Chapter 2 Review Questions

In-Class Discussion Questions

These questions are designed to be considered by groups of students in class. Often these questions work well for introducing a particular topic in class.

1. Which of the following is true about an individual atom? Explain.
   a. An individual atom should be considered to be a solid.
   b. An individual atom should be considered to be a liquid.
   c. An individual atom should be considered to be a gas.
   d. The state of the atom depends on which element it is.
   e. An individual atom cannot be considered to be a solid, liquid, or gas.

   Justify your choice, and for choices you did not pick, explain what is wrong with them.

2. You have gone back in time and are working with Dalton. He is working on a table of relative masses, and these are his data:

   0.602 g gas A reacts with 0.295 g gas B
   0.172 g gas B reacts with 0.401 g gas C
   0.320 g gas A reacts with 0.374 g gas C

   a. Assuming simplest formulas (AB, BC, and AC), construct a table of relative masses for Dalton.
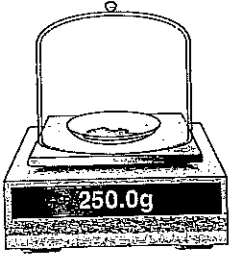
   Knowing some history of chemistry, you tell Dalton that if he finds the volumes of the gases at equal temperature and pressure, he need not assume simplest formulas. You collect the following data:

   6 volumes gas A + 1 volume gas B → 4 volumes product
   1 volume gas B + 4 volumes gas C → 4 volumes product
   3 volumes gas A + 2 volumes gas C → 6 volumes product

   b. Write out the simplest balanced equations, and find the actual relative masses of the elements. Explain your reasoning.

3. How would you go about finding the number of "chalk molecules" it takes to write your name on the board? Provide an explanation of all you would need to do and a sample calculation.

4. These questions concern the work of J. J. Thomson.
   a. From Thomson's work, which particles do you think he would feel are most important for the formation of compounds (chemical changes) and why?
   b. Of the remaining two subatomic particles, which do you place second in importance for forming compounds and why?
   c. Propose three models that explain Thomson's findings and evaluate them. To be complete you should include Thomson's findings.

5. Heat is applied to an ice cube in a closed container until only steam is present. Draw a representation of this process, assuming you can see it at an extremely high level of magnification. What happens to the size of the molecules? What happens to the total mass of the sample?

6. You have a chemical in a sealed glass container filled with air. The setup is sitting on a balance as shown below. The chemical is ignited by means of a magnifying glass focusing sunlight on the reactant. After the chemical has completely burned, which of the following is true? Explain your answer.

   a. The balance will read less than 250.0 g.
   b. The balance will read 250.0 g.
   c. The balance will read greater than 250.0 g.
   d. Cannot be determined without knowing the identity of the chemical.

7. You take three compounds consisting of two elements and decompose them. To determine the relative masses of X, Y, and Z, you collect and weigh the elements, obtaining the following data:

Elements in Compound	Masses of Elements
X and Y	$X = 0.4$ g, $Y = 4.2$ g
Y and Z	$Y = 1.4$ g, $Z = 1.0$ g
X and Y	$X = 2.0$ g, $Y = 7.0$ g

   a. What are the assumptions in solving this problem?
   b. What are the relative masses of X, Y, and Z?
   c. What are the chemical formulas of the three compounds?
   d. If you decompose 21 g of compound XY, how much of each element is present?

8. The vitamin niacin (nicotinic acid, $C_6H_5NO_2$) can be isolated from a variety of natural sources such as liver, yeast, milk, and whole grain. It also can be synthesized from commercially available materials. Which source of nicotinic acid, from a nutritional view, is best for use in a multivitamin tablet? Why?

9. One of the best indications of a useful theory is that it raises more questions for further experimentation than it originally answered. Does this apply to Dalton's atomic theory? Give examples.

10. Dalton assumed that all atoms of the same element were identical in all their properties. Explain why this assumption is not valid.

11. Evaluate each of the following as an acceptable name for water:
    a. dihydrogen oxide   c. hydrogen hydroxide
    b. hydroxide hydride   d. oxygen dihydride

12. Why do we call $Ba(NO_3)_2$ barium nitrate, but we call $Fe(NO_3)_2$ iron(II) nitrate?

13. Why is calcium dichloride not the correct systematic name for $CaCl_2$?

14. The common name for NH_3 is ammonia. What would be the systematic name for NH_3? Support your answer.

A blue question or exercise number indicates that the answer to that question or exercise appears at the back of this book and a solution appears in the *Solutions Guide*.

