ALWAYS LEARNING PEARSON

CHEMISTRY

THE CENTRAL SCIENCE

BROWN · LEMAY · BURSTEN · MURPHY
WOODWARD · LANGFORD · SAGATYS · GEORGE

3RD EDITION

Chapter 2

Atoms, Molecules and Ions

Visualising Concepts

2.1 (a) The path of the charged particle bends because it is repelled by the negatively charged plate and attracted to the positively charged plate.

(b) Like charges repel and opposite charges attract, so the sign of the electrical charge on the particle is negative.

(c) The greater the magnitude of the charges, the greater the electrostatic repulsion or attraction. As the charge on the plates is increased, the bending will increase.

(d) As the mass of the particle increases and speed and charge stay the same, it is more difficult to deflect the particle from its course and bending decreases. (See **A Closer Look**: The Mass Spectrometer, p. 39.)

2.2 In general, metals occupy the left side of the chart and non-metals the right side.

metals: red and green *non-metals*: blue and yellow

alkaline earth metal: red *noble gas*: yellow

2.3 Since the number of electrons (negatively charged particles) does not equal the number of protons (positively charged particles), the particle is an ion. The charge on the ion is 2−.

Atomic number = number of protons = 16. The element is S, sulfur.

Mass number = protons + neutrons = 32

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

2.4 In a solid, particles are close together and their relative positions are fixed. In a liquid, particles are close but moving relative to each other. In a gas, particles are far apart and moving. All ionic compounds are solids because of the strong forces among charged particles. Molecular compounds can exist in any state: solid, liquid, or gas.

Since the molecules in *ii* are far apart, *ii* must be a molecular compound. The particles in *i* are near each other and exist in a regular, ordered arrangement, so *i* is likely to be an ionic compound.

2.5 Formula: IF_5 Name: iodine pentafluoride
Since the compound is composed of elements that are all non-metals, it is molecular.

2.6 Cations (red spheres) have positive charges; anions (blue spheres) have negative charges. There are twice as many anions as cations, so the formula has the general form CA_2. Only $Ca(NO_3)_2$, calcium nitrate, is consistent with the diagram.

Atomic Theory and the Discovery of Atomic Structure

2.7 Postulate 4 of the atomic theory is the *law of constant composition*. It states that the relative number and kinds of atoms in a compound are constant, regardless of the source. Therefore, 1.000 g of pure water should always contain the same relative amounts of hydrogen and oxygen, no matter where or how the sample is obtained.

2.8 (a) 6.500 g compound – 0.384 g hydrogen = 6.116 g sulfur

(b) *Conservation of mass*

(c) According to postulate 3 of the atomic theory, atoms are neither created nor destroyed during a chemical reaction. If 0.384 g of H are recovered from a compound that contains only H and S, the remaining mass must be sulfur.

2.9 (a) $\frac{17.60 \text{ g oxygen}}{30.82 \text{ g nitrogen}} = \frac{0.5711 \text{ g O}}{1 \text{ g N}}$; $0.5711/0.5711 = 1.0$

$\frac{35.20 \text{ g oxygen}}{30.82 \text{ g nitrogen}} = \frac{1.142 \text{ g O}}{1 \text{ g N}}$; $1.142/0.5711 = 2.0$

$\frac{70.40 \text{ g oxygen}}{30.82 \text{ g nitrogen}} = \frac{2.284 \text{ g O}}{1 \text{ g N}}$; $2.284/0.5711 = 4.0$

$\frac{88.00 \text{ g oxygen}}{30.82 \text{ g nitrogen}} = \frac{2.855 \text{ g O}}{1 \text{ g N}}$; $2.855/0.5711 = 5.0$

(b) These masses of oxygen per one gram nitrogen are in the ratio of 1:2:4:5 and thus obey the *law of multiple proportions*. Multiple proportions arise because atoms are the indivisible entities combining, as stated in Dalton's theory. Since atoms are indivisible, they must combine in ratios of whole numbers.

