***General, Organic, and Biological Chemistry, 3e* (Frost)**
Chapter 2 Atoms and Radioactivity

2.1 Multiple-Choice

1) The smallest particle of an element that can be identified as that element is:
A) a proton
B) a neutron
C) a molecule
D) an atom
Answer: D
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

2) Which one of the following carries no electrical charge?
A) An electron
B) A proton
C) A neutron
D) A cation
Answer: C
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

3) The neutral atom always contains:
A) the same number of protons and neutrons
B) the same number of neutrons and electrons
C) the same number of protons and electrons
D) the same number of protons, neutrons and electrons
Answer: C
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

4) Which particle(s) are in the nucleus?
A) Protons only
B) Neutrons only
C) Protons and neutrons
D) Protons and electrons
Answer: C
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

5) Almost all of the mass of an atom exists in its:
A) first energy level
B) outermost energy level
C) nucleus
D) electrons
Answer: C
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

6) Which subatomic particle contributes least to the mass of the atom?
A) Proton
B) Neutron
C) Electron
D) All of these contribute equally.
Answer: C
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

7) Two atoms must represent the same element if they both have the same:
A) number of electron shells
B) atomic number
C) number of neutrons
D) atomic mass
Answer: B
Diff: 1
Section: 2-2
Global: G1
LO: 2.2

8) Mercury-202 has how many neutrons in its nucleus?
A) 22
B) 102
C) 122
D) 202
Answer: C
Diff: 1
Section: 2-2
Global: G2
LO: 2.2

9) Uranium-235 has how many protons in the nucleus?
A) 92
B) 143
C) 235
D) 51
Answer: A
Diff: 1
Section: 2-2
Global: G2
LO: 2.2

10) Cobalt is element 27. Cobalt-60 is used in the medical treatment of cancer. How many neutrons and protons are contained in the nucleus of this isotope?
A) 27 neutrons, 33 protons
B) 33 neutrons, 27 protons
C) 27 neutrons, 27 protons
D) 33 neutrons, 33 protons
Answer: B
Diff: 1
Section: 2-2
Global: G2
LO: 2.2

11) Adding one proton to the nucleus of an atom:
A) increases the atom ic number and the mass number by one unit
B) increases its atomic mass by one unit, but does not change its atomic number
C) increases its atomic number by one unit but does not change its atomic mass
D) does not change either its atomic number or its atomic mass
Answer: A
Diff: 1
Section: 2-2
Global: G2
LO: 2.2

12) Adding one neutron to the nucleus of an atom:
A) increases the atom ic number and the mass number by one unit
B) increases its atomic mass by one unit, but does not change its atomic number
C) increases its atomic number by one unit but does not change its atomic mass
D) does not change either its atomic number or its atomic mass
Answer: B
Diff: 1
Section: 2-2
Global: G2
LO: 2.2

13) The quantity (mass number - atomic number) provides:
A) the number of neutrons in a nucleus
B) the number of electrons in the atom
C) the number of protons in a nucleus
D) the combined number of all the neutrons and all the protons in a nucleus
Answer: A
Diff: 1
Section: 2-2
Global: G1
LO: 2.2

14) The mass number is:
A) the sum of protons + neutrons
B) the sum of protons + electrons
C) the sum of electrons + neutrons
D) the difference between neutrons and protons
Answer: A
Diff: 1
Section: 2-2
Global: G1
LO: 2.2

15) How many neutrons are in a neutral atom of Ar-40?
A) 18
B) 22
C) 40
D) 58
Answer: B
Diff: 1
Section: 2-2
Global: G2
LO: 2.2

16) How many neutrons are in a neutral atom of Fe-56?
A) 26
B) 30
C) 56
D) 82
Answer: B
Diff: 1
Section: 2-2
Global: G2
LO: 2.2

17) Isotopes have the:
A) same number of protons but different number of electrons
B) same number of protons but different number of neutrons
C) same number of neutrons but different number of electrons
D) all of the above
Answer: B
Diff: 1
Section: 2-3
Global: G1
LO: 2.3

18) A hypothetical element contains three isotopes of mass 16.0 amu, 17.0 amu, and 18.0 amu with relative abundances of 20.0%, 50.0% and 30.0%, respectively. The average atomic mass is:
A) 16.9 amu
B) 17.1 amu
C) 17.3 amu
D) 17.5 amu
Answer: B
Diff: 2
Section: 2-3
Global: G4
LO: 2.3