Questions

15. Use Dalton's atomic theory to account for each of the following.
    a. the law of conservation of mass
    b. the law of definite proportion
    c. the law of multiple proportions

16. What refinements had to be made in Dalton's atomic theory to account for Gay-Lussac's results on the combining volumes of gases?

17. What evidence led to the conclusion that cathode rays had a negative charge?

18. What discoveries were made by J. J. Thomson, Henri Becquerel, and Lord Rutherford? How did Dalton's model of the atom have to be modified to account for these discoveries?

19. Do the proton and the neutron have exactly the same mass? How do the masses of the proton and the neutron compare to the mass of the electron? Which particles make the greatest contribution to the mass of an atom? Which particles make the greatest contribution to the chemical properties of an atom?

20. Consider Ernest Rutherford's alpha-particle bombardment experiment illustrated in Figure 2.12. How did the results of this experiment lead Rutherford away from the plum pudding model of the atom to propose the nuclear model of the atom?

21. What is the distinction between atomic number and mass number? Between mass number and atomic mass?

22. Distinguish between the terms *family* and *period* in connection with the periodic table. For which of these terms is the term *group* also used?

23. When hydrogen is burned in oxygen to form water, the composition of water formed does not depend on the amount of oxygen reacted. Interpret this in terms of the law of definite proportions.

24. The two most reactive families of elements are the halogens and the alkali metals. How do they differ in their reactivities?

Exercises

In this section similar exercises are paired.

Development of the Atomic Theory

25. When mixtures of gaseous H_2 and gaseous Cl_2 react, a product forms that has the same properties regardless of the relative amounts of H_2 and Cl_2 used.

a. How is this result interpreted in terms of the law of definite proportion?
b. When a volume of H_2 reacts with an equal volume of Cl_2 at the same temperature and pressure, what volume of product having the formula HCl is formed?

26. A reaction of 1 liter of chlorine gas (Cl_2) with 3 liters of fluorine gas (F_2) yields 2 liters of a gaseous product. All gas volumes are at the same temperature and pressure. What is the formula of the gaseous product?

27. Several compounds containing only sulfur (S) and fluorine (F) are known. Three of them have the following compositions:
    i. 1.188 g of F for every 1.000 g of S
    ii. 2.375 g of F for every 1.000 g of S
    iii. 3.563 g of F for every 1.000 g of S
    How do these data illustrate the law of multiple proportions?

28. Hydrazine, ammonia, and hydrogen azide all contain only nitrogen and hydrogen. The mass of hydrogen that combines with 1.00 g of nitrogen for each compound is 1.44×10^{-1} g, 2.16×10^{-1} g, and 2.40×10^{-2} g, respectively. Show how these data illustrate the law of multiple proportions.

29. Early tables of atomic weights (masses) were generated by measuring the mass of a substance that reacts with 1.00 g of oxygen. Given the following data and taking the atomic mass of hydrogen as 1.00, generate a table of relative atomic masses for oxygen, sodium, and magnesium.

Element	Mass That Combines with 1.00 g Oxygen	Assumed Formula
Hydrogen	0.126 g	HO
Sodium	2.875 g	NaO
Magnesium	1.500 g	MgO

How do your values compare with those in the periodic table? How do you account for any differences?

30. Indium oxide contains 4.784 g of indium for every 1.000 g of oxygen. In 1869, when Mendeleev first presented his version of the periodic table, he proposed the formula In_2O_3 for indium oxide. Before that time it was thought that the formula was InO. What values for the atomic mass of indium are obtained using these two formulas? Assume that oxygen has an atomic mass of 16.00.

The Nature of the Atom

31. From the information in this chapter on the mass of the proton, the mass of the electron, and the sizes of the nucleus and the atom, calculate the densities of a hydrogen nucleus and a hydrogen atom.

32. If you wanted to make an accurate scale model of the hydrogen atom and decided that the nucleus would have a diameter of 1 mm, what would be the diameter of the entire model?

33. In an experiment it was found that the total charge on an oil drop was 5.93×10^{-18} C. How many negative charges does the drop contain?

