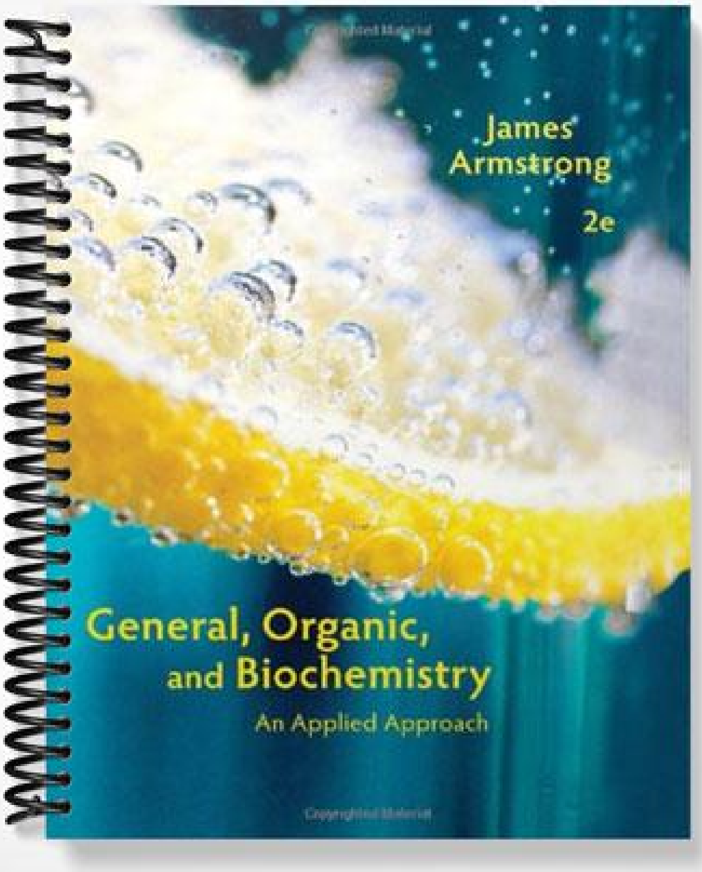
SOLUTIONS MANUAL



Atoms, Elements, Compounds

This chapter introduces the fundamental ideas of matter. Mixtures, compounds and elements are defined. The periodic table is presented early and periodic law towards the end of the chapter. Atoms and atomic structure are detailed, including isotopes, atomic weight, and rudimental shell information. Finally, moles and chemical formulas are introduced.

Sample Problem 2.1

Intensive

Sample Problem 2.2

30 protons, 36 neutrons

Sample Problem 2.3

shell 1: 2 electrons shell 2: 8 electrons shell 3: 7 electrons

Sample Problem 2.4

6 valence electrons; similar to sulfur

Sample Problem 2.5

Sample Problem 2.6

Si or Ge

Sample Problem 2.7

7 valence electrons in the fifth shell

Sample Problem 2.8

1 valence electron

Group IA

Cs

Sample Problem 2.9

$$191\,\text{g C} \times \frac{1\,\text{mol}}{12.01\,\text{g}} = 15.9\,\text{mol C}$$

Sample Problem 2.10

$NaHCO_3$

Sample Problem 2.11

$(2 \times 12.01) + (6 \times 1.01) + 16.00 = 46.08$ amu

$$118.2\text{ g ethanol} \times \frac{1\text{ mol}}{46.08\text{ g}} = 2.565\text{ mol ethanol}$$

CORE PROBLEMS

2.1

a) a homogeneous mixture as the salt will dissolve

b) a heterogeneous mixture as the pepper will not dissolve

2.2

a) a homogeneous mixture as the soap will dissolve

b) a heterogeneous mixture as the candle wax will not dissolve

2.3

a) intensive

b) extensive

c) extensive

d) intensive

2.4

a) intensive

b) intensive

c) extensive

d) extensive

2.5

a) a compound – it can be broken down but the ratio of the components never changes.

b) Not enough information to tell about quicklime.

