

Guide to Chapter 2. Atoms, Molecules and Ions

We will spend two days on this chapter in lecture. You should plan to spend at least six 1-hr sessions or four 90-minute sessions studying and working the problems. Some students may need to spend considerably more time than that.

This is a chapter study guide, given section-by-section. Work problems on separate sheets of paper and keep them with this guide. I recommend taking lecture notes and working problems on 3-hole loose-leaf paper and keeping everything in a binder. When working problems, use plenty of space and when appropriate, show all work.

There are two check-boxes (☐) for each learning objective. Check the first one as you complete the assignment. Use the second one while reviewing for the exam. There is one check-box for problems and reading assignments. Check the box when you complete the assignment.

☐ Memorization work required for this chapter:

- ☐ ☐ Learning Objective 1: For Chapter 1, you learned the first 18 elements. Know the elemental symbol and the name of the next 18 elements (potassium through krypton). In addition, know the locations of K, Ca, Br and Kr.
- ☐ ☐ Learning Objective 2: Know the names, formulas, and charges of the common polyatomic ions. (Table 2.3 and the notecards)

☐ Read the introductory paragraph to Chapter 2. Atoms, Molecules, Ions

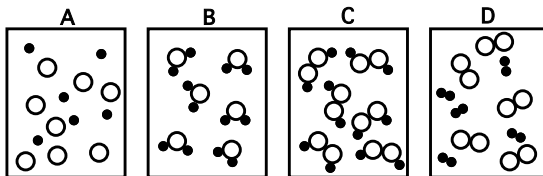
☐ Read Section 2.1 Conservation of Mass and the Law of Definite Proportions.

- ☐ ☐ Learning Objective 3: Know the significance of the law of conservation of mass.
- ☐ ☐ Learning Objective 4: Know the significance of the law of definite proportions.
- ☐ Do Problem 26 from the end of the chapter.

☐ Read Section 2.2 Dalton's Atomic Theory and the Law of Multiple Proportions

- ☐ ☐ Learning Objective 5: Understand the tenets of Dalton's atomic theory model.
- ☐ ☐ Learning Objective 6: Know the significance of the law of multiple proportions.
- ☐ Do Problem 1 at the end of the section
- ☐ Do the following end-of-chapter problems: 27, 34

□ Problem Club Question A. Which pair of the following figures depicts the Law of Multiple Proportions? Explain.

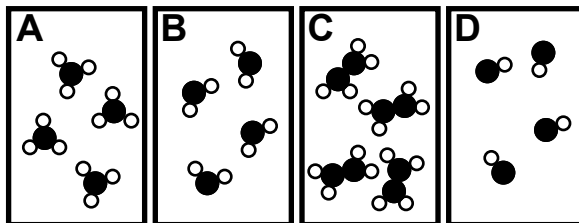


Answer: B and C because in these containers, the substances depicted are molecules of different formulas but of the same atoms.

□ Problem Club Question B. Two samples containing only vanadium and oxygen are analyzed. Sample #1 contains 0.6281 g O/g V and Sample #2 consists of 0.7851 g O/gV. If Sample #2 is V_2O_5 , what is the formula of Sample #1?

Answer: V_2O_4 or VO_2

□ Problem Club Question C. Which, if any, of these diagrams (A – D) show compounds that are related by the Law of Multiple Proportions? Which, if any, are not related to the others by the Law of Multiple Proportions?



Answer: All except for B and C are related by the Law of Multiple Proportions. The problem with B and C is that they have the same proportion of each atom. Thus you could say that A, B and D are related by the LMP or that A, C and D are related by the LMP.

Read Sections 2.3. The Structure of Atoms: Electrons and Section 2.4, Protons and Neutrons

□ □ Learning Objective 7: Understand the fundamental structure of the atom regarding its subatomic particles: electrons, neutrons and protons. Know the relative charges, masses and location of each particle within the atom.

□ Do Problems 2 and 3 at the end of Section 2.4.

□ Read Section 2.5 Atomic Number (and isotopes)

□ □ Learning Objective 8: Given an isotope of an element or ion determine the number of protons, neutrons, and electrons.

□ Do Problems 4 - 6 at the end of the section

□ Do the following end-of-chapter problems: 42, 44, 46, 48, 50, 52, 54

Advice from a former student:

Talk to your teacher. The professors have office hours that are open to students for any questions. If you are having any difficulties and can't seem to catch them during office hours, make an appointment or talk to the professor after lecture.

