KEY

Boyles' Law

Use Boyles' Law to answer the following questions:

1) 1.00 L of a gas at standard temperature and pressure is compressed to 473 mL. What is the new pressure of the gas?

$V_1 = 1.00 L$
$P_1 = 1 atm$
$V_2 = 473 mL = 0.473 L$
$P_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(1 atm)(1.00 L) = (0.473 L)P_2$$
$$P_2 = \frac{(1 atm)(1.00 L)}{0.473 L} = \boxed{2.11 atm}$$

2) In a thermonuclear device, the pressure of 0.050 liters of gas within the bomb casing reaches 4.0×10^6 atm. When the bomb casing is destroyed by the explosion, the gas is released into the atmosphere where it reaches a pressure of 1.00 atm. What is the volume of the gas after the explosion?

$P_1 = 4.0 \times 10^6 atm$
$V_1 = 0.050 L$
$P_2 = 1.00 atm$
$V_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(4.0 \times 10^6 atm)(0.050 L) = (1.00 atm)V_2$$
$$V_2 = \frac{(4.0 \times 10^6 atm)(0.050 L)}{1.00 atm} = \boxed{200000 L = 2.0 \times 10^5 L}$$

3) Synthetic diamonds can be manufactured at pressures of 6.00×10^4 atm. If we took 2.00 liters of gas at 1.00 atm and compressed it to a pressure of 6.00×10^4 atm, what would the volume of that gas be?

$P_2 = 6.00 \times 10^4 atm$
$P_1 = 1.00 atm$
$V_1 = 2.00 L$
$V_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(1.00 atm)(2.00 L) = (6.00 \times 10^4 atm)V_2$$
$$V_2 = \frac{(1.00 atm)(2.00 L)}{6.00 \times 10^4 atm} = \boxed{0.000033 L = 3.33 \times 10^{-5} L}$$

4) The highest pressure ever produced in a laboratory setting was about 2.0×10^6 atm. If we have a 1.0×10^{-5} liter sample of a gas at that pressure, then release the pressure until it is equal to 0.275 atm, what would the new volume of that gas be?

$P_1 = 2.0 \times 10^6 atm$
$V_1 = 1.0 \times 10^{-5} L$
$P_2 = 0.275 atm$
$V_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(2.0 \times 10^6 atm)(1.0 \times 10^{-5} L) = (0.275 atm)V_2$$
$$V_2 = \frac{(2.0 \times 10^6 atm)(1.0 \times 10^{-5} L)}{0.275 atm} = \boxed{72.73 L}$$

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$P_1 = 1\,atm$
$V_2 = 473\,mL = 0.473\,L$
$P_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(1\,atm)(1.00\,L) = (0.473\,L)P_2$$
$$P_2 = \frac{(1\,atm)(1.00\,L)}{0.473\,L} = \boxed{2.11\,atm}$$

2) In a thermonuclear device, the pressure of 0.050 liters of gas within the bomb casing reaches 4.0×10^6 atm. When the bomb casing is destroyed by the explosion, the gas is released into the atmosphere where it reaches a pressure of 1.00 atm. What is the volume of the gas after the explosion?

$P_1 = 4.0 \times 10^6\,atm$
$V_1 = 0.050\,L$
$P_2 = 1.00\,atm$
$V_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(4.0 \times 10^6\,atm)(0.050\,L) = (1.00\,atm)V_2$$
$$V_2 = \frac{(4.0 \times 10^6\,atm)(0.050\,L)}{1.00\,atm} = \boxed{200{,}000\,L = 2.0 \times 10^5\,L}$$

3) Synthetic diamonds can be manufactured at pressures of 6.00×10^4 atm. If we took 2.00 liters of gas at 1.00 atm and compressed it to a pressure of 6.00×10^4 atm, what would the volume of that gas be?

$P_2 = 6.00 \times 10^4\,atm$
$P_1 = 1.00\,atm$
$V_1 = 2.00\,L$
$V_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(1.00\,atm)(2.00\,L) = (6.00 \times 10^4\,atm)V_2$$
$$V_2 = \frac{(1.00\,atm)(2.00\,L)}{6.00 \times 10^4\,atm} = \boxed{0.000033\,L = 3.33 \times 10^{-5}\,L}$$

4) The highest pressure ever produced in a laboratory setting was about 2.0×10^6 atm. If we have a 1.0×10^{-5} liter sample of a gas at that pressure, then release the pressure until it is equal to 0.275 atm, what would the new volume of that gas be?

