously
   (1) Absorb electrons
   (2) Absorb protons
   (3) Decay
   (4) Oxidize

9. Which group of nuclear emissions is listed in order of increasing charge?
   (1) Alpha particle, beta particle, gamma radiation
   (2) Gamma radiation, alpha particle, beta particle
   (3) Positron, alpha particle, neutron
   (4) Neutron, positron, alpha particle

10. The diagram below represents radioactive emanations passing through an electric field.



What type of emanation is represented by the arrow labeled 1?
   (1) Alpha particle
   (2) Beta particle
   (3) positron
   (4) gamma ray

11. The table below indicates the stability of six nuclides.

All atoms of the unstable nuclides listed in this table have
   (1) An odd number of neutrons
   (2) An odd number of protons
   (3) More neutrons than protons
   (4) More protons than neutrons

Stability of Six Nuclides

Nuclide	Stability
C-12	stable
C-14	unstable
N-14	stable
N-16	unstable
O-16	stable
O-19	unstable

ASSIGN. #2

Decay Equations

Regents Practice

1. What is the total number of protons and neutrons in the nuclide $^{80}_{35}Br$?
   (1) 35
   (2) 45
   (3) 80
   (4) 115

2. Which term identifies a type of nuclear reaction?
   (1) transmutation
   (2) neutralization
   (3) deposition
   (4) reduction

3. A sample of which radioisotope emits particles having the greatest mass?
   (1) ^{137}Cs β^-
   (2) ^{53}Fe β^+
   (3) ^{220}Fr α
   (4) ^{3}H β^-

   α decay

   Table N

4. Given the equation representing a nuclear reaction in which X represents a nuclide:

$$^{232}_{90}\text{Th} \rightarrow {}^{4}_{2}\text{He} + X$$

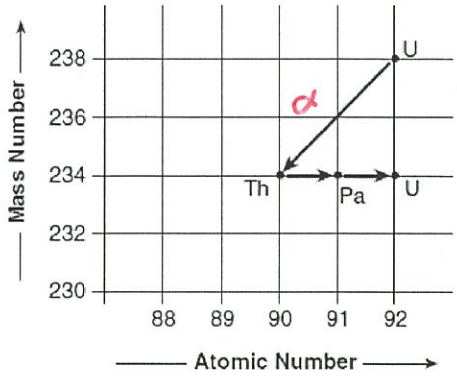
   Which nuclide is represented by X?
   (1) $^{236}_{92}Ra$
   (2) $^{228}_{88}Ra$
   (3) $^{236}_{92}U$
   (4) $^{228}_{88}U$

   228 Ra
   88
   ↑ atomic #

5. Which equation represents the radioactive decay of $^{226}_{88}Ra$?
   (1) $^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$
   (2) $^{226}_{88}\text{Ra} \rightarrow {}^{226}_{89}\text{Ac} + {}^{0}_{-1}\text{e}$
   (3) $^{226}_{88}\text{Ra} \rightarrow {}^{226}_{87}\text{Fr} + {}^{0}_{+1}\text{e}$
   (4) $^{226}_{88}\text{Ra} \rightarrow {}^{225}_{88}\text{Ra} + {}^{1}_{0}\text{n}$

   α decay

6. The chart below shows the spontaneous nuclear decay of U-238 to Th-234 to Pa-234 to U-234.



   What is the correct order of nuclear decay modes for the change from U-238 to U-234?
   (1) ß⁻ decay, γ decay, ß⁻ decay
   (2) ß⁻ decay, ß⁻ decay, α decay
   (3) α decay, α decay, ß⁻ decay
   (4) α decay, ß⁻ decay, ß⁻ decay

7. Which reaction is matched correctly with the particle represented by letter X?
   (1) $^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + X$; X is an alpha particle. ✓
   (2) $^{234}_{90}\text{Th} \rightarrow {}^{234}_{91}\text{Pa} + X$; X is an alpha particle.
   (3) $^{230}_{90}\text{Th} \rightarrow {}^{226}_{88}\text{Ra} + X$; X is a beta particle.
   (4) $^{234}_{92}\text{U} \rightarrow {}^{230}_{90}\text{Th} + X$; X is a beta particle.

