Project Advance Chemistry 116 Sample Questions
on Material in *General Chemistry*, Brown, LeMay, and Bursten

Chapter 21. Radioactivity and Nuclear Chemistry

1. In balancing the nuclear reaction $^{238}_{92}U \rightarrow {}^{234}_{90}U + {}^{4}_{2}He$

the identity of element E is determined from its

(a) mass number
(b) atomic weight
(c) atomic number
(d) number of neutrons
(e) number of electrons

2. Which type of radioactive decay results in no change in mass number and atomic number for the starting nucleus?

(a) alpha
(b) gamma
(c) beta
(d) positron emission
(e) electron capture

3. Alpha-decay produces a new nucleus whose _____ than those respectively of the original nucleus.

(a) atomic number is 2 more and mass number is 4 more
(b) atomic number is 1 less and mass number is 2 less
(c) atomic number is 2 less and mass number is 2 less
(d) atomic number is 2 less and mass number is 4 less
(e) atomic number is 2 more and mass number is 2 less

4. What is the product missing from this reaction?

$^{32}_{15}P \rightarrow {}^{32}_{16}S +$ _____

(a) $^{4}_{2}He$
(b) $^{0}_{-1}e$
(c) $^{0}_{+1}e$
(d) γ
(e) none of these.

5. This reaction is an example of _____ decay.

$^{210}_{84}Po \rightarrow {}^{206}_{82}Pb +$ _____

(a) alpha
(b) beta
(c) gamma
(d) positron
(e) none of these.

6. The product missing from this reaction is

$$^{131}_{53}I \rightarrow {}^{131}_{52}Te + \_\_\_\_\_$$

(a) $^{4}_{2}He$ (b) $^{0}_{-1}e$

(c) $^{1}_{0}n$ (d) $^{0}_{+1}e$

(e) none of these.

7. This reaction is an example of _____ .

$$^{41}_{20}Ca + \_\_\_\_\_ \rightarrow {}^{41}_{19}K$$

(a) positron decay (b) alpha decay

(c) beta decay (d) electron capture

(e) none of these.

8. The missing product in this reaction would be found in which group of the periodic table?

$$^{24}_{11}Na \rightarrow {}^{0}_{-1}e + \_\_\_\_\_$$

(a) 1A (b) 2A
(c) 3A (d) 8A
(e) none of these.

9. The missing product in this reaction combines with oxygen to form a compound with the formula

$$^{42}_{19}K \rightarrow {}^{0}_{-1}e + \_\_\_\_\_$$

(a) MO (b) M_2O
(c) MO_2 (d) M_2O_3
(e) none of these.

10. Which one of these radioactive decay products has the shortest average lifetime in the atmosphere?

(a) $^{4}_{2}He$ (b) $^{0}_{-1}e$

(c) $^{0}_{+1}e$ (d) $^{1}_{0}n$

(e) none of these.

11. Which of these nuclides is most likely to be radioactive?

(a) $^{39}_{19}K$ (b) $^{27}_{13}Al$

(c) $^{127}_{53}I$ (d) $^{243}_{95}Am$

(e) none of these.

12. A nucleus is most likely to be stable when it has an _____ number of protons and an _____ number of neutrons.

(a) odd, even (b) odd, odd

(c) even, odd (d) even, even

(e) none of these.

13. Radium undergoes alpha decay. The product of this reaction also undergoes alpha decay. What is the product of this second decay reaction?

(a) U (b) Rn

(c) Po (d) Th

(e) none of these.

14. ^{41}Ca decays by electron capture. The product of this reaction undergoes positron decay. What is the product of this second decay reaction?

(a) Ar (b) Ti

(c) Ca (d) Cl

(e) none of these.