$P_1 = 2.0 \times 10^6\,atm$
$V_1 = 1.0 \times 10^{-5}\,L$
$P_2 = 0.275\,atm$
$V_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(2.0 \times 10^6\,atm)(1.0 \times 10^{-5}\,L) = (0.275\,atm)V_2$$
$$V_2 = \frac{(2.0 \times 10^6\,atm)(1.0 \times 10^{-5}\,L)}{0.275\,atm} = \boxed{72.73\,L}$$

KEY

5) Atmospheric pressure on the peak of Mt. Everest can be as low as 150 mm Hg, which is why climbers need to bring oxygen tanks for the last part of the climb. If the climbers carry 10.0 liter tanks with an internal gas pressure of 3.04×10^4 mm Hg, what will be the volume of the gas when it is released from the tanks?

$V_1 = 10.0\ L$
$P_1 = 3.04 \times 10^4\ mmHg$
$P_2 = 150\ mmHg$
$V_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(3.04 \times 10^4\ mmHg)(10.0\ L) = (150\ mmHg)V_2$$
$$V_2 = \frac{(3.04 \times 10^4\ mmHg)(10.0\ L)}{150\ mmHg} = 2026.67\ L$$

6) Part of the reason that conventional explosives cause so much damage is that their detonation produces a strong shock wave that can knock things down. While using explosives to knock down a building, the shock wave can be so strong that 12 liters of gas will reach a pressure of 3.8×10^4 mm Hg. When the shock wave passes and the gas returns to a pressure of 760 mm Hg, what will the volume of that gas be?

$V_1 = 12\ L$
$P_1 = 3.8 \times 10^4\ mmHg$
$P_2 = 760\ mmHg$
$V_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(3.8 \times 10^4\ mmHg)(12\ L) = (760\ mmHg)V_2$$
$$V_2 = \frac{(3.8 \times 10^4\ mmHg)(12\ L)}{760\ mmHg} = \boxed{600\ L}$$

7) Submarines need to be extremely strong to withstand the extremely high pressure of water pushing down on them. An experimental research submarine with a volume of 15,000 liters has an internal pressure of 1.2 atm. If the pressure of the ocean breaks the submarine forming a bubble with a pressure of 250 atm pushing on it, how big will that bubble be?

$V_1 = 15000\ L$
$P_1 = 1.2\ atm$
$P_2 = 250\ atm$
$V_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(1.2\ atm)(15000\ L) = (250\ atm)V_2$$
$$V_2 = \frac{(1.2\ atm)(15000\ L)}{250\ atm} = \boxed{72\ L}$$

8) Divers get "the bends" if they come up too fast because gas in their blood expands, forming bubbles in their blood. If a diver has 0.05 L of gas in his blood under a pressure of 250 atm, then rises instantaneously to a depth where his blood has a pressure of 50.0 atm, what will the volume of gas in his blood be? Do you think this will harm the diver?

$V_1 = 0.05\ L$
$P_1 = 250\ atm$
$P_2 = 50.0\ atm$
$V_2 = ?$

$$P_1V_1 = P_2V_2$$
$$(250\ atm)(0.05\ L) = (50.0\ atm)V_2$$
$$V_2 = \frac{(250\ atm)(0.05\ L)}{50.0\ atm} = \boxed{0.25\ L}$$

KEY

Charles' Law Worksheet

1) The temperature inside my refrigerator is about 4^0 Celsius. If I place a balloon in my fridge that initially has a temperature of 22^0 C and a volume of 0.5 liters, what will be the volume of the balloon when it is fully cooled by my refrigerator?

$T_1 = 22°C = 295K$
$V_1 = 0.5L$
$T_2 = 4°C = 277K$
$V_2 = ?$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
$$\frac{0.5L}{295K} = \frac{V_2}{277K}$$
$$(295K)V_2 = (0.5L)(277K)$$
$$V_2 = \frac{(0.5L)(277K)}{295K} = \boxed{0.47L}$$

2) A man heats a balloon in the oven. If the balloon initially has a volume of 0.4 liters and a temperature of 20 ^{0}C, what will the volume of the balloon be after he heats it to a temperature of 250 ^{0}C?

