Name:

Skill Sheet 17-D Gases and Pressure

Have you ever pumped up a bicycle tire? What is happening inside of the tire? As you pump more air into the tire, more and more particles of air are pushed into the tire, increasing the pressure inside. On a microscopic level, each particle of air collides with the inside walls of the tire, exerting a force which pushes the inner surface of the tire outward. As you pump more air into the tire, there are more particles that can exert forces on the inside walls of the tire. The forces of all of the particles of air inside the tire add together to create pressure. This skill sheet will help you practice solving problems that involve changes in the pressure of a gas due to changes in volume or temperature.

1. Boyle's law: pressure and volume

The relationship between the volume of a gas and the pressure of a gas, at a constant temperature, is known as Boyle's law. The equation for Boyle's law is:

Boyle's law

Initial pressure → P_1, Initial volume → V_1, New pressure → P_2, New volume → V_2

$$P_1V_1 = P_2V_2$$

Here's how you solve a problem using this relationship:

A kit used to fix flat tires consists of an aerosol can containing compressed air, and a patch to seal the hole in the tire. Suppose 10.0 liters of air at atmospheric pressure (101.3 kilopascals, or kPa) is compressed into a 1.0 liter aerosol can. What is the pressure of the compressed air in the can?

1. Identify what you know and what you are trying to find out from the information given.

$\mathbf{P_1}$ = 101.3 kPa
$\mathbf{V_1}$ = 10.0 L
$\mathbf{P_2}$ = unknown
$\mathbf{V_2}$ = 1.0 L

2. Rearrange the variables in the equation to solve for the unknown variable.

Divide each side by $\mathbf{V_2}$ to isolate $\mathbf{P_2}$ on one side of the equation. The final equation is:

$$P_2 = \frac{P_1V_1}{V_2}$$

3. Plug in the values and solve the problem.

$$P_2 = \frac{101.3\ \text{kPa} \times 10.0\ \text{L}}{1.0\ \text{L}} = 1013\ \text{kPa}$$

The pressure inside of the aerosol can is 1,013 kPa.

2. Charles' law: pressure and temperature

The French scientist Jacques Charles was a pioneer in hot-air ballooning. He investigated how changing the temperature of a fixed amount of gas at constant pressure affected its volume. The equation for this relationship is:

Charles' law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

V_1: Initial volume; T_1: Initial temperature; V_2: Final volume; T_2: Final temperature

Charles' law shows a direct relationship between the volume of a gas and the temperature of a gas when the temperature is given in the **Kelvin scale**. Zero on the Kelvin scale is the coldest possible temperature, also known as absolute zero. Absolute zero is equal to -273 °C which is 273 °C below the freezing point of water. Why do you think this scale is used to solve these problems?

Converting from degrees Celsius to Kelvin is very easy. You *add* 273 to the Celsius temperature. To convert from Kelvins to degrees Celsius, you *subtract* 273 from the Kelvin temperature.

To solve problems with Charles' law, you can follow the same problem-solving steps you learned for Boyle's law, except you use the equation for Charles' law. You also need to convert degrees Celsius to Kelvin. To practice both equations, do the problems below.

3. Practice problems with Boyle's and Charles' laws

1. A truck tire holds 25.0 L of air at 25.0 °C. If the temperature drops to 0.00 °C, and the pressure remains constant, what will be the new volume of the tire?
   (HINT: remember to convert degrees Celsius to Kelvins!)

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2. You pump 25.0 L of air at atmospheric pressure (101.3 kPa) into a soccer ball that has a volume of 4.50 L. What is the pressure inside of the soccer ball if the temperature does not change?

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3. Hyperbaric oxygen chambers (HBO) are used to treat divers with decompression sickness. Research has shown that HBO can also aid in the healing of broken bones and muscle injuries. As pressure increases inside of the HBO, more oxygen is forced into the bloodstream of the patient inside of the chamber. To work properly, the pressure inside of the chamber should be three times greater than atmospheric pressure (101.3 kPa). What volume of oxygen, held at atmospheric pressure will need to be pumped into a 190 L HBO chamber to make the pressure inside three times greater than atmospheric pressure?

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4. A balloon holds 20.0 L of helium at 10 °C. If the temperature doubles, and the pressure does not change, what will be the new volume of the balloon?

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5. A SCUBA tank holds 12.5 L of oxygen at 1013 kPa. If the oxygen that was pumped into the SCUBA tank was held at a pressure of 202.6 kPa, what was the original volume of gas that was pumped into the SCUBA tank?

Use the space below to show your calculations for the problems: