1. Given the nuclear equation:
$^{14}_{7}N + X \rightarrow {}^{16}_{8}O + {}^{2}_{1}H$
What is particle *X*?

A) an alpha particle B) a beta particle
C) a deuteron D) a triton

2. The nucleus of a radium-226 atom is unstable, which causes the nucleus to spontaneously

A) absorb electrons B) absorb protons
C) decay D) oxidize

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

A) alpha particle, beta particle, gamma radiation
B) gamma radiation, alpha particle, beta particle
C) positron, alpha particle, neutron
D) neutron, positron, alpha particle

4. Which list of nuclear emissions is arranged in order from the *least* penetrating power to the greatest penetrating power?

A) alpha particle, beta particle, gamma ray
B) alpha particle, gamma ray, beta particle
C) gamma ray, beta particle, alpha particle
D) beta particle, alpha particle, gamma ray

5. Base your answer to the following question on Given the nuclear equation:

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

The particle represented by *X* is

A) $^{9}_{4}Li$ **B) $^{9}_{4}Be$** C) $^{10}_{5}Be$ D) $^{10}_{6}C$

6. Positrons are spontaneously emitted from the nuclei of

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

7. What is the decay mode of ^{37}K?

A) β^- **B)** β^+ C) γ D) a

8. Which equation represents positron decay?

A) $^{87}_{37}Rb \rightarrow {}^{0}_{-1}e + {}^{87}_{38}Sr$
B) $^{277}_{92}U \rightarrow {}^{223}_{90}Th + {}^{4}_{2}He$
C) $^{27}_{13}Al + {}^{4}_{2}He \rightarrow {}^{30}_{15}P + {}^{1}_{0}n$
D) $^{11}_{6}C \rightarrow {}^{0}_{+1}e + {}^{11}_{5}B$

9. As ^{14}C decays to ^{14}N, the number of protons in the nucleus

A) decreases **B) increases**
C) remains the same

10. Atoms of I-131 spontaneously decay when the

A) stable nuclei emit alpha particles
B) stable nuclei emit beta particles
C) unstable nuclei emit alpha particles
D) unstable nuclei emit beta particles

11. Which statement best describes gamma radiation?

A) It has a mass of 1 and a charge of 1.
B) It has a mass of 0 and a charge of –1.
C) It has a mass of 0 and a charge of 0.
D) It has a mass of 4 and a charge of +2.

12. Which nuclear decay emission consists of energy, only?

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

13. Which kind of nuclear radiation has high energy and no mass?

A) alpha B) beta
C) gamma D) neutron

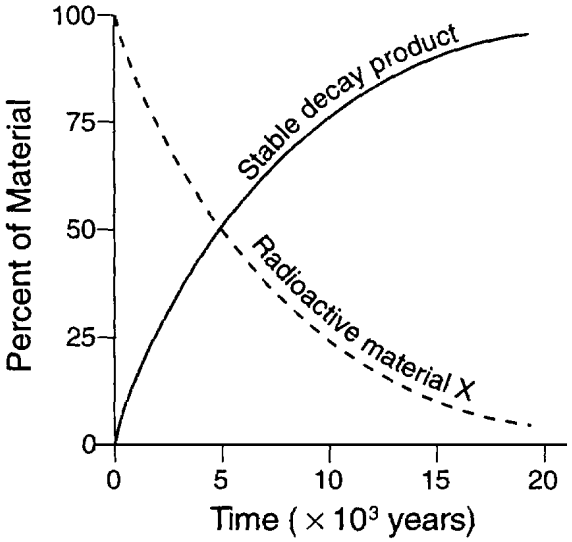
14. The half-life of a radioactive isotope is 20.0 minutes. What is the total amount of a 1.00-gram sample of this isotope remaining after 1.00 hour?

A) 0.500 g B) 0.333 g
C) 0.250 g **D) 0.125 g**

15. A radioactive element has a half-life of 2 days. Which fraction represents the amount of an original sample of this element remaining after 6 days?

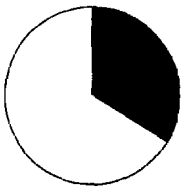
A) $\frac{1}{8}$
B) $\frac{1}{2}$
C) $\frac{1}{3}$
D) $\frac{1}{4}$

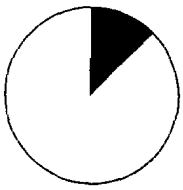
16. Base your answer to the following question on on the graph below. The graph represents the decay of radioactive material *X* into a stable decay product.

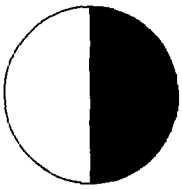


Which graph best represents the relative percentages of radioactive material *X* and its stable decay product after 15,000 years?(**The shaded region represents radioactive material while the non-shaded region represents stable decay products**.)

