CHAPTER 5 Review

Reflecting on Chapter 5

Summarize this chapter in the format of your choice. Here are a few ideas to use as guidelines:

- Describe the relationships among isotopic abundance, isotopic masses, and average atomic mass.
- Explain why you need to use a weighted average to calculate average atomic mass.
- Calculate isotopic abundance based on isotopic masses and average atomic mass.
- Explain how chemists use a mass spectrometer to determine isotopic abundance and the masses of different isotopes.
- Describe how and why chemists group atoms and molecules into molar amounts.
- Explain how chemists define the mole and why this definition is useful.
- Use the Avogadro constant to convert between moles and particles.
- Explain the relationship between average atomic mass and the mole.
- Find a compound's molar mass using the periodic table.
- Convert between particles, moles, and mass.

Reviewing Key Terms

For each of the following terms, write a sentence that shows your understanding of its meaning.

average atomic mass
Avogadro constant
isotopic abundance
mass spectrometer
mole
molar mass
weighted average

Knowledge/Understanding

1. Distinguish between atomic mass and average atomic mass. Give examples to illustrate each term.
2. Explain why you use a weighted average, based on the masses and abundances of the isotopes, to calculate the average atomic mass of an element.
3. The periodic table lists the average atomic mass of chlorine as 35.45 u. Are there any chlorine atoms that have a mass of 35.45 u? Explain your answer.
4. Explain how the Avogadro constant, average atomic mass, and molar mass are related.
5. Explain how a balance allows a chemist to count atoms or molecules indirectly.
6. **(a)** Describe the relationship between the mole, the Avogadro constant, and carbon-12.
   (b) Why do chemists use the concept of the mole to deal with atoms and molecules?
7. How is the molar mass of an element related to average atomic mass?
8. Explain what the term molar mass means for each of the following, using examples.
   (a) a metallic element
   (b) a diatomic element
   (c) a compound

Inquiry

9. The isotopes of argon have the following relative abundances: Ar-36, 0.34%; Ar-38, 0.06%; and Ar-40, 99.66%. Estimate the average atomic mass of argon.
10. The isotopes of gallium have the following relative abundances: Ga-69, 60.0%; and Ga-71, 40.0%. Estimate the average atomic mass of gallium using the mass numbers of the isotopes.
11. Estimate the average atomic mass of germanium, given its isotopes with their relative abundances: Ge-70 (20.5%), Ge-72 (27.4%), Ge-73 (7.8%), Ge-74 (36.5%), and Ge-76 (7.8%).
12. Potassium exists as two naturally occurring isotopes: K-39 and K-41. These isotopes have atomic masses of 39.0 u and 41.0 u respectively. If the average atomic mass of potassium is 39.10 u, calculate the relative abundance of each isotope.
13. How many moles of the given substance are present in each sample below?
   (a) 0.453 g of Fe_2O_3
   (b) 50.7 g of H_2SO_4
   (c) 1.24×10^{-2} g of Cr_2O_3
   (d) 8.2×10^{2} g of $C_2Cl_3F_3$
   (e) 12.3 g of NH_4Br

14. Convert each quantity to an amount in moles.
- **(a)** 4.27×10^{21} atoms of He
- **(b)** 7.39×10^{23} molecules of ICl
- **(c)** 5.38×10^{22} molecules of NO_2
- **(d)** 2.91×10^{23} formula units of $Ba(OH)_2$
- **(e)** 1.62×10^{24} formula units of KI
- **(f)** 5.58×10^{20} molecules of C_3H_8

15. Copy the following table into your notebook and complete it.

Sample	Molar mass (g/mol)	Mass of sample (g)	Formula units or molecules	Amount of molecules (mol)	Amount of atoms (mol)
NaCl	58.4	58.4	6.02×10^{23}	1.00	2.00
NH_3		24.8			
H_2O			5.28×10^{22}		
Mn_2O_3					0.332
K_2CrO_4		9.67×10^{-1}			
$C_8H_8O_3$			7.90×10^{24}		
$Al(OH)_3$				8.54×10^{2}	

16. Calculate the molar mass of each compound.
- **(a)** $PtBr_2$
- **(b)** $C_3H_5O_2H$
- **(c)** Na_2SO_4
- **(d)** $(NH_4)_2Cr_2O_7$
- **(e)** $Ca_3(PO_4)_2$
- **(f)** Cl_2O_7

