Chapter 02: Atoms, Ions, and Compounds

MULTIPLE CHOICE

1. What are cathode rays?
   a. electrons
   b. protons
   c. neutrons
   d. alpha particles
   e. X-rays

   ANS: A DIF: Easy REF: 2.1
   OBJ: Describe how cathode rays are generated and behave in magnetic/electric fields
   MSC: Remembering

2. Who discovered electrons?
   a. Henri Becquerel
   b. Robert Millikan
   c. Joseph John Thomson
   d. John Dalton
   e. James Chadwick

   ANS: C DIF: Easy REF: 2.1
   OBJ: Learn how the mass-to-charge ratio of the electron was determined
   MSC: Remembering

3. Which of the following statements is true regarding Thomson's cathode ray experiment and the discovery of electrons?
   a. Radioactivity was also discovered.
   b. Magnetic fields deflected cathode rays but electric fields did not.
   c. Cathode rays were split into two beams by magnetic fields.
   d. The charge of the electron was determined.
   e. The mass-to-charge ratio of the electron was determined.

   ANS: E DIF: Easy REF: 2.1
   OBJ: Learn how the mass-to-charge ratio of the electron was determined
   MSC: Understanding

4. Who was the first scientist to determine the charge of an electron?
   a. Henri Becquerel
   b. Robert Millikan
   c. Joseph John Thomson
   d. John Dalton
   e. James Chadwick

   ANS: B DIF: Easy REF: 2.1
   OBJ: Learn how the charge on the electron was determined MSC: Remembering

5. Which statement regarding Millikan's oil drop experiment is true?
   a. X-rays removed electrons from fine oil droplets to produce cations.
   b. The rate at which charged oil droplets fell in an adjustable magnetic field was related to the charge on an electron.
   c. The rate at which charged oil droplets fell in an adjustable electric field was related to the charge on an electron.
   d. The rate at which ionized N_2 and O_2 molecules fell between electrically charged metal plates was related to charge on an electron.
   e. Electrons were found to have either a positive or negative charge depending on how they were generated.

   ANS: C DIF: Easy REF: 2.1

OBJ: Learn how the charge on the electron was determined MSC: Understanding

6. Which of the following is NOT true regarding cations and anions?
   a. N^{3-} represents a nitrogen atom that has gained three electrons.
   b. An oxygen molecule can lose an electron to form O_2^-.
   c. Ca^{2+} represents a calcium atom that has lost two electrons.
   d. The formation of a chlorine anion can be written as $Cl + e^- \rightarrow Cl^-$.
   e. $N_2 \rightarrow N_2^+ + e^-$ describes a nitrogen molecule forming a +1 cation.

   ANS: B DIF: Medium REF: 2.1
   OBJ: Write notation for charged species (cations and anions) MSC: Analyzing

7. What is the correct symbol for an α particle?
   a. $^{4}_{1}\alpha$
   b. $^{2}_{2}\alpha$
   c. $^{2}_{4}\alpha$
   d. $^{4}_{2}\alpha$
   e. $^{0}_{0}\alpha$

   ANS: D DIF: Easy REF: 2.1
   OBJ: Define and describe types of radioactivity MSC: Applying

8. What is the correct symbol for a β^- particle?
   a. $^{1}_{0}\beta$
   b. $^{-1}_{0}\beta$
   c. $^{1}_{1}\beta$
   d. $^{0}_{1}\beta$
   e. $^{0}_{-1}\beta$

   ANS: E DIF: Easy REF: 2.1
   OBJ: Define and describe types of radioactivity MSC: Applying

9. Who discovered neutrons?
   a. Henri Becquerel
   b. Robert Millikan
   c. Joseph John Thomson
   d. John Dalton
   e. James Chadwick

   ANS: E DIF: Easy REF: 2.1
   OBJ: Describe Rutherford's experiment that discovered the atomic nucleus and the subsequent view of atomic structure MSC: Remembering

10. Which statement regarding Rutherford's nuclear model of the atom is false?
    a. The diameter of the atom is approximately 10,000 times larger than the nucleus.
    b. The nucleus is approximately 100 times smaller than the diameter of the atom.
    c. The nucleus is surrounded by a diffuse cloud of electrons.
    d. Electrons and protons are not mixed uniformly throughout the atom.
    e. The atom is mostly empty space.

    ANS: B DIF: Easy REF: 2.1
    OBJ: Describe Rutherford's experiment that discovered the atomic nucleus and the subsequent view of atomic structure MSC: Understanding

11. Which statement regarding the Geiger–Marsden experiment is false?
    a. Beta particles were occasionally deflected by electrons in the gold atoms.
    b. Alpha particles were occasionally deflected by small positively charged regions in the gold atoms.
    c. The results suggested that the positive charge of an atom is localized in a small region.
    d. The results suggested that most of the mass of an atom is contained in a small region.
    e. The results suggested that the plum-pudding model of the atom was incorrect.

ANS: A DIF: Easy REF: 2.1
OBJ: Describe Rutherford's experiment that discovered the atomic nucleus and the subsequent view of atomic structure MSC: Understanding

12. If the diameter of a carbon atom is approximately 140 pm, how many carbon atoms lined up side to side would span a pencil lead with a diameter of about 0.7 mm?
a. 5×10^1 atoms
b. 5×10^3 atoms
c. 5×10^5 atoms
d. 5×10^6 atoms
e. 5×10^9 atoms

ANS: D DIF: Medium REF: 2.1
OBJ: Describe Rutherford's experiment that discovered the atomic nucleus and the subsequent view of atomic structure MSC: Analyzing

13. The diameter of a carbon atom is approximately 140 pm, whereas the diameter of a pencil lead is approximately 0.7 mm. How many carbon nuclei would be required to span 0.70 mm? The radius of the nucleus is approximately 10,000 times smaller than the radius of an atom.
a. 5×10^9 nuclei
b. 5×10^{10} nuclei
c. 5×10^{12} nuclei
d. 5×10^{13} nuclei
e. 5×10^{15} nuclei

ANS: B DIF: Difficult REF: 2.1
OBJ: Describe Rutherford's experiment that discovered the atomic nucleus and the subsequent view of atomic structure MSC: Evaluating

14. A baseball has a diameter of approximately 7.4 cm (2.9 inches), whereas a carbon atom has a diameter of about 140 pm. How many times larger is the baseball than the carbon atom?
a. 5.3×10^{12}
b. 5.3×10^{10}
c. 5.3×10^8
d. 5.3×10^6
e. 5.3×10^3

ANS: C DIF: Difficult REF: 2.1
OBJ: Describe Rutherford's experiment that discovered the atomic nucleus and the subsequent view of atomic structure MSC: Evaluating

15. If the nucleus of an atom had a diameter of 1 cm (roughly that of a dime), what would be the approximate diameter of the atom? The radius of the nucleus is approximately 10,000 times smaller than the radius of an atom.
a. 1000 km
b. 10 km
c. 1000 m
d. 100 m
e. 1 m

ANS: D DIF: Difficult REF: 2.1
OBJ: Describe Rutherford's experiment that discovered the atomic nucleus and the subsequent view of atomic structure MSC: Evaluating

16. If the nucleus of an atom has a radius of about 5 fm and a mass of about 2×10^{-21} g, what is its approximate density? (Volume of a sphere = $4\pi r^3/3$)
a. 4×10^{15} g/cm^3
b. 4×10^{12} g/cm^3
c. 4×10^9 g/cm^3
d. 4×10^6 g/cm^3
e. 4×10^3 g/cm^3

ANS: A DIF: Difficult REF: 2.1
OBJ: Describe Rutherford's experiment that discovered the atomic nucleus and the subsequent view of atomic structure MSC: Evaluating

17. Which subatomic particles have opposite charges?
    a. protons and neutrons
    b. protons and electrons
    c. neutrons and electrons
    d. all protons
    e. all neutrons