A) 

B) 

C) 

D) 

17. A 40.0 milligram sample of ^{33}P decays to 10.0 milligrams in 50.0 days. What is the half-life of ^{33}P?

A) 12.5 days **B) 25.0 days**
C) 37.5 days D) 75.0 days

18. How many days are required for 200. grams of radon-222 to decay to 50.0 grams?

A) 1.91 days B) 3.82 days
C) 7.64 days D) 11.5 days

19. Radioactive cobalt-60 is used in radiation therapy treatment. Cobalt-60 undergoes beta decay. This type of nuclear reaction is called

A) natural transmutation
B) artificial transmutation
C) nuclear fusion
D) nuclear fission

20. The nuclear reaction:

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

Is an example of

A) nuclear fusion
B) nuclear fission
C) natural transmutation
D) artificial transmutation

21. Which equation represents artificial transmutation?

A) $H_2O \rightarrow H^+ + OH^-$
B) $UF_6 + 6\,Na \rightarrow 6\,NaF + U$
C) $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He$
D) $^{27}_{13}Al + ^{4}_{2}He \rightarrow ^{30}_{15}P + ^{1}_{0}n$

22. Which statement best describes a primary occurrence in an uncontrolled fission reaction?

A) Mass is created and energy is released.
B) Mass is created and energy is stored.
C) Mass is converted to energy, which is released.
D) Mass is converted to energy, which is stored.

23. An uncontrolled chain reaction takes place during the

A) operation of a fission nuclear reactor
B) explosion of an atomic bomb
C) production of energy by the Earth's Sun
D) fusion of light nuclei into heavier nuclei

24. Given the balanced equation representing a nuclear reaction:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{142}_{56}Ba + ^{91}_{36}Kr + 3X + \text{energy}$$

Which particle is represented by *X*?

A) $^{0}_{-1}e$ B) $^{1}_{1}H$ C) $^{4}_{2}H$ **D) $^{1}_{0}n$**

25. What is the primary result of a fission reaction?

A) conversion of mass to energy
B) conversion of energy to mass
C) binding together of two heavy nuclei
D) binding together of two light nuclei

26. 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.

27. Which nuclear equation represents a fusion reaction?

A) $^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{239}_{93}Np + {}^{0}_{-1}e$
B) $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{92}_{36}Kr + {}^{141}_{56}Ba + 3\ {}^{1}_{0}n$
C) $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$
D) $^{1}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He$

28. Which pair of nuclei can undergo a fusion reaction?

A) potassium-40 and cadmium-113
B) zinc-64 and calcium-44
C) uranium-238 and lead-208
D) hydrogen-2 and hydrogen-3

29. Which equation represents nuclear fusion?

A) $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$
B) $^{27}_{13}Al + {}^{4}_{2}He \rightarrow {}^{30}_{15}P + {}^{1}_{0}n$
C) $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3\ {}^{1}_{0}n$
D) $^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$

30. Which equation represents a fusion reaction?

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

31. Which balanced equation represents nuclear fusion?

A) $^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{142}_{56}Ba + {}^{91}_{36}Kr + 3{}^{1}_{0}n$
B) $^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$ C) $^{6}_{3}Li + {}^{1}_{0}n \rightarrow {}^{3}_{1}H + {}^{4}_{2}He$
D) $^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$

32. Given the reaction:

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

When the equation is correctly balanced the nucleus represented by X is

A) $^{234}_{92}U$ B) $^{235}_{92}U$
C) $^{230}_{90}Th$ D) $^{232}_{90}Th$

33. In the reaction:

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

The nucleus represented by X is

A) $^{9}_{3}Li$ B) $^{10}_{5}B$ **C) $^{9}_{4}Be$** D) $^{10}_{6}C$

34. In the equation:

$$^{239}_{40}Th \rightarrow {}^{234}_{91}Pa + X$$

The symbol X represents

A) $^{0}_{+1}e$ **B) $^{0}_{-1}e$** C) $^{1}_{0}n$ D) $^{1}_{1}H$

35. Given the nuclear reaction:

$$^{32}_{16}S + {}^{1}_{0}n \rightarrow {}^{1}_{1}H + X$$

What does X represent in this reaction?

A) $^{31}_{15}P$ **B) $^{32}_{15}P$** C) $^{31}_{16}P$ D) $^{32}_{16}P$

36. Given the nuclear reaction:

$$^{14}_{7}N + {}^{4}_{2}He \rightarrow {}^{1}_{1}H + X$$

Which isotope is represented by the X when the equation is correctly balanced?