2.10 (a) 1: $\frac{3.56 \text{ g fluorine}}{4.75 \text{ g iodine}} = 0.749$ g fluorine/1 g iodine

2: $\frac{3.43 \text{ g fluorine}}{7.64 \text{ g iodine}} = 0.449$ g fluorine/1 g iodine

3: $\frac{9.86 \text{ g fluorine}}{9.41 \text{ g iodine}} = 1.05$ g fluorine/1 g iodine

(b) To look for integer relationships among these values, divide each one by the smallest.

If the quotients aren't all integers, multiply by a common factor to obtain all integers.

1: 0.749/0.449 = 1.67; 1.67 $\times$ 3 = 5

2: 0.449/0.449 = 1.00; 1.00 $\times$ 3 = 3

3: 1.05/0.449 = 2.34; 2.34 $\times$ 3 = 7

The ratio of g fluorine to g iodine in the three compounds is 5:3:7. These are in the ratio of small whole numbers and, therefore, obey the *law of multiple proportions*. This integer ratio indicates that the combining fluorine 'units' (atoms) are indivisible entities.

2.11 Evidence that cathode rays were negatively charged particles was (1) that electric and magnetic fields deflected the rays in the same way they would deflect negatively charged particles and (2) that a metal plate exposed to cathode rays acquired a negative charge.

2.12 Since the unknown particle is deflected in the opposite direction from that of a negatively charged beta (β) particle, it is attracted to the (–) plate and repelled by the (+) plate. The unknown particle is positively charged. The magnitude of the deflection is less than that of the β particle, or electron, so the unknown particle has greater mass than the electron, because no particle has yet been discovered with a smaller charge than the electron. The unknown is a positively charged particle of greater mass than the electron.

2.13 (a) If the positive plate were lower than the negative plate, the oil drops 'coated' with negatively charged electrons would be attracted to the positively charged plate and would descend much more quickly.

(b) The more times a measurement is repeated, the better the chance of detecting and compensating for experimental errors. That is, if a quantity is measured five times and four measurements agree but one does not, the measurement that disagrees is probably the result of an error. Also, the four measurements that agree can be averaged to compensate for small random fluctuations. Millikan wanted to demonstrate the validity of his result via its reproducibility. By varying the size of the droplets, he could also measure and correct for a source of systematic error- the different air resistance experienced by different-sized droplets.

Modern View of Atomic Structure: Atomic Mass

2.14 (a) $1\,pm = 1 \times 10^{-12}$ m, $1\text{nm} = 1 \times 10^{-9}$ m, $1\text{pm} = 1 \times 10^{-3}$nm

$190 \times (1 \times 10^{-3}\text{ nm}) = 0.19\text{nm}$

(b) Aligned Kr atoms have **diameters** touching. $d = 2r = 2(190\text{ pm}) = 380\text{ pm}$

$$\text{number of atoms} = \frac{1.0\text{ mm}}{380 \times (1 \times 10^{-9}\text{ mm})} = 2.6 \times 10^{6}\text{ Kr atoms}$$

(c) $r = 190 \times (1 \times 10^{-10}\text{ cm}) = 190 \times 10^{-10}\text{ cm}$

$V = 4/3\,\pi\,r^3 = (4/3) \times \pi \times (190 \times 10^{-10}\text{ cm})^3 = 2.9 \times 10^{-23}\text{ cm}^3$

2.15 (a) $$r = \frac{2.8 \times 10^{-8}}{2} \times (1 \times 10^{10}\text{ pm}) = 140\text{ pm}$$

$$r = \frac{2.8 \times 10^{-8}}{2} \times (1 \times 10^{-2}\text{m}) = 1.4 \times 10^{-10}\text{m}$$

(b) $1\text{ cm} = 1 \times 10^{4}\ \mu\text{m}$

$$\frac{6.0\ \mu\text{m}}{2.8 \times 10^{-8} \times (1 \times 10^{4}\ \mu\text{m})} = 2.1 \times 10^{4}\text{ Sn atoms}$$

(c) $V = 4/3\,\pi\,r^3$; $r = 1.4 \times 10^{-10}$ m

$V = (4/3)[(\pi(1.4 \times 10^{-10})^3]\text{ m}^3 = 1.149 \times 10^{-29} = 1.1 \times 10^{-29}\text{ m}^3$

2.16 (a) *Atomic number* is the number of protons in the nucleus of an atom. *Mass number* is the total number of nuclear particles, protons plus neutrons, in an atom.