    ANS: B DIF: Easy REF: 2.1
    OBJ: Compare the mass and charge of atomic particles: electrons, protons, and neutrons
    MSC: Understanding

18. Which subatomic particles have approximately equal masses?
    a. protons and neutrons
    b. protons and electrons
    c. neutrons and electrons
    d. protons, neutrons, and electrons
    e. none of the above

    ANS: A DIF: Easy REF: 2.1
    OBJ: Compare the mass and charge of atomic particles: electrons, protons, and neutrons
    MSC: Understanding

19. What is the correct symbol for an electron?
    a. $^{1}_{-1}e$
    b. $^{-0}_{1}e$
    c. $^{0}_{1}e$
    d. $^{0}_{-1}e$
    e. $^{0}_{0}e$

    ANS: D DIF: Easy REF: 2.1
    OBJ: Compare the mass and charge of atomic particles: electrons, protons, and neutrons
    MSC: Understanding

20. What is the correct symbol for a proton?
    a. $^{0}_{-1}p$
    b. $^{0}_{1}p$
    c. $^{1}_{1}p$
    d. $^{1}_{0}p$
    e. $^{0}_{0}p$

    ANS: C DIF: Easy REF: 2.1
    OBJ: Compare the mass and charge of atomic particles: electrons, protons, and neutrons
    MSC: Understanding

21. What is the correct symbol for a neutron?
    a. $^{1}_{0}n$
    b. $^{1}_{1}n$
    c. $^{0}_{1}n$
    d. $^{1}_{}n$
    e. $^{-1}_{0}n$

    ANS: A DIF: Easy REF: 2.1
    OBJ: Compare the mass and charge of atomic particles: electrons, protons, and neutrons
    MSC: Understanding

22. Protons and neutrons are examples of _____
    a. nuclei.
    b. nuclides.
    c. nucleons.
    d. isotopes.
    e. charged particles.

    ANS: C DIF: Easy REF: 2.1

OBJ: Compare the mass and charge of atomic particles: electrons, protons, and neutrons
MSC: Understanding

23. Which of the following statements regarding the discovery of isotopes is false?
    a. Positively charged ions were deflected by a combination of electric and magnetic fields.
    b. Nuclides with equal charges but different masses were deflected to different degrees.
    c. The amount of deflection of an ion depended on its charge.
    d. An estimate of the relative abundance of the different isotopes of an element could be ascertained.
    e. If nuclides had the same mass but different positive charges, the ion with the smallest charge was deflected the most.

    ANS: E DIF: Medium REF: 2.2
    OBJ: Describe the experiment that discovered isotopes MSC: Analyzing

24. Isotopes have _____
    a. the same atomic mass.
    b. the same total number of protons and neutrons.
    c. the same number of neutrons but a different number of protons.
    d. the same number of protons but a different number of neutrons.
    e. the same number of protons but different numbers of electrons.

    ANS: D DIF: Easy REF: 2.2
    OBJ: Define isotope, atomic number, mass number MSC: Remembering

25. The $^{12}_{6}C$ nucleus is an example of _____
    a. a nuclide.
    b. an element.
    c. a proton.
    d. a neutron.
    e. a nucleon.

    ANS: A DIF: Easy REF: 2.2
    OBJ: Define isotope, atomic number, mass number MSC: Understanding

26. $^{12}_{6}C$ and $^{13}_{6}C$ are examples of _____
    a. ions.
    b. neutrons.
    c. nucleons.
    d. isotopes.
    e. charged particles.

    ANS: D DIF: Easy REF: 2.2
    OBJ: Define isotope, atomic number, mass number MSC: Understanding

27. The atomic model that includes isotopes differs from Dalton's view of the atom. Which of the following statements is false?
    a. The identity of an atom can be determined solely by its atomic number.
    b. The identity of an isotope can be determined solely by its mass number.
    c. Atoms of different elements may have the same mass numbers.
    d. Atoms of different elements cannot contain the same number of protons.
    e. The different isotopes of an element are not always equally abundant.

    ANS: B DIF: Medium REF: 2.2
    OBJ: Compare Dalton's definition of an element to the definition that realizes the existence of isotopes MSC: Analyzing

28. A $^{35}_{17}Cl$ atom has _____ protons, _____ neutrons, and _____ electrons.
    a. 17, 18, 17
    d. 18, 35, 17

b. 17, 35, 17
c. 35, 17, 17
e. 18, 17, 18

ANS: A DIF: Easy REF: 2.2
OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
MSC: Understanding

29. A phosphorus-31 atom has _____ protons, _____ neutrons, and _____ electrons.
a. 31, 31, 31
b. 15, 16, 16
c. 15, 31, 15
d. 15, 16, 15
e. 16, 15, 15

ANS: D DIF: Easy REF: 2.2
OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
MSC: Understanding

30. A strontium-90 atom that has a lost two electrons has _____ protons, _____ neutrons, and _____ electrons.
a. 38, 90, 36
b. 38, 52, 40
c. 38, 52, 36
d. 38, 90, 40
e. 90, 38, 88

ANS: C DIF: Easy REF: 2.2
OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
MSC: Understanding

31. A $^{16}_{8}O^{2-}$ ion has _____ protons, _____ neutrons, and _____ electrons.
a. 8, 8, 6
b. 8, 10, 10
c. 8, 8, 10
d. 8, 8, 8
e. 8, 16, 8

ANS: C DIF: Medium REF: 2.2
OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
MSC: Analyzing

32. A $^{133}_{55}Cs^{+}$ ion has _____ protons, _____ neutrons, and _____ electrons.
a. 55, 78, 54
b. 55, 78, 55
c. 55, 133, 54
d. 54, 78, 55
e. 54, 133, 55

ANS: A DIF: Medium REF: 2.2
OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
MSC: Analyzing

33. Identify the atom or ion: i)_____; ii) _____; and iii)_____.

Atom	*atomic number*	*mass number*	*no. of electrons*
i	56	137	54

ii	54	131	54
iii	52	128	54

a. $^{81}_{56}Ba^{2-}$; $^{77}_{54}Xe$; $^{76}_{52}Te^{2+}$
b. $^{54}_{56}Ba^{2+}$; $^{54}_{54}Xe$; $^{54}_{52}Te^{2-}$
c. $^{137}_{56}Ba^{2-}$; $^{131}_{54}Xe$; $^{128}_{52}Te^{2+}$
d. $^{81}_{56}Ba^{2+}$; $^{77}_{54}Xe$; $^{76}_{52}Te^{2-}$
e. $^{137}_{56}Ba^{2+}$; $^{131}_{54}Xe$; $^{128}_{52}Te^{2-}$

ANS: E DIF: Medium REF: 2.2
OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
MSC: Applying

34. Identify the atom or ion: i)_____; ii) _____; and iii)_____.

Atom	*Protons*	*Neutrons*	*Electrons*
i	17	20	18
ii	18	22	18
iii	19	20	18

a. $^{35}_{17}Cl^{-}$; $^{40}_{18}Ar$; $^{37}_{19}K^{+}$
b. $^{37}_{17}Cl^{-}$; $^{40}_{18}Ar$; $^{39}_{19}K^{+}$
c. $^{37}_{17}Cl^{+}$; $^{40}_{18}Ar$; $^{39}_{19}K^{-}$
d. $^{35}_{17}Cl^{+}$; $^{40}_{18}Ar$; $^{37}_{19}K^{-}$
e. $^{35}_{17}Cl^{-}$; $^{36}_{18}Ar$; $^{37}_{19}K^{-}$

ANS: B DIF: Medium REF: 2.2
OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
MSC: Applying

35. What is the nuclide symbol for the atom that has an atomic number equal to the number of electrons in $^{35}Cl^{-}$ and a neutron number equal to the mass number of a sodium atom containing 11 neutrons?

