Chapter 2: Atoms, Molecules, and Ions

1. The scientist who determined the magnitude of the electric charge of the electron was
   A) John Dalton
   B) Robert Millikan
   C) J. J. Thomson
   D) Henry Moseley
   E) J. Burdge
   Ans: B

2. When J. J. Thomson discovered the electron, what physical property of the electron did he measure?
   A) its charge, e
   B) its charge-to-mass ratio, e/m
   C) its temperature, T
   D) its mass, m
   E) its atomic number, Z
   Ans: B

3. What name is given to the concept that different samples of a given compound always contain the same elements in the same mass ratio?
   A) Ration Law
   B) Law of Equality
   C) 1^{st} Law of Thermodynamics
   D) Law of Definite Proportions
   E) 2^{nd} Law of thermodynamics
   Ans: D

4. Which field of study made a big contribution toward understanding the composition of the atom?
   A) Electricity
   B) Radiation
   C) Solution Chemistry
   D) Electrochemistry
   E) Quantum Mechanics
   Ans: B

5. Which of the following is a type of radioactive radiation which has no charge and are unaffected by external electric or magnetic fields?
   A) α rays B) β rays C) γ rays D) δ rays E) ε rays
   Ans: C

6. Which of the following is a type of radioactive radiation that consists of positively charged particles and is deflected away from the positively charged plate?
   A) α rays B) β rays C) γ rays D) δ rays E) ε rays
   Ans: A

7. Which of the following is a type of radioactive radiation that consists of electrons and is deflected away from the negatively charged plate?
   A) α rays B) β rays C) γ rays D) δ rays E) ε rays
   Ans: B

8. Which of these scientists developed the nuclear model of the atom?
   A) John Dalton
   B) Robert Millikan
   C) J. J. Thomson
   D) Henry Moseley
   E) Ernest Rutherford
   Ans: E

9. Rutherford's experiment with alpha particle scattering by gold foil established that
   A) protons are not evenly distributed throughout an atom.
   B) electrons have a negative charge.
   C) electrons have a positive charge.
   D) atoms are made of protons, neutrons, and electrons.
   E) protons are 1840 times heavier than electrons.
   Ans: A

10. J. J. Thomson studied cathode ray particles (electrons) and was able to measure the mass/charge ratio. His results showed that
   A) the mass/charge ratio varied as the cathode material was changed.
   B) the charge was always a whole-number multiple of some minimum charge.
   C) matter included particles much smaller than the atom.
   D) atoms contained dense areas of positive charge.
   E) atoms are largely empty space.
   Ans: B

11. Who is credited with measuring the mass/charge ratio of the electron?
   A) Dalton B) Chadwick C) Thomson D) Millikan E) Rutherford
   Ans: C

12. Who is credited with first measuring the charge of the electron?
   A) Dalton B) Gay-Lussac C) Thomson D) Millikan E) Rutherford
   Ans: D

13. Millikan's oil-drop experiment
   A) established the charge on an electron.
   B) showed that all oil drops carried the same charge.
   C) provided support for the nuclear model of the atom.
   D) suggested that some oil drops carried fractional numbers of electrons.
   E) suggested the presence of a neutral particle in the atom.
   Ans: A

14. Who is credited with discovering the atomic nucleus?
   A) Dalton B) Gay-Lussac C) Thomson D) Chadwick E) Rutherford
   Ans: E

15. Rutherford bombarded gold foil with alpha (α) particles and found that a small percentage of the particles were deflected. Which of the following was not accounted for by the model he proposed for the structure of atoms?
    A) the small size of the nucleus
    B) the charge on the nucleus
    C) the total mass of the atom
    D) the existence of protons
    E) the presence of electrons outside the nucleus
    Ans: C

16. Which one of the following statements about atoms and subatomic particles is correct?
    A) Rutherford discovered the atomic nucleus by bombarding gold foil with electrons.
    B) The proton and the neutron have identical masses.
    C) The neutron's mass is equal to that of a proton plus an electron.
    D) A neutral atom contains equal numbers of protons and electrons.
    E) An atomic nucleus contains equal numbers of protons and neutrons.
    Ans: D

17. Who discovered the subatomic particle having a neutral charge called neutron?
    A) Millikan B) Dalton C) Chadwick D) Rutherford E) Thomson
    Ans: C

