Introduction to General Organic and Biochemistry 11th Edition Bettelheim Solutions Manual

Chapter 2: Atoms

2.1 (a) $NaClO_3$ (b) AlF_3

2.2 (a) The mass number is 15 + 16 = 31.
(b) The mass number is 86 + 136 = 222.

2.3 (a) The element has 15 protons, making it phosphorus (P); its symbol is $^{31}_{15}P$.
(b) The element has 86 protons, making it radon (Rn); its symbol is $^{222}_{86}Rn$.

2.4 (a) The atomic number of mercury (Hg) is 80; that of lead (Pb) is 82.
(b) An atom of Hg has 80 protons; an atom of Pb has 82 protons.
(c) The mass number of this isotope of Hg is 80 + 120 = 200; the mass number for this isotope of Pb is 82 + 120 = 202.
(d) The symbols of these isotopes are $^{200}_{80}Hg$ and $^{202}_{82}Pb$.

2.5 The atomic number of iodine (I) is 53. The number of neutrons in each isotope is 125 - 53 = 72 for iodine-125 and 131 - 53 = 78 for iodine-131. The symbols for these two isotopes are $^{125}_{53}I$ and $^{131}_{53}I$.

2.6 The atomic weight is 6.941 amu, which is nearer to 7 amu than 6 amu. Therefore, lithium-7 is the more abundant isotope. The relative abundances for these two isotopes are 92.50 percent for lithium-7 and 7.50 percent for lithium-6.

2.7 This element has 13 electrons and, therefore, 13 protons. The element with atomic number 13 is Aluminum (Al).

$$\dot{\mathrm{Al}}:$$

2.8 Both Democritus and Dalton believed that matter was composed of tiny indivisible particles referred to as atoms. The major difference between Democritus and Dalton is that Dalton based his theory on evidence rather than belief.

2.10 (a) Oxygen - an element
(b) Table salt - a compound
(c) Sea water - a mixture
(d) Wine - a mixture
(e) Air - a mixture
(f) Silver - an element
(g) Diamond - an element
(h) A pebble - a mixture
(i) Gasoline - a mixture
(j) Milk - a mixture
(k) Carbon dioxide - a compound
(l) Bronze - a mixture

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2.12 Given here is the element, its symbol, and its atomic number:

(a) Bohrium (Bh, 107)
(b) Curium (Cm, 96)
(c) Einsteinium (Es, 99)
(d) Fermium (Fm, 100)
(e) Lawrencium (Lr, 103)
(f) Meitnerium (Mt, 109)
(g) Mendelevium (Md, 101)
(h) Nobelium (No, 102)
(i) Rutherfordium (Rf, 104)
(j) Seaborgium (Sg, 106)

2.14 The three elements named for planets are mercury (Hg, 80), uranium (U, 92), and neptunium (Np, 93).

2.16 (a) $NaHCO_3$ (b) C_2H_6O (c) $KMnO_4$

2.18 The law of conservation of mass

2.20 Mass percent of H and O in:

H_2O:	18.015 g/mol	H: 11.2%	O: 88.8%
H_2O_2:	34.014 g/mol	H: 5.9%	O: 94.1%

2.22 (a) Protons are located in the nucleus.
(b) Electrons are outside the nucleus.
(c) Neutrons are in the nucleus.

2.24 (a) Mass number = 22 protons + 26 neutrons = 48
(b) Mass number = 76 protons + 114 neutrons = 190
(c) Mass number = 34 protons + 45 neutrons = 79
(d) Mass number = 94 protons + 150 neutrons = 244

2.26 An element is identified by its atomic number, which is mass number - number of neutrons.
(a) 45 - 24 = 21 protons. The element is scandium (Sc), and its symbol is ${}^{45}_{21}Sc$.
(b) 48 - 26 = 22 protons. The element is titanium (Ti), and its symbol is ${}^{48}_{22}Ti$.
(c) 107 - 60 = 47 protons. The element is silver (Ag), and its symbol is ${}^{107}_{47}Ag$.
(d) 246 - 156 = 90 protons. The element is thorium (Th) and its symbol is ${}^{246}_{90}Th$.
(e) 36 - 18 = 18 protons. The element is argon (Ar) and its symbol is ${}^{36}_{18}Ar$.