(b) The mass number can vary without changing the identity of the atom, but the atomic number of every atom of a given element is the same.

2.17 (a) $^{31}_{16}\text{X}$ and $^{32}_{16}\text{X}$ are isotopes of the same element, because they have identical atomic numbers.

(b) These are isotopes of the element sulfur, S, atomic number = 16.

2.18 p = protons, n = neutrons, e = electrons

(a) ^{40}Ar has 18 p, 22 n, 18 e

(b) ^{65}Zn has 30 p, 35 n, 30 e

(c) ^{70}Ga has 31 p, 39 n, 31 e

(d) ^{80}Br has 35 p, 45 n, 35 e

(e) ^{184}W has 74 p, 110 n, 74 e

(f) ^{243}Am has 95 p, 148 n, 95 e

2.19 (a) ^{32}P has 15 p, 17 n (b) ^{51}Cr has 24 p, 27 n

(c) ^{60}Co has 27 p, 33 n (d) ^{99}Tc has 43 p, 56 n

(e) ^{131}I has 53 p, 78 n (f) ^{201}Tl has 81 p, 120 n

2.20

Symbol	^{52}Cr	^{55}Mn	^{112}Cd	^{222}Rn	^{207}Pb
Protons	24	25	48	86	82
Neutrons	28	30	64	136	125
Electrons	24	25	48	86	82
Mass no.	52	55	112	222	207

2.21 (a) $^{196}_{78}Pt$ (b) $^{84}_{36}Kr$ (c) $^{75}_{33}As$ (c) $^{24}_{12}Mg$

2.22 Since the two nuclides are atoms of the same element, by definition they have the same number of protons, 54. They differ in mass number (and mass) because they have different numbers of neutrons. ^{129}Xe has 75 neutrons and ^{130}Xe has 76 neutrons.

2.23 (a) $^{12}_{6}C$

(b) Atomic masses are really average atomic masses, the sum of the mass of each naturally occurring isotope of an element times its fractional abundance. Each B atom will have the mass of one of the naturally occurring isotopes, while the "atomic mass" is an average value. The naturally occurring isotopes of B, their atomic masses, and relative abundances are:

^{10}B, 10.012937, 19.9%; ^{11}B, 11.009305, 80.1%.

2.24 (a) 12 u

(b) The atomic mass of carbon reported on the front-inside cover of the text is the abundance-weighted average of the atomic masses of the two naturally occurring isotopes of carbon, ^{12}C, and ^{13}C. The mass of a ^{12}C atom is exactly 12 u, but the average atomic mass of 12.011 takes into account the presence of some ^{13}C atoms in every natural sample of the element.

2.25 Average atomic mass = Σ fractional abundance $\times$ mass of isotope

Average atomic mass = 0.014(203.97302) + 0.241(205.97444) + 0.221(206.97587) + 0.524(207.97663) = 207.22 = 207 u
(The result has 0 decimal places and 3 sig figs because the fourth term in the sum has 3 sig figs and 0 decimal places.)

The Periodic Table: Molecules and Ions

2.26 (a) Cr (metal) (b) He (non-metal) (c) P (non-metal)
(d) Zn (metal) (e) Mg (metal) (f) Br (non-metal)
(g) As (metalloid)

2.27 (a) sodium (metal) (b) titanium (metal)
(c) gallium (metal) (d) uranium (metal)
(e) palladium (metal) (f) selenium (non-metal)
(g) krypton (non-metal)

2.28 An *empirical formula* shows the simplest ratio of the different atoms in a molecule.

A *molecular formula* shows the exact number and kinds of atoms in a molecule.

A *structural formula* shows how these atoms are arranged.

2.29 Compounds with the same empirical but different molecular formulae differ by the integer number of empirical formula units in the respective molecules. Thus they can have very different molecular structure, size and mass, resulting in very different physical properties.