18. What term is used to represent the number of protons in the nucleus of each atom of an element and is equal to the number of electrons outside the nucleus?
    A) Isotope number
    B) Mass number
    C) Mass-to-charge ratio
    D) Atomic number
    E) Atomic mass units
    Ans: D

19. What term is used to represent the total number of neutrons and protons in the nucleus of each atom of an element?
    A) Isotope number
    B) Mass number
    C) Mass-to-charge ratio
    D) Atomic number
    E) Atomic mass units
    Ans: B

20. Bromine is the only nonmetal that is a liquid at room temperature. Consider the isotope bromine-81, $^{81}_{35}\mathrm{Br}$. Select the combination which lists the correct atomic number, neutron number, and mass number, respectively.
    A) 35, 46, 81 B) 35, 81, 46 C) 81, 46, 35 D) 46, 81, 35 E) 35, 81, 116
    Ans: A

21. Atoms X, Y, Z, and R have the following nuclear compositions:
$^{410}_{186}X$ $^{410}_{183}Y$ $^{412}_{186}Z$ $^{412}_{185}R$
Which two are isotopes?
A) X & Y B) X & R C) Y & R D) Z & R E) X & Z
Ans: E

22. Atoms of the same element with different mass numbers are called
A) ions. B) neutrons. C) allotropes. D) chemical families. E) isotopes.
Ans: E

23. How many neutrons are there in an atom of lead whose mass number is 208?
A) 82 B) 126 C) 208 D) 290 E) None of the above
Ans: B

24. An atom of the isotope sulfur-31 consists of how many protons, neutrons, and electrons? (p = proton, n = neutron, e = electron)
A) 15 p, 16 n, 15 e
B) 16 p, 15 n, 16 e
C) 16 p, 31 n, 16 e
D) 32 p, 31 n, 32 e
E) 16 p, 16 n, 15 e
Ans: B

25. Give the number of protons (p), electrons (e), and neutrons (n) in one atom of chlorine-37.
A) 37 p, 37 e, 17 n
B) 17 p, 17 e, 37 n
C) 17 p, 17 e, 20 n
D) 37 p, 17 e, 20 n
E) 17 p, 37 e, 17 n
Ans: C

26. Two isotopes of an element differ only in their
A) symbol.
B) atomic number.
C) atomic mass.
D) number of protons.
E) number of electrons.
Ans: C

27. A magnesium ion, Mg^{2+}, has
A) 12 protons and 13 electrons.
B) 24 protons and 26 electrons.
C) 12 protons and 10 electrons.
D) 24 protons and 22 electrons.
E) 12 protons and 14 electrons.
Ans: C

28. An aluminum ion, Al^{3+}, has:
A) 13 protons and 13 electrons
B) 27 protons and 24 electrons
C) 16 protons and 13 electrons
D) 13 protons and 10 electrons
E) 10 protons and 13 electrons
Ans: D

29. An oxide ion, O^{2-}, has:
    A) 8 protons and 10 electrons
    B) 10 protons and 8 electrons
    C) 8 protons and 9 electrons
    D) 8 protons and 7 electrons
    E) 10 protons and 7 electrons
    Ans: A

30. A sulfide ion, S^{2-}, has:
    A) 16 protons and 16 electrons
    B) 32 protons and 16 electrons
    C) 16 protons and 14 electrons
    D) 16 protons and 18 electrons
    E) 32 protons and 18 electrons
    Ans: D

31. How many protons and electrons are present in one Br^- ion?
    A) 35 p, 35 e
    B) 80 p, 81 e
    C) 35 p, 34 e
    D) 35 p, 36 e
    E) 80 p, 34 e
    Ans: D

32. The elements in a column of the periodic table are known as
    A) metalloids. B) a period. C) noble gases. D) a group. E) nonmetals.
    Ans: D

33. Which of these materials are usually poor conductors of heat and electricity?
    A) metals
    B) metalloids
    C) nonmetals
    D) alkaline earth metals
    E) alkali metals
    Ans: C

34. Which of these elements is most likely to be a good conductor of electricity?
    A) N B) S C) He D) Cl E) Fe
    Ans: E