A) $^{17}_{8}O$ B) $^{18}_{8}O$ C) $^{17}_{9}F$ D) $^{18}_{9}F$

37. 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

38. In a nuclear fusion reaction, the mass of the products is

A) less than the mass of the reactants because some of the mass has been converted to energy
B) less than the mass of the reactants because some of the energy has been converted to mass
C) more than the mass of the reactants because some of the mass has been converted to energy
D) more than the mass of the reactants because some of the energy has been converted to mass

39. Energy is released during the fission of Pu-239 atoms as a result of the

A) formation of covalent bonds
B) formation of ionic bonds
C) conversion of matter to energy
D) conversion of energy to matter

40. The radioactive isotope carbon-14 can be used for

A) determining the age of a sample
B) determining medical disorders
C) controlling fission reactions
D) controlling speeds of neutrons

41. Which nuclides are used to date the remains of a once-living organism?

A) C-14 and C-12 B) Co-60 and Co-59
C) I-131 and Xe-131 D) U-238 and Pb-206

42. 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

43. Which radioisotope is used in medicine to treat thyroid disorders?

A) cobalt-60 **B) iodine-131**
C) phosphorus-32 D) uranium-238

44. The radioisotope I-131 is used to

A) control nuclear reactors
B) determine the age of fossils
C) diagnose thyroid disorders
D) trigger fussion reactors

45. Which radioactive isotope is used in treating cancer?

A) carbon-14 **B) cobalt-60**
C) lead-206 D) uranium-238

46. 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

47. Refering to Table N, which substance is a radioactive waste product that is safest to release into the atmosphere after it has decayed to a safe radiation level?

A) radon-222 B) radium-226
C) cesium-137 D) cobalt-60

48. A serious risk factor associated with the operation of a nuclear power plant is the production of

A) acid rain
B) helium gas
C) greenhouse gases, such as CO_2
D) radioisotopes with long half-lives

49. Which risk is associated with using nuclear fission to produce energy in a power plant?

A) depletion of hydrocarbons
B) depletion of atmospheric oxygen
C) exposure of workers to radiation
D) exposure of workers to sulfur dioxide

50. Which substances are used in the control rods of nuclear reactors?

A) water and concrete
B) graphite and beryllium
C) cadmium and boron
D) sodium and carbon dioxide

51. The purpose of the high-density concrete used in some nuclear reactors is to

A) shield the reactor walls from radiation damage
B) shield the reactor personnel from radiation exposure
C) control the rate of the nuclear reaction
D) control the speed of the neutrons

Base your answers to questions **52** through **54** on the information below.

Nuclear radiation is harmful to living cells, particularly to fast-growing cells, such as cancer cells and blood cells. An external beam of the radiation emitted from a radioisotope can be directed on a small area of a person to destroy cancer cells within the body.

Cobalt-60 is an artificially produced radioisotope that emits gamma rays and beta particles. One hospital keeps a l00.0-gram sample of cobalt-60 in an appropriate, secure storage container for future cancer treatment.

52. Determine the total time that will have elapsed when 12.5 grams of the original Co-60 sample at the hospital remains unchanged.

53. Complete the nuclear equation below for the beta decay of the Co-60 by writing an isotopic notation for the missing product.

$$^{60}_{27}\text{Co} \leftrightarrow {}^{0}_{-1}\beta + \_\_\_\_\_$$

54. State *one* risk to human tissue associated with the use of radioisotopes to treat cancer.

Base your answers to questions **55** through **57** on the information below.

In the early 1800s, John Dalton proposed an atomic theory that was based on experimental observations made by several scientists. Three concepts of Dalton's atomic theory are stated below.

Statement *A*: Atoms are indivisible and cannot be destroyed or broken down into smaller parts.
Statement *B*: Atoms of one element cannot be changed into atoms of another element.
Statement *C*: All atoms of one element have the same mass.

55. Explain, in terms of particles in the atoms of an element, why statement *C* is *false*.

56. The decay of N-16 is represented by the balanced equation below.

$$^{16}_{7}\text{N} \rightarrow {}^{0}_{-1}\text{e} + {}^{16}_{8}\text{O}$$

State evidence that indicates statement *B* is *not* always true.

57. Explain, in terms of particles, why statement *A* is no longer accepted.

58. Base your answer to the following question on the information below.

The radioisotope uranium-238 occurs naturally in Earth's crust. The disintegration of this radioisotope is the first in a series of spontaneous decays.

The sixth decay in this series produces the radioisotope radon-222. The decay of radon-222 produces the radioisotope polonium-218 that has a half life of 3.04 minutes. Eventually, the stable isotope lead-206 is produced by the alpha decay of an unstable nuclide.

Complete the nuclear equation below for the decay of the unstable nuclide that produces Pb-206, by writing a notation for the missing nuclide.

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

59. Base your answer to the following question on in the information below.

When a uranium-235 nucleus absorbs a slow-moving neutron, different nuclear reactions may occur. One of these possible reactions is represented by the complete, balanced equation below.

