Additional Problems

In each of the following problems, assume that the molar quantity of gas does not change.

1. Calculate the unknown quantity in each of the following measurements of gases.

	P_1	V_1	P_2	V_2
a.	127.3 kPa	796 cm^3	? kPa	965 cm^3
b.	7.1×10^2 atm	? mL	9.6×10^{-1} atm	3.7×10^3 mL
c.	? kPa	1.77 L	30.79 kPa	2.44 L
d.	114 kPa	2.93 dm^3	4.93×10^4 kPa	? dm^3
e.	1.00 atm	120. mL	? atm	97.0 mL
f.	0.77 atm	3.6 m^3	1.90 atm	? m^3

2. A gas cylinder contains 0.722 m^3 of hydrogen gas at a pressure of 10.6 atm. If the gas is used to fill a balloon at a pressure of 0.96 atm, what is the volume in m^3 of the filled balloon?
3. A weather balloon has a maximum volume of 7.50×10^3 L. The balloon contains 195 L of helium gas at a pressure of 0.993 atm. What will be the pressure when the balloon is at maximum volume?
4. A rubber ball contains 5.70×10^{-1} dm^3 of gas at a pressure of 1.05 atm. What volume will the gas occupy at 7.47 atm?
5. Calculate the unknown quantity in each of the following measurements of gases.

	V_1	T_1	V_2	T_2
a.	26.5 mL	? K	32.9 mL	290. K
b.	? dm^3	100.°C	0.83 dm^3	−9°C
c.	7.44×10^4 mm^3	870.°C	2.59×10^2 mm^3	?°C
d.	5.63×10^{-2} L	132 K	? L	190. K
e.	? cm^3	243 K	819 cm^3	409 K
f.	679 m^3	−3°C	? m^3	−246°C

6. A bubble of carbon dioxide gas in some unbaked bread dough has a volume of 1.15 cm^3 at a temperature of 22°C. What volume will the bubble have when the bread is baked and the bubble reaches a temperature of 99°C?
7. A perfectly elastic balloon contains 6.75 dm^3 of air at a temperature of 40.°C. What is the temperature if the balloon has a volume of 5.03 dm^3?

Problem Solving *continued*

8. Calculate the unknown quantity in each of the following measurements of gases.

	P_1	T_1	P_2	T_2
a.	0.777 atm	?°C	5.6 atm	192°C
b.	152 kPa	302 K	? kPa	11 K
c.	? atm	−76°C	3.97 atm	27°C
d.	395 atm	46°C	706 atm	?°C
e.	? atm	−37°C	350. atm	2050°C
f.	0.39 atm	263 K	0.058 atm	? K

9. A 2 L bottle containing only air is sealed at a temperature of 22°C and a pressure of 0.982 atm. The bottle is placed in a freezer and allowed to cool to −3°C. What is the pressure in the bottle?

10. The pressure in a car tire is 2.50 atm at a temperature of 33°C. What would the pressure be if the tire were allowed to cool to 0°C? Assume that the tire does not change volume.

11. A container filled with helium gas has a pressure of 127.5 kPa at a temperature of 290. K. What is the temperature when the pressure is 3.51 kPa?

12. Calculate the unknown quantity in each of the following measurements of gases.

	P_1	V_1	T_1	P_2	V_2	T_2
a.	1.03 atm	1.65 L	19°C	0.920 atm	? L	46°C
b.	107.0 kPa	3.79 dm^3	73°C	? kPa	7.58 dm^3	217°C
c.	0.029 atm	249 mL	? K	0.098 atm	197 mL	293 K
d.	113 kPa	? mm^3	12°C	149 kPa	3.18×10^3 mm^3	−18°C
e.	1.15 atm	0.93 m^3	−22°C	1.01 atm	0.85 m^3	?°C
f.	? atm	156 cm^3	195 K	2.25 atm	468 cm^3	584 K

13. A scientist has a sample of gas that was collected several days earlier. The sample has a volume of 392 cm^3 at a pressure of 0.987 atm and a temperature of 21°C. On the day the gas was collected, the temperature was 13°C and the pressure was 0.992 atm. What volume did the gas have on the day it was collected?

14. Hydrogen gas is collected by water displacement. Total volume collected is 0.461 L at a temperature of 17°C and a pressure of 0.989 atm. What is the pressure of dry hydrogen gas collected?