□ Problem Club Question D. Complete the following table with the aid of the periodic table.

Symbol	Charge	Number of Protons	Number of Neutrons	Number of Electrons
	0	9	10	
P	0		16	
	3	26	30	
		16	16	18
As	5		42	
Te	-2		76	

Answer:

Symbol	Charge	Number of Protons	Number of Neutrons	Number of Electrons
F	0	9	10	9
P	0	15	16	15
Fe	3	26	30	23
S	-2	16	16	18
As	5	33	42	28
Te	-2	52	76	54

□ Problem Club Question E. (ACS-style) Answer: D

□ Problem Club Question F. (ACS-style) Answer: D

□ Problem Club Question G. (ACS-style) Answer: C

□ Problem Club Question H. (ACS-style) Answer: D

□ Problem Club Question I. (ACS-style) Answer: C

□ Problem Club Question J. Mount St. Helens in Washington produced considerable amounts of radioactive radon-222 when it erupted. This same gas is being found in America's basements (not from the volcano, however). How many protons and neutrons does radon-222 possess? Write the isotopic symbol notation for radon.

Answer $^{222}_{86}\text{Rn}$ has 86 protons and 136 neutrons

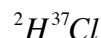
□ *Problem Club Question K. Studies have found that there is an inverse relationship between selenium content in blood and the incidence of breast cancer in women. How many protons and neutrons are in the most common isotope of selenium, Se-80?*

Answer: 34 protons and 46 neutrons

□ *Problem Club Question L. Hydrogen exists in two isotopic forms, H-1 and H-2. Chlorine also exists in two isotopic forms, Cl-35 and Cl-37. How many varieties of the molecule HCl are possible? What are they?*



Answer $^2\text{H}^{35}\text{Cl}$



□ *Problem Club Question M. (ACS-style)* *Answer: B*

□ *Problem Club Question N. Iodine consists of a single isotope. Given the atomic mass from the periodic table, identify this isotope and tell how many protons, neutrons and electrons are in this isotope.*

Answer: $^{127}_{53}\text{I}$ iodine has 53 protons, 74 neutrons and 53 electrons

□ Read Section 2.6 Atomic Mass

□ □ Learning Objective 9: Be able to do isotope calculations: Given exact masses and abundance data, be able to calculate average atomic mass. Given average atomic mass and either the exact isotopic mass data or the abundance data, be able to calculate the missing items.

□ Do Problems 7 and 8 at the end of the section

□ Do the following end-of-chapter problems: 57 — 59

□ *Problem Club Question O. (ACS-style)* *Answer: C*

Advice from a former student:

Work harder than you think you should for the first month and you will be happy with how well it sets you up for the rest of semester. You will understand the basics well and that will carry you through the harder chapters without having to back track.

□ *Problem Club Question P. Silver exists as two isotopes, Ag-107 with an exact mass of 106.9051 and Ag-109 with an exact mass of 108.9048. Given the actual atomic mass of silver, determine the percent composition of each isotope.*

Answer: 51.75% Ag-107 and 48.25% Ag-109

□ *Problem Club Question Q. Calculate the atomic mass of Mg from this information:*

Isotope	Exact mass	Abundance
Mg-24	23.985042	78.99%
Mg-25	24.98537	10.00%
Mg-26	25.982593	11.01%

Answer: Atomic mass =

$$23.985042 \cdot 78.99 + 24.98537 \cdot 10.00 + 25.982593 \cdot 11.01 = 24.3050$$

□ Read Section 2.7 Compounds and Mixtures

- □ Learning Objective 10: Classify a substance as a pure substance or a mixture.
- □ Learning Objective 11: Classify pure substances as either elements or compounds.
- □ Learning Objective 12: Classify mixtures as either heterogeneous or homogeneous.