$V_1 = 0.4L$
$T_1 = 20°C = 293K$
$T_2 = 250°C = 523K$
$V_2 = ?$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
$$\frac{0.4L}{293K} = \frac{V_2}{523K}$$
$$(293K)V_2 = (0.4L)(523K)$$
$$V_2 = \frac{(0.4L)(523K)}{293K} = \boxed{0.71L}$$

3) On hot days, you may have noticed that potato chip bags seem to "inflate", even though they have not been opened. If I have a 250 mL bag at a temperature of 19 ^{0}C, and I leave it in my car which has a temperature of 60^0 C, what will the new volume of the bag be?

$V_1 = 250mL$
$T_1 = 19°C = 292K$
$V_2 = ?$
$T_2 = 60°C = 333K$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
$$\frac{250mL}{292K} = \frac{V_2}{333K}$$
$$(292K)V_2 = (250mL)(333K)$$
$$V_2 = \frac{(250mL)(333K)}{292K} = \boxed{285.10mL}$$

4) A soda bottle is flexible enough that the volume of the bottle can change even without opening it. If you have an empty soda bottle (volume of 2 L) at room temperature (25 ^{0}C), what will the new volume be if you put it in your freezer (-4 ^{0}C)?

$V_1 = 2L$
$T_1 = 25°C = 298K$
$T_2 = -4°C = 269K$
$V_2 = ?$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
$$\frac{2L}{298K} = \frac{V_2}{269K}$$
$$V_2 = \frac{(2L)(269K)}{298K}$$
$$\boxed{V_2 = 1.81L}$$
$$(298K)V_2 = (2L)(269K)$$

KEY

5) Some students believe that teachers are full of hot air. If I inhale 2.2 liters of gas at a temperature of 18^0 C and it heats to a temperature of 38^0 C in my lungs, what is the new volume of the gas?

$V_1 = 2.2L$
$T_1 = 18°C = 291K$
$T_2 = 38°C = 311K$
$V_2 = ?$

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

$$\frac{2.2L}{291K} = \frac{V_2}{311K}$$

$$(291K)V_2 = (2.2L)(311K)$$

$$V_2 = \frac{(2.2L)(311K)}{291K} = \boxed{2.35L}$$

6) How hot will a 2.3 L balloon have to get to expand to a volume of 400 L? Assume that the initial temperature of the balloon is 25^0C.

$V_1 = 2.3L$
$V_2 = 400L$
$T_1 = 25°C = 298K$
$T_2 = ?$

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

$$\frac{2.3L}{298K} = \frac{400L}{T_2}$$

$$(2.3L)T_2 = (400L)(298K)$$

$$T_2 = \frac{(400L)(298K)}{2.3L} = \boxed{51826.09K}$$

7) I have made a thermometer which measures temperature by the compressing and expanding of gas in a piston. I have measured that at 100^0 C the volume of the piston is 20 L. What is the temperature outside if the piston has a volume of 15 L? What would be appropriate clothing for the weather?

$T_1 = 100°C = 373K$
$V_1 = 20L$
$T_2 = ?$
$V_2 = 15L$

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

$$\frac{20L}{373K} = \frac{15L}{T_2}$$

$$(20L)T_2 = (373K)(15L)$$

$$T_2 = \frac{(373K)(15L)}{20L} = \boxed{279.75K}$$

KEY

Gay-Lussac Gas Law

1) Determine the pressure change when a constant volume of gas at 1.00 atm is heated from 20.0 °C to 30.0 °C.

$P_1 = 1.00\,atm$

$T_1 = 20.0\,°C = 293\,K$

$P_2 = ?$

$T_2 = 30.0 = 303\,K$

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

$$\frac{1.00\,atm}{293\,K} = \frac{P_2}{303\,K}$$

$$(293\,K)P_2 = (1.00\,atm)(303\,K)$$

$$P_2 = \frac{(1.00\,atm)(303\,K)}{(293\,K)} = 1.03\,atm$$

Pressure decreases by 0.03 atm to a final pressure of 1.03 atm.

2) A gas has a pressure of 0.370 atm at 50.0 °C. What is the pressure at standard temperature?