8. In the equation:

$$^{239}_{90}\text{Th} \rightarrow {}^{239}_{91}\text{Pa} + X$$

   The symbol X represents
   (1) $^{0}_{+1}e$
   (2) $^{0}_{-1}e$
   (3) $^{1}_{0}n$
   (4) $^{1}_{1}H$

   $^{0}_{-1}e$

   239 + 0 = 239 ✓

   91 + -1 = 90 ✓

Complete the nuclear equation (use isotopic notation) for...

9. The beta decay of Zr-97 $^{97}_{40}Zr \rightarrow {}^{0}_{-1}e + {}^{97}_{41}Nb$

10. The nuclear decay of Mo-99 into Tc-99. $^{99}_{42}Mo \rightarrow {}^{0}_{-1}e + {}^{99}_{43}Tc$

11. The alpha decay of U-238. $^{238}_{92}U \rightarrow {}^{4}_{2}\alpha + {}^{234}_{90}Th$

12. The radioactive decay of tritium (hydrogen-3) $^{3}_{1}H \rightarrow {}^{0}_{-1}e + {}^{3}_{2}He$

ASSIGN. #3

Half Life

Regents Practice

1 → 1/2 → 1/4 → 1/8 → 1/16

1. Which radioisotope has the fastest rate of decay?

   A) ^{14}C B) ^{37}Ca C) ^{53}Fe D) ^{42}K

   152 ms

2. Which phrase describes the decay modes and the half-lives of K-37 and K-42?

   A) the same decay mode but different half-lives
   B) the same decay mode and the same half-life
   C) different decay modes and different half-lives ✓
   D) different decay modes but the same half-life

3. A radioactive isotope has a half-life of 2.5 years. Which fraction of the original mass remains unchanged after 10. years?

   A) 1/2 B) 1/4 C) 1/8 D) 1/16

HL	Amt	T
0	1	0
1	1/2	2.5
2	1/4	5
3	1/8	7.5
4	1/16	10

4. What fraction of a Sr-90 sample remains unchanged after 87.3 years?

   A) 1/2
   B) 1/3
   C) 1/4
   D) 1/8

HL	Amt	Time
0	1	0
1	1/2	29.1
2	1/4	58.2
3	1/8	87.3

5. After decaying for 48 hours, $\frac{1}{16}$ of the original mass of a radioisotope sample remains unchanged. What is the half-life of this radioisotope?

   A) 3.0 h B) 9.6 h C) 12 h D) 24 h

   48 / 4

6. Which radioisotopes have the same decay mode and have half-lives greater than 1 hour?

   A) Au-198 and N-16 B) Ca-37 and Fe-53
   C) I-131 and P-32 D) Tc-99 and U-233

7. What is the total number of years that must pass before only 25.00 grams of an original 100.0-gram sample of C-14 remains unchanged?

   A) 2865 y B) 5730 y
   C) 11 460 y D) 17 190 y

HL	Amt	Time
0	100	0
1	50	5715
2	25	11430

8. What is the half-life of a radioisotope if 25.0 grams of an original 200.-gram sample of the isotope remains unchanged after 11.46 days?

   A) 2.87 d B) 3.82 d
   C) 11.46 d D) 34.38 d

HL	Amt	Time
0	200	0
1	100	
2	50	
3	25	11.46

11.46 / 3

Base your answers to questions **9** and **10** on the information below and on your knowledge of chemistry.

The radioisotope Mo-99 naturally decays to produce the metastable isotope Tc-99m, which is used in medical diagnosis. A doctor can obtain images of organs and bones by injecting a patient with a solution of Tc-99m. The half-life of the metastable Tc-99m is six hours.