2.28 The number of neutrons is equal to the mass number - atomic number (number of protons).
(a) 13 - 6 = 7 neutrons
(b) 73 - 32 = 41 neutrons
(c) 188 -76 = 112 neutrons
(d) 195 - 78 = 117 neutrons

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2.30 (a) Neon-22 has 10 protons and 22 - 10 = 12 neutrons
(b) Palladium-104 has 46 protons and 104 - 46 = 58 neutrons
(c) Chlorine-35 has 17 protons and 35 - 17 = 18 neutrons
(d) Tellurium-128 has 52 protons and 128 - 52 = 76 neutrons
(e) Lithium-7 has 3 protons and 7 - 3 = 4 neutrons
(f) Uranium-238 has 92 protons and 238 - 92 = 146 neutrons

2.32 The atomic number is the number of protons in the nucleus of an element. The mass number is the number of protons and neutrons in the nucleus.

2.34 The atomic weight (121.75 amu) is nearer to that of antimony-121 (120.90 amu) than it is to antimony-123 (122.90 amu). Therefore, antimony-121 has the greater natural abundance. The observed abundances are 57.3 percent antimony-121, and 42.7 percent antimony-123.

2.36 Carbon-14 has 6 protons, 6 electrons, and 8 neutrons.

2.38 Fluorine-18 has 9 protons, 9 electrons, and 9 neutrons.
Nitrogen-13 has 7 protons, 7 electrons, and 6 neutrons.
Oxygen-15 has 8 protons, 8 electrons, and 7 neutrons.

2.40 Rubidium-87 has 37 protons, 37 electrons, and 50 neutrons.
Strontium-87 has 38 protons, 38 electrons, and 49 neutrons.

2.42 In period 3, there are three metals (Na, Mg, and Al), one metalloid (Si) and four nonmetals (P, S, Cl, and Ar).

2.44 Periods 1 - 3 contain more nonmetals than metals. Periods 4 -7 contain more metals than nonmetals.

2.46 Palladium (Pd), cobalt (Co), and chromium (Cr) are transition elements. Cerium (Ce) is an inner transition element; K and Br are main group elements.

2.48 (a) Argon is a nonmetal
(b) Boron is a metalloid
(c) Lead is a metal
(d) Arsenic is a metalloid
(e) Potassium is a metal
(f) Silicon is a metalloid
(g) Iodine is a nonmetal
(h) Antimony is a metalloid
(i) Vanadium is a metal
(j) Sulfur is a nonmetal
(k) Nitrogen is a nonmetal

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<u>2.50</u> Only Period 1 has two elements. Periods 2 and 3 have eight elements. Periods 4 and 5 have 18 elements and Period 6 has 32 elements. Period 7 is filling with recently discovered elements, and upon confirmation, will contain its full capacity of 32 elements.

<u>2.52</u> The group number tells the number of Lewis dots to be placed around the symbol of the element.

(a) $:\dot{\mathrm{C}}\cdot$ (b) $:\dot{\mathrm{Si}}\cdot$ (c) $\cdot\ddot{\underset{..}{\mathrm{O}}}\cdot$

(d) $\cdot\ddot{\underset{..}{\mathrm{S}}}\cdot$ (e) $\ddot{\mathrm{Al}}\cdot$ (f) $:\ddot{\underset{..}{\mathrm{Br}}}\cdot$

<u>2.54</u> Following are Lewis dot structures for each element in Problem 2.49:

(a) $\mathrm{Li}\cdot$ (b) $:\ddot{\underset{..}{\mathrm{N}}}\mathrm{e}:$ (c) $\mathrm{Be}:$ (d) $:\dot{\mathrm{C}}\cdot$ (e) $\mathrm{Mg}:$

<u>2.56</u> Following are Lewis dot structures for each element in Problem 2.55:

(a) $\mathrm{He}:$ (b) $\mathrm{Na}\cdot$ (c) $:\ddot{\underset{..}{\mathrm{Cl}}}\cdot$ (d) $:\dot{\underset{.}{\mathrm{P}}}\cdot$ (e) $\mathrm{H}\cdot$

<u>2.58</u> In the ground state, 3*s* and 3*p* orbitals are occupied by four valence electrons.

<u>2.60</u> (a) Rb(37): $1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^1$
(b) Sr(38): $1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^2$
(c) Br(35): $1s^22s^22p^63s^23p^64s^23d^{10}4p^5$

<u>2.62</u> The properties are similar because all of them have the same outer-shell electron configuration. They are not identical because each has a different number of filled inner shells.