Equation 1: $^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{92}_{36}\mathrm{Kr} + {}^{142}_{56}\mathrm{Ba} + 2{}^{1}_{0}\mathrm{n} + \text{energy}$

For this reaction, the sum of the masses of the products is slightly less than the sum of the masses of the reactants. Another possible reaction of U-235 is represented by the incomplete, balanced equation below.

Equation 2: $^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{92}_{38}\mathrm{Sr} + \_\_\_\_ + 2{}^{1}_{0}\mathrm{n} + \text{energy}$

Determine the half-life of krypton-92 if only 6.0 milligrams of an original 96.0-milligram sample remains unchanged after 7.36 seconds.

60. Base your answer to the following question on the information below and on your knowledge of chemistry.

Nuclear Waste Storage Plan for Yucca Mountain

In 1978, the U.S. Department of Energy began a study of Yucca Mountain which is located 90 miles from Las Vegas, Nevada. The study was to determine if Yucca Mountain would be suitable for a long-term burial site for high-level radioactive waste. A three-dimensional (3-D) computer scale model of the site was used to simulate the Yucca Mountain area. The computer model study for Yucca Mountain included such variables as: the possibility of earthquakes, predicted water flow through the mountain, increased rainfall due to climate changes, radioactive leakage from the waste containers, and increased temperatures from the buried waste within the containers.

The containers that will be used to store the radioactive waste are designed to last 10,000 years. Within the 10,000-year time period, cesium and strontium, the most powerful radioactive emitters, would have decayed. Other isotopes found in the waste would decay more slowly, but are not powerful radioactive emitters.

In 1998, scientists discovered that the compressed volcanic ash making up Yucca Mountain was full of cracks. Because of the arid climate, scientists assumed that rainwater would move through the cracks at a slow rate. However, when radioactive chlorine-36 was found in rock samples at levels halfway through the mountain, it was clear that rainwater had moved quickly down through Yucca Mountain. It was only 50 years earlier when this chlorine-36 isotope had contaminated rainwater during atmospheric testing of the atom bomb.

Some opponents of the Yucca Mountain plan believe that the uncertainties related to the many variables of the computer model result in limited reliability of its predictions. However, advocates of the plan believe it is safer to replace the numerous existing radioactive burial sites around the United States with the one site at Yucca Mountain. Other opponents of the plan believe that transporting the radioactive waste to Yucca Mountain from the existing 131 burial sites creates too much danger to the United States. In 2002, after years of political debate, a final legislative vote approved the development of Yucca Mountain to replace the existing 131 burial sites.

If a sample of cesium-137 is stored in a waste container in Yucca Mountain, how much time must elapse until only $\frac{1}{32}$ of the original sample remains unchanged?

Answer Key
Regents review Nuclear Chemistry 2011-2012

1. **A**
2. **C**
3. **D**
4. **A**
5. **B**
6. **A**
7. **B**
8. **D**
9. **B**
10. **D**
11. **C**
12. **C**
13. **C**
14. **D**
15. **A**
16. **C**
17. **B**
18. **C**
19. **A**
20. **D**
21. **D**
22. **C**
23. **B**
24. **D**
25. **A**
26. **A**
27. **D**
28. **D**
29. **D**
30. **C**
31. **D**
32. **A**
33. **C**
34. **B**
35. **B**
36. **A**
37. **A**
38. **A**
39. **C**
40. **A**
41. **A**
42. **C**
43. **B**
44. **C**
45. **B**
46. **C**
47. **A**
48. **D**
49. **C**
50. **C**
51. **B**
52. 15.813 y / 15.8 y
53. $^{60}_{28}Ni$/ ^{60}Ni/ nickel-60
54. —Nuclear radiation is harmful to all living cells. —Radioisotopes can cause gene mutations. — Treatments can cause stomach problems, such as nausea.
55. Acceptable responses include, but are not limited to: • Atoms of different isotopes of an element have different masses because they have different numbers of neutrons. • Atoms of an element can differ in the number of neutrons and, therefore, masses.
56. Acceptable responses include, but are not limited to: • An atom of nitrogen (atomic number 7) changed into an atom of oxygen (atomic number 8). • The decay of N-16 atoms produced O-16 atoms. • Radioactive decay results in an element being changed into another element.
57. Acceptable responses include, but are not limited to: • Smaller parts of atoms exist, such as protons, neutrons, and electrons. • During some nuclear reactions, unstable atoms can spontaneously decay into smaller particles. • Atoms can lose electrons.
58. $^{210}_{84}Po$ *or* ^{210}Po *or* Po-210
59. 1.84 s
60. Examples: – any response from 150 to 152; – 5 half-lives