2.6

a) Not enough information to tell about dephlogisticated air.

b) a compound – it can be broken down but the ratio of the components never changes

2.7 As the combined result is so different from the starting species, it is likely to be a compound.

2.8 As the combined result is so different from the starting species, it is likely to be a compound.

2.9

a) carbon
b) nitrogen
c) chlorine
d) magnesium
e) cobalt
f) selenium

2.10

a) hydrogen
b) oxygen
c) calcium
d) chromium
e) iodine
f) barium

2.11

a) Fe
b) Na
c) Ag
d) Pb

2.12

a) K
b) Hg
c) Au
d) Sn

2.13

a) electrons
b) protons¸ neutrons
c) protons
d) protons, electrons

2.14

a) electrons
b) neutrons
c) protons, neutrons

d) electrons

2.15

a) 16 + 17 = 33

b) 16

c) 33 amu

d) sulfur

2.16

a) 20+22 = 20

c) 42 amu

d) calcium

2.17 Atomic number = protons and electrons. So there are 47 of each.

Mass number = 107 = number of protons plus number of neutrons

So number of neutrons = 107 – 47 = 60

2.18 Atomic number = protons and electrons. So there are 29 of each.

Mass number = number of protons plus number of neutrons

So number of neutrons = 63 – 29 = 34

2.19 It is the mass number – which is number of protons plus number of neutrons. All oxygen atoms have the same number of protons (8); different isotopes have different numbers of neutrons. Thus, the mass number is used to identify the isotope.

2.20 It is the mass number – which is number of protons plus number of neutrons. All potassium atoms have the same number of protons (19); different isotopes have different numbers of neutrons. Thus, the mass number is used to identify the isotope.

2.21 c) – electrons can go anywhere

2.22 c) – electrons can go anywhere

2.23

a) shell 1: 2 electrons shell 2: 5 electrons

b) shell 1: 2 electrons shell 2: 8 electrons shell 3: 2 electrons

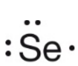
2.24

a) shell 1: 2 electrons shell 2: 7 electrons

b) shell 1: 2 electrons shell 2: 8 electrons shell 3: 5 electrons

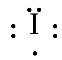
2.25

a) 6

b) 

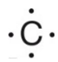
2.26

a) 7

b) 

2.27

a) 4

b) 

2.28

a) 2

b) 

2.29 C and Si

2.30 B and Al

2.31

a) O, S, or Se

b) Sn or Pb

c) Ge or As

d) Lots. All in IA, IIA, Al and below in IIIA, Sn, Pb, Bi, and all group B elements.

e) Cl

f) Be, Mg, Ca, Sr, Ba, Ra.

2.32

a) Sn or Pb

b) None

c) As or Sb

d) Cl etc

e) K

f) He etc

2.33 metal as it is shiny, conducts electricity etc (it's actually niobium)

2.34 nonmetal as it does not conduct electricity (it's actually sulfur)

2.35 There are 6 valence electrons in Se in the 4^{th} shell.

2.36 There are 2 valence electrons in Sr in the 5^{th} shell.

2.37

a) 1

b) 1A

c) 5th

2.38

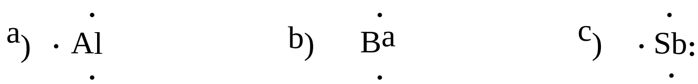
a) 2

b) 2A

c) 7th

2.39

2.40



2.41

a) Bi

b) Cs, Ba, Tl, Pb, Bi, Po, At, Rn

c) Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn

d) S, Se, Te, Po, Lv

2.42

a) C

b) Rb, Sr, or In through Xe

c) La through Hg

d) Be, Ca, Sr, Ba, Ra

2.43

a) Yes – both are potassium atoms with different masses.

b) no – different types of atoms, one with 7 protons (N), one with 8 protons (O).

2.44

a) no – different types of atoms

b) Yes – both have 7 protons (nitrogen); the first with 7 neutrons is N-14; the second with 8 neutrons is N-15.

2.45

a) no – different number of protons

b) no – different number of protons

c) Yes – same number of protons

2.46

a) Yes – same number of protons

b) no – different number of protons

c) no – different number of protons

2.47

a) no – this is only the weighted average

b) no – half could weigh 196 and half 198

c) no – same as b

d) therefore correct!

2.48

a) no – this is only the weighted average

b) no copper atoms weigh 63.55 amu

c) no – there is reason to assume that each isotope has the same abundance

d) therefore correct!