<u>2.64</u> Going from left to right within a period, increasing positive charge holds onto the outer electrons more tightly, thus decreasing the atomic radius and increasing the ionization energy. So, for the following atoms B, C, and N:
(a) Boron has the largest atomic radius.
(b) Nitrogen has the smallest atomic radius.
(c) Nitrogen has the largest ionization energy.
(d) Boron has the lowest ionization energy.

<u>2.66</u> Ionization energy generally increases from left to right within a period in the Periodic Table and from bottom to top within a column:
(a) K < Na < Li   (b) C < N < Ne   (c) C < O < F   (d) Br < Cl < F

2.68 Following are the ground-state electron configurations of Mg atom, Mg^+, Mg^{2+}, and Mg^{3+}.

Electron configuration	Mg $1s^22s^22p^63s^2$	$\longrightarrow$	Mg^+ + e^- $1s^22s^22p^63s^1$	IE = 738 kJ/mol
Electron configuration	Mg^+ $1s^22s^22p^63s^1$	$\longrightarrow$	Mg^{2+} + e^- $1s^22s^22p^6$	IE = 1450 kJ/mol
Electron configuration	Mg^{2+} $1s^22s^22p^6$	$\longrightarrow$	Mg^{3+} + e^- $1s^22s^22p^5$	IE = 7734 kJ/mol

The first electron is removed from the 3s orbital. The removal of each subsequent electron requires more energy because, after the first electron is removed, each subsequent electron is removed from a positive ion, which strongly attracts the remaining electrons. The third ionization energy is especially large because the electron is removed from the filled second principal energy level, meaning that it is removed from an ion that has the same electron configuration as neon.

2.70 The most abundant elements by weight (a) in the Earth's crust are oxygen and silicon, and (b) in the human body they are oxygen and carbon.

2.72 Bronze is an alloy of copper and tin.

2.74 (a) 1*s* (b) 2*s*, 2*p* (c) 3*s*, 3*p*, 3*d* (d) 4*s*, 4*p*, 4*d*, 4*f*

2.76 (a) The atomic radius decreases going from left to right across a period in the Periodic Table. Although the principal quantum number of the outermost orbital remains the same, as each successive electron is added, the nuclear charge also increases by the addition of one proton. The resulting increased attraction between nucleus and electrons is somewhat stronger than the increasing repulsion between electrons, which causes the atomic radius to decrease.

(b) To pull a valence electron from an atom, energy is required to overcome the attractive forces on the electron from the positively charged nucleus.

2.78 (a) s^2p^1 (b) s^2p^5 (c) s^2p^3

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2.80 (a) Carbon-12 has 6 protons and 6 neutrons. Neutrons contribute 50% of its mass.
(b) Calcium-40 has 20 protons and 20 neutrons. Neutrons contribute 50% of its mass.
(c) Iron-55 has 26 protons and 29 neutrons. Neutrons contribute 53% of its mass.
(d) Bromine-79 has 35 protons and 44 neutrons. Neutrons contribute 56% of its mass.
(e) Platinum-195 has 78 protons and 117 neutrons. Neutrons contribute 60% of its mass.
(f) Uranium-238 has 92 protons and 146 neutrons. Neutrons contribute 61% of its mass.

2.82 (a) P (b) K (c) Na (d) N (e) Br
(f) Ag (g) Ca (h) C (i) Sn (j) Zn

2.84 (a) Silicon is in Group 4A. It has four outer-shell electrons.
(b) Bromine is in Group 7A. It has seven outer-shell electrons.
(c) Phosphorus is in Group 5A. It has five outer-shell electrons.
(d) Potassium is in Group 1A. It has one outer-shell electron.
(e) Helium is in Group 8A. It has two outer-shell electrons.
(f) Calcium is in Group 2A. It has two outer-shell electrons.
(g) Krypton is in Group 8A. It has eight outer-shell electrons.
(h) Lead is in Group 4A. It has four outer-shell electrons.
(i) Selenium is in Group 6A. It has six outer-shell electrons.
(j) Oxygen is in Group 6A. It has six outer-shell electrons.

2.86 (a) An electron has a charge of -1, a proton a charge of +1, and a neutron has no charge.
(b) An electron has a mass of 0.0005 amu; both protons and neutrons have masses of 1 amu.

2.88 Xenon (Xe) will have the highest ionization energy. Ionization energy increases from left to right going across the periodic table.