35. Which of the following elements are the least reactive?
    A) alkali metals
    B) noble gases
    C) halogens
    D) alkaline earth metals
    E) metalloids
    Ans: B

36. Which of the following is a non-metal?
    A) lithium, Li, Z = 3
    B) bromine, Br, Z = 35
    C) mercury, Hg, Z = 80
    D) bismuth, Bi, Z = 83
    E) sodium, Na, Z = 11
    Ans: B

37. Which of the following is a metal?
A) nitrogen, N, Z = 7
B) phosphorus, P, Z = 15
C) arsenic, Z = 33
D) thallium, Tl, Z = 81
E) silicon, Si, Z = 14
Ans: D

38. Which of the following is a metalloid?
A) carbon, C, Z = 6
B) sulfur, S, Z = 16
C) germanium, Ge, Z = 32
D) iridium, Z = 77
E) bromine, Br, Z = 35
Ans: C

39. A row of the periodic table is called a
A) group B) period C) isotopic mixture D) family E) subshell
Ans: B

40. Silicon, which makes up about 25% of Earth's crust by mass, is used widely in the modern electronics industry. It has three naturally occurring isotopes, ^{28}Si, ^{29}Si, and ^{30}Si. Calculate the atomic mass of silicon.

Isotope	Isotopic Mass (amu)	Abundance %
^{28}Si	27.976927	92.23
^{29}Si	28.976495	4.67
^{30}Si	29.973770	3.10

A) 29.2252 amu
B) 28.9757 amu
C) 28.7260 amu
D) 28.0855 amu
E) 27.9801 amu
Ans: D

41. Lithium forms compounds which are used in dry cells and storage batteries and in high-temperature lubricants. It has two naturally occurring isotopes, ^{6}Li (isotopic mass = 6.015121 amu) and ^{7}Li (isotopic mass = 7.016003 amu). Lithium has an atomic mass of 6.9409 amu. What is the percent abundance of lithium-6?
A) 92.50% B) 86.66% C) 46.16% D) 7.503% E) 6.080%
Ans: D

42. What is the name used to define a mass which is exactly equal to 1/12 the mass of one carbon-12 atom?
A) Isotope number
B) Mass number
C) Mass-to-charge ratio
D) Atomic number
E) Atomic mass units
Ans: E

43. Which of the following cannot exist as a homonuclear diatomic molecule?
A) hydrogen B) phosphorus C) fluorine D) nitrogen E) oxygen
Ans: B

44. Which is the correct definition of a diatomic molecule?
A) A molecule which contains two or more of the same atoms
B) A molecule which contains two or more different atoms
C) A molecule which contains two identical atoms
D) A molecule which contains two different atoms
E) c and d
Ans: E

45. Which is the correct definition of a polyatomic molecule?
A) A molecule which contains two or more of the same atoms
B) A molecule which contains two or more different atoms
C) a and b
D) A molecule which contains two identical atoms
E) A molecule which contains two different atoms
Ans: C

46. Which is the correct definition of a heteronuclear diatomic molecule?
A) A molecule which contains two or more of the same atoms
B) A molecule which contains two or more different atoms
C) a and b
D) A molecule which contains two identical atoms
E) A molecule which contains two different atoms
Ans: E

47. What represents the exact number of atoms of each element in a molecule?
A) Chemical formula
B) Compound
C) Constitutional formula
D) Molecular formula
E) Atomic formula
Ans: D

48. Which of the following are allotropes?
A) diamond and graphite
B) hydrogen and deuterium
C) bromine and chlorine
D) hydrogen and oxygen
E) None of the above
Ans: A

49. Which of these elements is chemically similar to magnesium?
A) sulfur B) calcium C) iron D) nickel E) potassium
Ans: B

50. Which of these elements is chemically similar to oxygen?
A) sulfur B) calcium C) iron D) nickel E) potassium
Ans: A

51. Which of these elements is chemically similar to potassium?
A) calcium B) arsenic C) phosphorus D) cerium E) cesium
Ans: E

52. Which, if any, of the following elements do not occur in the major classes of organic compounds?
A) H
B) C
C) N
D) O
E) All the above elements occur in the major classes of organic compounds.
Ans: E

