CHAPTER 12 Review

Reflecting on Chapter 12

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

- Describe Avogadro's hypothesis, and explain how it relates to the properties of gases.
- Explain how the ideal gas law came about. Describe how to use it to calculate gas properties.
- Explain how to use the ideal gas law for stoichiometric problems involving gases as reactants or products in a chemical reaction.
- Describe how to identify an unknown gas using the ideal gas law.
- Explain the importance of ozone, and describe the action of CFCs on ozone. Explain what the Montréal Protocol has done for the ozone issue.

Reviewing Key Terms

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

law of combining volumes	molar volume
	ideal gas law
law of multiple proportions	chlorofluorocarbons (CFCs)
Avogadro's hypothesis	Montréal Protocol

Knowledge/Understanding

1. (a) How did the work of John Dalton and Joseph Gay-Lussac lead to Avogadro's hypothesis?
   (b) How does Avogadro's hypothesis help us to understand gas behaviour and gas reactions?
2. (a) What is the law of multiple proportions?
   (b) State Gay-Lussac's law of combining volumes.
   (c) How are the two laws related? What useful problem-solving gas law did they lead to?
3. What is the molar volume of an ideal gas at STP?
4. What are the characteristics of an ideal gas? How is it different from a real gas?
5. Is the density of one mole of hydrogen gas at STP the same as the density of one mole of oxygen gas at STP? Explain your answer.
6. (a) Additional gas is added to a container with a fixed volume. What happens to the pressure and temperature of the gas?
   (b) A balloon filled with gas experiences a drop in pressure. What happens to the volume of the gas?
7. A student reacts a sample of zinc with hydrochloric acid. He collects the gas as it bubbles through water. How will this student need to correct his measurements? Explain your answer.
8. What are the effects of ozone pollution near the ground?
9. Why are high levels of ultraviolet radiation potentially dangerous?
10. How is the Montréal Protocol attempting to improve future air quality?

Inquiry

11. As you work on gas reactions in the laboratory, your barometer shatters. Now it is impossible to measure the pressure of the room.
    (a) Design a simple investigation that allows you to calculate the pressure of the room. Assume you have a thermometer.
    (b) Identify the materials and equipment you will need to carry out the investigation.
    (c) Which variables will you hold constant? Which will you change? Which will you measure?
12. What volume does each amount of helium occupy at STP?
    (a) 1.00 mol
    (b) 12.5 mol
    (c) 100.0 g
13. How many molecules are in 0.250 m^3 of oxygen at STP?
14. What volume does 2.00 mol of oxygen occupy at 750 torr and 30.0°C?
15. What volume does 1.50 g of nitrogen gas occupy at 100.0°C and 5.00 atm?
16. Oxygen that is needed in a school laboratory is stored in a pressurized 2.00 L cylinder. 25.0 g of oxygen is contained in the cylinder at 20.0°C. Under what pressure is the oxygen stored?
17. Propane, C_3H_8, that is needed for a barbecue is stored in a 40.0 dm^3 metal cylinder. The pressure gauge on the cylinder reads 25.0 atm

at 20.0°C. What mass of propane is in the cylinder? (**Hint:** 1 dm^3 = 1 L)

18. Find the density (in g/L) of each atmospheric gas.

(a) oxygen at 1000 torr and 30.0°C

(b) helium at 10.0 atm and 20°C

19. (a) Pressurized CO_2 is used in the soft-drink manufacturing industry. How many grams of carbon dioxide are in a 500.0 cm^3 tank at –50.0°C and 2.00 atm?

(b) How many grams of oxygen does this tank hold at the same temperature and pressure?

20. 9.0 g of an unknown gas is stored in a 5.00 L metal tank at 0.0°C and 202.0 kPa. To identify the gas, investigators decide to find out its molecular mass.

(a) What is the molecular mass of the gas?

(b) What is the gas?

21. A 25.0 L tank, stored at –20.0°C, contains 10.0 g of helium and 10.0 g of hydrogen gas.

(a) What is the total number of moles of gas in the tank?

(b) What is the total pressure (in kPa) in the tank?

(c) What is the partial pressure of helium in the tank?

22. A 60.0 g sample of nitrogen gas is stored in a 5.0 L tank at a pressure of 10.0 atm. At what temperature (in °C) is the gas stored?

23. A 13.4 g sample of an unknown liquid is vapourized at 85.0°C and 100.0 kPa. The vapour has a volume of 4.32 L. The percentage composition of the liquid is found to be 52.1% carbon, 13.2% hydrogen, and 34.7% oxygen. What is the molecular formula of the liquid?

24. An unlabelled bottle of an unknown liquid is found on a shelf in a laboratory storeroom. 10.0 g of the liquid is vaporized at 120.0°C and 5.0 atm. The volume of the vapour is found to be 568.0 cm^3. The liquid is found to be made up of 84.2% carbon and 15.8% hydrogen. What is the molecular formula of the liquid?

25. A 4.2 g sample of a volatile liquid contains 1.0 g of carbon and 0.25 g of hydrogen. The rest of the liquid is chlorine. When the sample is vaporized at 101.0 kPa and 60.0°C, it occupies a volume of 2.2 L. What is the molecular formula of the liquid?

26. Methanol has potential to be used as an alternative fuel. It burns in the presence of oxygen to produce carbon dioxide and water.

$CH_3OH_{(\ell)} + O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$

(a) Balance this equation.

(b) 10 L of oxygen is completely consumed at STP. What volume of CO_2 is produced?

(c) What mass of methanol is consumed in this reaction?

27. A student wants to prepare carbon dioxide using sodium carbonate and dilute hydrochloric acid.

$Na_2CO_{3(s)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + CO_{2(g)} + H_2O_{(\ell)}$

How much sodium carbonate should the student react with excess hydrochloric acid to produce 1.00 L of carbon dioxide at 24.0°C and 760 torr?