19) Which of the following represents a pair of isotopes?
A) $^{14}_{6}C$, $^{14}_{7}N$
B) $^{1}_{1}H$, $^{2}_{1}H$
C) $^{32}_{16}S$, $^{32}_{16}S^{-2}$
D) O_2, O_3
Answer: B
Diff: 1
Section: 2-3
Global: G2
LO: 2.3

20) What is the correct symbol for the isotope of copper with a mass number of 63?
A) $^{63}_{27}Co$

B) $^{29}_{63}Cu$

C) $^{63}_{29}Cu$

D) $^{63}_{24}Cr$

Answer: C
Diff: 1
Section: 2-3
Global: G2
LO: 2.3

21) The element rhenium (Re) exists as two stable isotopes and 18 unstable isotopes. Rhenium-185 (^{185}Re) has in its nucleus:
A) 75 protons, 75 neutrons
B) 75 protons, 130 neutrons
C) 130 protons, 75 neutrons
D) 75 protons, 110 neutrons
Answer: D
Diff: 1
Section: 2-3
Global: G2
LO: 2.3

22) The masses on the periodic table are expressed in what units?
A) Grams
B) Amus
C) Tons
D) Pounds
Answer: B
Diff: 1
Section: 2-3
Global: G1
LO: 2.3

23) Of the following, the radioisotope most useful in treating disorders of the thyroid gland is:
A) C-14
B) Tc-99m
C) U-238
D) I-131
Answer: D
Diff: 2
Section: 2-4
Global: G1
LO: 2.4

24) Made up of helium nuclei traveling at 5-7% speed of light:
A) alpha particles
B) gamma rays
C) beta particles
D) neutrons
Answer: A
Diff: 1
Section: 2-4
Global: G1
LO: 2.4

25) The form of radioactivity that penetrates matter most easily is:
A) alpha particles
B) gamma rays
C) beta particles
D) protons
Answer: B
Diff: 1
Section: 2-4
Global: G1
LO: 2.4

26) The form of radioactivity that penetrates matter the least is:
A) alpha particles
B) gamma rays
C) beta particles
D) protons
Answer: A
Diff: 1
Section: 2-4
Global: G1
LO: 2.4

27) Form of radiation that has no mass:
A) alpha particles
B) beta particles
C) gamma rays
D) neutrons
Answer: C
Diff: 1
Section: 2-4
Global: G1
LO: 2.4

28) Made up of electrons from the nucleus traveling at 90-95% speed of light:
A) alpha particles
B) gamma rays
C) beta particles
D) neutrons
Answer: C
Diff: 1
Section: 2-4
Global: G1
LO: 2.4

29) The radioactive particles, alpha, beta and gamma ray, are called ionizing radiation because, as they pass through an object, they:
A) repel ions
B) knock electrons off atoms or molecules in their path
C) decay into ions
D) attract ions
Answer: B
Diff: 2
Section: 2-4
Global: G1
LO: 2.4

30) What protective shielding is sufficient for gamma rays?
A) Paper
B) Aluminium sheet
C) Lead sheet
D) All of the above
Answer: C
Diff: 1
Section: 2-4
Global: G1
LO: 2.4

31) What protective shielding is sufficient for alpha particles?
A) Paper
B) Aluminium sheet
C) Lead sheet
D) All of the above
Answer: D
Diff: 1
Section: 2-4
Global: G1
LO: 2.4

32) The correct symbol for the positron is:
A) $^{1}_{1}e$

B) $^{0}_{1}p$

C) $^{0}_{1}e$

D) $^{1}_{0}e$

Answer: C
Diff: 1
Section: 2-4
Global: G2
LO: 2.4

33) What radioactive particle is missing in the following nuclear reaction?
$^{98}_{42}Mo + \_\_\_\_\_ \rightarrow {}^{99}_{42}Mo$

A) $^{1}_{0}n$

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

C) $^{4}_{2}He$

D) $^{1}_{1}p$

Answer: A
Diff: 2
Section: 2-5
Global: G2
LO: 2.5

34) What radioactive particle is missing in the following nuclear reaction?
$^{99}_{42}\text{Mo} \rightarrow {}^{99m}_{43}\text{Tc} + \_\_\_\_\_$

A) $^{1}_{0}\text{n}$

B) $^{0}_{-1}\text{e}$

C) $^{4}_{2}\text{He}$

D) $^{1}_{1}\text{p}$

Answer: B
Diff: 2
Section: 2-5
Global: G2
LO: 2.5

35) When Phosphorous-30 loses a positron what is the product of this radioactive decay?
A) $^{30}_{14}\text{Si}$