15. Bombardment of uranium-238 with a deuteron generates neptunium-238 and _____ neutrons.

(a) 1 (b) 2
(c) 3 (d) 4
(e) 5

16. Bombardment of uranium-235 with a neutron generates tellurium-135, 2 neutrons, and

(a) zirconium-99 (b) strontium-103
(c) krypton-101 (d) krypton-103
(e) strontium-99

17. The reaction shown below is responsible for creating ^{14}C in the atmosphere. What is the bombarding particle?

$$^{14}_{7}N + \_\_\_\_\_ \rightarrow {}^{14}_{6}C + {}^{1}_{1}H$$

(a) $^{4}_{2}He$ or alpha (b) $^{0}_{-1}e$

(c) neutron (d) positron

(e) none of these.

18. The nuclide ^{77}Se can be formed in a cyclotron by bombarding _____ with alpha particles (assuming no fragmentation).

(a) $^{73}_{32}Ge$ (b) $^{77}_{35}Br$

(c) $^{81}_{36}Kr$ (d) $^{77}_{33}As$

(e) none of these.

19. The rate at which a radioactive nuclide decays depends upon

(a) temperature (b) pressure

(c) state of chemical combination (d) all of the above.

(e) none of the above.

20. The carbon-14 dating method can be used to determine the age of a

(a) stone axe head (b) flint arrowhead

(c) papyrus scroll (d) clay pot

(e) none of these.

21. The basis for the carbon-14 dating method is that

(a) the ratio of carbon-14 to carbon-12 in the atmosphere is a constant.
(b) the amount of carbon-14 in all objects is the same.
(c) carbon-14 is very unstable and is readily lost from the atmosphere.
(d) living tissue will not absorb carbon-14 but will absorb carbon-12.
(e) none of these.

22. ^{210}Pb has a half-life of 22.3 years and decays to produce ^{206}Hg. If one starts with 7.50 g of ^{210}Pb, how many grams of ^{206}Hg will be left after 17.5 years?

(a) 3.50 (b) 3.15
(c) 4.35 (d) 3.09
(e) 0.0600

23. When two atoms of ^{2}H are fused to form one atom of ^{4}He, the total energy evolved is 3.83×10^{-12} J. What is the total change in mass for this reaction?

(a) 1.28×10^{-17} g (b) 4.26×10^{-26} g
(c) 3.45×10^{8} g (d) 1.15 g
(e) none of these.

24. Energy is released from a nuclear fission reaction because the total mass of products is _____ than that of the reactants. Energy is released in a nuclear fusion reaction because the total mass of products is _____ than that of the reactants.

(a) less, more
(b) more, more
(c) less, less
(d) more, less
(e) none of these.

25. The noble gas thought to be significantly carcinogenic due to its radioactive decay and that of its decay products is

(a) argon (b) helium
(c) xenon (d) radon
(e) neon

26. The following reaction is an example of

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

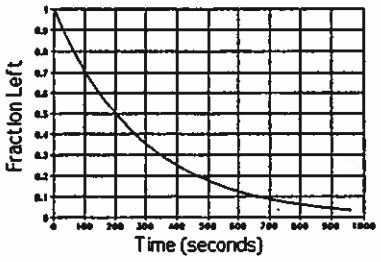
(a) a breeder reaction.
(b) a nuclear voltaic reaction.
(c) a nuclear fusion reaction.
(d) a nuclear fission reaction.
(e) none of these.

27. The following reaction is an example of

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{103}_{42}Mo + {}^{131}_{50}Sn + 2\,{}^{1}_{0}n + \text{energy}$$

(a) a breeder reaction.
(b) a nuclear fusion reaction.
(c) a nuclear voltaic reaction.
(d) a nuclear chain reaction.
(e) none of these.

28. A radioactive substance has the decay curve shown below. Initially there are 3.0 grams of the substance. After 15.0 minutes there are 0.133 g of the substance left. What is the half-life of this radioactive substance.



(a) 960 seconds

(b) 350 seconds

(c) 600 seconds

(d) 200 seconds

(e) none of these.

29. The substance known as deuterium is

(a) an isotope of hydrogen with one neutron in the nucleus.
(b) the nucleus of the helium atom.
(c) an isotope of hydrogen with two neutrons in the nucleus.
(d) an isotope of helium with 2 neutrons in the nucleus.
(e) none of these.