$P_1 = 0.370\,atm$

$T_1 = 50.0\,°C = 323\,K$

$T_2 = 0\,°C = 273\,K$

$P_2 = ?$

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

$$\frac{0.370\,atm}{323\,K} = \frac{P_2}{273\,K}$$

$$(323\,K)P_2 = (0.370\,atm)(273\,K)$$

$$P_2 = \frac{(0.370\,atm)(273\,K)}{323\,K} = \boxed{0.31\,atm}$$

3) A gas has a pressure of 699.0 mm Hg at 40.0 °C. What is the temperature at standard pressure?

$P_1 = 699.0\,mm\,Hg$

$T_1 = 40\,°C = 313\,K$

$P_2 = 1.0\,atm = 760\,mm\,Hg$

$T_2 = ?$

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

$$\frac{699.0\,mmHg}{313\,K} = \frac{760\,mmHg}{T_2}$$

$$T_2 = \frac{(760\,mmHg)(313\,K)}{699.0\,mmHg} = \boxed{340.31\,mmHg}$$

4) If a gas is cooled from 323.0 K to 273.15 K and the volume is kept constant what final pressure would result if the original pressure was 750.0 mm Hg?

$T_1 = 323\,K$

$T_2 = 273.15\,K$

$P_2 = ?$

$P_1 = 750.0\,mmHg$

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

$$\frac{750.0\,mmHg}{323\,K} = \frac{P_2}{273.15\,K}$$

$$P_2 = \frac{(750.0\,mmHg)(273.15\,K)}{323\,K} = \boxed{634.25\,mmHg}$$

KEY

5) If a gas in a closed container is pressurized from 15.0 atmospheres to 16.0 atmospheres and its original temperature was 25.0 °C, what would the final temperature of the gas be?

$P_1 = 15.0 \text{ atm}$
$P_2 = 16.0 \text{ atm}$
$T_1 = 25.0°C = 298 K$
$T_2 = ?$

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

$$\frac{15.0 \text{ atm}}{298 K} = \frac{16.0 \text{ atm}}{T_2}$$

$$(15.0 \text{ atm})T_2 = (298 K)(16.0 \text{ atm})$$

$$T_2 = \frac{(298 K)(16.0 \text{ atm})}{15.0 \text{ atm}} = \boxed{317.87 K = 44.87°C}$$

6) A 30.0 L sample of nitrogen inside a rigid, metal container at 20.0 °C is placed inside an oven whose temperature is 50.0 °C. The pressure inside the container at 20.0 °C was at 3.00 atm. What is the pressure of the nitrogen after its temperature is increased?

$T_1 = 20.0°C = 293 K$
$T_2 = 50.0°C = 323 K$
$P_1 = 3.00 \text{ atm}$
$P_2 = ?$

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

$$\frac{3.00 \text{ atm}}{293 K} = \frac{P_2}{323 K}$$

$$(293 K)P_2 = (3.00 \text{ atm})(323 K)$$

$$P_2 = \frac{(3.00 \text{ atm})(323 K)}{293 K} = \boxed{3.31 \text{ atm}}$$

7) A sample of gas at 3.00 x 10³ mm Hg inside a steel tank is cooled from 500.0 °C to 0.00 °C. What is the final pressure of the gas in the steel tank?

$P_1 = 3.00 \times 10^3 \text{ mm Hg}$
$T_1 = 500°C = 773 K$
$T_2 = 0.00°C = 273 K$
$P_2 = ?$

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

$$\frac{3.00 \times 10^3 \text{ mm Hg}}{773 K} = \frac{P_2}{273 K}$$

$$(773 K)P_2 = (3.00 \times 10^3 \text{ mm Hg})(273 K)$$

$$P_2 = \frac{(3.00 \times 10^3 \text{ mm Hg})(273 K)}{773 K} = \boxed{1059.51 \text{ mmHg} = 1.39 \text{ atm}}$$

8) The temperature of a sample of gas in a steel container at 30.0 kPa is increased from -100.0 °C to 1.00 x 10³ °C. What is the final pressure inside the tank?

$P_1 = 30.0 \text{ kPa}$
$T_1 = -100.0°C = 173 K$
$T_2 = 1.00 \times 10^3 °C = 1273 K$
$P_2 = ?$

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

$$\frac{30.0 \text{ kPa}}{173 K} = \frac{P_2}{1273 K}$$

$$(173 K)P_2 = (30.0 \text{ kPa})(1273 K)$$

$$P_2 = \frac{(30.0 \text{ kPa})(1273 K)}{173 K} = \boxed{220.75 \text{ kPa} = 2.18 \text{ atm}}$$

KEY

9) Calculate the final pressure inside a scuba tank after it cools from 1.00×10^3 °C to 25.0 °C. The initial pressure in the tank is 130.0 atm.

