Equations and Constants
1 atm = 760 mm Hg
1 atm = 14.70 psi
$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
$PV = nRT$
R = 0.0821 L·atm/mol·K
Avogadro's #: 6.02×10^{23}

Chapter 10 Practice

10.1 Interactions between Particles

1. How does the motion of particles change as a substance transitions from liquid to gas? In this transition, does the substance absorb or release heat energy?

   As the temperature increases, particles move faster and faster. As a substance transitions from solid to liquid, the particles absorb energy to break out of their fixed positions and move freely around each other. As it transitions from liquid to gas, the particles pull completely away from each other, moving freely about with very few interactions. To transition from solid to liquid or from liquid to gas, a substance absorbs energy from its surroundings.

10.2 Solids and Liquids

2. Describe each of the following as ionic, metallic, or molecular solids:

Sodium fluoride	ionic	Sucrose, $C_6H_{12}O_6$	covalent
Bronze, an alloy of copper and tin	metallic	KNO_3	ionic

3. The following compounds have very similar formula masses. Classify these compounds as ionic or covalent. Predict which compound would have the highest and lowest boiling points.

LiF	H_2O	N_2	HCl
ionic	covalent (polar)	covalent (nonpolar)	covalent (polar)
highest bp		lowest bp	

4. How is a polymer different from a molecular solid?

   A molecular solid is composed of smaller, distinct molecules.
   A polymer contains long chains of covalently bonded molecules. As a result, the physical properties of polymers are much different.

10.3 Describing Gases

5. Standard atmospheric pressure is 1 atmosphere. Express standard atmospheric pressure in mm Hg, kilopascals, and bars.

   1 atm = 760 mm Hg = 101.3 kPa = 1.013 bar

10.4 The Gas Laws

6. A gas occupies a volume of 224 cm^3 and a pressure of 1.51 bar. If the gas expands to a volume of 578 cm^3, what will the new pressure be? (Assume the temperature remains constant.)

$$P_2 = \frac{P_1V_1}{V_2} = \frac{(1.51\ \text{bar})(224\ \text{cm}^3)}{578\ \text{cm}^3} = 0.585\ \text{bar}$$

7. A cylinder with a constant volume of 2.80 L has a pressure of 32.0 psi at a temperature of 25.0 °C. If the cylinder is warmed to a temperature of 75.0 °C, what will be the pressure inside the cylinder?

$$P_2 = \frac{P_1 T_2}{T_1} = \frac{(32.0\ \text{psi})(348.2\ \cancel{\text{K}})}{(298.2\ \cancel{\text{K}})} = 37.4\ \text{psi}$$

8. A gas occupies a volume of 600.0 mL at a temperature of 25.00 °C. At what temperature would the gas occupy only half this volume?

T_1 = 25.0 °C = 273.15 K
V_1 = 600.0 mL

V_2 = 600.0 mL/2 = 300.0 mL

$$T_2 = \frac{V_2 T_1}{V_1} = \frac{(300.0\ \cancel{\text{mL}})(273.15\ \text{K})}{600.0\ \cancel{\text{mL}}} = 136.6\ \text{K}$$

9. In air-conditioning systems, compressed gases are allowed to expand, and this expansion results in cooling. A gas with a volume of 12.0 mL at a pressure of 8.0 bar at a temperature of 45 °C is allowed to expand to a volume of 40.0 mL at a pressure of 2.0 bar. What is the temperature of the gas after it expands?

$$T_2 = \frac{P_2 V_2 T_1}{P_1 V_1} = \frac{(2.0\ \cancel{\text{bar}})(40.0\ \cancel{\text{mL}})(318\ \text{K})}{(8.0\ \cancel{\text{bar}})(12.0\ \cancel{\text{mL}})} = 265\ \text{K} = -8\,°\text{C}$$

10. What is the volume of 4.52 moles of gas, calculated at standard temperature and pressure?

At STP, 1 mole of gas = 22.4 L

$$4.52\ \cancel{\text{mol}} \times \frac{22.4\ \text{L}}{1\ \cancel{\text{mol}}} = 101\ \text{L}$$