53. What name is given to a class of compounds that generally do not contain carbon?
A) Acarbonic compounds
B) Carbonic compounds
C) Organic compounds
D) Inorganic compounds
E) Aldehyde compounds
Ans: D

54. Which of the following is the empirical formula for hexane, C_6H_{14}?
A) $C_{12}H_{28}$ B) C_6H_{14} C) C_3H_7 D) $CH_{2.3}$ E) $C_{0.43}H$
Ans: C

55. Which of the following is a molecular formula for CH?
A) C_2H_6 B) C_3H_9 C) C_4H_{10} D) C_6H_6 E) None of the answers are correct.
Ans: D

56. What is the name of PCl_3?
A) phosphorus chloride
B) phosphoric chloride
C) phosphorus trichlorate
D) trichlorophosphid
E) phosphorus trichloride
Ans: E

57. The compound, P_4S_{10}, is used in the manufacture of safety matches. What is its name?
A) phosphorus sulfide
B) phosphoric sulfide
C) phosphorus decasulfide
D) tetraphosphorus decasulfide
E) phosphorus sulfite
Ans: D

58. Diiodine pentaoxide is used as an oxidizing agent that converts carbon monoxide to carbon dioxide. What is its chemical formula?
A) I_2O_5 B) IO_5 C) $2IO_5$ D) I_5O_2 E) $(IO_5)_2$
Ans: A

59. What is the name of P_4Se_3?
A) phosphorus selenide
B) phosphorus triselenide
C) tetraphosphorus selenide
D) phosphoric selenide
E) tetraphosphorus triselenide
Ans: E

60. What is the name of ClO^-?
A) hypochlorite B) chlorate C) chlorite D) perchlorate E) perchlorite
Ans: A

61. What is the formula for the permanganate ion?
A) MnO_2^- B) MnO_4^- C) MgO_4^{2-} D) $Mn_2O_7^-$ E) MgO_2^{2-}
Ans: B

62. Tetrasulfur dinitride decomposes explosively when heated. What is its formula?
A) S_2N_4 B) S_4N_2 C) $4SN_2$ D) S_4N E) S_2N
Ans: B

63. An anion is defined as
A) a charged atom or group of atoms with a net negative charge.
B) a stable atom.
C) a group of stable atoms.
D) an atom or group of atoms with a net positive charge.
E) neutral.
Ans: A

64. Which one of these species is an ion?
A) B^{3+} B) NaCl C) He D) ^{14}C E) None of the above
Ans: A

65. Which of these pairs of elements would be most likely to form an ionic compound?
A) P and Br B) Cu and K C) C and O D) O and Zn E) Al and Rb
Ans: D

66. Which pair of elements would be most likely to form an ionic compound?
A) P and Br B) Zn and K C) F and Al D) C and S E) Al and Rb
Ans: C

67. What is the formula for the ionic compound formed by calcium ions and nitrate ions?
A) Ca_3N_2 B) $Ca(NO_3)_2$ C) Ca_2NO_3 D) Ca_2NO_2 E) $CaNO_3$
Ans: B

68. What is the formula for the ionic compound formed by calcium and selenium?
A) CaSe B) Ca_2Se C) $CaSe_2$ D) Ca_3Se E) $CaSe_3$
Ans: A

69. Which is the correct formula for copper (II) phosphate?
A) Cu_2PO_4 B) $Cu_3(PO_4)_2$ C) Cu_2PO_3 D) $Cu(PO_4)_2$ E) $Cu(PO_3)_2$
Ans: B

70. The chemical name for ClO^{3-} is "chlorate ion". What is the common name for $HClO_3$?
A) hydrochloric acid
B) chloroform
C) hydrogen trioxychloride
D) chlorous acid
E) chloric acid
Ans: E

71. The formula for magnesium sulfate is
A) MnS B) MgS C) $MnSO_3$ D) $MgSO_4$ E) $MnSO_4$
Ans: D

72. The formula for sodium sulfide is
A) NaS B) K_2S C) NaS_2 D) Na_2S E) SeS
Ans: D

73. The chemical formula for iron (II) nitrate is
A) $Fe_2(NO_3)_3$ B) $Ir(NO_2)_2$ C) Fe_2N_3 D) $Fe(NO_3)_2$ E) $Fe(NO_2)_2$
Ans: D