□ *Problem Club Question R. In which of the figures in the Problem Club Question A do you see depicted: (a) a compound of more than one element (b) a molecular compound (c) a mixture of atoms. In which of the figures in the Problem Club Question A do you see depicted: (d) a mixture (e) a pure substance*

Answer: (a) B and C; (b) B, C and D (there is a mixture of two molecular compounds in D); (c) A; (d) A and D; (e) B and C

□ Do the following end-of-chapter problem: 25, 60, 62, 64, 68

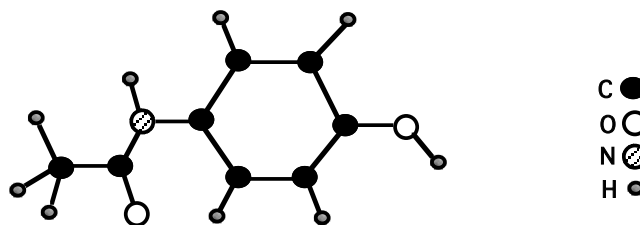
□ Read Section 2.8 Molecules, Ions and Chemical Bonds

- □ Learning Objective 13: Be able to determine by inspection of the formula, if a formula is covalent or ionic.

□ Do Problems 9 - 13 in this section

□ Do the following end-of-chapter problems: 28, 30, 31, 70

□ *Problem Club Question S. Acetaminophen, the ingredient in Tylenol and other non-aspirin pain relievers, has this structure. What is its formula?*



Answer: $C_8H_9O_2N$

□ □ Read Section 2.9 Acids and bases

□ □ Learning Objective 14: Know the definition of an acid and a base. Know how strong acids and bases behave like ionic materials in water. Know how to name acids.

□ Do Problem 14 at the end of the section

□ Do the following end-of-chapter problems: 74, 76

□ *Problem Club Question T. Write the reaction that takes place for strong acids such as HCl when they are in a water solution.*

Answer: $HCl + H_2O = H_3O^+ + Cl^-$

□ Read Section 2.10 Naming Chemical Compounds

□ □ Learning Objective 15: Recognize a formula as (a) binary ionic, binary molecular, polyatomic ionic or an acid. Know that you must do this before you can name it as the rules are different for each of these.

□ □ Learning Objective 16: Recognize a binary ionic compound and know how to properly name it.

□ □ Learning Objective 17: Given the name of a binary ionic compound, write its correct formula.

□ □ Learning Objective 18: Recognize an ionic compound with a polyatomic ion, and know how to properly name it.

□ □ Learning Objective 19: Given the name of an ionic compound with a polyatomic ion, write its correct formula.

□ □ Learning Objective 20: Recognize a covalent compound and know how to properly name it.

□ □ Learning Objective 21: Given the name of a covalent ionic compound, write its correct formula.

□ □ Learning Objective 22: Recognize an acidic compound and know how to properly name it.

□ □ Learning Objective 23: Given the name of an acid, write its correct formula.

□ Do Problems 15 - 23 in this section

□ Do the following end-of-chapter problems: 78, 80, 82, 84, 86

□ *Problem Club Question U. Give the formula (or name) for each of the following compounds. Classify each as Ionic, Covalent or Acidic for purposes of naming by circling either "I", "C" or "A": (a) calcium carbonate; (b) dinitrogen trioxide; (c) ammonium sulfate; (d) potassium nitrate; (e) iron(II) phosphide; (f) nitric acid; (g) CoBr_3 ; (h) H_2SO_4 ; (i) PF_5 ; (j) K_3PO_4*

Answer: (a) I; (b) C; (c) I; (d) I; (e) I; (f) A; (g) I; (h) A; (i) C; (j) I

□ *Problem Club Question V. Name these ions: (a) SO_4^{2-} ; (b) SO_3^{2-} ; (c) HCO_3^- ; (d) ClO_4^- ; (e) CO_3^{2-} ; (f) CN^- ; (g) Na^+ ; (h) Cl^- ; (i) NO_3^- ; (j) O^{2-} ; (k) ClO^- ; (l) MnO_4^- ; (m) NO_2^- ; (n) Fe^{+3} ; (o) S^{2-}*

Answer: (a) sulfate; (b) sulfite; (c) bicarbonate or hydrogen carbonate; (d) perchlorate; (e) carbonate; (f) cyanide; (g) sodium; (h) chloride; (i) nitrate; (j) oxide; (k) hypochlorite; (l) permanganate; (m) nitrite; (n) ferric or Fe(III); (o) sulfide