2.49

a) 35.45 amu

b) 35.45 g

2.50

a) 39.10 amu

b) 39.10 g

2.51

a) $82.77\text{ g Na} \times \dfrac{1\text{ mol}}{22.99\text{ g}} = 3.600\text{ mol Na}$

b) $2.31\text{ g Cu} \times \dfrac{1\text{ mol}}{63.55\text{ g}} = 0.0363\text{ mol Cu}$

c) $2.5\times10^{8}\text{ g Pb} \times \dfrac{1\text{ mol}}{207.2\text{ g}} = 1.2\times10^{6}\text{ mol Pb}$

2.52

a) $982\text{ g C}\times\dfrac{1\text{ mol}}{12.01\text{ g}} = 81.8\text{ mol C}$

b) $0.3380\text{ g Fe} \times \dfrac{1\text{ mol}}{55.85\text{ g}} = 6.9052\ 10^{-3}\text{ mol Fe}$

c) $6.1 \times 10^{-5}\text{ g S} \times \dfrac{1\text{ mol}}{32.06\text{ g}} = 1.9 \times 10^{-6}\text{ mol S}$

2.53

a) $2.33\text{ mol Zn} \times \dfrac{65.38\text{ g}}{1\text{ mol}} = 152\text{ g Zn}$

b) $0.02155\text{ mol Br} \times \dfrac{79.90\text{ g}}{1\text{ mol}} = 1.722\text{ g Br}$

2.54

a) $16.15\text{ mol He} \times \dfrac{4.003\text{ g}}{1\text{ mol}} = 64.65\text{ g He}$

b) $0.00336\text{ mol Cr} \times \dfrac{52.0\text{ g}}{1\text{ mol}} = 0.175\text{ g Cr}$

2.55 $C_{12}H_{22}O_{11}$

2.56 $C_6H_5NO_2$

2.57

a) An atom of sodium (Na), five atoms of carbon (C), eight atoms of hydrogen (H), one atom of nitrogen (N), and four atoms of oxygen (O).

b) 3 × 5 = 15

2.58

a) 16 carbon; 18 hydrogen; 2 nitrogen; 5 oxygen; 1 sulfur

b) 4 × 18 = 72

2.59

a) (2 × 22.99) + 12.01 + (3 × 16.00) = 105.99 amu

b) (2 × 22.99) + 12.01 + (3 × 16.00) = 105.99 g

2.60

a) (3 × 107.87) + 30.97 + (4 × 16.00) = 418.58 amu

b) (3 × 107.87) + 30.97 + (4 × 16.00) = 418.58 g

2.61

a) $$13.47\text{ g KMnO}_4 \times \frac{1\text{ mol KMnO}_4}{158.04\text{ g KMnO}_4} = 0.08523\text{ mol KMnO}_4$$

b) $$12.99\text{ g C}_9\text{H}_{11}\text{NO}_2 \times \frac{1\text{ mol C}_9\text{H}_{11}\text{NO}_2}{165.21\text{ g C}_9\text{H}_{11}\text{NO}_2} = 0.07863\text{ mol C}_9\text{H}_{11}\text{NO}_2$$

c) $$6.47\text{ kg C}_9\text{H}_8\text{O}_4 \times \frac{1000\text{ g}}{1\text{ kg}} \times \frac{1\text{ mole C}_9\text{H}_8\text{O}_4}{180.17\text{ g C}_9\text{H}_8\text{O}_4} = 35.9\text{ mol C}_9\text{H}_8\text{O}_4$$

2.62

a) $$6.131\text{ g Al}_2\text{O}_3 \times \frac{1\text{ mol Al}_2\text{O}_3}{101.96\text{ g Al}_2\text{O}_3} = 0.06013\text{ mol Al}_2\text{O}_3$$

b) $$29.06\text{ g C}_7\text{H}_5\text{NO}_3\text{S} \times \frac{1\text{ mol C}_7\text{H}_5\text{NO}_3\text{S}}{183.2\text{ g C}_7\text{H}_5\text{NO}_3\text{S}} = 0.1586\text{ mol C}_7\text{H}_5\text{NO}_3\text{S}$$

c) $$822\text{ mg H}_2\text{O}_2 \times \frac{1\text{ g}}{1000\text{ mg}} \times \frac{1\text{ mole H}_2\text{O}_2}{34.02\text{ g H}_2\text{O}_2} = 0.0242\text{ mol H}_2\text{O}_2$$

2.63

a) $$0.381\text{ mol KClO}_4 \times \frac{138.55\text{ g KClO}_4}{1\text{ mol KClO}_4} = 52.8\text{ g KClO}_4$$

b) $$13.77\text{ mol C}_9\text{H}_{11}\text{NO}_2 \times \frac{165.21\text{ g C}_9\text{H}_{11}\text{NO}_2}{1\text{ mol C}_9\text{H}_{11}\text{NO}_2} = 2{,}275\text{ g C}_9\text{H}_{11}\text{NO}_2$$