34. A chemist in a galaxy far, far away performed the Millikan oil drop experiment and got the following results for the charges on various drops. Use these data to calculate the charge of the electron in zirkombs.

2.56×10^{-12} zirkombs 7.68×10^{-12} zirkombs
3.84×10^{-12} zirkombs 6.40×10^{-13} zirkombs

35. What are the symbols of the following metals: sodium, beryllium, manganese, chromium, uranium?

36. What are the symbols of the following nonmetals: fluorine, chlorine, bromine, sulfur, oxygen, phosphorus?

37. Give the names of the metals that correspond to the following symbols: Sn, Pt, Co, Ni, Mg, Ba, K.

38. Give the names of the nonmetals that correspond to the following symbols: As, I, Xe, He, C, Si.

39. List the noble gas elements. Which of the noble gases has only radioactive isotopes? (This situation is indicated on most periodic tables by parentheses around the mass of the element. See inside front cover.)

40. Which lanthanide element and which transition element have only radioactive isotopes? (See Exercise 39.)

41. In the periodic table, how many elements are found in
    a. the second period?   c. the fourth period?
    b. the third period?   d. Group 5A?

42. In the periodic table, how many elements are found in
    a. Group 2A?   c. the nickel group?
    b. the oxygen family?   d. Group 8A?

43. Give the number of protons and neutrons in the nucleus of each of the following atoms:
    a. $^{238}_{94}Pu$ d. $^{4}_{2}He$
    b. $^{65}_{29}Cu$ e. $^{60}_{27}Co$
    c. $^{52}_{24}Cr$ f. $^{54}_{24}Cr$

44. How many protons and neutrons are in the nucleus of each of the following atoms? In a neutral atom of each element, how many electrons are present?
    a. ^{79}Br d. ^{133}Cs
    b. ^{81}Br e. ^{3}H
    c. ^{239}Pu f. ^{56}Fe

45. Write the atomic symbol ($^{A}_{Z}X$) for each of the atoms described below.
    a. $Z = 5$, $A = 12$
    b. the isotope with 7 protons and 8 neutrons in its nucleus
    c. atomic number $= 17$, number of neutrons $= 18$
    d. $Z = 92$, number of neutrons $= 143$
    e. number of protons $= 6$, mass number $= 14$
    f. the isotope of phosphorus with 16 neutrons in its nucleus

46. Write the atomic symbol ($^{A}_{Z}X$) for each of the following isotopes.

a. $Z = 8$; number of neutrons $= 9$
b. the isotope of chlorine in which $A = 37$
c. $Z = 27$, $A = 60$
d. number of protons $= 26$, number of neutrons $= 31$
e. the isotope of I with a mass number of 131
f. $Z = 3$, number of neutrons $= 4$

47. What is the symbol for an ion with 63 protons, 60 electrons, and 88 neutrons? If an ion contains 50 protons, 68 neutrons, and 48 electrons, what is its symbol?

48. What is the symbol of an ion with 16 protons, 18 neutrons, and 18 electrons? What is the symbol for an ion that has 16 protons, 16 neutrons, and 18 electrons?

49. Complete the following table:

Symbol	Number of Protons in Nucleus	Number of Neutrons in Nucleus	Number of Electrons	Net Charge
	33	42		3+
$^{128}_{52}Te^{2-}$			54	
	16	16	16	
	81	123		1+
$^{195}_{78}Pt$				

50. Complete the following table:

Symbol	Number of Protons in Nucleus	Number of Neutrons in Nucleus	Number of Electrons	Net Charge
$^{238}_{92}U$				
	20	20		2+
	23	28	20	
$^{89}_{39}Y$				
	35	44	36	
	15	16		3-

51. Classify the following elements as metals or nonmetals:

Mg   Si   Rn
Ti   Ge   Eu
Au   B   Am
Bi   At   Br

52. The distinction between metals and nonmetals is really not a clear one. Some elements, called *metalloids*, are intermediate in their properties. Which elements in Exercise 51 would you reclassify as metalloids? What other elements in the periodic table would you expect to be metalloids?