74. Which one of the following formulas of ionic compounds is the least likely to be correct?
A) NH_4Cl B) $Ba(OH)_2$ C) Na_2SO_4 D) Ca_2NO_3 E) $Cu(CN)_2$
Ans: D

75. What is the formula for lead (II) oxide?
A) PbO B) PbO_2 C) Pb_2O D) PbO_4 E) Pb_2O_3
Ans: A

76. Potassium permanganate is a strong oxidizer that reacts explosively with easily oxidized materials. What is its formula?
A) $KMnO_3$ B) $KMnO_4$ C) K_2MnO_4 D) $K(MnO_4)_2$ E) $K_2Mn_2O_7$
Ans: B

77. Ferric oxide is used as a pigment in metal polishing. Which of the following is its formula?
A) FeO B) Fe_2O C) FeO_3 D) Fe_2O_5 E) Fe_2O_3
Ans: E

78. What is the name of $Mn(CO_3)_2$?
A) manganese carbide
B) magnesium (IV) carbonate
C) manganese (II) carbonate
D) magnesium (II) carbonate
E) manganese (IV) carbonate
Ans: E

79. Iron (III) chloride hexahydrate is used as a coagulant for sewage and industrial wastes. What is its formula?
A) $Fe(Cl{\cdot}6H_2O)_3$
B) $Fe_3Cl{\cdot}6H_2O$
C) $FeCl_3(H_2O)_6$
D) $Fe_3Cl(H_2O)_6$
E) $FeCl_3{\cdot}6H_2O$
Ans: E

80. Which of the following is the oxoanion of bromine called the bromate ion?
A) BrO_3^- B) BrO_3^{2-} C) BrO_4^{2-} D) BrO_2^- E) BrO^-
Ans: A

81. The mass of a neutron is equal to the mass of a proton plus the mass of an electron.
Ans: False

82. All neutral atoms of tin have 50 protons and 50 electrons.
Ans: True

83. Copper (Cu) is a transition metal.
Ans: True

84. Lead (Pb) is a main-group element.
Ans: True

85. Ionic compounds may carry a net positive or negative charge.
Ans: False

86. When an alkali metal combines with a non-metal, a covalent bond is normally formed.
Ans: False

87. The empirical formula of C_6H_6 is CH.
Ans: True

88. Almost all the mass of an atom is concentrated in the nucleus.
Ans: True

89. When a beam of alpha particles passes between two electrically charged plates, the beam is deflected toward the positive plate.
Ans: False

90. J. J. Thomson suggested the name “radioactivity” to describe the spontaneous emission of particles and/or radiation.
Ans: False

91. An allotrope is a mixture of forms of the same compound that exist in the same physical state under the same conditions of temperature and pressure.
Ans: False

92. An ionizable hydrogen atom is a hydrogen atom that separates from the molecule when the molecule is dissolved in a solution and becomes a hydrogen ion, H^+.
Ans: True

93. What is the law that describes different samples of a given compound that always contain the same elements in the same mass ratio?
Ans: law of definite proportions

94. What is the law of conservation of mass?
Ans: Matter can be neither created nor destroyed.

95. How many neutrons are in ^{13}C?
Ans: 7

96. What name is given to the simplest organic compounds which only contain carbons and hydrogens?
Ans: hydrocarbons

97. What is the name of Cu_2O?
Ans: Copper (I) oxide

98. What is the formula for sodium dichromate?
Ans: $Na_2Cr_2O_7$

99. What is the name given for the elements in Group 1A in the periodic table?
Ans: Alkali metals

100. What is the name given for the elements in Group 7A in the periodic table?
Ans: Halogens

101. Which group is given the name chalcogens?
Ans: Group 6A

102. What are the three types of radiation produced by the decay of substances like uranium?
Ans: Alpha, beta, and gamma radiation

103. Define ion.
Ans: An ion is an atom or group of atoms that has a net positive or negative charge.

104. Fill in the blank spaces and write out all the symbols in the left hand column in full, in the form $^{A}_{Z}X$ (i.e., include the appropriate values of Z and A as well as the correct symbol X).