17. Express each quantity as a mass in grams.
- **(a)** 3.70 mol of H_2O
- **(b)** 8.43×10^{23} molecules of PbO_2
- **(c)** 14.8 mol of $BaCrO_4$
- **(d)** 1.23×10^{22} molecules of Cl_2
- **(e)** 9.48×10^{23} molecules of HCl
- **(f)** 7.74×10^{19} molecules of Fe_2O_3

18. How many atoms of C are contained in 45.6 g of C_6H_6?

19. How many atoms of F are contained in 0.72 mol of BF_3?

20. Calculate the following.
- **(a)** the mass (u) of one atom of xenon
- **(b)** the mass (g) of one mole of xenon atoms
- **(c)** the mass (g) of one atom of xenon
- **(d)** the mass (u) of one mole of xenon atoms
- **(e)** the number of atomic mass units in one gram

21. How many atoms of C are in a mixture containing 0.237 mol of CO_2 and 2.38 mol of CaC_2?

22. How many atoms of H are in a mixture of 3.49×10^{23} molecules of H_2O and 78.1 g of CH_3OH?

23. How many nitrate ions are in a solution that contains 3.76×10^{-1} mol of calcium nitrate, $Ca(NO_3)_2$?

24. Ethanol, C_2H_5OH, is frequently used as the fuel in wick-type alcohol lamps. One molecule of C_2H_5OH requires three molecules of O_2 for complete combustion. What mass of O_2 is required to react completely with 92.0 g of C_2H_5OH?

25. Bromine exists as two isotopes: Br-79 and Br-81. Calculate the relative abundance of each isotope. You will need to use information from the periodic table.

26. Examine the following double displacement reaction.

$$NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$$

In this reaction, one formula unit of NaCl reacts with one formula unit of $AgNO_3$.
- **(a)** How many moles of NaCl react with one mole of $AgNO_3$?
- **(b)** What mass of $AgNO_3$ reacts with 29.2 g of NaCl?

27. The planet Zoltan is located in a solar system in the Andromeda galaxy. On Zoltan, the standard unit for the amount of substance is the wog and the standard unit for mass is the wibble. The Zoltanians, like us, chose carbon-12 to define their standard unit for the amount of substance. By definition, one wog of C-12 atoms contains 2.50×10^{21} atoms. It has a mass of exactly 12 wibbles.
- **(a)** What is the mass, in wibbles, of 1 wog of nitrogen atoms?
- **(b)** What is the mass, in wibbles, of 5.00×10^{-1} wogs of O_2?
- **(c)** What is the mass, in grams, of 1 wog of hydrogen atoms?

Communication

28. Use the definition of the Avogadro constant to explain why its value must be determined by experiment.

29. Why is carbon-12 the only isotope with an atomic mass that is a whole number?

30. Draw a concept map for the conversion of mass (g) of a sample to amount (mol) of a sample to number of molecules in a sample to number of atoms in a sample. Be sure to include proper units.

31. Explain why 1 mol of carbon dioxide contains 6.02×10^{23} molecules and not 6.02×10^{23} atoms.

Making Connections

32. The RNI (Recommended Nutrient Intake) of iron for women is listed as 14.8 mg per day. Ferrous gluconate, $Fe(C_6H_{11}O_7)_2$ is often used as an iron supplement for those who do not get enough iron in their diet because it is relatively easy for the body to absorb. Some iron-fortified breakfast cereals contain elemental iron metal as their source of iron.

(a) Calculate the number of moles of elemental iron, Fe, required by a woman, according to the RNI.

(b) What mass, in milligrams, of ferrous gluconate, would satisfy the RNI for iron?

(c) The term *bioavailability* refers to the extent that the body can absorb a certain vitamin or mineral supplement. There is evidence to suggest that the elemental iron in these iron-fortified cereals is absorbed only to a small extent. If this is the case, should cereal manufacturers be allowed to add elemental iron at all? How could cereal manufacturers assure that the consumer absorbs an appropriate amount of iron? Would adding more elemental iron be a good solution? List the pros and cons of adding more elemental iron, then propose an alternative solution.