2.30 (a) $AlBr_3$ (b) C_4H_5 (c) C_2H_4O (d) P_2O_5
(e) C_3H_2Cl (f) BNH_2

2.31 A molecular formula contains all atoms in a molecule. An empirical formula shows the simplest ratio of atoms in a molecule or elements in a compound.

(a) molecular formula: C_6H_6; empirical formula: CH

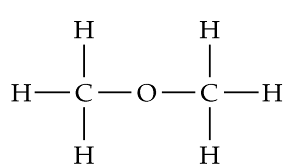
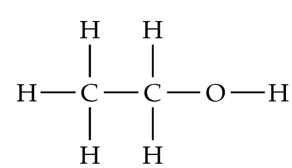
(b) molecular formula: $SiCl_4$; empirical formula: $SiCl_4$ (1:4 is the simplest ratio)

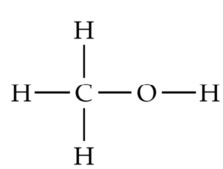
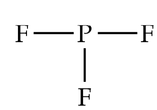
(c) molecular: B_2H_6; empirical: BH_3

(d) molecular: $C_6H_{12}O_6$; empirical: CH_2O

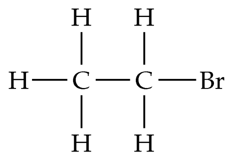
2.32 (a) 6 (b) 6 (c) 12

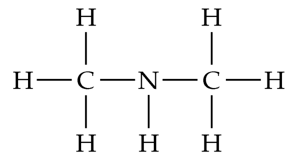
2.33 (a) 4 (b) 6 (c) 9

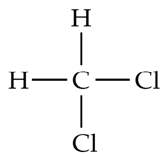
2.34 (a) C_2H_6O  (b) C_2H_6O 

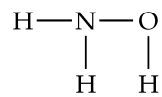
(c) CH_4O  (d) PF_3 

2.35

(a) C_2H_5Br 

(b) C_2H_7N 

(c) CH_2Cl_2 

(d) NH_2OH 

2.36

Symbol	$^{59}Co^{3+}$	$^{80}Se^{2-}$	$^{192}Os^{2+}$	$^{200}Hg^{2+}$
Protons	27	34	76	80
Neutrons	32	46	116	120
Electrons	24	36	74	78
Net Charge	3+	2–	2+	2+

2.37

Symbol	$^{75}As^{3-}$	$^{59}Ni^{2+}$	$^{127}I^{-}$	$^{197}Au^{3+}$
Protons	33	28	53	79
Neutrons	42	31	74	118
Electrons	36	26	54	76
Net Charge	3–	2+	1–	3+

2.38 (a) Mg^{2+} (b) Al^{3+} (c) K^{+} (d) S^{2-} (e) F^{-}

2.39 (a) Sr^{2+} (b) Sc^{3+} (c) P^{3-} (d) I^{-} (e) Se^{2-}

2.40 (a) GaF_3, gallium(III) fluoride (b) LiH, lithium hydride

(c) AlI_3, aluminium iodide (d) K_2S, potassium sulfide

2.41 (a) AgI (b) Ag_2S (c) AgF

Naming Inorganic Compounds; Organic Molecules

2.42 (a) ClO_2^- (b) Cl^- (c) ClO_3^- (d) ClO_4^-

(e) ClO^-

2.43 (a) selenate (b) selenide (c) hydrogen selenide (biselenide)

(d) hydrogen selenite (biselenite)

2.44 (a) magnesium oxide (b) aluminium chloride

(c) lithium phosphate (d) barium perchlorate

(e) copper(II) nitrate (cupric nitrate) (f) iron(II) hydroxide (ferrous hydroxide)

(g) calcium acetate (h) chromium(III) carbonate (chromic carbonate)

(i) potassium chromate (j) ammonium sulfate

2.45 (a) lithium oxide (b) sodium hypochlorite

(c) strontium cyanide (d) chromium(III) hydroxide (chromic hydroxide)

(e) iron(III) carbonate (ferric carbonate) (f) cobalt(II) nitrate (cobaltous nitrate)

