_____1. Which nuclear emission has the greatest mass?

(A) β^- (C) β^+

(B) γ (D) α

_____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 of these types of nuclear radiation has the greatest penetrating power?

(A) neutron (C) alpha

(B) beta (D) gamma

_____4. Given the reaction:

$$^{226}_{88}Ra \rightarrow ^{222}_{86}Rn + X$$

Which type of emanation is represented by *X*?

(A) proton (C) alpha particle

(B) beta particle (D) positron

_____5. Which notation of a radioisotope is correctly paired with the notation of its emission particle?

(A) ^{16}N and $^{1}_{1}p$ (C) ^{3}H and $^{0}_{-1}e$

(B) ^{37}Ca and $^{4}_{2}He$ (D) ^{235}U and $^{0}_{+1}e$

_____6. In the reaction $^{239}_{93}Np \rightarrow ^{239}_{94}Pu + X$, what does *X* represent?

(A) a beta particle (C) a neutron

(B) an alpha particle (D) a proton

_____7. When an atom emits a beta particle, the total number of nucleons

(A) decreases (C) remains the same

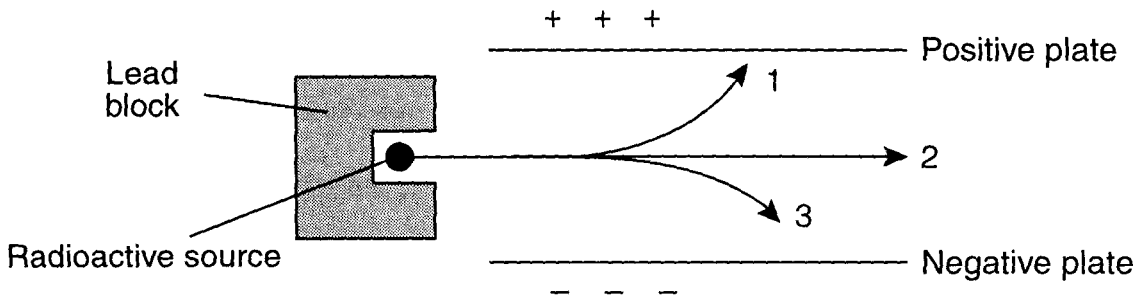
(B) increases

_____8. What was the original mass of a radioactive sample that decayed to 25 grams in four half-life periods?

(A) 400 g (C) 200 g

(B) 100 g (D) 50 g

___9. The diagram below represents radioactive emanations passing through an electric field.



Which type of emanation is represented by the arrow labeled 1?

(A) gamma ray (B) positron (C) beta particle (D) alpha particle

____10. Gamma rays are emanations that have

(A) mass but no charge
(B) charge but no mass
(C) neither mass nor charge
(D) both mass and charge

____11. What is the half-life of sodium-25 if 1.00 gram of a 16.00-gram sample of sodium-25 remains unchanged after 237 seconds?

(A) 118 s (C) 79.0 s
(B) 59.3 s (D) 47.4 s

____12. What total mass of a 16 gram sample of ^{60}Co will remain unchanged after 15.9 years?

(A) 1.0 g (C) 8.0 g
(B) 2.0 g (D) 4.0 g

____13. Radioactive cobalt-60 is used in radiation therapy treatment. Cobalt-60 undergoes beta decay. This type of nuclear reaction is called

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

____14. Based on Reference Table *N*, what fraction of a sample of gold-198 remains radioactive after 2.69 days?

(A) $\frac{1}{4}$ (C) $\frac{7}{8}$
(B) $\frac{1}{2}$ (D) $\frac{3}{4}$

____15. The reaction:

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

Is an example of

(A) a fission reaction
(B) a natural transmutation
(C) an artificial transmutation
(D) a chain reaction

____16. 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 absorbed and more stable elements are formed.
(D) Energy is released and less stable elements are formed.

____17. In which reaction is mass converted to energy by the process of fission?

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

____18. Which equation represents a fusion reaction?

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

____19. Which radioactive isotope is used in geological dating?

(A) technetium-99 (C) uranium-238
(B) iodine-131 (D) cobalt-60

____20. Nuclear fusion *differs* from nuclear fission because nuclear fusion reactions

(A) form lighter isotopes from heavier isotopes
(B) convert mass to energy
(C) convert energy to mass
(D) form heavier isotopes from lighter isotopes

____21. In the fusion reaction:

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

The X represents

(A) mass converted from energy
(B) a released electron
(C) another neutron
(D) energy converted from mass

____22. Which isotope is most commonly used in the radioactive dating of the remains of organic materials?

(A) ^{14}C (C) ^{16}N
(B) ^{32}P (D) ^{37}K

____23. The radioisotope I-131 is used to

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

____24. Radioisotopes used for medical diagnosis must have

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

____25. A radioisotope is called a tracer when it is used to

(A) determine the way in which a chemical reaction occurs
(B) kill cancerous tissue
(C) determine the age of animal skeletal remains
(D) kill bacteria in food

____26. Radiation used in the processing of food is intended to

(A) increase the rate of nutrient decomposition
(B) kill microorganisms that are found in the food
(C) convert ordinary nutrients to more stable forms
(D) replace chemical energy with nuclear energy