53. Which of the following sets of elements are all in the same group in the periodic table?
    a. Fe, Ru, Os   c. Sn, As, S
    b. Rh, Pd, Ag   d. Se, Te, Po

54. For each of the following sets of elements, label each as either noble gases, halogens, alkali metals, alkaline earth metals, or transition metals.
    a. Ti, Fe, Ag   d. Ne, Kr, Xe
    b. Mg, Sr, Ba   e. F, Br, I
    c. Li, K, Rb

55. Consider the elements of Group 4A (the "carbon family"): C, Si, Ge, Sn, and Pb. What is the trend in metallic character as one goes down this group?

56. What is the trend in metallic character going from left to right across a period in the periodic table?

57. Would you expect each of the following atoms to gain or lose electrons when forming ions? What ion is the most likely in each case?
    a. Na   c. Ba   e. Al
    b. Sr   d. I   f. S

58. Would you expect each of the following atoms to gain or lose electrons when forming ions? What ion is the most likely in each case?
    a. Ra   c. P   e. Br
    b. In   d. Te   f. Rb

Nomenclature

59. Name each of the following compounds:
    a. NaCl   c. CaS
    b. Rb_2O d. AlI_3

60. Name each of the following compounds:
    a. Hg_2O c. CoS
    b. $FeBr_3$ d. $TiCl_4$

61. Name each of the following compounds:
    a. CrO_3 c. Al_2O_3 e. $CaBr_2$
    b. Cr_2O_3 d. NaH   f. $ZnCl_2$

62. Name each of the following compounds:
    a. CsF   c. Ag_2S e. TiO_2
    b. Li_3N d. MnO_2 f. Sr_3P_2

63. Name each of the following compounds:
    a. $KClO_4$ c. $Al_2(SO_4)_3$
    b. $Ca_3(PO_4)_2$ d. $Pb(NO_3)_2$

64. Name each of the following compounds:
    a. $BaSO_3$ c. $KMnO_4$
    b. $NaNO_2$ d. $K_2Cr_2O_7$

65. Name each of the following compounds:
    a.

○ N
● I

b.

○ F
◔ S
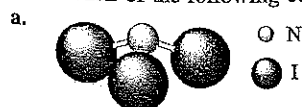
c. PCl_3
d. N_2F_4

66. Name each of the following compounds:
    a.

◔ O
○ N

b.

◔ I
○ Cl
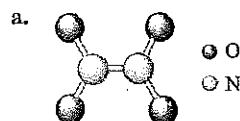
c. SO_2
d. P_2S_5

67. Name each of the following compounds:
    a. CuI   f. S_4N_4
    b. CuI_2 g. SF_6
    c. CoI_2 h. NaOCl
    d. Na_2CO_3 i. $BaCrO_4$
    e. $NaHCO_3$ j. NH_4NO_3

68. Name each of the following compounds:
    a. $HC_2H_3O_2$ g. H_2SO_4
    b. NH_4NO_2 h. Sr_3N_2
    c. Co_2S_3 i. $Al_2(SO_3)_3$
    d. ICl   j. SnO_2^-
    e. $Pb_3(PO_4)_2$ k. Na_2CrO_4
    f. KIO_3 l. HClO

69. Write the formula for each of the following compounds:
    a. cesium bromide   e. silicon tetrachloride
    b. barium sulfate   f. chlorine trifluoride
    c. ammonium chloride   g. beryllium oxide
    d. chlorine monoxide   h. magnesium fluoride

70. Write the formula for each of the following compounds:
    a. sulfur difluoride
    b. sulfur hexafluoride
    c. sodium dihydrogen phosphate
    d. lithium nitride
    e. chromium(III) carbonate
    f. tin(II) fluoride
    g. ammonium acetate
    h. ammonium hydrogen sulfate
    i. cobalt(III) nitrate   k. potassium chlorate
   j. mercury(I) chloride   l. sodium hydride

71. Write the formula for each of the following compounds:
    a. sodium oxide   h. copper(I) chloride
    b. sodium peroxide   i. gallium arsenide
    c. potassium cyanide   j. cadmium selenide
    d. copper(II) nitrate   k. zinc sulfide
    e. selenium tetrabromide   l. nitrous acid
    f. lead(II) sulfide   m. diphosphorus pentoxide
    g. lead(IV) sulfide

72. Write the formula for each of the following compounds:
   a. ammonium hydrogen phosphate
   b. mercury(I) sulfide
   c. silicon dioxide
   d. sodium sulfite
   e. aluminum hydrogen sulfate
   f. nitrogen trichloride
   g. hydrobromic acid
   h. bromous acid
   i. perbromic acid
   j. potassium hydrogen sulfide
   k. calcium iodide
   l. cesium perchlorate

Additional Exercises

73. Chlorine has two natural isotopes: $^{37}_{17}Cl$ and $^{35}_{17}Cl$. Hydrogen reacts with chlorine to form the compound HCl. Would a given amount of hydrogen react with different masses of the two chlorine isotopes? Does this conflict with the law of definite proportion? Why or why not?