2.64

a) $$6.65\text{ mol ZnBr}_2 \times \frac{225.18\text{ g ZnBr}_2}{1\text{ mol ZnBr}_2} = 1.50 \times 10^3\text{ g ZnBr}_2$$

b) $$0.0304\text{ mol C}_6\text{H}_8\text{O}_7 \times \frac{192.14\text{ g C}_6\text{H}_8\text{O}_7}{1\text{ mol C}_6\text{H}_8\text{O}_7} = 5.84\text{ g C}_6\text{H}_8\text{O}_7$$

2.65

a) 1, 2

b) 207.2, 70.9

2.66

a) 2, 3

b) 53.96, 48.00

CONCEPT QUESTIONS

2.67

a) Both mixtures and compounds are made up of two or more other substances, but mixtures have variable composition (any proportions of the other substances can be mixed, within certain limits) while compounds have constant composition (only certain very specific amounts of two or more elements will combine to form a compound).

b) Both elements and compounds are pure substances (cannot be separated into two or more other substances by physical processes). However, compounds can be broken down into two or more other substances by chemical processes, while elements cannot.

2.68 Yes. If you add enough salt so that there is a saturated solution, extra salt added will not dissolve. You will have a solid and liquid together.

2.69 Physiological saline is a mixture, not a compound. Here are three possible ways to explain or rationalize this:

(1) While the term “physiological saline” is only applied to a mixture that has the composition above, those percentages are agreed upon by humans, they aren’t a law of nature. (It’s essentially a labeling law—similar to the rule for the maximum amount of fat a product could contain and still be labeled “low-fat.”) Salt and water can be mixed in any proportions to make saltwater.

(2) The salt and water are not chemically bonded to each other; they can still be easily separated by physical methods (for example, letting the water evaporate away from the salt). This is a characteristic of mixtures.

(3) The mixture of salt and water looks like one of its components (water) and has properties that are a combination of those of the components, a common characteristic of a mixture. Compounds typically have properties that are very different from those of the component elements.

2.70 Ultimately, you would reach copper atoms. However, in reality, you wouldn’t get that far.

2.71 While it’s true that atoms are built from smaller particles, these smaller particles are not “carbon,” just as a brick is not a house, a piece of fingernail is not a hand, and a grain of sand is not a beach. **If you take apart an atom of carbon into smaller particles, it’s not carbon anymore.**

2.72 Attracted to the nucleus (negative attracted to positive)

2.73 An atom is so small that its weight in grams or milligrams or even nanograms is an extremely small, inconvenient number to work with. The whole purpose of the unit amu is to easily work with the masses of individual atoms and subatomic particles.

2.74

a) same number of protons and electrons

b) different number of neutrons so different mass

c) Yes – all with the formula $ZnCl_2$

d) it would be a teeny bit higher as each atom is heavier

2.75

a) a group of electrons that are probably approximately the same distance from the nucleus

b) an orbital is a region of a shell (THIS IS SO WRONG!!!!!!!!)

2.76

a) He

b) 2

c) Behaves similarly to the other elements in group 8A

2.77 $C_6H_5NO_2$

2.78

a) By definition, a formula unit is the smallest possible sample of a compound, just as an atom is the smallest possible unit of an element. The smallest possible unit of morphine has seventeen carbon atoms. If you break up the formula unit, it's not morphine anymore.

b) It is possible. Since each formula unit of morphine contains one nitrogen atom, a sample of morphine that contained five formula units would contain five nitrogen atoms (along with 17 × 5 = 85 atoms of carbon, 19 × 5 = 95 atoms of hydrogen, and 3 × 5 = 15 atoms of oxygen.)

2.79 1 mole of carbon contains the same number of carbon atoms as 1 mole of lead.

1 mole of carbon has a much smaller mass than 1 mole of lead.

2.80 Aluminum has a smaller atomic mass (27) than iron (56). Thus, in the same mass of each, there will be more aluminum atoms.

2.81 a) is the only one that must be true.

2.82 It means that potassium iodide contains the same number of "atoms" of potassium and "iodine."

As the two "atoms" have different masses, the masses will be different.

2.83 3 moles of C, 6 moles of H, 3 moles of O. You can tell from the formula.