28. A scientist makes hydrogen gas in the laboratory by reacting calcium metal with an excess of hydrochloric acid.

$Ca_{(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_{2(g)}$

The scientist reacts 5.00 g of calcium and collects the hydrogen over water at 25.0°C and 103.0 kPa. What volume of dry hydrogen is produced?

29. A chemist collects oxygen over water at 22.0°C and 105.0 kPa using the following reaction:

$2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$

What volume of dry oxygen is obtained if the chemist heats 25.0 g of potassium chlorate?

30. Ammonia, a useful fertilizer, is produced by the following reaction:

$CH_{4(g)} + H_2O_{(\ell)} + N_2O_{(g)} \rightarrow 2NH_{3(g)} + CO_{2(g)}$

500.0 g of methane reacts with excess H_2O and N_2O. At 27.0°C and 1.20 atm, what volume of ammonia gas is produced?

31. Hydrochloric acid dissolves limestone, as shown in the following chemical equation:

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(\ell)}$

12.0 g of $CaCO_3$ reacts with 110 mL of 1.25 mol/L HCl. At 22.0°C and 99.0 kPa, what volume of carbon dioxide is produced?

32. Butane from a disposable lighter burns according to the following equation:

$C_4H_{10(g)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(\ell)}$

(a) Balance this chemical equation.

(b) How many grams of butane are needed to produce 300.0 mL of carbon dioxide at 50.0˚C and 1.25 atm? How many grams of oxygen are needed?

Communication

33. Draw a concept map showing the connections between the following gas laws:
    - Boyle's law
    - Charles' law
    - Gay-Lussac's law
    - the combined gas law
    - the ideal gas law
    - Gay-Lussac's law of combining volumes
    - Dalton's law of partial pressures

34. Prepare a poster that will explain the relationships between the pressure, volume, and temperature of a gas to students in a younger grade.

35. Express the ideal gas constant in each of the following units.
    (a) kPa·L/mol·K
    (b) atm·L/mol·K
    (c) torr·L/mol·K

Making Connections

36. Complex carbohydrates are starches that your body can convert to glucose, a type of sugar. Simple carbohydrate foods contain glucose, ready for immediate use by the human body. Breathing and burning glucose, $C_6H_{12}O_6$, produces energy in a jogger's muscles, according to the following unbalanced equation:
$C_6H_{12}O_{6(aq)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$
Just before running, Myri eats two oranges. The oranges give her body 25 g of glucose to make energy. The temperature outside is 27˚C, and the atmospheric pressure is 102.3 kPa. Although 21% of the air Myri breathes in is oxygen, she breathes out about 16% of this oxygen. (In other words, she only uses about 5%.)
    (a) How many litres of air does Myri breathe while running to burn up the glucose she consumed?
    (b) How many litres of water vapour does she produce? How many litres of carbon dioxide gas does she produce?
    (c) Suppose that the water vapour Myri breathes out is condensed to its liquid form. If the density of the water is 1.0 g/mL, what is its volume?

37. Sulfur dioxide reacts with oxygen in air to produce sulfur trioxide. The sulfur trioxide then reacts with water to produce sulfuric acid. Write balanced chemical equations for these reactions.

38. Write a story to describe what your life would be like if you did not participate in any polluting activities (such as riding in petroleum-powered cars) or use any products (such as plastic) that cause pollution. Include as many pollution-causing products as possible.

Answers to Practice Problems and Short Answers to Section Review Questions:

Practice Problems: **1.** 24 L/mol **2.** 42.8 L/mol **3.** 25.9 L/mol **4.(a)** 0.446 mol **(b)** 12.5 g **5.** 0.089 mol **6.** 0.500 mol, 3.01×10^{23} molecules **7.** 77.3 L **8.** 1.0×10^2 L **9.** 78.38 L **10.(a)** 56. 0 L **(b)** 1.51×10^{24} molecules **(c)** 3.01×10^{24} atoms **11.** 74.4 L **12.** 45.7 K **13.** 626 kg **14.** 23.3 L **15.** 25 kPa **16.** 1.71 g/L **17.** 2.35 g/L **18.** 3.65 g/L **19.** 578 kPa **20.** 48.2 g/mol **21.** 2.0×10^2 g/mol **22.** 71.3 g/mol **23.(a)** 1.69 g/L **(b)** 1.78 g/L **24.** C_2H_2 **25.(a)** 1:2 **(b)** 1:2 **(c)** 2:1 **(d)** 1:1 **26.(a)** 4.5 L **(b)** 7.5 L **27.(b)** 6.00 L **28.(b)** a_4b_2 **29.(a)** 65.0 L **(b)** 1.63×10^{24} molecules **(c)** 3.25×10^{24} atoms **30.** 16 L **31.** 0.20 g **32.** 0.047 g **33.(a)** 79 L **(b)** 98 L **34.** 0.32 g **35.** 79 L **36.** 1.1×10^2 g **37.** 0.71 L **38.** 4.8×10^6 L **39.(a)** 0.201 mol **(b)** $FeCl_3$

Section Review: **12.1:** **1.** 104 g **2.** 8.7×10^2 L **3.** 2.5×10^2 kPa **4.** 58 g; 2.2×10^{23} molecules **5.** –19˚C **7.** 6.2 atm **12.2:** **1.** 0.72 g/L **2.(a)** 2.0 g/mol **(b)** hydrogen gas **3.** N_2O_4 **12.3:** **5.** 2.0 L **6.(b)** 1.7 L **7.** 41 L **8.(a)** 1.1×10^2 g **(b)** 0.075 atm