□ *Problem Club Question W. What is the most common ion (single atom - no oxygen-containing ions) formed by each of these atoms? (Write the atomic symbol and the charge: for example: Be^{+2}) (a) sodium; (b) chlorine; (c) oxygen; (d) aluminum; (e) calcium; (f) magnesium; (g) bromine; (h) nitrogen; (i) potassium; (j) sulfur; (k) strontium; (l) scandium*

Answer: (a) Na^+ (b) chloride, Cl^- (c) oxide, O^{2-} (d) Al^{+3} (e) Ca^{+2} (f) Mg^{+2} (g) bromide, Br^- (h) nitride, N^{3-} (i) K^+ (j) sulfide, S^{2-} (k) Sr^{+2} (l) Sc^{+3}

□ *Problem Club Question X. Determine which of the following substances are covalent, ionic and metallic. Indicate **c**, **i**, or **m**. (a) LiCl ; (b) CH_4 ; (c) KI ; (d) Na ; (e) NO_2 ; (f) MgSO_4 ; (g) CO_2 ; (h) $\text{C}_{12}\text{H}_{22}\text{O}_{11}$; (i) FeCl_2 ; (j) Ni ; (k) $\text{Sn}(\text{O}_2\text{C}_2\text{H}_3)_2$; (l) XeF_4*

Answer: (a) i (b) c (c) i (d) m (e) c (f) i (g) c (h) c (i) i (j) m (k) i (l) c

□ *Problem Club Question Y. Name these compounds: (a) NaCl ; (b) MgSO_4 ; (b) $\text{Mg}_3(\text{PO}_4)_2$; (c) KMnO_4 ; (d) $\text{Na}_2\text{Cr}_2\text{O}_7$; (e) KBr ; (f) Li_2SO_3 ; (g) Fe_2O_3 ; (h) $\text{Ca}(\text{NO}_2)_2$; (i) $\text{Pb}(\text{O}_2\text{C}_2\text{H}_3)_2$*

Answer: (a) sodium chloride; (b) magnesium sulfate; (b) magnesium phosphate; (c) potassium permanganate; (d) sodium dichromate; (e) potassium bromide; (f) lithium sulfite; (g) iron (III) oxide; (h) calcium nitrite; (i) lead (II) acetate

□ Problem Club Question Z. Write the formulas for the following compounds: (a) calcium iodide; (b) barium oxide; (c) ferric sulfate; (d) lithium carbonate; (e) sodium phosphate; (f) ferrous sulfide; (g) potassium peroxide; (h) sulfur dichloride; (i) sulfur dioxide; (j) calcium chlorate; (k) carbon dioxide; (l) barium cyanide; (m) aluminum sulfate; (n) aluminum sulfide; (o) phosphoric acid; (p) sulfurous acid; (q) sulfuric acid; (r) nitric acid

Answer: (a) CaI_2 ; (b) BaO ; (c) $\text{Fe}_2(\text{SO}_4)_3$; (d) Li_2CO_3 ; (e) Na_3PO_4 ; (f) FeS ; (g) K_2O_2 or KO ; (h) SCl_2 ; (i) SO_2 ; (j) $\text{Ca}(\text{ClO}_3)_2$; (k) CO_2 ; (l) $\text{Ba}(\text{CN})_2$; (m) $\text{Al}_2(\text{SO}_4)_3$; (n) Al_2S_3 ; (o) H_3PO_4 ; (p) H_2SO_3 ; (q) H_2SO_4 ; (r) HNO_3

□ Problem Club Question AA. Workers who clean the outside of buildings by sand-blasting often contract a lung disease known as silicosis from inhaling the dust formed during the process. The dust contains mostly silica, a compound of silicon and oxygen. From what you know about ionic charges, what is the most plausible formula for this material?

Answer: SiO_2

□ Problem Club Question BB. Name these acids: (a) HNO_2 ; (b) HCl ; (c) HClO_3 ; (d) HClO_4 ; (e) HBr ; (f) $\text{HC}_2\text{H}_3\text{O}_2$

Answer: (a) nitrous acid; (b) hydrochloric acid (c) chloric acid; (d) perchloric acid (e) hydrobromic acid (f) acetic acid

□ Problem Club Question CC. (ACS-style) Answer A

□ Problem Club Question DD. (ACS-style) Answer B

□ Problem Club Question EE. (ACS-style) Answer D

□ Problem Club Question FF. (ACS-style) Answer C

□ Problem Club Question GG. (ACS-style) Answer A