a. $^{41}_{18}Ar$
b. $^{42}_{20}Ca$
c. $^{75}_{35}Br$
d. $^{40}_{18}Ar$
e. $^{52}_{24}Cr$

ANS: D DIF: Medium REF: 2.2
OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
MSC: Analyzing

36. What is the nuclide symbol for the ion that has a charge of 2+, 50 neutrons more than its number of protons, and an atomic number equal to the number of electrons in a zirconium atom that has lost 2 electrons?

a. $^{72}_{50}Sn^{2+}$
b. $^{88}_{38}Sr^{2+}$
c. $^{90}_{40}Zr^{2+}$
d. $^{90}_{40}Zr^{2+}$
e. $^{90}_{38}Sr^{2+}$

ANS: B DIF: Medium REF: 2.2
OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
MSC: Analyzing

37. Nuclei with certain numbers of protons and neutrons (or combinations thereof) appear to be more stable than others. “Magic numbers” that are consistent with known nuclides are 2, 8, 20, 28, 50, 82, and 126, with 180 and 306 being hypothesized as the next in the series. Using this information, along with your knowledge of atoms and isotopes, you try to synthesize a new atom (symbol X) based on stable combinations of nucleons. Which do you think is a likely candidate?

a. $^{18}_{2}X$
b. $^{8}_{8}X$
c. $^{306}_{180}X$
d. $^{306}_{20}X$
e. $^{126}_{180}X$

ANS: C DIF: Difficult REF: 2.2
OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
MSC: Creating

38. What is the symbol for sulfur?

a. Si
b. Sc
c. Su
d. S
e. Sf

ANS: D DIF: Easy REF: 2.3
OBJ: Learn how the periodic table is organized MSC: Remembering

39. What is the symbol for magnesium?

a. M
b. Mg
c. Mn
d. Mo
e. Md

ANS: B DIF: Easy REF: 2.3
OBJ: Learn how the periodic table is organized MSC: Remembering

40. Cm is the symbol for _____

a. cerium.
b. chromium.
c. calcium.
d. curium.
e. cesium.

ANS: D DIF: Easy REF: 2.3
OBJ: Learn how the periodic table is organized MSC: Remembering

41. Which two elements would you expect to show the most similar behavior?

a. Se and Br
b. B and C
c. Li and Be
d. Sn and Bi
e. Ca and Sr

ANS: E DIF: Easy REF: 2.3
OBJ: Learn how the periodic table is organized MSC: Remembering

42. The sixth period of the periodic table contains _____ elements.

a. 18
b. 32
c. 24
d. 16
e. 8

ANS: B DIF: Difficult REF: 2.3
OBJ: Learn how the periodic table is organized MSC: Evaluating

43. Which of the following is NOT a common ion?

a. Rb^{+}
d. I^{-}

b. S^{2-}
c. Al^{3+}
e. Ba^{+}

ANS: E DIF: Easy REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Remembering

44. Which element forms ionic compounds with the formula XBr_2?
a. sodium
b. aluminum
c. lithium
d. calcium
e. carbon

ANS: D DIF: Easy REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Remembering

45. Which element forms an ionic compound with the formula Na_2X?
a. magnesium
b. carbon
c. iodine
d. phosphorus
e. sulfur

ANS: E DIF: Easy REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Remembering

46. Which element forms an ionic compound with nitrogen that has the formula XN?
a. tin
b. aluminum
c. lithium
d. calcium
e. potassium

ANS: B DIF: Easy REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Remembering

47. What is the correct formula for the compound formed between sodium and iodine based on their positions in the periodic table?
a. Na_2I
b. NaI_2
c. NaI
d. Na_2I_2
e. Na_3I

ANS: C DIF: Medium REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Analyzing

48. What is the formula for the ionic compound formed when calcium and bromine combine?
a. CBr
b. $CaBr_2$
c. Ca_2Br
d. CaBrO
e. CaB_2

ANS: B DIF: Medium REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Analyzing

49. Zinc oxide, a combination of zinc and oxygen, is found in skin ointments. What formula best describes this compound?
a. ZnO
d. Zn_2O_2

b. Zn_2O
c. ZnO_2
e. Zn_2O_3

ANS: A DIF: Medium REF: 2.6
OBJ: Determine charge from the position of the element in the periodic table
MSC: Applying

50. What is the charge on the thallium ion in Tl_2O_3?
a. +1
b. +2
c. +3
d. –3
e. –1

ANS: C DIF: Medium REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Applying

51. What is the charge on the manganese ion in MnS_2?
a. +4
b. +2
c. +1
d. –1
e. –2

ANS: A DIF: Medium REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Applying

52. What is the charge on the iron ion in $FeCl_3$?
a. –3
b. +3
c. –1
d. +1
e. 0

ANS: B DIF: Medium REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Applying

53. In what ratio will alkaline earth metals pair with halogens when they form ionic compounds?
a. 3:1
b. 2:1
c. 1:1
d. 1:2
e. 1:3

ANS: D DIF: Medium REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Applying

54. Active metals often react with oxygen in air to form a protective surface film that prevents further reaction. Which one of the following formulas for a metal-oxygen combination is NOT correct?
a. Al_2O_3
b. Fe_2O_3
c. Na_2O
d. MgO_2
e. MnO

ANS: D DIF: Medium REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Applying

55. What ion would you predict element 118 would form?
a. +2
b. +1
d. –2
e. 0 (unlikely to form an ion)

c. –1

ANS: E DIF: Medium REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Analyzing

56. You synthesize a superheavy atom that fits into the periodic table below radium. If it were to form an ion, what ionic charge would you predict?
a. +2
b. +1
c. –1
d. –2
e. 0 (unlikely to form an ion)

ANS: A DIF: Difficult REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Creating

57. Which of the following is an alkali metal?
a. K
b. Mg
c. Al
d. Cu
e. Ca

ANS: A DIF: Easy REF: 2.3
OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
MSC: Remembering

58. Elements 21 through 30 are known as _____
a. alkaline earths.
b. chalcogens.
c. halides.
d. transition metals.
e. rare earths.

ANS: D DIF: Easy REF: 2.3
OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
MSC: Remembering

59. Calcium is an example of _____
a. an alkali metal.
b. a transition metal.
c. an alkaline earth metal.
d. a halogen.
e. a chalcogen.

ANS: C DIF: Easy REF: 2.3
OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
MSC: Remembering

60. Elements in group 17 (VIIA) are called _____
a. alkali metals.
b. pnictogens.
c. alkaline earth metal.
d. halogens.
e. chalcogens.

ANS: D DIF: Easy REF: 2.4
OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
MSC: Remembering

61. Elements in group 18 (VIIIA) are called _____
    a. alkali metals.
    b. noble gases.
    c. alkaline earth metals.
    d. halogens.
    e. chalcogens.

    ANS: B DIF: Easy REF: 2.3
    OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
    MSC: Remembering

62. Silicon is best described as a _____
    a. metalloid.
    b. metal.
    c. transition metal.
    d. noble gas.
    e. nonmetal.

    ANS: A DIF: Easy REF: 2.3
    OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
    MSC: Remembering

63. Sodium is best described as a _____
    a. metalloid.
    b. metal.
    c. transition metal.
    d. noble gas.
    e. nonmetal.

    ANS: B DIF: Easy REF: 2.3
    OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
    MSC: Remembering

64. Cobalt is best described as a _____
    a. metalloid.
    b. transition metal.
    c. chalcogen.
    d. noble gas.
    e. nonmetal.

    ANS: B DIF: Easy REF: 2.3
    OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
    MSC: Remembering

65. Oxygen is best described as a _____
    a. metalloid.
    b. metal.
    c. transition metal.
    d. noble gas.
    e. nonmetal.