9. Determine the fraction of an original sample of metastable Tc-99m that remains unchanged after 24 hours.

   1/16

10. State *both* the number of protons and the number of neutrons in a Tc-99 nuclide.

mass # is protons + neutrons

atomic # = 43

99 − 43 = 56

HL	Amt	Time
0	1	0
1	1/2	6
2	1/4	12
3	1/8	18
4	1/16	24

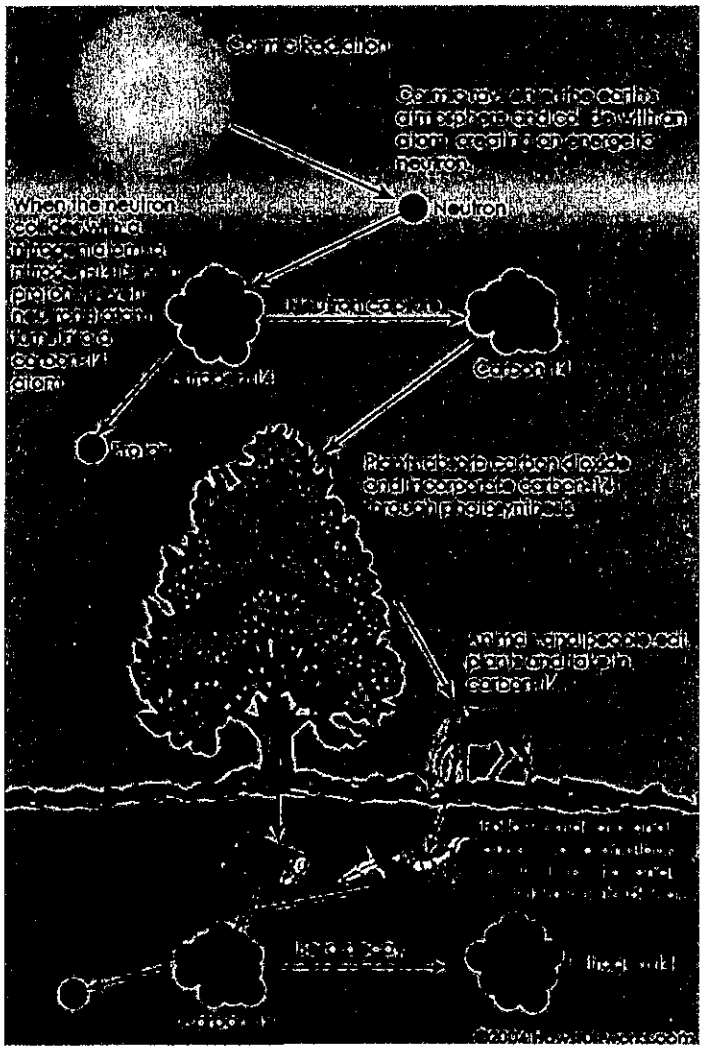
43 protons

56 neutrons

TOPIC 12.4

Useful Isotopes

How can radioisotopes benefit society?



Uses of Radioisotopes

Dating

Carbon – 14 (C – 14) is measured in dead organism to find out when it was last alive based on its ½ life

Uranium – 238 is used to date geological formations → decays to lead-206

Medical

Certain radioisotopes are useful because they have short half-lives and thus are quickly removed from the body

- Iodine – 131 : used to detect & treat thyroid disorders
- Cobalt – 60: emits gamma rays that can destroy cancer cells
- Technetium – 99: detects cancerous tumors

Risks

Large amounts of radiation given off by isotopes can cause serious illness and death and environmental damage

Assignment #4:

1. Which radioisotope is used in dating geological formations?

   A) I-131 (B) U-238
   C) Ca-37 D) Fr-220

2. Which radioisotope is used for diagnosing thyroid disorders?

   A) U-238 B) Pb-206
   (C) I-131 D) Co-60

3. Which isotope is used to treat cancer?

   A) C-14 B) U-238
   (C) Co-60 D) Pb-206

4. Cobalt-60 and iodine-131 are radioactive isotopes that are used in

   A) dating geologic formations
   B) industrial measurements
   (C) medical procedures
   D) nuclear power

5. Which nuclide is paired with a specific use of that nuclide?

   A) carbon-14, treatment of cancer
   B) cobalt-60, dating of rock formations
   (C) iodine-131, treatment of thyroid disorders
   D) uranium-238, dating of once-living organisms

6. Radioisotopes used for medical diagnosis must have

   A) long half-lives and be quickly eliminated by the body
   B) long half-lives and be slowly eliminated by the body
   (C) short half-lives and be quickly eliminated by the body
   D) short half-lives and be slowly eliminated by the body