$T_1 = 1.00 \times 10^3$ °C = 1273 K

$T_2 = 25.0$ °C = 298 K

$P_1 = 130.0$ atm

$P_2 = ?$

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

$$\frac{130.0\ \text{atm}}{1273\ \text{K}} = \frac{P_2}{298\ \text{K}}$$

$$(1273\ \text{K}) P_\alpha = (130.0\ \text{atm})(298\ \text{K})$$

$$P_a = \frac{(130.0\ \text{atm})(298\ \text{K})}{1273\ \text{K}} = \boxed{30.43\ \text{atm}}$$

KEY

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?

$P_1 = 12atm$
$V_1 = 23L$
$T_1 = 200K$
$P_2 = 14atm$
$T_2 = 300K$
$V_2 = ?$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(12atm)(23L)}{200K} = \frac{(14atm)V_2}{300K}$$

$$\frac{(200K)(14atm)V_2}{(200K)(14atm)} = \frac{(12atm)(23L)(300K)}{(200K)(14atm)}$$

$$V_2 = \frac{(12atm)(23L)(300K)}{(200K)(14atm)} = \boxed{29.57L}$$

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?

$V_1 = 17L$
$P_1 = 2.3atm$
$T_1 = 299K$
$T_2 = 350K$
$P_2 = 1.5atm$
$V_2 = ?$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(2.3atm)(17L)}{299K} = \frac{(1.5atm)V_2}{350K}$$

$$\frac{(299K)(1.5atm)V_2}{(299K)(1.5atm)} = \frac{(2.3atm)(17L)(350K)}{(299K)(1.5atm)}$$

$$V_2 = \frac{(2.3atm)(17L)(350K)}{(299K)(1.5atm)} = \boxed{30.51L}$$

3) A gas that has a volume of 28 liters, a temperature of 45 ^{0}C, and an unknown pressure has its volume increased to 34 liters and its temperature decreased to 35 ^{0}C. If I measure the pressure after the change to be 2.0 atm, what was the original pressure of the gas?

$P_1 = ?$
$V_1 = 28L$
$T_1 = 45°C = 318K$
$V_2 = 34L$
$T_2 = 35°C = 308K$
$P_2 = 2.0atm$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(28L)P_1}{318K} = \frac{(2.0atm)(34L)}{308K}$$

$$\frac{(28L)(308K)P_1}{(28L)(308K)} = \frac{(318K)(2.0atm)(34L)}{(28L)(308K)}$$

$$P_1 = \frac{(318K)(2.0atm)(34L)}{(28L)(308K)} = \boxed{2.51atm}$$

4) A gas has a temperature of 14 ^{0}C, and a volume of 4.5 liters. If the temperature is raised to 29 ^{0}C and the pressure is not changed, what is the new volume of the gas?

$T_1 = 14°C = 287K$
$V_1 = 4.5L$
$T_2 = 29°C = 302K$
$V_2 = ?$
$P_1 = P_2$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

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

$$\frac{4.5L}{287K} = \frac{V_2}{302K}$$

$$\frac{(287K)V_2}{287K} = \frac{(4.5L)(302K)}{287K}$$

$$V_2 = \frac{(4.5L)(302K)}{287K} = \boxed{4.74L}$$

KEY

5) If I have 17 liters of gas at a temperature of 67 ^{0}C and a pressure of 88.89 atm, what will be the pressure of the gas if I raise the temperature to 94 ^{0}C and decrease the volume to 12 liters?

$V_1 = 17L$
$T_1 = 67°C = 340K$
$P_1 = 88.89 atm$
$P_2 = ?$
$T_2 = 94°C = 367K$
$V_2 = 12L$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(88.89atm)(17L)}{340K} = \frac{(12L)P_2}{367K}$$

$$\frac{(340K)(12L)P_2}{(340K)(12L)} = \frac{(88.89atm)(17L)(367K)}{(340K)(12L)}$$

$$P_2 = \frac{(88.89atm)(17L)(367K)}{(340K)(12L)} = \boxed{135.93atm}$$

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?