    ANS: E DIF: Easy REF: 2.3
    OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
    MSC: Remembering

66. What is the name of the metalloid in period four that is in the same family as nitrogen?
    a. bismuth
    b. antimony
    c. arsenic
    d. carbon
    e. selenium

    ANS: C DIF: Medium REF: 2.3

OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
MSC: Analyzing

67. What is the name of the halogen in period five?
    a. selenium
    b. tellurium
    c. bromine
    d. iodine
    e. antimony

    ANS: D DIF: Easy REF: 2.3
    OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
    MSC: Remembering

68. Which halogen is radioactive?
    a. astatine
    b. polonium
    c. iodine
    d. tellurium
    e. bismuth

    ANS: A DIF: Easy REF: 2.3
    OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
    MSC: Remembering

69. Which characteristic would you expect indium NOT to exhibit?
    a. shiny luster
    b. electrically insulating
    c. malleable
    d. a +3 ionic charge
    e. solid at room temperature

    ANS: B DIF: Easy REF: 2.3
    OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
    MSC: Remembering

70. You create a superheavy atom with an atomic number of 120. To which category does it belong?
    a. halogens
    b. actinides
    c. transition metals
    d. alkali metals
    e. alkaline earth metals

    ANS: E DIF: Medium REF: 2.3
    OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
    MSC: Analyzing

71. You create a superheavy atom with an atomic number of 120. What is probably true about that element?
    a. It is probably a gas.
    b. It is probably a metalloid.
    c. It is probably nonmetallic.
    d. It is probably metallic.
    e. It probably forms a stable +1 cation.

    ANS: D DIF: Medium REF: 2.3
    OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
    MSC: Analyzing

72. One isotope makes up 97% of all calcium atoms. Which one?
a. ^{40}Ca
b. ^{42}Ca
c. ^{43}Ca
d. ^{44}Ca
e. ^{48}Ca

ANS: A DIF: Easy REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Understanding

73. For each of the elements below, there are only two naturally occurring isotopes. Using the atomic masses on the periodic table, identify the pair in which the heavier isotope is the more abundant one.
a. ^{63}Cu and ^{65}Cu
b. ^{85}Rb and ^{87}Rb
c. ^{10}B and ^{11}B
d. ^{79}Br and ^{81}Br
e. ^{14}N and ^{15}N

ANS: C DIF: Medium REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Analyzing

74. For each of the elements below, there are only two naturally occurring isotopes. Using the atomic masses on the periodic table, identify the pair in which the lighter isotope is the more abundant one.
a. ^{6}Li and ^{7}Li
b. ^{79}Br and ^{81}Br
c. ^{10}B and ^{11}B
d. ^{121}Sb and ^{123}Sb
e. ^{50}V and ^{51}V

ANS: B DIF: Medium REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Analyzing

75. Gallium has two naturally occurring isotopes with the following masses and natural abundances. Calculate the average atomic mass of Ga.

^{69}Ga 68.9256 amu 60.108%

^{71}Ga 70.9247 amu 39.892%

a. 69.925 amu
b. 70.127 amu
c. 70.000 amu
d. 69.824 amu
e. 69.723 amu

ANS: E DIF: Medium REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Analyzing

76. Rubidium has two naturally occurring isotopes, ^{85}Rb (84.912 amu) and ^{87}Rb (86.909 amu). Rubidium-85 is the more abundant isotope (72.17%). Calculate the average atomic mass of Rb.
a. 86.91 amu
b. 85.47 amu
c. 85.91 amu
d. 86.35 amu
e. 86.00 amu

ANS: B DIF: Medium REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Analyzing

77. The average atomic mass of lithium is 6.941 amu. Lithium has two naturally occurring isotopes, ^{6}Li (7.52%) and ^{7}Li (92.48%). The mass of ^{6}Li is 6.0151 amu. What is the isotopic mass of ^{7}Li?
a. 7.016 amu
b. 0.926 amu
d. 7.000 amu
e. 6.941 amu

c. 6.001 amu

ANS: A DIF: Difficult REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Evaluating

78. The average atomic mass of silver is 107.868 amu. Silver has two naturally occurring isotopes, ^{107}Ag (106.905 amu, 51.839%) and ^{109}Ag. What is the isotopic mass of ^{109}Ag?
a. 109.11 amu
b. 108.89 amu
c. 108.52 amu
d. 108.91 amu
e. 108.48 amu

ANS: D DIF: Difficult REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Evaluating

79. The average atomic mass of nickel is 58.693 amu. Given the data in the following table, what is the natural abundance of nickel-64?

Isotope	***Mass (amu)***	***Natural Abundance (%)***
^{58}Ni	57.935	68.0769
^{60}Ni	59.931	26.2231
^{61}Ni	60.931	1.1399
^{62}Ni	61.928	3.6345
^{64}Ni	63.928	?

a. 92.56%
b. 9.256%
c. 7.440%
d. 0.9256%
e. 0.7440%

ANS: D DIF: Medium REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Analyzing

80. Identify the element based on the following values for its three isotopes: 38.9637 amu (93.08%), 39.9640 amu (0.012%), and 40.9618 amu (6.91%).
a. K
b. Cl
c. S
d. Ar
e. Ca

ANS: A DIF: Difficult REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Evaluating

81. Identify the element based on the following values for its five isotopes: 179.947 amu (0.12%), 181.948 amu (26.50%), 182.950 amu (14.31%), 183.951 amu (30.64%), and 185.954 amu (28.43%).
a. Ir
b. Os
c. Re
d. Ta
e. W

ANS: E DIF: Medium REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Applying

82. Iron has four naturally occurring isotopes, one of which is far more abundant that the others. Iron has an average atomic mass of 55.845 amu. Which isotope is most abundant?
a. ^{54}Fe, 53.9396 amu
b. ^{56}Fe, 55.9349 amu
c. ^{57}Fe, 56.9354 amu
d. ^{58}Fe, 57.9333 amu
e. ^{70}Zn, 69.9253 amu

ANS: B DIF: Difficult REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Evaluating

83. Highly enriched weapons-grade uranium might consist of exactly 90% U-235 (235.044 amu), with the remainder being U-238 (238.051 amu). What is the average atomic mass of this sample of highly enriched uranium? Assume the percentages are exact.
a. 238.051 amu
b. 236.547 amu
c. 235.754 amu
d. 235.645 amu
e. 235.345 amu

ANS: E DIF: Difficult REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Evaluating

84. Weapons-grade plutonium consists of 93% Pu-239 (239.0522 amu), with the remainder being Pu-40 (240.0538 amu). What is the average atomic mass of this sample of weapons-grade plutonium? Assume the percentages are exact.
a. 239.5530 amu
b. 239.1223 amu
c. 239.0522 amu
d. 239.9478 amu
e. 239.9822 amu

ANS: B DIF: Difficult REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Evaluating

85. You synthesize a sample of a superheavy element with an atomic number of 180. In a mass spectrometer, you find two peaks at 5.08113×10^{-25} kg and 5.11434×10^{-25} kg, with the former appearing to be about 2.500 times larger than the latter. What is the approximate average atomic mass of this element in amu?
(1 amu = 1.6605×10^{-27} kg)
a. 475.0 amu
b. 306.8 amu
c. 306.6 amu
d. 430.4 amu
e. 1073 amu

ANS: C DIF: Difficult REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Creating

86. What is the molecular mass of phosphorus pentachloride (PCl_5)?
a. 177.3 amu
b. 190.3 amu
c. 208.2 amu
d. 172.8 amu
e. 202.8 amu

ANS: C DIF: Easy REF: 2.4
OBJ: Compute the molecular mass from a formula MSC: Remembering

87. What is the molecular mass of sulfuric acid (H_2SO_4)?
a. 49.0 amu
d. 98.1 amu

b. 24.5 amu
c. 101 amu
e. 97.0 amu

ANS: D DIF: Easy REF: 2.4
OBJ: Compute the molecular mass from a formula MSC: Remembering