B) $^{30}_{16}\text{S}$

C) $^{31}_{16}\text{S}$

D) $^{31}_{15}\text{P}$

Answer: A
Diff: 1
Section: 2-5
Global: G2
LO: 2.5

36) When Americium-242 loses a beta particle the product of this process is:
A) $^{243}_{96}\text{Cm}$

B) $^{242}_{96}\text{Cm}$

C) $^{242}_{94}\text{Pu}$

D) $^{241}_{94}\text{Pu}$

Answer: B
Diff: 1
Section: 2-5
Global: G2
LO: 2.5

37) The amount of a radioisotope that remains after two half-lives have passed is:
A) 98%
B) 75%
C) 50%
D) 25%
Answer: D
Diff: 2
Section: 2-6
Global: G4
LO: 2.6

38) In order to have 1/16 of a radioactive sample left how many half lives must the sample go through to reach this amount?
A) 3
B) 4
C) 5
D) 6
Answer: B
Diff: 2
Section: 2-6
Global: G4
LO: 2.6

39) The half life of a specific radionuclide is 8 days. How much of an 80 mg sample will be left after 24 days?
A) 40 mg
B) 20 mg
C) 10 mg
D) 2.7 mg
Answer: C
Diff: 2
Section: 2-6
Global: G4
LO: 2.6

40) The half life of a specific Tc-99m is 6 hours. How much of an 192 mg sample will have decayed after 30 hours?
A) 186 mg
B) 160 mg
C) 32 mg
D) 6 mg
Answer: A
Diff: 3
Section: 2-6
Global: G4
LO: 2.6

41) A fossil found in a cave was found to have a Carbon-14 ratio to carbon of 1/ 32 of a live object. If the half life of Carbon-14 is 5730 yrs, how old is the object?
A) 5730 yrs
B) 28,650 yrs
C) 34,480 yrs
D) 17,190 yrs
Answer: B
Diff: 2
Section: 2-6
Global: G4
LO: 2.6

42) Using Table 2.7 in the text, identify which of the following radioactive nuclides would disappear first given the same initial quantities.
A) U-238
B) C-14
C) I-123
D) F-18
Answer: D
Diff: 1
Section: 2-6
Global: G3
LO: 2.6

43) Use Table 2.7 to determine which of the following isotopes will have the highest concentration after a long duration beginning with the same initial quantities.
A) H-3
B) P-32
C) Cr-51
D) F-18
Answer: A
Diff: 1
Section: 2-6
Global: G3
LO: 2.6

2.2 True/False

1) Different elements can contain the same atoms.
Answer: FALSE
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

2) Atoms are made up of smaller particles called molecules.
Answer: FALSE
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

3) The neutral atom contains equal numbers of protons and electrons.
Answer: TRUE
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

4) The neutral atom always contains equal numbers of protons and neutrons.
Answer: FALSE
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

5) The mass of the atom is almost all in the nucleus.
Answer: TRUE
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

6) A neutron has no charge and negligible mass.
Answer: FALSE
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

7) Atoms are electrically neutral.
Answer: TRUE
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

8) An electron has no charge and negligible mass.
Answer: FALSE
Diff: 1
Section: 2-1
Global: G1
LO: 2.1

9) An atom of K-40 contains 40 neutrons.
Answer: FALSE
Diff: 1
Section: 2-2
Global: G2
LO: 2.2

10) An atom of Pb-208 contains 126 neutrons.
Answer: TRUE
Diff: 1
Section: 2-2
Global: G2
LO: 2.2

11) Isotopes always have the same atomic number.
Answer: TRUE
Diff: 1
Section: 2-3
Global: G1
LO: 2.3

12) Isotopes always have the same mass number.
Answer: FALSE
Diff: 1
Section: 2-3
Global: G1
LO: 2.3

13) All elements with atomic number 83 or greater are radioactive.
Answer: TRUE
Diff: 1
Section: 2-4
Global: G1
LO: 2.4

14) All isotopes of elements with atomic 82 or lower are not radioactive.
Answer: FALSE
Diff: 1
Section: 2-4
Global: G1
LO: 2.4

15) A positron is a positively charged electron.
Answer: TRUE
Diff: 1
Section: 2-4
Global: G1
LO: 2.4