2.84

a) They contain the same number of formula units as they are both 1 mol

b) B contains more atoms as there are 4 atoms in a formula unit of hydrogen peroxide but only 3 atoms in a formula unit of water.

c) The contain the same number of hydrogen atoms as there are 2 in each formula unit

d) B contains more oxygen atoms as there are more oxygen atoms in a formula unit of hydrogen peroxide

e) B as the molar mass of hydrogen peroxide is greater.

SUMMARY AND CHALLENGE PROBLEMS

2.85

a) true

b) false (NOT SURE IF THEY MEAN THIS TO BE TRUE OR NOT – can make true by inserting "one type of")

c) false

d) true

e) true

2.86 a), d) and e)

2.87

a) 29

b) 65

c) 65 amu

d) Cu

e) 1B

f) 4th

2.88

a) $23.985\ \text{amu} \times \dfrac{1.661\times10^{-24}\ \text{g}}{1\ \text{amu}} = 3.984\times10^{-23}\ \text{g}$

b) $1.395\times10^{-22}\ \text{g} \times \dfrac{1\ \text{amu}}{1.661\times10^{-24}\ \text{g}} = 83.99\ \text{amu}$ (rounded to 4 significant figures)

c) $10{,}000\ \text{atoms} \times \dfrac{23.985\ \text{amu}}{1\ \text{atom}} \times \dfrac{1.661\times10^{-24}\ \text{g}}{1\ \text{amu}} \times \dfrac{1\ \text{kg}}{10^{3}\text{g}} = 3.984\times10^{-22}\ \text{kg}$

2.89 53 protons and electrons, 131-53 = 78 neutrons

2.90

a) Not with different atomic numbers

b) Yes – that is the very definition of an isotope

2.91

a) 68

b) 20 × 2 = 40

c) 200 ÷ 4 = 50

d) (300 ÷ 10 O atoms per molecule) = 30 molecules

30 molecules × 66 C atoms per molecule = 1980 C atoms.

2.92

a) 8

b) 4

c) 0

2.93

a) N, P, As, Sb, Bi.

b) Ca, with its two valence electrons. But generally elements 21 (Sc) through 30 (Zn) also have two electrons in shell 4

c) Ne is the first element that has eight electrons in shell 2. But every element after Ne also has eight electrons in shell 2

d) O

2.94 It has 25 electrons so is Mn

2.95 Group IVA, so must have 4 in the valence, 6th shell.

Then, also subtracting the 60 that are in shells 1 through 4, there must be 18 in shell 5.

2.96 $11.0\text{ g O} \times \dfrac{1\text{ mol O}}{16.00\text{ g O}} = 0.688\text{ mol O atoms}$

$10.0\text{ g N} \times \dfrac{1\text{ mol N}}{14.01\text{ g N}} = 0.714\text{ mol N atoms}$

As there are more mol of N, there are more N atoms

2.97

a) 207.2 + 32.07 + 4 × 16.00 = 303.27 amu

b) $31.3\text{ g PbSO}_4 \times \dfrac{1\text{ mol PbSO}_4}{303.27\text{ g PbSO}_4} = 0.103\text{ mol PbSO}_4$

c) $0.2275\text{ mol PbSO}_4 \times \dfrac{303.27\text{ g PbSO}_4}{1\text{ mol PbSO}_4} = 68.99\text{ g PbSO}_4$

2.98

a) 1 mol = 1000 mmol

b) $32.7\text{ mmol Cu} \times \dfrac{1\text{ mol}}{1000\text{ mmol}} = 0.0327\text{ mol Cu}$

c) $8.241\text{ mmol C}_{22}\text{H}_{24}\text{N}_2\text{O}_8 \times \dfrac{1\text{ mol}}{1000\text{ mmol}} \times \dfrac{444.48\text{ g C}_{22}\text{H}_{24}\text{N}_2\text{O}_8}{1\text{ mol C}_{22}\text{H}_{24}\text{N}_2\text{O}_8} = 3.663\text{ g C}_{22}\text{H}_{24}\text{N}_2\text{O}_8$

2.99 3 × 5 = 15 mol Cl

2.100 $2.18\text{ g Cu}_2\text{O} \times \dfrac{1\text{ mol Cu}_2\text{O}}{143.1\text{ g Cu}_2\text{O}} = 0.0152\text{ mol Cu}_2\text{O}$

$$0.0152\text{ mol FeCl}_3 \times \frac{162.2\text{ g FeCl}_3}{1\text{ mol FeCl}_3} = 2.47\text{ g FeCl}_3$$

2.101

a) 1 mol O

b) 2 mol O

c) 0.5 mol O