88. What is the formula unit mass of chromium(III) oxide (Cr_2O_3)?
a. 152.0 amu
b. 136.0 amu
c. 120.0 amu
d. 104.0 amu
e. 68.0 amu

ANS: A DIF: Easy REF: 2.4
OBJ: Compute the molecular mass from a formula MSC: Remembering

89. Which has the highest molecular mass?
a. Br_2O
b. IBr_2
c. CBr_4
d. Br_2O_8
e. BrF_5

ANS: C DIF: Medium REF: 2.4
OBJ: Compute the molecular mass from a formula MSC: Analyzing

90. Which has the highest formula unit mass?
a. $CaBr_2$
b. NaI_2
c. CdF_2
d. $HgCl_2$
e. Ag_2S

ANS: B DIF: Medium REF: 2.4
OBJ: Compute the molecular mass from a formula MSC: Analyzing

91. Which of the following compounds contains the most nitrogen atoms?
a. N_2H_4
b. NH_4NO_3
c. NaN_3
d. $(NH_4)_2SO_4$
e. $C_8H_{12}N_4O_3$

ANS: E DIF: Medium REF: 2.4
OBJ: Compute the molecular mass from a formula MSC: Analyzing

92. How many $CaCl_2$ formula units are in 125 amu of calcium chloride?
a. 0.888 formula units
b. 1.00 formula units
c. 1.13 formula units
d. 1.25 formula units
e. 3.75 formula units

ANS: C DIF: Medium REF: 2.4
OBJ: Compute the molecular mass from a formula MSC: Applying

93. How many hydrogen atoms are in 51 amu of pure ammonia (NH_3)?
a. 3 H atoms
b. 9 H atoms
c. 17 H atoms
d. 50 H atoms
e. 150 H atoms

ANS: B DIF: Difficult REF: 2.4
OBJ: Compute the molecular mass from a formula MSC: Evaluating

94. Which contains the most bromine by mass?
a. Br_2O
d. Br_2O_8

b. $CsBr$
c. CBr_4
e. $PtBr_2$

ANS: C DIF: Difficult REF: 2.4
OBJ: Compute the molecular mass from a formula MSC: Evaluating

95. Iron can form two ionic compounds with sulfur, one containing Fe^{2+} and the other containing Fe^{3+}. What is the difference in their formula unit masses?
a. 143.76 amu
b. 119.97 amu
c. 87.91 amu
d. 55.85 amu
e. 32.06 amu

ANS: B DIF: Difficult REF: 2.4
OBJ: Compute the molecular mass from a formula MSC: Evaluating

96. What is the mass of one oxygen molecule, O_2, in grams? Round your answer to two significant figures.
a. 16 g
b. 5.2×10^{-26} g
c. 1.9×10^{23} g
d. 2.7×10^{-24} g
e. 5.3×10^{-24} g

ANS: E DIF: Easy REF: 2.5
OBJ: Calculate mass of an atom in grams from atomic mass units (amu)
MSC: Understanding

97. Which statement is true about the mole and molar mass?
a. A mole is a number of particles equal to the number of atoms in exactly 12 grams of carbon-12.
b. A mole is a number of particles equal to the number of atoms in exactly 12 grams of naturally occurring carbon.
c. A mole is a number of particles equal to the number of atoms in exactly 16 grams of oxygen-16.
d. Molecular mass in amu and molar mass in grams per mole are independent of each other.
e. The mole requires that the numbers of atoms in equal masses of different substances are equal.

ANS: A DIF: Easy REF: 2.5 OBJ: Define a mole
MSC: Remembering

98. Calculate the number of molecules in 0.25 moles of strychnine, $C_{21}H_{22}N_2O_2$.
a. 8.4×10^{24} molecules
b. 8.4×10^{23} molecules
c. 2.1×10^{23} molecules
d. 1.5×10^{23} molecules
e. 1.5×10^{24} molecules

ANS: D DIF: Easy REF: 2.5
OBJ: Convert between moles and numbers of atoms/molecules MSC: Understanding

99. Calculate the number of hydrogen atoms in 0.25 moles of strychnine, $C_{21}H_{22}N_2O_2$.
a. 5.5×10^{24} atoms
b. 3.3×10^{24} atoms
c. 2.5×10^{24} atoms
d. 1.5×10^{24} atoms
e. 5.0×10^{25} molecules

ANS: B DIF: Medium REF: 2.5
OBJ: Convert between moles and numbers of atoms/molecules MSC: Understanding

100. Suppose you were given one gold atom every second since the Big Bang occurred about 14 billion years ago (1.4×10^{10} years). How many moles of gold atoms would you have?

a. 4.4×10^{17} moles
b. 4.4×10^{-17} moles
c. 1.4×10^{-8} moles
d. 2.3×10^{-7} moles
e. 7.3×10^{-7} moles

ANS: E DIF: Difficult REF: 2.5
OBJ: Convert between moles and numbers of atoms/molecules MSC: Evaluating

101. Cyanidin chloride ($C_{15}H_{11}O_6Cl$, 322.7 g/mol) contains the cyanidin ion, a pigment found in many berries. Calculate the number of moles of cyanidin chloride equivalent to 7.2 mg.
a. 2.2×10^{1} mol
b. 3.2×10^{-2} mol
c. 2.2×10^{-2} mol
d. 2.2×10^{-5} mol
e. 7.2×10^{-5} mol

ANS: D DIF: Easy REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Understanding

102. A 1.5 g tablet for pain might contain 0.30 g acetaminophen ($C_8H_9NO_2$, 151.16 g/mol) and 0.044 g codeine ($C_{18}H_{21}NO_3$, 299.36 g/mol). Calculate the number of moles of codeine in the tablet.
a. 1.5×10^{-4} mol
b. 2.9×10^{-4} mol
c. 1.0×10^{-3} mol
d. 5.0×10^{-3} mol
e. 1.1×10^{-1} mol

ANS: A DIF: Easy REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Understanding

103. Antirrhinin chloride ($C_{27}H_{11}O_6Cl$, 630.97 g/mol) contains the antirrhinin ion, a pigment found in açai berries. Calculate the number of moles of carbon in 0.75 g of antirrhinin chloride.
a. 1.2×10^{-3} mol
b. 3.2×10^{-2} mol
c. 4.3×10^{-2} mol
d. 1.6×10^{-3} mol
e. 4.4×10^{-5} mol

ANS: B DIF: Medium REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Analyzing

104. TNT, or trinitrotoluene, has the chemical formula $C_7H_5N_3O_6$. How many grams of nitrogen are present in 25 grams TNT (227.13 g/mol)?
a. 0.11 g
b. 0.33 g
c. 1.5 g
d. 4.6 g
e. 5.4 g

ANS: D DIF: Medium REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Analyzing

105. Calculate the number of americium-241 atoms present in a smoke alarm containing 0.30 μg of radioactive ^{241}Am (241.06 g/mol).
a. 7.5×10^{14} atoms
b. 1.8×10^{17} atoms
c. 2.5×10^{21} atoms
d. 6.0×10^{23} atoms
e. 1.4×10^{5} atoms

ANS: A DIF: Medium REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Applying

106. Gold prices in early 2013 were approximately $51 per gram. Given that the mass of a gold atom is approximately 3.27×10^{-22} grams, how many gold atoms could you buy with a quarter ($0.25)?
a. 7.6×10^{20} atoms
b. 1.5×10^{19} atoms
c. 6.5×10^{19} atoms
d. 1.2×10^{22} atoms
e. 1.1×10^{23} atoms

ANS: B DIF: Difficult REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Evaluating

107. In early 2013, platinum (195.078 g/mol) was selling for about $1575 per troy ounce (one troy ounce is equal to 31.10 g). How many platinum atoms could you buy for $20.00?
a. 1.219×10^{21} atoms
b. 7.817×10^{21} atoms
c. 7.587×10^{21} atoms
d. 2.360×10^{23} atoms
e. 2.431×10^{23} atoms