16) In beta decay the atomic number and mass number increase by 1.
Answer: FALSE
Diff: 1
Section: 2-5
Global: G2
LO: 2.5

17) In alpha decay both the mass number and atomic number decrease.
Answer: TRUE
Diff: 1
Section: 2-5
Global: G1
LO: 2.5

18) In positron decay the atomic number decreases by 1.
Answer: TRUE
Diff: 1
Section: 2-5
Global: G2
LO: 2.5

19) After four half-lives the activity of a radioactive sample has decreased to one quarter of the initial value.
Answer: FALSE
Diff: 2
Section: 2-6
Global: G4
LO: 2.6

20) After three half-lives 25 radioactive nuclei remain from an initial 200.
Answer: TRUE
Diff: 2
Section: 2-6
Global: G4
LO: 2.6

21) After three half-lives 12.5% of the radioactive sample has decayed.
Answer: FALSE
Diff: 2
Section: 2-6
Global: G4
LO: 2.6

22) A nucleotide with a long half-life will decay more rapidly than one with a short half-life.
Answer: FALSE
Diff: 1
Section: 2-6
Global: G2
LO: 2.6

23) 1 Ci = 3.7×10^{10} Bq
Answer: TRUE
Diff: 1
Section: 2-6
Global: G1
LO: 2.6

2.3 Short Answer

1) Write the symbolic notation ($^{A}_{Z}X$) for the following information.

A) 20 protons, 20 electrons, 20 neutrons _____
B) 16 protons, 16 electrons, 16 neutrons _____
C) 30 protons, 30 electrons, 35 neutrons _____
D) 92 protons, 92 electrons, 146 neutrons _____

Answer: $^{40}_{20}Ca$; $^{32}_{16}S$; $^{65}_{35}Br$; $^{238}_{92}U$

Diff: 1
Section: 2-2
Global: G2
LO: 2.2

2) Complete the following table:

Symbol	Atomic #	Mass #	#p	#n	#e
$^{131}_{53}$I	_____	_____	_____	_____	53
_____	43	99	43	_____	43
$^{37}_{17}$Cl	_____	_____	17	20	_____
_____	26	56	_____	_____	23

Answer:
Line 1: 53, 131, 53, 78
Line 2: $^{99}_{43}$Tc, 56
Line 3: 17, 37, 17
Line 4: $^{56}_{26}$Fe, 26, 30

Diff: 2
Section: 2-2
Global: G3
LO: 2.2

3) Write the symbol for the isotope of bismuth with 125 neutrons.
Answer: $^{208}_{83}$Bi

Diff: 1
Section: 2-2
Global: G2
LO: 2.2

4) The element rubidium (Rb) comprises two naturally occurring isotopes with mass numbers 85 (atomic mass 84.91 amu) and 87 (atomic mass 86.91 amu). If the atomic mass of the element is 85.47 amu, deduce which isotope is more abundant. Calculate the isotope distribution of Rb.
Answer: The isotope with mass number 85 is more abundant. 72.0% of mass number 85 and 28.0% of mass number 87.
Diff: 2
Section: 2-3
Global: G4
LO: 2.3

5) The element magnesium (Mg) comprises three isotopes with mass numbers 24 (atomic mass 23.99 amu), 25 (atomic mass 24.99 amu) and 26 (atomic mass 25.98 amu), with the natural abundance of 78.99%, 10.00% and 11.01%, respectively. Calculate the atomic mass of Mg.
Answer: The average atomic mass is 24.31 amu.
Diff: 3
Section: 2-3
Global: G4
LO: 2.3

6) Complete the following table.

Emission	Symbol	Charge
	$^{4}_{2}\text{He}$	
beta		-1
	$^{0}_{0}\gamma$	
	$^{0}_{1}\text{e}$	
neutron		0

Answer:
line 1: alpha, +2
line 2: $^{0}_{-1}\text{e}$
line 3: gamma, 0
line 4: positron, +1
line 5: $^{1}_{0}\text{n}$

Diff: 1
Section: 2-4
Global: G2
LO: 2.4

7) Complete the following equations with the symbol for the atom or particle represented by the blank space. Show the mass numbers and atomic numbers of the isotopes formed or the symbols of the subatomic particles:

A) $^{210}_{84}\text{Po} \rightarrow \_\_\_\_\_ + {}^{206}_{82}\text{Pb}$

B) $^{234}_{91}\text{Pa} \rightarrow \_\_\_\_\_ + {}^{0}_{-1}\text{e}$

C) $\_\_\_\_\_ \rightarrow {}^{236}_{92}\text{U} + {}^{4}_{2}\text{He}$

D) $^{2}_{1}\text{H} + {}^{2}_{1}\text{H} \rightarrow {}^{3}_{2}\text{He} + \_\_\_\_\_$