(g) ammonium sulfite (h) sodium dihydrogen phosphate

(i) potassium permanganate (j) silver dichromate

2.46 (a) $Al(OH)_3$ (b) K_2SO_4 (c) Cu_2O (d) $Zn(NO_3)_2$

(e) $HgBr_2$ (f) $Fe_2(CO_3)_3$ (g) $NaBrO$

2.47 (a) Na_3PO_4 (b) $Co(NO_3)_2$ (c) $Ba(BrO_3)_2$
(d) $Cu(ClO_4)_2$

(e) $Mg(HCO_3)_2$ (f) $Cr(CH_3COO)_3$ (g) $K_2Cr_2O_7$

2.48 (a) bromic acid (b) hydrobromic acid (c) phosphoric acid

(d) $HClO$ (e) HIO_3 (f) H_2SO_3

2.49 (a) HBr (b) H_2S (c) HNO_2

(d) carbonic acid (e) chloric acid (f) acetic acid

2.50 (a) sulfur hexafluoride (b) iodine pentafluoride (c) xenon trioxide

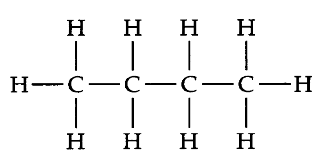
(d) N_2O_4 (e) HCN (f) P_4S_6

2.51 (a) dinitrogen monoxide (b) nitrogen monoxide
(c) nitrogen dioxide (d) dinitrogen pentoxide
(e) dinitrogen tetroxide

2.52 (a) $ZnCO_3$, ZnO, CO_2 (b) HF, SiO_2, SiF_4, H_2O
(c) SO_2, H_2O, H_2SO_3 (d) PH_3
(e) $HClO_4$, Cd, $Cd(ClO_4)_2$ (f) VBr_3

2.53 (a) A hydrocarbon is a compound composed of the elements hydrogen and carbon only.

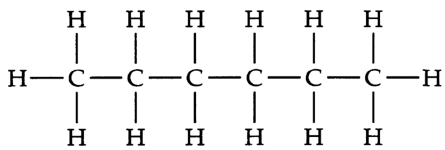
(b)



molecular: C_4H_{10}
empirical: C_2H_5

2.54 (a) -ane

(b) Hexane has 6 carbons in its chain.

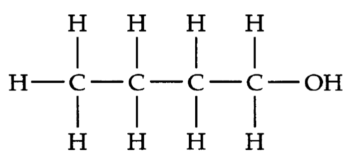


molecular: C_6H_{14}
empirical: C_3H_7

2.55 (a) A function group is a group of specific atoms that are constant from one molecule to the next. For example, the alcohol functional group is an –OH. Whenever a molecule is called an alcohol, it contains the –OH group.

(b) -OH

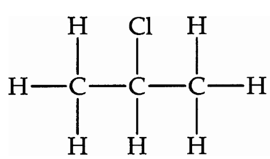
(c)

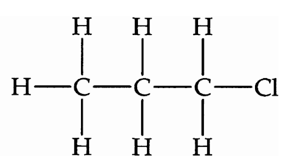


2.56 (a) They both have two carbon atoms in their molecular backbone, or chain.

(b) In 1-proanol, one of the H atoms on an outer (terminal) C atoms has been replaced by an –OH group.

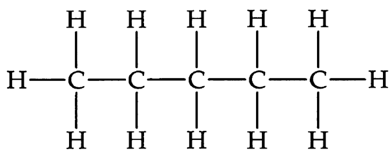
2.57 (a)

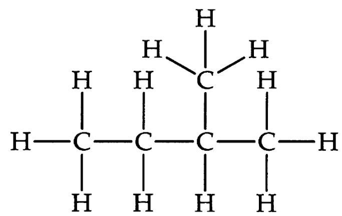


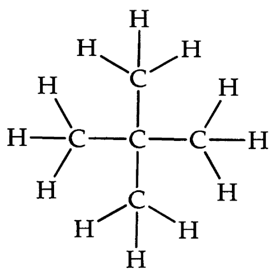


(b) 2-chloropropane 1-chloropropane

2.58







Additional Exercises

2.59 (a) Since most of the α particles passed through the gold foil and were not deflected, Rutherford determined that most of the volume of an atom is empty space where the electrons move around.