30. The half-life of $^{44}_{19}K$ is 22 min. If a 1-g sample of this isotope is taken, how much $^{44}_{19}K$ will remain after 66 min?

(a) 0.125 g (b) 0.500 g
(c) 0.333 g (d) 0.250 g
(e) none of these.

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Chapter 21. Radioactivity and Nuclear Chemistry
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1. Francium, Fr, does not occur in nature and is made by artificial means. The francium-223 isotope has a half-life of only 22 minutes and it decays by α emission. What is the balanced nuclear equation for this reaction?

   (a) $^{223}_{87}\text{Fr} \rightarrow {}^{1}_{1}\text{H} + {}^{222}_{86}\text{Rn}$

   (b) $^{223}_{87}\text{Fr} \rightarrow {}^{0}_{-1}\text{e} + {}^{223}_{88}\text{Ra}$

   (c) $^{223}_{87}\text{Fr} \rightarrow {}^{4}_{2}\text{He} + {}^{219}_{85}\text{At}$

   (d) $^{223}_{87}\text{Fr} \rightarrow {}^{4}_{2}\text{He} + {}^{227}_{91}\text{Pa}$

   (e) none of these.

2. Gadolinium-159, $^{159}_{64}\text{Gd}$, does not occur in nature; it decays by β emission with a half-life of 18 hours. What element results when Gd-159 decays by loss of a β particle?

   (a) $^{155}_{62}\text{Sm}$

   (b) $^{159}_{63}\text{Eu}$

   (c) $^{158}_{65}\text{Gd}$

   (d) $^{159}_{65}\text{Tb}$

   (e) none of these.

3. Sodium-22 decays by positron emission with a half-life of 2.6 years. What is the balanced nuclear equation for this reaction?

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

   (b) $^{22}_{11}\text{Na} + {}^{0}_{-1}\text{e} \rightarrow {}^{22}_{10}\text{Ne}$

   (c) $^{22}_{11}\text{Na} \rightarrow {}^{22}_{12}\text{Mg} + {}^{0}_{-1}\text{e}$

   (d) $^{22}_{11}\text{Na} \rightarrow {}^{22}_{12}\text{Mg} + {}^{0}_{+1}\text{e}$

   (e) none of these.

4. In the early moments of the detonation of a thermonuclear bomb, lithium-6 nuclei react with neutrons to give α particles and an unnamed nucleus. What is this nucleus?

   $$^{6}_{3}\text{Li} + {}^{1}_{0}\text{n} \rightarrow \alpha + ?$$

   (a) $^{2}_{1}\text{H}$
   (b) $^{0}_{-1}\text{e}$
   (c) $^{3}_{1}\text{H}$
   (d) $^{4}_{2}\text{He}$
   (e) none of these.

5. In the natural decay series involving uranium-235, radon-219, $^{219}_{86}Rn$, undergoes α decay with a half-life of about 4 seconds to give another element. What is the balanced equation for this process?

   (a) $^{219}_{86}Rn + {}^{0}_{-1}e \rightarrow {}^{215}_{83}Bi + {}^{4}_{2}He$

   (b) $^{219}_{86}Rn \rightarrow {}^{219}_{87}Fr + {}^{0}_{-1}e$

   (c) $^{219}_{86}Rn \rightarrow {}^{215}_{85}At + {}^{4}_{2}He$

   (d) $^{219}_{86}Rn \rightarrow {}^{215}_{84}Po + {}^{4}_{2}He$

   (e) none of these.

6. Cobalt-60 is an artificial isotope of cobalt that is used extensively in radiation therapy for cancer. It undergoes β decay with a half-life of 5.24 years. What is the balanced nuclear equation for the decay of cobalt-60?

   (a) $^{60}_{27}Co \rightarrow {}^{60}_{28}Ni + {}^{0}_{-1}e$

   (b) $^{60}_{27}Co + {}^{4}_{2}He \rightarrow {}^{64}_{29}Ni$

   (c) $^{60}_{27}Co \rightarrow {}^{60}_{28}Co + {}^{0}_{-1}e$

   (d) $^{60}_{27}Co \rightarrow {}^{60}_{26}Fe + {}^{0}_{+1}e$

   (e) none of these.

