

STP = 0°C @ 1 atm
 273 K @ 760 mmHg
 101.3 kPa
 14.7 psi

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Combined Gas Law Problems

Use the combined gas law to solve the following problems:

- 1) If I initially have a gas at a pressure of 12 atm, a volume of 23 liters, and a temperature of 200 K, and then I raise the pressure to 14 atm and increase the temperature to 300 K, what is the new volume of the gas?

$$\begin{array}{l}
 P_1 = 12 \text{ atm} \\
 V_1 = 23 \text{ L} \\
 T_1 = 200 \text{ K} \\
 P_2 = 14 \text{ atm} \\
 V_2 = ? \text{ (unknown)} \\
 T_2 = 300 \text{ K}
 \end{array}
 \quad
 \frac{T_2 P_1 V_1}{P_2 T_1} = \frac{300 \text{ K} \times 12 \text{ atm} \times 23 \text{ L}}{14 \text{ atm} \times 200 \text{ K}}$$

$$= 29.6 \text{ L} \checkmark$$

- 2) A gas takes up a volume of 17 liters, has a pressure of 2.3 atm, and a temperature of 299 K. If I raise the temperature to 350 K and lower the pressure to 1.5 atm, what is the new volume of the gas?

$$\begin{array}{l}
 P_1 = 2.3 \text{ atm} \\
 V_1 = 17 \text{ L} \\
 T_1 = 299 \text{ K} \\
 P_2 = 1.5 \text{ atm} \\
 V_2 = ? \text{ (unknown)} \\
 T_2 = 350 \text{ K}
 \end{array}
 \quad
 \frac{T_2 P_1 V_1}{P_2 T_1} = \frac{350 \text{ K} \times 2.3 \text{ atm} \times 17 \text{ L}}{1.5 \text{ atm} \times 299 \text{ K}}$$

$$= 30.5 \text{ L} \checkmark$$

- 3) A gas that has a volume of 28 liters, a temperature of 45 °C, and an unknown pressure has its volume increased to 34 liters and its temperature decreased to 35 °C. If I measure the pressure after the change to be 2.0 atm, what was the original pressure of the gas?

$$\begin{array}{l}
 P_1 = ? \text{ (unknown)} \\
 V_1 = 28 \text{ L} \\
 T_1 = 45^\circ \text{C} = 318 \text{ K} \\
 P_2 = 2.0 \text{ atm} \\
 V_2 = 34 \text{ L} \\
 T_2 = 35^\circ \text{C} = 308 \text{ K}
 \end{array}
 \quad
 \frac{P_2 V_2 T_1}{T_2 V_1} = \frac{2.0 \text{ atm} \times 34 \text{ L} \times 318 \text{ K}}{308 \text{ K} \times 28 \text{ L}}$$

$$= 2.51 \text{ atm} \checkmark$$

- 4) A gas has a temperature of 14 °C, and a volume of 4.5 liters. If the temperature is raised to 29 °C and the pressure is not changed, what is the new volume of the gas?

$$\begin{array}{l}
 P_1 = x \\
 V_1 = 4.5 \text{ L} \\
 T_1 = 14^\circ \text{C} = 277 \text{ K} \\
 P_2 = x \\
 V_2 = ? \\
 T_2 = 29^\circ \text{C} = 302 \text{ K}
 \end{array}
 \quad
 \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad V_2 = \frac{V_1 T_2}{T_1} = \frac{4.5 \text{ L} \times 302 \text{ K}}{277 \text{ K}} = 4.74 \text{ L}$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

- 5) If I have 17 liters of gas at a temperature of 67 °C and a pressure of 88.89 atm, what will be the pressure of the gas if I raise the temperature to 94 °C and decrease the volume to 12 liters?

$$P_1 = 88.89 \text{ atm} \quad P_2 = ? \quad P_2 = \frac{P_1 V_1 T_2}{T_1 V_2} = \frac{88.89 \text{ atm} \times 17 \text{ L} \times 367 \text{ K}}{340 \text{ K} \times 12 \text{ L}} = 135.9 \text{ atm}$$

$$V_1 = 17 \text{ L} \quad V_2 = 12 \text{ L}$$

$$T_1 = 67^\circ\text{C} = 340 \text{ K} \quad T_2 = 94 + 273 = 367 \text{ K}$$

- 6) I have an unknown volume of gas at a pressure of 0.5 atm and a temperature of 325 K. If I raise the pressure to 1.2 atm, decrease the temperature to 320 K, and measure the final volume to be 48 liters, what was the initial volume of the gas?

$$P_1 = 0.5 \text{ atm} \quad P_2 = 1.2 \text{ atm} \quad V_1 = \frac{T_1 P_2 V_2}{P_1 T_2} = \frac{325 \text{ K} \times 1.2 \text{ atm} \times 48 \text{ L}}{0.5 \text{ atm} \times 320 \text{ K}} = 117 \text{ L}$$

$$V_1 = ? \quad V_2 = 48 \text{ L}$$

$$T_1 = 325 \text{ K} \quad T_2 = 320 \text{ K}$$

- 7) If I have 21 liters of gas held at a pressure of 78 atm and a temperature of 900 K, what will be the volume of the gas if I decrease the pressure to 45 atm and decrease the temperature to 750 K?

$$P_1 = 78 \text{ atm} \quad P_2 = 45 \text{ atm} \quad V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{78 \text{ atm} \times 21 \text{ L} \times 750 \text{ K}}{900 \text{ K} \times 45 \text{ atm}} = 30.3 \text{ L}$$

$$V_1 = 21 \text{ L} \quad V_2 = ?$$

$$T_1 = 900 \text{ K} \quad T_2 = 750 \text{ K}$$

- 8) If I have 2.9 L of gas at a pressure of 5 atm and a temperature of 50 °C, what will be the temperature of the gas if I decrease the volume of the gas to 2.4 L and decrease the pressure to 3 atm?

$$P_1 = 5 \text{ atm} \quad P_2 = 3 \text{ atm} \quad T_2 = \frac{P_2 V_2 T_1}{P_1 V_1} = \frac{3 \text{ atm} \times 2.4 \text{ L} \times 323 \text{ K}}{5 \text{ atm} \times 2.9 \text{ L}} = 160.4 \text{ K}$$

$$V_1 = 2.9 \text{ L} \quad V_2 = 2.4 \text{ L}$$

$$T_1 = 50^\circ\text{C} = 323 \text{ K} \quad T_2 = ?$$

- 9) I have an unknown volume of gas held at a temperature of 115 K in a container with a pressure of 60 atm. If by increasing the temperature to 225 K and decreasing the pressure to 30 atm causes the volume of the gas to be 29 liters, how many liters of gas did I start with?

$$P_1 = 60 \text{ atm} \quad P_2 = 30 \text{ atm} \quad V_1 = \frac{P_2 V_2 T_1}{P_1 T_2} = \frac{115 \text{ K} \times 30 \text{ atm} \times 29 \text{ L}}{60 \text{ atm} \times 225 \text{ K}} = 7.41 \text{ L}$$

$$V_1 = ? \quad V_2 = 29 \text{ L}$$

$$T_1 = 115 \text{ K} \quad T_2 = 225 \text{ K}$$