____27. Given the nuclear equation:

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

The particle represented by X is

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

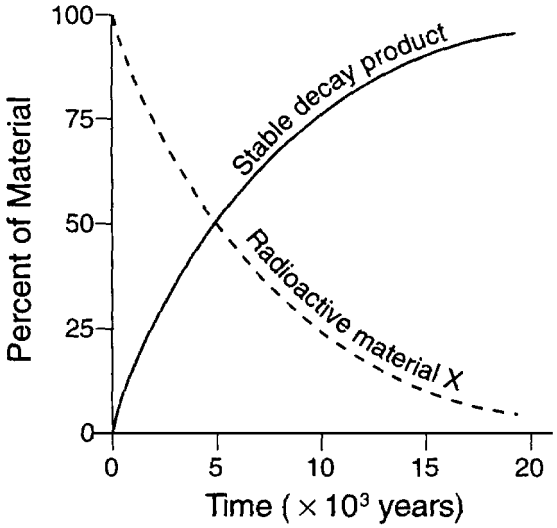
____28. Which radioisotope undergoes beta decay and has a half-life of less than 1 minute?

(A) K-42 (C) P-32
(B) Fr-220 (D) N-16

____29. Which equation is an example of artificial transmutation?

(A) $Mg(OH)_2 + 2\ HCl \rightarrow 2\ H_2O + MgCl_2$
(B) $Ca + 2\ H_2O \rightarrow Ca(OH)_2 + H_2$
(C) $U + 3\ F_2 \rightarrow UF_6$
(D) $^{9}_{4}Be + ^{4}_{2}He \rightarrow ^{12}_{6}C + ^{1}_{0}n$

_____30. 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.



If radioactive material *X* were heated, the length of its half-life period would

(A) decrease (C) remain the same

(B) increase

Base your answers to questions **31** and **32** on the information below.

Some radioisotopes used as tracers make it possible for doctors to see the images of internal body parts and observe their functions. The table below lists information about three radioisotopes and the body part each radioisotope is used to study.

Medical Uses of Some Radioisotopes

Radioisotope	Half-life	Decay Mode	Body Part
^{24}Na	15 hours	beta	circulatory system
^{59}Fe	44.5 days	beta	red blood cells
^{131}I	8.1 days	beta	thyroid

31. It could take up to 60. hours for a radioisotope to be delivered to the hospital from the laboratory where it is produced. What fraction of an original sample of ^{24}Na remains unchanged after 60. hours?

32. Write the equation for the nuclear decay of the radioisotope used to study red blood cells. Include *both* the atomic number and the mass number for *each* missing particle.

$^{59}Fe \rightarrow$ _____ + _____ + energy

Base your answers to questions **33** through **35** on the reading passage below and on your knowledge of chemistry.

A Clow in the Dark, and Scientific Peril

The [Marie and Pierre] Curies set out to study radioactivity in 1898. Their first accomplishment was to show that radioactivity was a property of atoms themselves. Scientifically,that was the most important of their findings, because it helped other researchers refine their understanding of atomic structure. More famous was their discovery of polonium and radium. Radium was the most radioactive substance the Curies had encountered. Its radioactivity is due to the large size of the atom, which makes the nucleus unstable and prone to decay, usually to radon and then lead, by emitting particles and energy as it seeks a more stable configuration.Marie Curie struggled to purify radium for medical uses, including early radiation treat-ment for tumors. But radiums bluish glow caught peoples fancy, and companies in theUnited States began mining it and selling it as a novelty: for glow-in-the-dark light pulls, for instance, and bogus cure-all patent medicines that actually killed people.What makes radium so dangerous is that it forms chemical bonds in the same way as calcium, and the body can mistake it for calcium and absorb it into the bones. Then, it can bombard cells with radiation at close range, which may cause bone tumors or bone-marrow damage that can give rise to anemia or leukemia.

– Denise Grady, The New York Times, October 6, 1998

33. State one risk associated with the use of Radium.

34. Using Reference Table *IV*, complete the equation for the nuclear

    decay of $^{226}_{88}Ra$. Include *both* atomic number and mass number

    for *each* particle.

35. If a scientist purifies 1.0 gram of radium-226, how many years must pass before only 0.50 gram of the original radium-226 sample remains unchanged?

Nuclear Chemistry Test
Answer Key
nuclear exam 2009 [May 26, 2009]

1. D
2. D
3. D
4. C
5. C
6. A
7. C
8. A
9. C
10. C
11. B
12. B
13. C
14. B
15. C
16. A
17. D
18. C
19. C
20. D
21. D
22. A
23. B
24. A
25. A
26. B
27. C
28. D
29. D
30. C

31. Examples: $\frac{1}{16}$ *or* 0.0625 *or* $6\frac{1}{4}$ %

32. Examples: $^{59}_{26}FE \rightarrow {}^{0}_{-1}e + {}^{59}_{27}Co$ *or* $^{59}_{26}Fe \rightarrow {}^{59}_{27}Co + {}^{0}_{-1}\beta$

33. cause bone tumors *or* damage bone marrow *or* can cause leukemia or anemia *or* radioactive *or* DNA damage *or* death

34. $^{226}Ra \rightarrow {}^{4}He + {}^{222}Rn$ *or* $^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}\alpha$

35. 1600

Version A