7. A radioisotope which is sometimes used by doctors to pinpoint a brain tumor is

   A) carbon-12 B) lead-206
   (C) technetium-99 D) uranium-238

8. Iodine-131 is used for diagnosing thyroid disorders because it is absorbed by the thyroid gland and

   (A) has a very short half-life
   B) has a very long half-life
   C) emits alpha radiation
   D) emits gamma radiation

ASSIGN. #5

Artificial Transmutation
Regents Practice

1. Which equation represents natural transmutation?
   (1) $^{10}_{5}B + {}^{4}_{2}He \rightarrow {}^{13}_{7}N + {}^{1}_{0}n$
   (2) $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$
   (3) $S + 2e^- \rightarrow S^{2-}$
   (4) $Na \rightarrow Na^+ + e^-$

2. Which nuclear equation represents a natural transmutation?
   (1) $^{9}_{4}Be + {}^{1}_{1}H \rightarrow {}^{6}_{3}Li + {}^{4}_{2}He$
   (2) $^{27}_{13}Al + {}^{4}_{2}He \rightarrow {}^{30}_{15}P + {}^{1}_{0}n$
   (3) $^{14}_{7}N + {}^{4}_{2}He \rightarrow {}^{17}_{8}O + {}^{1}_{1}H$
   (4) $^{235}_{92}U \rightarrow {}^{231}_{90}Th + {}^{4}_{2}He$

3. Radioactive cobalt-60 is used in radiation therapy treatment. Cobalt-60 undergoes beta decay. This type of nuclear reaction is called
   (1) Natural transmutation
   (2) Artificial transmutation
   (3) Nuclear fusion
   (4) Nuclear fission

4. Which equation is an example of artificial transmutation?
   (1) $^{9}_{4}Be + {}^{4}_{2}He \rightarrow {}^{12}_{6}C + {}^{1}_{0}n$
   (2) $U + 3\,F_2 \rightarrow UF_6$
   (3) $Mg(OH)_2 + 2\,HCl \rightarrow 2\,H_2O + MgCl_2$
   (4) $Ca + 2\,H_2O \rightarrow Ca(OH)_2 + H_2$

5. The change that is undergone by an atom of an element made radioactive by bombardment with high-energy protons is called
   (1) Natural transmutation
   (2) Artificial transmutation
   (3) Natural decay
   (4) Radioactive decay

6. Which equation represents artificial transmutation?
   (1) $^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$
   (2) $^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + {}^{0}_{-1}e$
   (3) $^{218}_{84}Po \rightarrow {}^{214}_{82}Pb + {}^{4}_{2}He$
   (4) $^{9}_{4}Be + {}^{4}_{2}He \rightarrow {}^{12}_{6}C + {}^{1}_{0}n$

7. Which equation represents a spontaneous / natural transmutation?
   (1) $Ca(s) + 2H_2O(\ell) \rightarrow Ca(OH)_2(aq) + H_2(g)$
   (2) $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$
   (3) $^{239}_{94}Pu + 2\,^{1}_{0}n \rightarrow {}^{241}_{95}Am + {}^{0}_{-1}e$
   (4) $^{37}_{20}Ca \rightarrow {}^{37}_{19}K + {}^{0}_{+1}e$

8. Given the nuclear equation:

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

   Which particle is represented by X?
   (1) $^{4}_{2}He$
   (2) $^{0}_{-1}e$
   (3) $^{1}_{0}n$
   (4) $^{0}_{+1}e$

   $253 + 4 = 257$ ✓
   $99 + 2 = 101$ ✓

Elements with an atomic number greater than 92 can be artificially produced in nuclear reaction by bombarding a naturally occurring nuclide with a different nuclide. One of these elements is roentgenium, Rg. The equation below represents a nuclear reaction that produces Rg-272.

9. State the location and the total charge of the protons in a Ni-64 atom.

   Location: nucleus Total charge: +28

10. Determine the number of neutrons in an atom of Rg-272.

    272 − 111 = 161

11. Based on the Periodic Table, classify the element produced by this nuclear reaction as a metal, metalloid, nonmetal, or noble gas.

