Chapter 2 The Components of Matter

1. Kaolinite, a clay mineral with the formula $Al_4Si_4O_{10}(OH)_8$, is used as a filler in slick-paper for magazines and as a raw material for ceramics. Analysis shows that 14.35 g of kaolinite contains 8.009 g of oxygen. Calculate the mass percent of oxygen in kaolinite.
   A) 1.792 mass %
   B) 24.80 mass %
   C) 30.81 mass %
   D) 34.12 mass %
   E) 55.81 mass %
   Ans: E

2. Compound 1 has a composition of 46.7 mass % of element A and 53.3 mass % of element B. A and B also form a second binary compound (compound 2). If the compositions of the two compounds are consistent with the law of multiple proportions, which of the following compositions could be that of compound 2?
   A) 23.4 mass % A 76.6 mass % B
   B) 30.4 mass % A 69.6 mass % B
   C) 33.3 mass % A 66.7 mass % B
   D) 53.3 mass % A 46.7 mass % B
   E) 73.3 mass % A 26.7 mass % B
   Ans: B

3. 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: C

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

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

6. 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

7. In a Millikan oil-drop experiment, the charges on several different oil drops were as follows: -5.92; -4.44; -2.96; -8.88. The units are arbitrary. What is the likely value of the electronic charge in these arbitrary units?
   A) -1.11 B) -1.48 C) -2.22 D) -2.96 E) -5.55
   Ans: B

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

9. Rutherford bombarded gold foil with alpha (α) particles and found that a small percentage of the particles were deflected. Which of the following was <u>not</u> 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

10. 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

11. 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

12. Atoms X, Y, Z, and R have the following nuclear compositions:

    $^{410}_{186}\mathrm{X}$ $^{410}_{183}\mathrm{Y}$ $^{412}_{186}\mathrm{Z}$ $^{412}_{185}\mathrm{R}$

    Which two are isotopes?
    A) X & Y B) X & R C) Y & R D) Z & R E) X & Z
    Ans: E

13. 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

14. 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

15. 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

16. 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

17. 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

18. 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

19. A column of the periodic table is called a
A) group B) period C) isotopic mixture D) pillar E) shell
Ans: A

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

21. Which of the following compounds is ionic?
A) PF_3 B) CS_2 C) HCl D) SO_2 E) $MgCl_2$
Ans: E

22. Which of the following ions occurs commonly?
A) N^{3+} B) S^{6+} C) O^{2-} D) Ca^{+} E) Cl^{+}
Ans: C

23. Which of the following ions occurs commonly?
A) P^{3+} B) Br^{7+} C) O^{6+} D) Ca^{2+} E) K^{-}
Ans: D

24. Which of the following compounds is covalent?
A) $CaCl_2$ B) MgO C) Al_2O_3 D) Cs_2S E) PCl_3
Ans: E

25. 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

26. Sodium oxide combines violently with water. Which of the following gives the formula and the bonding for sodium oxide?
A) NaO, ionic compound
B) NaO, covalent compound
C) Na_2O, ionic compound
D) Na_2O, covalent compound
E) Na_2O_2, ionic compound
Ans: C

27. Barium fluoride is used in embalming and in glass manufacturing. Which of the following gives the formula and bonding for barium fluoride?
A) BaF_2, ionic compound
B) BaF_2, covalent compound
C) BaF, ionic compound
D) BaF, covalent compound
E) Ba_2F, ionic compound
Ans: A

28. The colorless substance, MgF_2, is used in the ceramics and glass industry. What is its name?
    A) magnesium difluoride
    B) magnesium fluoride
    C) magnesium(II) fluoride
    D) monomagnesium difluoride
    E) none of these choices is correct, since they are all misspelled
    Ans: B

29. The compound, BaO, absorbs water and carbon dioxide readily and is used to dry gases and organic solvents. What is its name?
    A) barium oxide
    B) barium(II) oxide
    C) barium monoxide
    D) baric oxide
    E) barium peroxide
    Ans: A

30. What is the name of Na_2O?
    A) disodium monoxide
    B) sodium monoxide
    C) sodium dioxide
    D) sodium(I) oxide
    E) sodium oxide
    Ans: E

31. The substance, CaSe, is used in materials which are electron emitters. What is its name?
    A) calcium monoselenide
    B) calcium(II) selenide
    C) calcium selenide
    D) calcium(I) selenide
    E) calcium(II) selenium
    Ans: C

32. The substance, $CoCl_2$, is useful as a humidity indicator because it changes from pale blue to pink as it gains water from moist air. What is its name?
    A) cobalt dichloride
    B) cobalt(II) chloride
    C) cobalt chloride
    D) cobaltic chloride
    E) copper(II) chloride
    Ans: B

33. Which one of the following combinations of names and formulas of ions is incorrect?
    A) O_2^- oxide
    B) Al^{3+} aluminum
    C) NO_3^- nitrate
    D) PO_4^{3-} phosphate
    E) CrO_4^{2-} chromate
    Ans: A