2.90 Going from left to right across a period in the Periodic Table, protons are being added to the nucleus and electrons are added to the valence shell. For elements in the same period, the principal energy level remains the same (for example, the valence electrons of all second period elements occupy the second principal energy level). But in going from one element to the next across a period, one more proton is added to the nucleus, thus increasing the nuclear charge by one unit for each step from left to right. The result is that the nucleus exerts an increasingly stronger pull on the valence electrons and atomic radius decreases.

2.92 The O^{2-} has a larger radius than F and F^- for several reasons. The most important being that O^{2-} has two (-) charged electrons in excess of the positively charged nucleus. This increases the amount of electron-electron repulsions, expanding the electron cloud relative to F and F^-. Another factor is that oxygen is less electronegative than fluorine, therefore, oxygen holds on to its electrons less tightly.

2.94 The nucleus takes up only a small portion of the size of an atom. The nucleus also holds most of the mass of the atom. Moving from potassium to vanadium, the atomic radii of the atoms get smaller, but the nuclei gain mass, therefore, the density increases.

2.96 (a) Condensed electronic configuration for Ti: $1s^22s^22p^63s^23p^64s^23d^2$
Noble gas notation for Ti: $[Ar]4s^23d^2$

$1s^2$	$2s^2$	$2p^6$			$3s^2$	$3p^6$			$4s^2$	$3d^2$				
↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑	↑			

(b) Condensed electronic configuration for Ti^{2+}: $1s^22s^22p^63s^23p^64s^2$
Noble gas notation for Ti^{2+}: $[Ar]4s^2$

$1s^2$	$2s^2$	$2p^6$			$3s^2$	$3p^6$			$4s^2$
↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓

(c) Condensed electronic configuration for Ti^{4+}: $1s^22s^22p^63s^23p^6$
Noble gas notation for Ti^{4+}: $[Ne]3s^23p^6$

$1s^2$	$2s^2$	$2p^6$			$3s^2$	$3p^6$		
↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓

2.98 The ionization energy is the energy required to remove the most loosely held electron(s) from an atom in the gas phase. The ionization energies of elements decrease going down a group in the Periodic Table. This periodic property occurs because as we go down a group, the valence electrons exist further away from the influence of the positive nucleus, rendering it more easily removed through ionization.

2.100 The reaction of magnesium with oxygen is described as follows:

$$2Mg + O_2 \rightarrow 2MgO$$

$$\text{Mg needed} = \frac{2.00\ \cancel{\text{g MgO}}}{}\left(\frac{1\ \cancel{\text{mol MgO}}}{40.304\ \cancel{\text{g MgO}}}\right)\left(\frac{2\ \cancel{\text{mol Mg}}}{2\ \cancel{\text{mol MgO}}}\right)\left(\frac{24.305\ \text{g Mg}}{1\ \cancel{\text{mol Mg}}}\right) = 1.21\ \text{g}$$

$$O_2\ \text{needed} = \frac{2.00\ \cancel{\text{g MgO}}}{}\left(\frac{1\ \cancel{\text{mol MgO}}}{40.304\ \cancel{\text{g MgO}}}\right)\left(\frac{1\ \cancel{\text{mol O}_2}}{2\ \cancel{\text{mol MgO}}}\right)\left(\frac{32.00\ \text{g O}_2}{1\ \cancel{\text{mol O}_2}}\right) = 0.794\ \text{g}$$

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2.102 The average atomic mass can be calculated as:

$$\left(\frac{90.51}{100} \times 19.992 \text{ amu}\right) + \left(\frac{0.27}{100} \times 20.994 \text{ amu}\right) + \left(\frac{9.22}{100} \times 21.990 \text{ amu}\right) = 20.18 \text{ amu}$$

The element in question is neon (Ne).

2.104 $6.01512 \text{ amu } (x) + 7.01600 \text{ amu } (1 - x) = 6.941 \text{ amu}$

$$x = \frac{(6.941 \text{ amu} - 7.01600 \text{ amu})}{(6.01512 \text{ amu} - 7.01600 \text{ amu})} = 0.0750$$

$x = 0.0750 \times 100\% = 7.50\%$

therefore, ^{6}Li is 7.50% of the isotopic mixture, ^{7}Li is 100% − 7.50% = 92.50%

2.106 We can make the following generalizations. As illustrated by the answer to Problem 2.81, the neutron to proton ratio of the elements generally increases as atomic number increases. For light elements (H through Ca), the stable isotopes usually have equal numbers of protons and neutrons. Beyond calcium (Ca), the neutron/proton ratio becomes increasingly greater than 1.

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