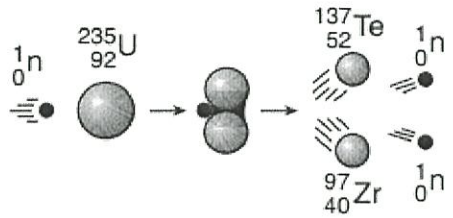
    metal

ASSIGN. #6

Fission and Fusion
Regents Practice

1. A nuclear fission reaction and a nuclear fusion reaction are similar because both reactions?
   (1) Form heavy nuclides from light nuclides
   (2) Form light nuclides from heavy nuclides
   (3) Release a large amount of energy
   (4) Absorb a large amount of energy

2. Given the diagram representing a reaction:



   Which phrase best describes this type of reaction and the overall energy change that occurs?
   (1) Nuclear, and energy is released
   (2) Nuclear, and energy is absorbed
   (3) Chemical, and energy is released
   (4) Chemical, and energy is absorbed

3. Which change occurs during a nuclear fission reaction?
   (1) Covalent bonds are converted to ionic bonds
   (2) Isotopes are converted to isomers
   (3) Temperature is converted to mass
   (4) Matter is converted to energy

4. The greatest amount of energy released per gram of reactants occurs during a
   (1) Redox reaction
   (2) Fission reaction
   (3) Substitution reaction
   (4) Neutralization reaction

5. What is one benefit associated with a nuclear fission reaction?
   (1) The products are not radioactive
   (2) Stable isotopes are used as reactants
   (3) There is no chance of biological exposure
   (4) A large amount of energy is produced

6. In which reaction is mass converted to energy by the process of fission?
   (1) $^{14}_{7}\mathrm{N} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{14}_{6}\mathrm{C} + {}^{1}_{1}\mathrm{H}$
   (2) $^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{87}_{35}\mathrm{Br} + {}^{146}_{57}\mathrm{La} + 3\,{}^{1}_{0}\mathrm{n}$
   (3) $^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Ra} + {}^{4}_{2}\mathrm{He}$
   (4) $^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He}$

7. Which balanced equation represents nuclear fusion?
   (1) $^{3}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{He} + {}^{0}_{-1}\mathrm{e}$
   (2) $^{235}_{92}\mathrm{U} \rightarrow {}^{231}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$
   (3) $^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He}$
   (4) $^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{90}_{38}\mathrm{Sr} + {}^{143}_{54}\mathrm{Xe} + 3{}^{1}_{0}\mathrm{n}$

8. Given the balanced equation representing a nuclear reaction:

$$^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$$

   Which phrase identifies and describes this reaction?
   (1) Fission, mass converted to energy
   (2) Fission, energy converted to mass
   (3) Fusion, mass converted to energy
   (4) Fusion, energy converted to mass

9. Which reaction releases the greatest amount of energy per kilogram of reactants?
   (1) $^{1}_{0}\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{141}_{56}\mathrm{Ba} + {}^{92}_{36}\mathrm{Kr} + 3{}^{1}_{0}\mathrm{n}$
   (2) $2\mathrm{C} + \mathrm{H_2} \rightarrow \mathrm{C_2H_2}$
   (3) $\mathrm{C_3H_8(g)} + 5\mathrm{O_2(g)} \rightarrow 3\mathrm{CO_2(g)} + 4\mathrm{H_2O(\ell)}$
   (4) $\mathrm{NaOH(aq)} + \mathrm{HCl(aq)} \rightarrow \mathrm{NaCl(aq)} + \mathrm{H_2O(\ell)}$

10. Which risk is associated with using nuclear fission to produce energy in a power plant?
    (1) Depletion of hydrocarbons
    (2) Depletion of atmospheric oxygen
    (3) Exposure of workers to radiation
    (4) Exposure of workers to sulfur dioxide

11. What is a problem commonly associated with nuclear power facilities?
    (1) A small quantity of energy is produced
    (2) Reaction products contribute to acid rain
    (3) It is impossible to control nuclear fission
    (4) It is difficult to dispose of wastes

12. Which statement explains why nuclear waste materials may pose a problem?
    (1) They frequently have short half-lives and remain radioactive for brief periods of time
    (2) They frequently have short half-lives and remain radioactive for extended periods of time
    (3) They frequently have long half-lives and remain radioactive for brief periods of time
    (4) They frequently have long half-lives and remain radioactive for extended periods of time