(b) Since only a few α particles were deflected, Rutherford determined that atoms have a small, positively charged centre he called the nucleus.

(c) Beryllium has a smaller radius than gold, so there is less empty space between atoms. With less empty space, α particles would be more likely to come close enough to the nucleus to be deflected. However, beryllium has a smaller positive charge than gold, so the deflection will not be as drastic.

2.60 (a) ^{3}He has 2 protons, 1 neutron, and 2 electrons.

(b) ^{3}H has 1 proton, 2 neutrons, and 1 electron.

^{3}He: $2(1.6726231 \times 10^{-24}\text{ g}) + 1.6749286 \times 10^{-24}\text{ g} + 2(9.1093897 \times 10^{-28}\text{ g}) = 5.021996 \times 10^{-24}\text{ g}$

^{3}H: $1.6726231 \times 10^{-24}\text{ g} + 2(1.6749286 \times 10^{-24}\text{ g}) + 9.1093897 \times 10^{-28}\text{ g} = 5.023391 \times 10^{-24}\text{ g}$

Tritium, ^{3}H, should be more massive.

(c) The masses of the two particles differ by 0.0014×10^{-24} g. Each particle loses

1 electron to form the +1 ion, so the difference in the masses of the ions is still 1.4×10^{-27}. A mass spectrometer would need precision to 1×10^{-27} g to differentiate $^{3}He^{+}$ and ^{3}H.

2.61 (a) Calculate the mass of a single gold atom, then divide the mass of the cube by the mass of the gold atom.

$$\frac{197.0\ \text{u}}{\text{gold atom}} \times \frac{1\ \text{g}}{6.022 \times 10^{23}\ \text{u}} = 3.2713 \times 10^{-22} = 3.271 \times 10^{-22}\ \text{g/gold atom}$$

$$\frac{19.3\,\text{g}}{\text{cube}} \times \frac{1\,\text{gold atom}}{3.271 \times 10^{-22}\ \text{g}} = 5.90 \times 10^{22}\ \text{Au atoms in the cube}$$

(b) The shape of atoms is spherical; spheres cannot be arranged into a cube so that there is no empty space. The question is, how much empty space is there? We can calculate the two limiting cases, no empty space and maximum empty space. The true diameter will be somewhere in this range.

No empty space: volume cube/number of atoms = volume of one atom

vol. of cube = $(1.0 \times 1.0 \times 1.0)\ \text{cm}^3 = 1.0\ \text{cm}^3$

$$\text{vol. of one atom} = \frac{1.0\ \text{cm}^3}{5.90 \times 10^{22}\ \text{Au atoms}} = 1.695 \times 10^{-23}$$

$$= 1.7 \times 10^{-23}\text{cm}^3$$

$V = 4/3\pi\, r^3$; $r = (3V/4\pi)^{1/3}$; $d = 2r$

r = $[3\ (1.695 \times 10^{-23}\ \text{cm}^3)/4\pi]^{1/3} = 1.6 \times 10^{-8}$ cm; $d = 2r = 3.2 \times 10^{-8}$ cm

Centimetres can then be converted into picometres.

1 pm = 1×10^{-12} m, 1 cm = 1×10^{-2} m, 1 cm = 1×10^{10} pm
$3.2 \times 10^{-8} \times (1 \times 10^{10}$ pm) = 320 pm

Maximum empty space: assume atoms are arranged in rows in all three directions so they are touching across their diameters. That is, each atom occupies the volume of a cube, with the atomic diameter as the length of the side of the cube. The number of atoms along one edge of the gold cube is then

$(5.90 \times 10^{22})^{1/3} = 3.893 \times 10^7 = 3.89 \times 10^7$ atoms/1.0 cm.

The diameter of a single atom is 1.0 cm/3.89×10^7 atoms = $2.569 \times 10^{-8} = 2.6 \times 10^{-8}$ cm.
$2.6 \times 10^{-8} \times (1 \times 10^{10}$ pm) = 260 pm

The diameter of a gold atom is between 260 pm and 320 pm

Some atomic arrangement must be assumed, since none is specified. The solid state is characterised by an orderly arrangement of particles, so it isn't surprising that atomic arrangement is required to calculate the density of a solid.