ANS: A DIF: Difficult REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Evaluating

108. In the presence of cyanuric acid ($C_3H_3N_3O_3$), melamine ($C_3H_6N_6$) can form crystals that potentially cause renal failure if ingested. Which contains the most nitrogen?
a. 1.22×10^{24} $C_3H_6N_6$ molecules
b. 2.78 mol $C_3H_6N_6$
c. 6.54×10^{24} $C_3H_3N_3O_3$ molecules
d. 10.3 mol $C_3H_3N_3O_3$
e. 2.56 mol $C_3H_6N_6$ + 2.56 mol $C_3H_3N_3O_3$

ANS: C DIF: Difficult REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Evaluating

109. TNT, or trinitrotoluene, has the chemical formula $C_7H_5N_3O_6$ (227.13 g/mol). Which of the following amounts of TNT contains the most nitrogen?
a. 1.22×10^{24} molecules
b. 278 g
c. 1.33 mol
d. the number of moles of TNT containing 9 moles of O
e. the number of moles of TNT containing 8 moles of C

ANS: A DIF: Difficult REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Evaluating

110. TNT ($C_7H_5N_3O_6$, 227.13 g/mol) and RDX ($C_3H_6N_6O_6$, 222.12 g/mol) are explosive materials. Which of the following contains the most nitrogen?
a. 3.45×10^{23} molecules RDX
b. 145 g TNT
c. 95.4 g RDX
d. 4.25×10^{23} molecules TNT
e. 0.875 mol RDX

ANS: E DIF: Difficult REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Evaluating

111. How many grams of P_4 (123.88 g/mol) would contain the same number of atoms as 154 g S_8 (256.48 g/mol)?

a. 18.6 g P_4
b. 40.2 g P_4
c. 124 g P_4
d. 149 g P_4
e. 596 g P_4

ANS: D DIF: Difficult REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Evaluating

112. Silicon brass contains 82.0% Cu, 14.0% Zn, and 4.00% Si by mass, and its density is 8.28 g/cm^3. How many moles of silicon are present in 22.0 cm^3 of silicon brass?
a. 6.48 mol Si
b. 5.32 mol Si
c. 0.908 mol Si
d. 0.260 mol Si
e. 0.0946 mol Si

ANS: B DIF: Difficult REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Evaluating

113. Two inorganic blue pigments are Han blue ($BaCuSi_4O_{10}$) and Egyptian blue ($CaCuSi_4O_{10}$). Which has a higher molar mass and by how much?
a. Egyptian blue by 137.3 g/mol
b. Egyptian blue by 40.08 g/mol
c. Han blue by 97.22 g/mol
d. Han blue by 137.3 g/mol
e. Han blue by 177.4 g/mol

ANS: C DIF: Easy REF: 2.5
OBJ: Determine the molar mass/formula mass of a substance using the periodic table
MSC: Understanding

114. Which of the following is a high-energy particle with a negative charge?
a. α
b. β
c. γ
d. neutron
e. positron

ANS: B DIF: Easy REF: 2.6
OBJ: Describe the nucleosynthesis of the elements up to uranium after the Big Bang
MSC: Remembering

115. In the early stages of primordial nucleosynthesis, a nuclear reaction involving one proton and one neutron formed which of the following?
a. $^{2}_{1}\mathrm{D}$
b. $^{1}_{1}\mathrm{H}$
c. $^{4}_{2}\mathrm{He}$
d. $^{0}_{-1}\mathrm{e}$
e. $^{0}_{-1}\mathrm{e} + \gamma$

ANS: A DIF: Easy REF: 2.6
OBJ: Describe the nucleosynthesis of the elements up to uranium after the Big Bang
MSC: Understanding

116. Extremely high temperatures were required to initiate nuclear fusion, but, once started, large amounts of energy were released while fusion reactions of lighter nuclei formed isotopes up to ^{56}Fe. This is analogous to _____
a. boiling a liquid by heating it.
b. melting a solid by heating it.
c. lighting a match to start a fire.
d. two magnets attracting each other.
e. lifting a mass against gravity.

ANS: C DIF: Easy REF: 2.7
OBJ: Describe the nucleosynthesis of the elements up to uranium after the Big Bang

MSC: Understanding

117. According to the Big Bang theory, which statement about the origin of the elements is NOT correct?
a. Initially, energy was transformed into electrons and other elementary particles.
b. As the universe cooled, neutrons and protons were formed.
c. Collisions of neutrons and protons produced deuterons, which then led to the formation of alpha particles.
d. Nuclear fusion reactions in the interior of stars formed elements up to ^{56}Fe.
e. All nuclear reactions forming the elements required an input of energy.

ANS: E DIF: Medium REF: 2.6
OBJ: Describe the nucleosynthesis of the elements up to uranium after the Big Bang
MSC: Analyzing

118. Which statement is NOT correct regarding primordial nucleosynthesis?
a. Colliding pairs of electrons annihilated each other to form two gamma rays.
b. Deuterons fused together, forming alpha particles.
c. More stable nuclides were formed from less stable nuclides.
d. Gamma rays were produced.
e. Neutrons and protons fused together, forming deuterons.

ANS: A DIF: Medium REF: 2.6
OBJ: Describe the nucleosynthesis of the elements up to uranium after the Big Bang
MSC: Analyzing

119. Which nuclear reaction is NOT correctly written?
a. $^{209}_{83}Bi + {}^{1}_{0}n \rightarrow {}^{210}_{82}Pb$
b. $^{12}_{6}C + {}^{1}_{1}H \rightarrow {}^{13}_{7}N$
c. $^{12}_{6}C + {}^{4}_{2}\alpha \rightarrow {}^{16}_{8}O$
d. $^{15}_{7}N + {}^{1}_{1}H \rightarrow {}^{12}_{6}C + {}^{4}_{2}\alpha$
e. $^{206}_{82}Pb + 3\,{}^{1}_{0}n \rightarrow {}^{209}_{82}Pb$

ANS: A DIF: Medium REF: 2.7
OBJ: Write and balance nuclear reactions MSC: Analyzing

120. Which reactant and product would balance the following nuclear reaction equation?

reactant + $^{12}C \rightarrow {}^{11}B$ + product

a. reactant = β^-, product = ^1H
b. reactant = β^-, product = ^1p
c. reactant = β^-, product = ^1n
d. reactant = β^-, product = α
e. reactant = ^1H, product = α

ANS: C DIF: Difficult REF: 2.7
OBJ: Write and balance nuclear reactions MSC: Evaluating

121. The peak in nuclear binding energy/nucleon occurs at an isotope of _____
a. helium.
b. iron.
c. uranium.
d. carbon.
e. lead.

ANS: B DIF: Easy REF: 2.7
OBJ: Use the mass defect to calculate the binding energy of a nucleus and the binding energy per nucleon MSC: Remembering

122. Calculate the nuclear binding energy of the ^{56}Fe nucleus given the following data:

^{56}Fe nuclear mass	55.920679 amu	9.285846×10^{-26} kg
Proton mass	1.00727646 amu	1.672622×10^{-27} kg
Neutron mass	1.00866492 amu	1.674927×10^{-27} kg

Speed of light 2.998×10^8 m/s

a. 8.346×10^{-9} J
b. 4.417×10^{-9} J
c. 4.370×10^{-9} J
d. 7.804×10^{-11} J
e. 7.887×10^{-11} J

ANS: E DIF: Difficult REF: 2.6
OBJ: Use the mass defect to calculate the binding energy of a nucleus and the binding energy per nucleon MSC: Evaluating

123. Which of the following statements regarding the mass defect and nuclear binding energy is false?
a. The mass of the nucleus is slightly less than the combined mass of its separate constituent nucleons.
b. Separated protons and neutrons are more stable than when they are in the nucleus.
c. Mass is converted to energy when separated nucleons combine to form a nucleus.
d. The binding energy reflects the amount of energy that would be required to break up the nucleus.
e. $E = mc^2$ allows binding energies to be calculated.