7. Carbon-11 is an unstable isotope of carbon and it decays with a half-life of 20 minutes to give boron-11. What type of particle does carbon-11 emit in the process?

   (a) α
   (b) β
   (c) positron
   (d) neutron
   (e) none of these.

8. A variety of isotopes of the artifically produced element californium have been made. The synthesis of californium-244, $^{244}_{98}Cf$, was accomplished by bombarding a selected nucleus with carbon ions; 6 neutrons are a by-product of this reaction. What element was used as the target?

$$? + {}^{12}_{6}C \rightarrow 6\ {}^{1}_{0}n + {}^{244}_{98}Cf$$

   (a) $^{238}_{94}Pu$

   (b) $^{232}_{86}Rn$

   (c) $^{240}_{90}Th$

   (d) $^{238}_{92}U$

   (e) none of these.

9. Hahn and Strassman identified one of the fission products of uranium-235 as an isotope of barium. If uranium-235 and a neutron produced barium-138 and 3 neutrons, what would the balanced equation have been?

(a) $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{138}_{56}Ba + {}^{95}_{36}Xe + 3\ {}^{1}_{0}n$

(b) $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{138}_{56}Ba + {}^{95}_{36}Kr + 3\ {}^{1}_{0}n$

(c) $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{138}_{56}Ba + {}^{97}_{36}Kr + {}^{1}_{0}n$

(d) $^{235}_{92}U + {}^{0}_{-1}n \rightarrow {}^{138}_{56}Ba + {}^{97}_{32}Ge + 3\ {}^{0}_{-1}n$

(e) none of these.

10. In 1932, James Chadwick discovered the neutron by bombarding beryllium-9 atoms with α particles. The result was a new nucleus and a neutron. The balanced nuclear equation for this process is

(a) $^{9}_{4}Be + {}^{0}_{-1}e \rightarrow {}^{8}_{3}Li + {}^{1}_{0}n$

(b) $^{9}_{4}Be + {}^{1}_{0}n \rightarrow {}^{6}_{2}He + {}^{4}_{2}He$

(c) $^{9}_{4}Be + {}^{4}_{2}He \rightarrow {}^{12}_{6}C + {}^{1}_{0}n$

(d) $^{9}_{4}Be + {}^{4}_{2}He \rightarrow {}^{13}_{5}B + {}^{0}_{1}n$

(e) none of these.

11. Hyperthyroidism in humans is treated with radioactive iodide salts. The I^- ions quickly concentrate in the thyroid through metabolic processes and irradiate the gland to treat the problem. Iodine-131, as $Na^{131}_{53}I$, used in this treatment is a β emitter with a half-life of 8 days. What is the balanced nuclear equation for this decay process?

(a) $^{131}_{53}I \rightarrow {}^{131}_{54}Xe + {}^{0}_{-1}e$

(b) $^{131}_{53}I \rightarrow {}^{131}_{52}Te + {}^{0}_{-1}e$

(c) $^{131}_{53}I \rightarrow {}^{127}_{51}Sb + {}^{4}_{2}He$

(d) $^{131}_{53}I \rightarrow {}^{131}_{52}Te + {}^{0}_{+1}e$

(e) none of these.

12. A sample of sodium-24 was prepared. This isotope of sodium undergoes β decay with a half-life of 15.0 hours. If 0.00288 g of sodium-24 is present to start the experiment at 8:00 AM on Monday, how much will still be present at 8:00 PM on Wednesday (two days later)?

(a) 0.00009 g
(b) 0.00018 g
(c) 0.00036 g
(d) 0.00072 g
(e) none of these.