2.62 (a) The purpose of the magnet in a mass spectrometer is to deflect that positively charged particles into a curved path to the detector. At the same time, particles will be separated due to different masses by the magnetic field created.

(b) The reported mass of an element is a weighted average based on the abundance of each of that element's isotopes. The masses of the two isotopes for chlorine are 35 and 37. Since the spectrum shows a much higher abundance of ^{35}Cl, it would make sense that the weighted average of the mass of chlorine would be between 35 and 37, being closer to 35.

(c) Since a phosphorous spectrum only shows a single peak, phosphorous does not have any other stable isotopes.

2.63 (a) $^{16}_{8}O$, $^{17}_{8}O$, $^{18}_{8}O$

(b) All isotopes are atoms of the same element, oxygen, with the same atomic number (Z = 8), 8 protons in the nucleus and 8 electrons. Elements with similar electron arrangements have similar chemical properties (Section 2.5). Since the 3 isotopes all have 8 electrons, we expect their electron arrangements to be the same and their chemical properties to be essentially identical. Each has a different number of neutrons (8, 9, or 10), a different mass number (A = 16, 17, or 18) and thus a different atomic mass. Because of these different masses, you would expect the densities of these three isotopes of oxygen to be different.

2.64 $F = k\, q_1 q_2/r^2$; $k = 9.0 \times 10^9$ N m^2 C^{-2}; r = 0.53×10^{-10} m;

q_1 (electron) = -1.6×10^{-19} C; q_2 (proton) = $-q_1$ (electron) = 1.6×10^{-19} C

$$F = \frac{9.0\times10^{9}\,\text{N m}^2\,\text{C}^{-2} \times -1.6\times10^{-19}\,\text{C} \times 1.6 \times 10^{-19}\,\text{C}}{(0.53 \times 10^{-10})^2\,\text{m}^2} = -8.202\times10^{-8} = -8.2\times10^{-8}\,\text{N}$$

The negative sign tell us that the force is attractive.

2.65 (a) The 68.926 u isotope has a mass number of 69, with 31 protons, 38 neutrons and the symbol $^{69}_{31}Ga$. The 70.925 u isotope has a mass number of 71, 31 protons, 40 neutrons and symbol $^{71}_{31}Ga$. (All Ga atoms have 31 protons.)

(b) The average mass of a Ga atom is 69.72 u. Let *x* = abundance of the lighter isotope, 1–*x* = abundance of the heavier isotope. Then $x(68.926) + (1-x)(70.925) = 69.72$; $x = 0.6028 = 0.603$, ^{69}Ga = 60.3%, ^{71}Ga = 39.7%.

2.66 copper: Cu, 11

tin: Sn, 14

zinc: Zn, 12

phosphorus: P, 15

lead: Pb, 14

2.67 (a) an alkali metal: K (b) an alkaline earth metal: Ca (c) a noble gas: Ar

(d) a halogen: Br (e) a metalloid: Ge (f) a non-metal in 1: H

(g) a metal that forms a 3+ ion: Al (h) a non-metal that forms a 2– ion: O

(i) an element that resembles Al: Ga

2.68 (a) chlorine gas, Cl_2: ii (b) propane, C_3H_8: v
(c) nitrate ion, NO_3^- : I (d) sulfur trioxide, SO_3: iii
(e) methyl chloride, CH_3Cl: iv

2.69 (a) nickel(II) oxide, 2+ (b) manganese(IV) oxide, 4+

(c) chromium(III) oxide, 3+ (d) molybdenum(VI) oxide, 6+

2.70 (a) IO_3^- (b) IO_4^- (c) IO^- (d) HIO
(e) HIO_4 or (H_5IO_6)

2.71 (a) perbromate anion (b) selenite anion

(c) AsO_4^{3-} (d) $HTeO_4^-$

2.72 (a) sodium chloride (b) sodium bicarbonate (or sodium hydrogen carbonate)

(c) sodium hypochlorite (d) sodium hydroxide

(e) ammonium carbonate (f) calcium sulfate