ANS: B DIF: Medium REF: 2.7
OBJ: Use the mass defect to calculate the binding energy of a nucleus and the binding energy per nucleon MSC: Analyzing

124. Which statement regarding the strong nuclear force is false?
a. The strong nuclear force prevents radioactive decay from occurring.
b. The strong nuclear force is about 100 times stronger than the repulsive force between protons.
c. Nuclear stability depends on the competition between the strong nuclear force and electrostatic repulsions.
d. The strong nuclear force acts only over very short distances.
e. The strong nuclear force binds nucleons together and stabilizes the nucleus.

ANS: A DIF: Easy REF: 2.7
OBJ: Describe the strong nuclear force MSC: Understanding

125. A supernova event is the explosion caused by the collapse of a dying star that has run out of its nuclear fuel. These stars and events are responsible for _____
a. the production of elements heavier than iron-56.
b. nuclear fission of heavy elements.
c. the distribution of heavy elements throughout the universe.
d. both a and c.
e. both b and c.

ANS: D DIF: Medium REF: 2.7
OBJ: Describe the role supernovas have in nucleosynthesis MSC: Applying

126. Elements higher than uranium in the periodic table must be synthesized. Identify the nuclear synthesis reaction that is NOT correctly written.
a. $^{244}_{94}\mathrm{Pu} + {}^{48}_{20}\mathrm{Ca} \rightarrow {}^{289}_{114}\mathrm{Fl} + 3\,{}^{1}_{0}\mathrm{n}$
b. $^{249}_{98}\mathrm{Cf} + {}^{14}_{7}\mathrm{N} \rightarrow {}^{260}_{105}\mathrm{Db} + 4\,{}^{1}_{0}\mathrm{n}$
c. $^{209}_{83}\mathrm{Bi} + {}^{54}_{24}\mathrm{Cr} \rightarrow {}^{262}_{107}\mathrm{Bh} + {}^{1}_{0}\mathrm{n}$
d. $^{238}_{92}\mathrm{U} + {}^{48}_{20}\mathrm{Ca} \rightarrow {}^{282}_{112}\mathrm{Cn} + 4\,{}^{1}_{0}\mathrm{n}$
e. $^{248}_{96}\mathrm{Cm} + {}^{48}_{20}\mathrm{Ca} \rightarrow {}^{293}_{116}\mathrm{Cn} + 3\,{}^{1}_{0}\mathrm{n}$

ANS: B DIF: Medium REF: 2.7
OBJ: Describe how elements heavier than uranium are synthesized
MSC: Analyzing

127. Which of the following would correctly complete this fusion reaction: ${}_1^2\mathrm{H} + {}_2^3\mathrm{He} \rightarrow \_\_\_\_\_ + {}_1^1\mathrm{H}$?

a. ${}_0^1\mathrm{n}$
b. ${}_3^4\mathrm{Li}$
c. $4\,{}_{-1}^{0}\beta$
d. ${}_2^4\mathrm{He}$
e. ${}_1^3\mathrm{H}$

ANS: D DIF: Medium REF: 2.7
OBJ: Balance nuclear fusion reactions MSC: Analyzing

SHORT ANSWER

1. Uranium ores sometimes contain pockets of trapped helium. What is the origin of the helium?

ANS:
Alpha decay.

DIF: Easy REF: 2.1 OBJ: Define and describe types of radioactivity
MSC: Remembering

2. In one sentence, describe the picture of the atom that emerged from the Geiger–Marsden experiment.

ANS:
The atom was pictured as consisting of a tiny, positively charged nucleus surrounded by a diffuse cloud of negatively charged electrons.

DIF: Easy REF: 2.1
OBJ: Describe Rutherford's experiment that discovered the atomic nucleus and the subsequent view of atomic structure MSC: Remembering

3. ^{1}H, ^{2}H, and ^{3}H are examples of _____ because they have different numbers of _____.

ANS:
isotopes/neutrons

DIF: Easy REF: 2.2 OBJ: Define isotope, atomic number, mass number
MSC: Remembering

4. Give the number of protons, neutrons, and electrons in the following atoms or ions: ^{56}Fe, $^{32}S^{2-}$, $^{133}Cs^{+}$, $^{89}Y^{3+}$, $^{31}P^{3-}$.

ANS:
26, 30, 26
16, 16, 18
55, 78, 54
39, 50, 36
15, 16, 18

DIF: Easy REF: 2.2
OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
MSC: Remembering

5. Write the complete atomic symbol with both a superscript and a subscript for the atom or ion that contains 11 protons, 10 electrons, and 12 neutrons.

   ANS:
   $^{23}_{11}Na^{+}$

   DIF: Easy REF: 2.2
   OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
   MSC: Understanding

6. Write the complete atomic symbol with both a superscript and a subscript for the atom or ion that contains the same number of protons as the number of neutrons in ^{56}Fe, has a +2 charge, and has a mass number that equals the atomic number of terbium, Tb.

   ANS:
   $^{65}_{30}Zn^{2+}$

   DIF: Medium REF: 2.2
   OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
   MSC: Analyzing

7. Write the complete atomic symbol with both a superscript and a subscript for the atom or ion that contains the same number of electrons as argon, has a –2 charge, and contains equal numbers of protons and neutrons.

   ANS:
   $^{32}_{16}S^{2-}$

   DIF: Medium REF: 2.2
   OBJ: Interpret and write symbols for nuclides, identify nuclides from mass numbers and atomic numbers, and determine their charges from the number of electrons
   MSC: Analyzing

8. A cation has a _____ charge because it has _____ electrons.

   ANS:
   positive/lost

   DIF: Easy REF: 2.3
   OBJ: Determine charge from the position of the element in the periodic table
   MSC: Understanding

9. An anion has a _____ charge because it has _____ electrons.

   ANS:
   negative/gained

   DIF: Easy REF: 2.3
   OBJ: Determine charge from the position of the element in the periodic table
   MSC: Understanding

10. What is the charge on an alkali metal atom when it is in an ionic compound?

ANS:
+1

DIF: Easy REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Remembering

11. What is the charge on the phosphorus atom when it forms an ionic compound with magnesium?

ANS:
–3

DIF: Easy REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Remembering

12. What is the charge on the copper ion in $CuCl_2$?

ANS:
+2

DIF: Medium REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Analyzing

13. How many nitrogen atoms would be required to form an ionic compound with barium?

ANS:
2

DIF: Medium REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Analyzing

14. How many oxygen atoms would be required to form an ionic compound with aluminum?

ANS:
3

DIF: Medium REF: 2.3
OBJ: Determine charge from the position of the element in the periodic table
MSC: Analyzing

15. Give an example of an alkali metal.

ANS:
lithium, sodium, potassium, rubidium, cesium, francium; answers will vary.

DIF: Easy REF: 2.3
OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
MSC: Remembering

16. Give an example of an alkaline earth metal.

ANS:
beryllium, magnesium, calcium, strontium, barium, radium; answers will vary.

DIF: Easy REF: 2.3
OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
MSC: Remembering

17. Give an example of a halogen.

ANS:
fluorine, chlorine, bromine, iodine, astatine; answers will vary.

DIF: Easy REF: 2.3
OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
MSC: Remembering

18. Give an example of a period 4 transition metal.

ANS:
scandium, titanium, vanadium, chromium, manganese, iron, cobalt, nickel, copper, zinc; answers will vary.

DIF: Easy REF: 2.3
OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
MSC: Remembering

19. Give an example of a nonmetal.

ANS:
carbon, nitrogen, oxygen, fluorine, sulfur, etc.; answers will vary.