E) $^{233}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{133}_{51}\text{Sb} + \_\_\_\_\_ + 2\ {}^{1}_{0}\text{n}$

F) $^{122}_{53}\text{I} \rightarrow {}^{122}_{54}\text{Xe} + \_\_\_\_\_$

G) $^{32}_{16}\text{S} + {}^{1}_{0}\text{n} \rightarrow {}^{1}_{1}\text{p} + \_\_\_\_\_$

Answer: A) $^{4}_{2}\text{He}$; B) $^{234}_{92}\text{U}$; C) $^{240}_{94}\text{Pu}$; D) $^{1}_{0}\text{n}$; E) $^{99}_{41}\text{Nb}$; F) $^{0}_{-1}\text{e}$; G) $^{32}_{15}\text{P}$

Diff: 2
Section: 2-5
Global: G2
LO: 2.5

8) Write a nuclear equation for the following processes:
A) Bismuth-214 undergoes beta decay.
B) Thorium-230 decays to a radium isotope.
C) Magnesium-23 undergoes positron emission.

Answer: A) $^{214}_{83}\text{Bi} \rightarrow {}^{0}_{-1}\text{e} + {}^{214}_{84}\text{Po}$; B) $^{230}_{90}\text{Th} \rightarrow {}^{4}_{2}\text{He} + {}^{226}_{88}\text{Ra}$; C) $^{23}_{12}\text{Mg} \rightarrow {}^{0}_{1}\text{e} + {}^{23}_{11}\text{Na}$

Diff: 2
Section: 2-5
Global: G2
LO: 2.5

9) What is the product of positron emission from F-18?
Answer: O-18
Diff: 1
Section: 2-5
Global: G2
LO: 2.5

10) You obtain a new sample of cobalt-60, half-life 5.25 years, with a mass of 400 mg. How much cobalt-60 remains after 15.75 years?
Answer: 50 mg
Diff: 2
Section: 2-6
Global: G4
LO: 2.6

11) The units of activity are known as the curie (Ci) and the becquerel (Bq). Write down the relationship between them.
Answer: $1\ \text{Ci} = 3.7 \times 10^{10}\ \text{Bq}$
Diff: 1
Section: 2-6
Global: G2
LO: 2.6

12) If a radioactive sample has an activity of 75 mCi. Calculate the activity in Bq. The units of activity are known as the curie (Ci) and the becquerel (Bq). Write down the relationship between them.
Answer: $\text{Activity} = 2.8 \times 10^{9}\ \text{Bq}$
Diff: 2
Section: 2-6
Global: G4
LO: 2.6

13) Why can't we use Carbon-14 dating techniques to date the age of a dinosaur bone?
Answer: Because after 10 half lives there is not enough C-14 left to measure it is less than 0.1% of the original value and dinosaurs lived over one billion years ago.
Diff: 2
Section: 2-6
Global: G2
LO: 2.6

14) A 100-mg technetium-99m sample is used in a medical study. How much of the Technetium-99m sample remains after 24 hours? The half-life of Tc-99m is 6 hours.
Answer: 24 hours/6 hours = 4 half lives; 100 mg → 50 mg → 25 mg → 12.5 mg → <u>6.25 mg</u>
Diff: 2
Section: 2-6
Global: G4
LO: 2.6

15) Krypton-81m is used for lung ventilation studies. Its half-life is 13 seconds. How long does it take the activity of this isotope to reach one-quarter of its original value?
Answer: $1 \rightarrow 1/2 \rightarrow 1/4$, so that is two half lives; therefore, 26 secs
Diff: 2
Section: 2-6
Global: G4
LO: 2.6

16) In order for a radionuclide to be used for medical diagnosis it must have certain properties. Name two and explain why.
Answer: They must have a short half life in order to disappear from the body as soon as possible and they should either be a beta or gamma ray emitter.
Diff: 2
Section: 2-7
Global: G2
LO: 2.7

17) Why is a radioactive nuclide which is an alpha emitter a bad choice in medical diagnostics or imaging?
Answer: Because of the short absorption depth, alpha particles cause the largest damage to tissue.
Diff: 2
Section: 2-7
Global: G2
LO: 2.7