Symbol	# protons	# neutrons	# electrons
…	17	18	…
Au	…	118	…
…	…	20	20

Ans:

Cl	17	18	17
Au	79	118	79
Ca	20	20	20

105. _____ is the emission and transmission of energy through space in the form of waves.
Ans: Radiation

106. _____ is the negatively charged plate connected to a high-voltage source.
Ans: Cathode

107. _____ coined the term radioactivity to describe the spontaneous emission of particles and/or radiation.
Ans: Marie Curie

108. _____ are electrons that are deflected away from negatively charged plates.
Ans: β particles

109. _____ are atoms that have the same atomic number (Z) but different mass numbers (A).
Ans: Isotopes

110. _____ have properties that are intermediate between those of metals and nonmetals.
Ans: Metalloids

111. _____ are the name given for the elements in Group VIIIA.
Ans: Noble gases

112. _____ compounds consist of two different elements.
Ans: Binary

113. _____ is defined as a mass exactly equal to one-twelfth the mass of one carbon-12 atom.
Ans: One atomic mass unit

114. _____ are one of two or more distinct forms of an element.
Ans: Allotropes

115. When one of the hydrogen atoms in a molecule is replaced by a group of atoms, this group of atoms is known as a _____.
Ans: functional group

116. Briefly explain the relationship between hypothesis and experiment in the scientific method.
Ans: A hypothesis should be capable of leading to a prediction which is testable by experiment. If the experimental result differs from the prediction, the hypothesis should be modified.

117. The table below describes four atoms.

	Atom A	Atom B	Atom C	Atom D
Number of protons	79	80	80	79
Number of neutrons	118	120	118	120
Number of electrons	79	80	80	79

Which atoms represent the same element?
Ans: Atoms A and D represent the same element, Atoms B and C represent the same element.

118. In the early 1900s, Ernest Rutherford performed an experiment with gold foil, targets and alpha particles to probe the structure of the atoms. He observed that most of these alpha particles penetrated the foil undeflected. Realizing that atoms are electrically neutral (that is, they have equal numbers of protons and electrons) and that the mass of a proton is significantly greater than the mass of an electron, use Rutherford's data to propose a structural model of an atom.
Ans: (Answers will vary.) Atoms are mostly empty space. The mass is concentrated mostly at the center of the atom.

119. Describe the contributions of Marie Curie.
Ans: (note that answers will vary) Marie Curie discovered two new elements, and is one of three people to win two Nobel Prizes. She also suggested the term "radioactivity" to describe the spontaneous emission of particles and/or radiation.

120. State the two important experimental results (and the names of the responsible scientists) which enabled the mass of the electron to be determined.
Ans: Thomson measured m/e, the mass-to-charge ratio. Millikan measured e, the charge. Thus, the mass m could be calculated.

121. Name the three important "laws" that were accounted for by Dalton's atomic theory.
Ans: Laws of conservation of mass; definite composition; multiple proportions

122. Dalton's atomic theory has required some modifications in the light of subsequent discoveries. For any three appropriate postulates of Dalton's atomic theory: state the postulate in its original form and in one sentence, describe why the postulate has needed modification.
Ans: Matter consists of atoms which are indivisible, cannot be created or destroyed. But, atoms are divisible, as the existence of subatomic particles shows.
Atoms of one element cannot be converted into atoms of another element. They can be converted in various nuclear reactions, including radioactive decay. Atoms of an element are identical in mass and other properties. Isotopes of an element differ in their masses and other properties.

123. Describe the difference between an empirical formula and a molecular formula.
Ans: An empirical formula is the simplest chemical formula that has the smallest possible whole number ratio of atoms in the formula and a molecular formula is the true formula of a molecule which is a whole number multiple of its empirical formula.

124. Determine the average atomic mass of boron is the natural abundance of ^{10}B weighing exactly 10.0129 amu is 19.9% and the natural abundance of ^{11}B weighing exactly 11.0093 amu is 80.1%? Show all your work.
Ans: (10.0129)(0.199) + (11.0093)(0.801) = 10.81 amu

125. Explain what is meant by an ionizable hydrogen atom.
Ans: It is one that separates from the molecule upon dissolving and becomes a hydrogen ion, H^+.

126. Describe what is meant by the term 'functional group' in organic chemistry.
Ans: A functional group is a group atoms that have replaced one of the hydrogen atoms in an organic compound.