DIF: Easy REF: 2.3
OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
MSC: Remembering

20. Give an example of a metalloid (also known as a semimetal).

ANS:
boron, silicon, germanium, arsenic, antimony, tellurium; answers will vary.

DIF: Easy REF: 2.3
OBJ: Identify on the periodic table: groups, periods, metals, metalloids, nonmetals, representative elements, transition metals, alkali metals, alkaline earth metals, halogens, noble gases
MSC: Remembering

21. What is the average atomic mass of a sample of highly enriched uranium uranium that contains exactly 20% uranium-235 (235.04 amu) and 80% uranium-238 (238.05 amu)?

ANS:
237.45 amu

$(0.20)(235.04) + (0.80)(238.050) = 237.45 \text{ amu}$

DIF: Difficult REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Evaluating

22. Boron, which has an average atomic mass of 10.81 amu, has two stable isotopes: boron-10 and boron-11. Boron-10 has an atomic mass of 10.0129 amu and a natural abundance of 19.78%. What is the atomic mass of boron-11?

ANS:
11.01 amu

$(0.1978)(10.0129) + (0.8022)(x) = 10.81 \text{ amu}$

DIF: Difficult REF: 2.4
OBJ: Compute the average atomic masses using natural abundances of isotopes for an element
MSC: Evaluating

23. What is the mass in amu of one molecule of glucose, $C_6H_{12}O_6$?

ANS:
180.16 amu

DIF: Easy REF: 2.5 OBJ: Compute the molecular mass from a formula
MSC: Understanding

24. How many atoms are there in 2.5 moles of water?

ANS:
4.5×10^{24}
$2.5 \times 3 \times 6.02 \times 10^{23} = 4.5 \times 10^{24}$

DIF: Medium REF: 2.5
OBJ: Convert between moles and numbers of atoms/molecules MSC: Applying

25. How many hydrogen atoms are there in 473 g of water (roughly 16 fluid ounces)?

ANS:
3.16×10^{25}
$473 / 18.02 \times 6.02 \times 10^{23} \times 2 = 3.16 \times 10^{25}$

DIF: Medium REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Applying

26. Using a scanning tunneling microscope, Don Eigler at IBM arranged 99 iron atoms on a copper surface to form the Kanji characters for "atom." What is the total mass of iron present in grams and in atomic mass units? Assume that the Fe atoms are "average" in terms of their mass.

ANS:

9.182×10^{-21} g; 5529 amu

DIF: Medium REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Analyzing

27. Fill in the following table.

Substance	Mass (g)	Moles (mol)	#molecules	#atoms
NO	64.0			
NO_2		0.786		
N_2O			7.52×10^{21}	
N_2O_4				1.48×10^{26}

ANS:

Substance	Mass (g)	Moles (mol)	#molecules	#atoms
NO	64.0	2.13	1.28×10^{24}	2.56×10^{24}
NO_2	36.2	0.786	4.73×10^{23}	1.42×10^{24}
N_2O	0.550	0.0125	7.52×10^{21}	2.26×10^{22}
N_2O_4	3770	41.0	2.47×10^{25}	1.48×10^{26}

DIF: Difficult REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Evaluating

28. Hydrogen sulfide (H_2S) is a highly toxic gas that smells like rotten eggs. Suppose the odor detection limit is approximately 4.7×10^{-7} g H_2S per one gram of air. At this level, how many moles of H_2S are present in
1.0 L air? How many H_2S molecules? Assume the density of air is 0.0013 g/mL.

ANS:
1.8×10^{-8} moles; 1.1×10^{16} molecules.

DIF: Difficult REF: 2.5
OBJ: Use molar mass to convert between mass and moles of a substance
MSC: Evaluating

29. Calculate the formula unit mass of sodium phosphate (Na_3PO_4) in which all of the phosphorus is ^{32}P, a radioactive isotope of phosphorus used in medical applications. A ^{32}P atom has an atomic mass of 31.97 amu.

ANS:
164.94 g/mol

$$3(22.99) + 1(31.974) + 4(16.00) = 164.94$$

DIF: Medium REF: 2.5
OBJ: Determine the molar mass/formula mass of a substance using the periodic table
MSC: Analyzing

30. Write nuclear reaction equations to show how helium-4 nuclides are produced from protons in our Sun using the following information: step (1) 2 protons react to form hydrogen-2 and a high-energy electron; step (2) hydrogen-2 reacts with a proton to form helium-3; and step (3) two helium-3 combine to helium-4 and two protons.

ANS:
$^{1}p + {}^{1}p \rightarrow {}^{2}H + e^{-}$
$^{2}H + {}^{1}p \rightarrow {}^{3}He$
$2\ {}^{3}He \rightarrow {}^{4}He + 2\,{}^{1}p$

DIF: Medium REF: 2.6 OBJ: Write and balance nuclear reactions
MSC: Analyzing

31. The carbon-nitrogen-oxygen cycle in stars is one process by which hydrogen is converted to helium. Write the complete nuclear reaction for the reaction of a carbon-12 nucleus with a hydrogen nucleus to form nitrogen. What isotope of nitrogen is produced?

ANS:
$^{12}_{6}C + {}^{1}_{1}H \rightarrow {}^{13}_{7}N$; nitrogen-13.

DIF: Medium REF: 2.6 OBJ: Write and balance nuclear reactions
MSC: Applying

32. Suppose the reaction $^{13}_{6}C + {}^{1}_{1}H \rightarrow {}^{14}_{7}N$ produces 1.21×10^{-12} J of energy (1.21×10^{-12} kg · m^2/s^2). Calculate the change in mass that occurs during the reaction in amu. $E = mc^2$, where $c = 2.998 \times 10^8$ m/s;
1 kg = 6.0221415×10^{26} amu.

ANS:
0.00811 amu

1.21×10^{-12} kg · m^2/s^2 / $(2.998 \times 10^8$ m/s$)^2 \times 6.0221415 \times 10^{26} = 0.00811$ amu

DIF: Difficult REF: 2.6
OBJ: Use the mass defect to calculate the binding energy of a nucleus and the binding energy per nucleon MSC: Evaluating

33. Calculate the binding energy of a helium-4 nucleus in J/mol ^{4}He. 1 amu = 1.6605×10^{-27} kg

helium-4 nucleus	4.00153 amu
proton mass	1.00728 amu
neutron mass	1.00866 amu
speed of light	2.998×10^8 m/s

ANS:
2.728×10^{12} J/mol

DIF: Difficult REF: 2.6
OBJ: Use the mass defect to calculate the binding energy of a nucleus and the binding energy per nucleon MSC: Evaluating

34. Iron-56 has one of the highest binding energies of all nuclides. Calculate its nuclear binding energy in kJ per mol nucleon. 1 amu is equivalent to 1.492×10^{-10} J.

mass of iron-56 nuclide	55.934994 amu (includes electrons)
proton mass	1.00728 amu
neutron mass	1.00866 amu
electron mass	5.4858×10^{-4} amu
speed of light	2.998×10^{8} m/s

ANS:
8.477×10^{8} kJ/mol nucleon

56.44908 – 55.92073 = 0.52835 amu × 1.492×10^{-10} J × 6.022×10^{23} /1000 / 56 = 8.477×10^{8} kJ/mol nucleon

DIF: Difficult REF: 2.6
OBJ: Use the mass defect to calculate the binding energy of a nucleus and the binding energy per nucleon MSC: Evaluating

35. Darmstadtium was first created in 1994 when ^{208}Pb was bombarded with ^{62}Ni to produce ^{269}Ds and one neutron. Write the complete nuclear equation.

ANS:
$^{208}_{82}\text{Pb} + {}^{62}_{28}\text{Ni} \rightarrow {}^{269}_{110}\text{Ds} + {}^{1}_{0}\text{n}$

DIF: Easy REF: 2.7
OBJ: Describe how elements heavier than uranium are synthesized
MSC: Understanding