11. What is the pressure of 12.5 moles of gas at a temperature of 360.0 K and a volume of 5.02 liters?

$$P = \frac{nRT}{V} = \frac{(12.5\ \cancel{\text{mol}})\left(0.0821\ \frac{\cancel{\text{L}}\cdot\text{atm}}{\cancel{\text{mol}}\cdot\cancel{\text{K}}}\right)(360.0\ \cancel{\text{K}})}{5.02\ \cancel{\text{L}}} = 73.6\ \text{atm}$$

12. A helium balloon has a volume of 3.4 liters and a pressure of 1.05 atmospheres at 25 °C. How many moles of Helium gas are in the balloon? How many grams of gas?

$$n = \frac{PV}{RT} = \frac{(1.05\ \cancel{\text{atm}})(3.4\ \cancel{\text{L}})}{\left(0.0821\ \frac{\cancel{\text{L}}\cdot\cancel{\text{atm}}}{\text{mol}\cdot\cancel{\text{K}}}\right)(298\ \cancel{\text{K}})} = 0.146\ \text{moles}$$

$$0.146\ \cancel{\text{mol He}} \times \frac{4.00\ \text{g He}}{1\ \cancel{\text{mol He}}} = 0.584\ \text{g He}$$

10.5 Diffusion and Effusion

13. What is the difference between diffusion and effusion?

Diffusion is the spread of particles through random motion. Effusion is the process of a gas escaping from a container. Both properties depend on the speed of the gas particles.

10.6 Gas Stoichiometry

14. Propane gas (C_3H_8) reacts with oxygen according to the balanced equation shown below. If 12.0 moles of propane react in this way,

$$C_3H_8\,(g) + 5O_2\,(g) \rightarrow 3CO_2\,(g) + 4H_2O\,(g)$$

a. how many moles of water can form?

$$12.0\ \cancel{\text{mol } C_3H_8} \times \frac{4\ \text{mol } H_2O}{1\ \cancel{\text{mol } C_3H_8}} = 48.0\ \text{mol } H_2O$$

b. how many moles of carbon dioxide can form?

$$12.0\ \cancel{\text{mol } C_3H_8} \times \frac{3\ \text{mol } CO_2}{1\ \cancel{\text{mol } C_3H_8}} = 36.0\ \text{mol } CO_2$$

c. at STP, what volume of CO_2 can form?

$$36.0\ \cancel{\text{mol}}\ CO_2 \times \frac{22.4\ \text{L}}{1\ \cancel{\text{mol}}} = 806\ \text{L } CO_2$$

d. are more moles of gas produced or consumed in this reaction?

Reactants: 1 mole C_3H_8 + 5 moles O_2 = 6 moles of gas consumed
Products: 3 moles CO_2 + 4 moles H_2O = 7 moles of gas produced
More moles of gas are produced in this reaction.

15. If 50.0 grams of $NaHCO_3$ reacted as shown, how many moles of CO_2 would form? At 1.2 atmospheres of pressure and a temperature of 52.3 °C, what volume would this occupy?

$$NaHCO_3\,(s) \rightarrow NaOH\,(s) + CO_2\,(g)$$

First determine moles of CO_2 produced:

$$50.0\ \cancel{\text{g } NaHCO_3} \times \frac{1\ \text{mol } \cancel{NaHCO_3}}{83.00\ \cancel{\text{g } NaHCO_3}} \times \frac{1\ \text{mol } CO_2}{1\ \text{mol } \cancel{NaHCO_3}} = 0.602\ \text{moles } CO_2$$

Then determine the volume occupied:

$$V = \frac{nRT}{P} = \frac{(0.602\ \cancel{\text{mol}})\left(0.0821\ \frac{\text{L}\cdot\cancel{\text{atm}}}{\cancel{\text{mol}}\cdot\cancel{\text{K}}}\right)(325.5\ \cancel{\text{K}})}{1.2\ \cancel{\text{atm}}} = 13.4\ \text{L}$$