74. Technetium (Tc) was the first synthetically produced element. Technetium comes from the Greek word for "artificial". It was first produced by Perries and Segre in 1937 in Berkeley, California, by bombarding a molybdenum plate with ^2H nuclei. Elemental technetium is produced from ammonium pertechnetate. How many protons and neutrons are in the nuclei of ^{98}Tc and ^{99}Tc? What is the formula of ammonium pertechnetate?

75. Name the following acids illustrated below.
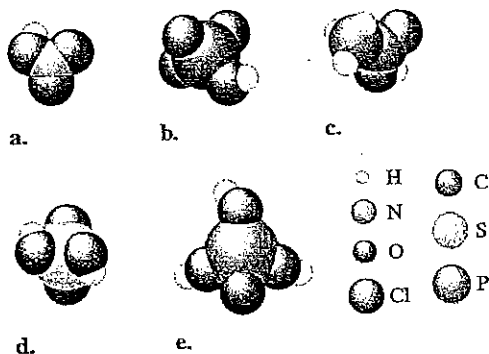
76. For each of the following ions, indicate the total number of protons and electrons in the ion. For the positive ions in the list, predict the formula of the simplest compound formed between each positive ion and the oxide ion. For the negative ions in the list, predict the formula of the simplest compound formed between each negative ion and the aluminum ion.
   a. Fe^{2+} e. S^{2-}
   b. Fe^{3+} f. P^{3-}
   c. Ba^{2+} g. Br^-
   d. Cs^+ h. N^{3-}

77. The formulas and common names for several substances are given below. Give the systematic names for these substances.
   a. sugar of lead $Pb(C_2H_3O_2)_2$
   b. blue vitrol $CuSO_4$
   c. quicklime CaO
   d. Epsom salts $MgSO_4$
   e. milk of magnesia $Mg(OH)_2$
   f. gypsum $CaSO_4$
   g. laughing gas N_2O

78. Identify each of the following elements:
   a. a member of the same family as oxygen whose most stable ion contains 54 electrons
   b. a member of the alkali metal family whose most stable ion contains 36 electrons
   c. a noble gas with 18 protons in the nucleus
   d. a halogen with 85 protons and 85 electrons

79. How many hydrogen atoms are there in 1 molecule of $C_6H_{12}O_6$? in 2 molecules of C_2H_6? in 3 molecules of CH_4? in 4 molecules of H_3PO_4? in 6 molecules of H_2O?

80. An element's most stable ion forms an ionic compound with bromine, having the formula XBr_2. If the ion of element X has a mass number of 230 and has 86 electrons, what is the identity of the element, and how many neutrons does it have?

81. The designations 1A through 8A used for certain families of the periodic table are helpful for predicting the charges on ions in binary ionic compounds. In these compounds, the metals generally take on a positive charge equal to the family number, while the nonmetals take on a negative charge equal to the family number minus eight. Thus the compound between sodium and chlorine contains Na^+ ions and Cl^- ions and has the formula NaCl. Predict the formula and the name of the binary compound formed from the following pairs of elements.
   a. Ca and N   e. Ba and I
   b. K and O   f. Al and Se
   c. Rb and F   g. Cs and P
   d. Mg and S   h. In and Br

82. By analogy with phosphorous compounds, name the following: Na_3AsO_4, H_3AsO_4, $Mg_3(SbO_4)_2$.

Challenge Problems

83. The elements in one of the groups in the periodic table are often called the **coinage metals**. Identify the elements in this group based on your own experience.

84. A combustion reaction involves the reaction of a substance with oxygen gas. The complete combustion of any hydrocarbon (binary compound of carbon and hydrogen) produces carbon dioxide and water as the only products. Octane is a hydrocarbon that is found in gasoline. Complete combustion of octane produces 8 liters of carbon dioxide for every 9 liters of water vapor (both measured at the same temperature and