33. Vitamin B_3, also known as niacin, helps maintain the normal function of the skin, nerves, and digestive system. The disease pellagra results from a severe niacin deficiency. People with pellagra experience mouth sores, skin irritation, and mental deterioration. Niacin has the following formula: $C_6H_5NO_2$. Often vitamin tablets contain vitamin B_3 in the form of niacinamide, $C_6H_6N_2O$, which is easier for the body to absorb.

(a) A vitamin supplement tablet contains 100 mg of niacinamide. What mass of niacin contains an equivalent number of moles as 100 mg of niacinamide?

(b) Do some research to find out how much niacin an average adult should ingest each day.

(c) Do some research to find out what kinds of food contain niacin.

(d) What are the consequences of ingesting too much niacin?

(e) Choose another vitamin to research. Find out its chemical formula, its associated recommended nutrient intake, and where it is found in our diet. Prepare a poster to communicate your findings.

Answers to Practice Problems and Short Answers to Section Review Questions

Practice Problems: **1.** 10.81 u **2.** 28.09 u **3.** 63.55 u **4.** 207.2 **5.** 99.8%, 0.2% **6.** very low, **7.** 72% **8.** 99.8%, 0.2% **9.** 3.37×10^{16} rows **10.** 2.80×10^{14} **11.** 1.44×10^{27} km **12.** 1.91×10^{16} a **13.** 1.07×10^{22} **14.** 2.83×10^{20} **15.** 1.3×10^{23} **16.** 3.35×10^{25} **17.(a)** 1.5×10^{24} **(b)** 2.1×10^{25} **(c)** 6.0×10^{24} **18.(a)** 4.99×10^{23} **(b)** 9.98×10^{23} **19.** 12.8 mol **20.** 1.33×10^{3} mol **21.** 1.84×10^{-2} mol **22.** 1.16×10^{-1} mol **23.(a)** 131.29 g/mol **(b)** 190.23 g/mol **(c)** 137.33 g/mol **(d)** 127.60 g/mol **24.(a)** 17.04 g/mol **(b)** 180.2 g/mol **(c)** 294.2 g/mol **(d)** 399.9 g/mol **25.** 183.68 g/mol **26.** 131.7 g/mol **27.(a)** 46.8 g **(b)** 1.20×10^{2} g **(c)** 1.05×10^{9} **(d)** 3.66×10^{-3} **28.(a)** 1.5 mol Cl_2 **(b)** 7.31 mol O_2 **29.** 1.00×10^{3} g **30.** 26.6 kg **31.(a)** 1.07 mol **(b)** 1.24×10^{2} mol **(c)** 14.2 mol **(d)** 7.75×10^{-4} mol **32.(a)** 0.652 mol **(b)** 0.156 mol **(c)** 1.76×10^{6} **(d)** 3.49×10^{-8} **33.** 1.7×10^{2} mol **34.** 1.75×10^{2} mol **35.(a)** 1.36×10^{3} g **(b)** 9.95 g **(c)** 7.32×10^{2} g **(d)** 2.15×10^{7} **36.** 2.93×10^{-21} g **37.** 7.95×10^{-23} g **38.** 6.25×10^{-22} g **39.(a)** 3.34×10^{23} molecules **(b)** 9.84×10^{23} molecules **(c)** 1.05×10^{23} molecules **(d)** 2.50×10^{20} formula units **40.** 4.2×10^{5} atoms **41.** 1.36×10^{20} **42.(a)** 2.14×10^{20} **(b)** 4.27×10^{20}

Section Review: 5.1: **2.** 24.31 u **3.** No **5.2:** **2.** $\$1.00 \times 10^{14}$ **3.** 1.9×10^{16} years **4.** 2.08×10^{24} atoms **5.(a)** 4.25 mol **(b)** 12.8 mol **6.** 3.0×10^{23} atoms **7.(a)** 3.43×10^{24} molecules **(b)** 2.06×10^{25} atoms **8.(a)** 7.04×10^{23} molecules **(b)** 3.52×10^{24} atoms **(c)** 2.11×10^{24} atoms **10.** Compound **5.3:** **2.(a)** 4.61 mol **(b)** 2.78×10^{24} **3.(a)** 4.67×10^{-23} g **(b)** 1.69×10^{25} u **4.(a)** 46.1 g **(b)** 4.75×10^{23} formula units **(c)** 9.50×10^{23} **5.** 5.01×10^{22} atoms **6.** 2.50×10^{-3} g