Problem Solving *continued*

15. One container with a volume of 1.00 L contains argon at a pressure of 1.77 atm, and a second container of 1.50 L volume contains argon at a pressure of 0.487 atm. They are then connected to each other so that the pressure can become equal in both containers. What is the equalized pressure? Hint: Each sample of gas now occupies the total space. Dalton's law of partial pressures applies here.

16. Oxygen gas is collected over water at a temperature of 10.°C and a pressure of 1.02 atm. The volume of gas plus water vapor collected is 293 mL. What volume of oxygen at STP was collected?

17. A 500 mL bottle is partially filled with water so that the total volume of gases (water vapor and air) remaining in the bottle is 325 cm^3, measured at 20.°C and 101.3 kPa. The bottle is sealed and taken to a mountaintop where the pressure is 76.24 kPa and the temperature is 10°C. If the bottle is upside down and the seal leaks, how much water will leak out? The key to this problem is to determine the pressure in the 325 cm^3 space when the bottle is at the top of the mountain.

18. An air thermometer can be constructed by using a glass bubble attached to a piece of small-diameter glass tubing. The tubing contains a small amount of colored water that rises when the temperature increases and the trapped air expands. You want a 0.20 cm^3 change in volume to equal a 1°C change in temperature. What total volume of air at 20.°C should be trapped in the apparatus below the liquid?

19. A sample of nitrogen gas is collected over water, yielding a total volume of 62.25 mL at a temperature of 22°C and a total pressure of 97.7 kPa. At what pressure will the nitrogen alone occupy a volume of 50.00 mL at the same temperature?

20. The theoretical yield of a reaction that gives off nitrogen trifluoride gas is 844 mL at STP. What total volume of NF_3 plus water vapor will be collected over water at 25°C and a total pressure of 1.017 atm?

21. A weather balloon is inflated with 2.94 kL of helium at a location where the pressure is 1.06 atm and the temperature is 32°C. What will be the volume of the balloon at an altitude where the pressure is 0.092 atm and the temperature is −35°C?

22. The safety limit for a certain can of aerosol spray is 95°C. If the pressure of the gas in the can is 2.96 atm when it is 17°C, what will the pressure be at the safety limit?

23. A chemistry student collects a sample of ammonia gas at a temperature of 39°C. Later, the student measures the volume of the ammonia as 108 mL, but its temperature is now 21°C. What was the volume of the ammonia when it was collected?

24. A quantity of CO_2 gas occupies a volume of 624 L at a pressure of 1.40 atm. If this CO_2 is pumped into a gas cylinder that has a volume of 80.0 L, what pressure will the CO_2 exert on the cylinder?

Name _____ Class _____ Date _____

Skills Worksheet

Problem Solving

The Ideal Gas Law

In 1811, the Italian chemist Amedeo Avogadro proposed the principle that *equal volumes of gases at the same temperature and pressure contain equal numbers of molecules.* He determined that at standard temperature and pressure, one mole of gas occupies 22.414 10 L (usually rounded to 22.4 L).

At this point, if you know the number of moles of a gas, you can use the molar volume of 22.4 L/mol to calculate the volume that amount of gas would occupy at STP. Then you could use the combined gas law to determine the volume of the gas under any other set of conditions. However, a much simpler way to accomplish the same task is by using the ideal gas law.

The *ideal gas law* is a mathematical relationship that has the conditions of standard temperature (273 K) and pressure (1 atm or 101.3 kPa) plus the molar gas volume (22.4 L/mol) already combined into a single constant. The following equation is the mathematical statement of the ideal gas law.

$$PV = nRT$$

in which

- P = the pressure of a sample of gas
- V = the volume of a sample of gas
- n = the number of moles of gas present
- T = the Kelvin temperature of the gas
- R = the ideal gas constant, which combines standard conditions and molar volume into a single constant

The value of the ideal gas constant, R, depends on the units of P and V being used in the equation. Temperature is always in kelvins and amount of gas is always in moles. The most common values used for R are shown below.

Units of P and V	Value of R
Atmospheres and liters	$0.0821 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}$
Kilopascals and liters	$8.314 \frac{\text{L}\cdot\text{kPa}}{\text{mol}\cdot\text{K}}$