13. Phosphorus-32 is an artificial isotope of phosphorus that is used as a "tracer" in research in biochemistry and molecular biology. It can be prepared in three ways:

$$X + {}^{1}_{0}n \rightarrow {}^{32}_{15}P$$

$$Y + {}^{1}_{0}n \rightarrow {}^{32}_{15}P + {}^{1}_{1}H$$

$$Z + {}^{1}_{0}n \rightarrow {}^{32}_{15}P + {}^{4}_{2}He$$

What are X, Y, and Z?

(a) $X = {}^{31}_{15}P$; $Y = {}^{32}_{17}Cl$; $Z = {}^{35}_{18}Ar$

(b) $X = {}^{31}_{16}S$; $Y = {}^{32}_{15}P$; $Z = {}^{35}_{17}Cl$

(c) $X = {}^{31}_{14}Si$; $Y = {}^{32}_{16}S$; $Z = {}^{35}_{17}Ar$

(d) $X = {}^{31}_{15}P$; $Y = {}^{32}_{16}S$; $Z = {}^{35}_{17}Cl$

(e) none of these.

14. Barium-140 undergoes β decay with a half-life of 12.8 days. If a sample of barium-140 contains 194 g of barium-140, how long will it take until the amount of barium-140 is reduced to 6.1 g?

(a) 76.8 days
(b) 38.4 days
(c) 51.2 days
(d) 64.0 days
(e) none of these.

15. The decay constant for a radionuclide that has a half-life of 3.6×10^9 years is

(a) 3.6×10^9 year^{-1}

(b) 2.8×10^{-10} year^{-1}

(c) 1.9×10^{-10} year^{-1}

(d) 1.7×10^{-8} year^{-1}

(e) none of these.

16. Radium was discovered by Marie and Pierre Curie. Radium-226, ${}^{226}_{88}Ra$, decays with a half-life of 1622 years to give radon gas, ${}^{222}_{86}Rn$. What particle is involved in the decay of radium-226 to give radon-222?

(a) α particle

(b) β particle

(c) positron

(d) neutron

(e) none of these.

17. As stars age, they use up their primary fuel, hydrogen atoms, and begin to get even hotter using other nuclear reactions involving other nuclei besides hydrogen. In these later stages heavier elements like magnesium, aluminum, silicon and phosphorus are formed. It is thought that the naturally occurring aluminum isotope, aluminum-27, is formed in stars by a sequence of two reactions:

A. $^{24}_{12}Mg + \alpha \rightarrow X + {}^{1}_{0}n$

B. $X \rightarrow {}^{27}_{13}Al + {}^{0}_{+1}e$

What is X?

(a) $^{28}_{14}Si$
(b) $^{27}_{15}P$
(c) $^{27}_{14}Si$
(d) $^{28}_{13}Al$
(e) none of these.

18. Which one of the following balanced equations is labeled incorrectly?

(a) Fission: $^{209}_{83}Bi + {}^{4}_{2}He \rightarrow {}^{211}_{85}At + 2\ {}^{1}_{0}n$

(b) Fusion: $^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{1}H + {}^{1}_{1}H$

(c) Bombardment: $^{239}_{94}Pu + {}^{1}_{0}n \rightarrow {}^{240}_{90}Am + {}^{0}_{-1}e$

(d) β production: $^{239}_{92}U \rightarrow {}^{239}_{93}Np + {}^{0}_{-1}e$

(e) All are correctly labeled.

19. An experiment in biology requires that the total volume of blood in a live mouse be determined. To do this 0.10 mL of a saline suspension of red blood cells, to which some radioactive $^{59}_{26}Fe$ (a gamma ray emitter) has been added, is injected into the tail vein of the mouse. Before injection the gamma rays were counted for this 0.10 mL solution and the count rate found to be 1.0×10^4 cpm. After a sufficient time for the blood to be thoroughly mixed with the blood labeled with the radioactive iron, 0.10 mL of blood is removed and counted. The sample is found to have a count rate of 476 cpm. What is the approximate blood volume of the mouse?

(a) 0.48 mL

(b) 21 mL

(c) 4.8 mL

(d) 4.7 mL

(e) 2.1 mL