34. Which one of the following combinations of names and formulas of ions is incorrect?
    A) O^{2-} oxide
    B) Cd^{2+} cadmium
    C) ClO_3^- chlorate
    D) HCO_3^- hydrogen carbonate
    E) NO_2^- nitrate
    Ans: E

35. Which one of the following combinations of names and formulas of ions is incorrect?
    A) Ba^{2+} barium
    B) S^{2-} sulfate
    C) CN^- cyanide
    D) ClO_4^- perchlorate
    E) HCO_3^- bicarbonate
    Ans: B

36. Which one of the following combinations of names and formulas of ions is incorrect?
    A) NH_4^+ ammonium
    B) S^{2-} sulfide
    C) CN^- cyanide
    D) $S_2O_3^{2-}$ thiosulfate
    E) ClO_3^- perchlorate
    Ans: E

37. A red glaze on porcelain can be produced by using $MnSO_4$. What is its name?
    A) manganese disulfate
    B) manganese(II) sulfate
    C) manganese(IV) sulfate
    D) manganese sulfate
    E) manganese(I) sulfate
    Ans: B

38. The compound, $(NH_4)_2S$, can be used in analysis for trace amounts of metals present in a sample. What is its name?
    A) ammonium sulfide
    B) diammonium sulfide
    C) ammonium sulfite
    D) ammonia(I) sulfite
    E) ammonium(I) sulfide
    Ans: A

39. The substance, $KClO_3$, is a strong oxidizer used in explosives, fireworks, and matches. What is its name?
    A) potassium chlorite
    B) potassium chloride
    C) potassium(I) chlorite
    D) potassium(I) chlorate
    E) potassium chlorate
    Ans: E

40. The compound, NaH_2PO_4, is present in many baking powders. What is its name?
    A) sodium biphosphate
    B) sodium hydrogen phosphate
    C) sodium dihydrogen phosphate
    D) sodium hydrophosphate
    E) sodium dihydride phosphate
    Ans: C

41. Zinc acetate is used in preserving wood and in manufacturing glazes for porcelain. What is its formula?
A) $ZnAc_2$
B) $ZnCH_3COO$
C) $Zn(CH_3COO)_2$
D) Zn_2CH_3COO
E) $ZnCH_3COCH_3$
Ans: C

42. Silver chloride is used in photographic emulsions. What is its formula?
A) Ag_2Cl_3 B) Ag_2Cl C) $AgCl_3$ D) $AgCl_2$ E) $AgCl$
Ans: E

43. Barium sulfate is used in manufacturing photographic paper. What is its formula?
A) $BaSO_4$ B) $Ba(SO_4)_2$ C) Ba_2SO_4 D) $Ba_2(SO_4)_3$ E) $BaSO_3$
Ans: A

44. Sodium peroxide is an oxidizer used to bleach animal and vegetable fibers. What is its formula?
A) NaO B) NaO_2 C) Na_2O_2 D) Na_2O E) NaH_2O_2
Ans: C

45. What is the formula for magnesium sulfide?
A) MgS B) MgS_2 C) Mg_2S D) Mg_2S_3 E) $MgSO_4$
Ans: A

46. 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

47. 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

48. 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

49. Calcium hydroxide is used in mortar, plaster and cement. What is its formula?
A) $CaOH$ B) $CaOH_2$ C) Ca_2OH D) $Ca(OH)_2$ E) $CaHO_2$
Ans: D

50. What is the formula for lithium nitrite?
A) $LiNO_2$ B) Li_2NO_2 C) $LiNO_3$ D) Li_2NO_3 E) $LiNO_4$
Ans: A

51. 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

52. 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

53. Which one of the following formulas of ionic compounds is the least likely to be correct?
    A) $CaCl_2$ B) $NaSO_4$ C) $MgCO_3$ D) KF E) $Cu(NO_3)_2$
    Ans: B

54. What is the name of the acid formed when H_2S gas is dissolved in water?
    A) sulfuric acid
    B) sulfurous acid
    C) hydrosulfuric acid
    D) hydrosulfurous acid
    E) sulfidic acid
    Ans: C

55. What is the name of the acid formed when HBr gas is dissolved in water?
    A) bromic acid
    B) bromous acid
    C) hydrobromic acid
    D) hydrobromous acid
    E) hydrobromidic acid
    Ans: C

56. What is the name of the acid formed when $HClO_4$ liquid is dissolved in water?
    A) hydrochloric acid
    B) perchloric acid
    C) chloric acid
    D) chlorous acid
    E) hydrochlorate acid
    Ans: B

57. What is the name of the acid formed when HCN gas is dissolved in water?
    A) cyanic acid
    B) hydrocyanic acid
    C) cyanous acid
    D) hydrocyanous acid
    E) hydrogen cyanide
    Ans: B

58. Which one of the following combinations of names and formulas is incorrect?
    A) H_3PO_4 phosphoric acid
    B) HNO_3 nitric acid
    C) $NaHCO_3$ sodium carbonate
    D) H_2CO_3 carbonic acid
    E) KOH potassium hydroxide
    Ans: C

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

60. 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
    Ans: D

61. What is the name of BBr_3?
    A) boron bromide
    B) boric bromide
    C) boron tribromide
    D) tribromoboride
    E) bromine triboride
    Ans: C

62. What is the name of IF_7?
    A) iodine fluoride
    B) iodic fluoride
    C) iodine heptafluoride
    D) heptafluoroiodide
    E) heptafluorine iodide
    Ans: C

63. 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

64. 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

65. 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

66. Chlorine dioxide is a strong oxidizer that is used for bleaching flour and textiles and for purification of water. What is its formula?
    A) $(ClO)_2$ B) Cl_2O C) Cl_2O_2 D) Cl_2O_4 E) ClO_2
    Ans: E

67. Ammonium sulfate, $(NH_4)_2SO_4$, is a fertilizer widely used as a source of nitrogen. Calculate its molecular mass.
A) 63.07 amu
B) 114.l0 amu
C) 118.13 amu
D) 128.11 amu
E) 132.13 amu
Ans: E

68. Sodium chromate is used to protect iron from corrosion and rusting. Determine its molecular mass.
A) 261.97 amu
B) 238.98 amu
C) 161.97 amu
D) 138.98 amu
E) 74.99 amu
Ans: C

69. Iodine pentafluoride reacts slowly with glass and violently with water. Determine its molecular mass.
A) 653.52 amu
B) 259.89 amu
C) 221.90 amu
D) 202.90 amu
E) 145.90 amu
Ans: C

70. Determine the molecular mass of iron (III) bromide hexahydrate, a substance used as a catalyst in organic reactions.
A) 403.65 amu
B) 355.54 amu
C) 317.61 amu
D) 313.57 amu
E) 295.56 amu
Ans: A

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

72. Dalton's atomic theory has required some modifications in the light of subsequent discoveries. For any two appropriate postulates of Dalton's atomic theory
a. state the postulate in its original form
b. 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 an element are identical in mass and other properties. Isotopes of an element differ in their masses and other properties.
(Another possible answer: Atoms of one element cannot be converted into atoms of another element. They can be converted in various nuclear reactions, including radioactive decay.)

73. Fill in the blank spaces and write out all the symbols in the left hand column in full, in the form ${}^{A}_{Z}\mathrm{X}$ (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:

Symbol	# protons	# neutrons	# electrons
${}^{35}_{17}\mathrm{Cl}$	17	18	17
${}^{197}_{79}\mathrm{Au}$	79	118	79
${}^{20}_{20}\mathrm{Ca}$	20	20	20

74. The following charges on individual oil droplets were obtained during an experiment similar to Millikan's. Use them to determine a charge for the electron in coulombs (C), showing all your working.

Charges (C): -3.184×10^{-19}; -4.776×10^{-19}; -7.960×10^{-19}
Ans: -1.59×10^{-19} C

75. 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.

76. For each of the following elements, indicate whether it is a metal, a non-metal or a metalloid:
a. S
b. Ge
c. Hg
d. H
e. I
f. Si
Ans: a. nonmetal
b. metalloid
c. metal
d. nonmetal
e. nonmetal
f. metalloid

77. Give the common name of the group in the periodic table to which each of the following elements belongs:
    a. Rb
    b. Br
    c. Ba
    d. Ar
    Ans: a. alkali metals
    b. halogens
    c. alkaline earth metals
    d. noble gases

78. a. Give the names of the following ions:
    (i) NH_4^+
    (ii) SO_3^{2-}
    b. Write down the formulas of the following ions:
    (i) aluminum
    (ii) carbonate
    Ans: a. (i) ammonium
    (ii) sulfite
    b. (i) Al^{3+}
    (ii) CO_3^{2-}

79. a. Give the names of the following ions:
    (i) O_2^{2-}
    (ii) SO_4^{2-}
    b. Write down the formulas of the following ions:
    (i) ammonium
    (ii) nitrate
    Ans: a. (i) peroxide
    (ii) sulfate
    b. (i) NH_4^+
    (ii) NO_3^-

80. For each of the following names, write down the corresponding formula, including charge where appropriate (atomic numbers and mass numbers are not required):
    a. zinc ion
    b. nitrite ion
    c. carbonic acid
    d. cyanide ion
    Ans: a. Zn^{2+}
    b. NO_2^-
    c. H_2CO_3
    d. CN^-

81. Calculate the molecular masses of the following:
    a. Cl_2
    b. H_2O_2
    c. $(NH_4)_2SO_4$
    d. $Ba(NO_3)_2$
    Ans: a. 70.90 amu
    b. 34.02 amu
    c. 132.2 amu
    d. 261.3 amu

82. In nature, some elements exist as molecules, while others do not.
    Ans: True

83. Modern studies have shown that the Law of Multiple Proportions is not valid.
    Ans: False

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

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

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

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

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

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

90. The molecular formula of a compound provides more information than its structural formula.
    Ans: False

91. The formula C_9H_{20} is an empirical formula.
    Ans: True