$V_1 = ?$
$P_1 = 0.5atm$
$T_1 = 325K$
$P_2 = 1.2atm$
$T_2 = 320K$
$V_2 = 48L$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(0.5atm)V_1}{325K} = \frac{(1.2atm)(48L)}{320K}$$

$$\frac{(320K)(0.5atm)V_1}{(320K)(0.5atm)} = \frac{(325K)(1.2atm)(48L)}{(320K)(0.5atm)}$$

$$V_1 = \frac{(325K)(1.2atm)(48L)}{(320K)(0.5atm)} = \boxed{117 L}$$

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?

$V_1 = 21L$
$P_1 = 78atm$
$T_1 = 900K$
$V_2 = ?$
$P_2 = 45atm$
$T_2 = 750K$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(78atm)(21L)}{900K} = \frac{(45atm)V_2}{750K}$$

$$\frac{(900K)(45atm)V_2}{(900K)(45atm)} = \frac{(78atm)(21L)(750K)}{(900K)(45atm)}$$

$$V_2 = \frac{(78atm)(21L)(750K)}{(900K)(45atm)} = \boxed{30.33L}$$

8) If I have 2.9 L of gas at a pressure of 5 atm and a temperature of 50 ^{0}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?

$V_1 = 2.9L$
$P_1 = 5atm$
$T_1 = 50°C = 323K$
$V_2 = 2.4L$
$P_2 = 3atm$
$T_2 = ?$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(5atm)(2.9L)}{323K} = \frac{(3atm)(2.4L)}{T_2}$$

$$(5atm)(2.9L)T_2 = (323K)(3atm)(2.4L)$$

$$T_2 = \frac{(323K)(3atm)(2.4L)}{(5atm)(2.9L)} = \boxed{160.39K = -112.61°C}$$

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?

$V_1 = ?$
$T_1 = 115K$
$P_2 = 60atm$
$T_2 = 225K$
$P_2 = 30atm$
$V_2 = 29L$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(60atm)V_1}{115K} = \frac{(30atm)(29L)}{225K}$$

$$\frac{(225K)(60atm)V_1}{(225K)(60atm)} = \frac{(115K)(30atm)(29L)}{(225K)(60atm)}$$

$$V_1 = \frac{(115K)(30atm)(29L)}{(225K)(60atm)} = \boxed{7.41 L}$$

KEY

Ideal Gas Law Problems

Use the ideal gas law to solve the following problems:

1) If I have 4 moles of a gas at a pressure of 5.6 atm and a volume of 12 liters, what is the temperature?

n = 4 mol, P = 5.6 atm, V = 12 L, T = ?

$PV = nRT$

$(5.6\,atm)(12\,L) = (4\,mol)(0.0821\,\frac{L\cdot atm}{K\cdot mol})T$

$T = \frac{(5.6\,atm)(12\,L)}{(4\,mol)(0.0821\,\frac{L\cdot atm}{K\cdot mol})} = 204.63\,K = -68.37\,°C$

2) If I have an unknown quantity of gas at a pressure of 1.2 atm, a volume of 31 liters, and a temperature of 87 ^{0}C, how many moles of gas do I have?

P = 1.2 atm, V = 31 L, T = 87°C = 360 K, n = ?

$PV = nRT$

$(1.2\,atm)(31\,L) = n(0.0821\,\frac{L\cdot atm}{K\cdot mol})(360\,K)$

$n = \frac{(1.2\,atm)(31\,L)}{(0.0821\,\frac{L\cdot atm}{K\cdot mol})(360\,K)} = 1.2586\,mol = 1.26\,mol$

3) If I contain 3 moles of gas in a container with a volume of 60 liters and at a temperature of 400 K, what is the pressure inside the container?

n = 3 mol, V = 60 L, T = 400 K, P = ?

$PV = nRT$

$P(60\,L) = (3\,mol)(0.0821\,\frac{L\cdot atm}{K\cdot mol})(400\,K)$

$P = \frac{(3\,mol)(0.0821\,\frac{L\cdot atm}{K\cdot mol})(400\,K)}{60\,L} = 1.64\,atm$

4) If I have 7.7 moles of gas at a pressure of 0.09 atm and at a temperature of 56 ^{0}C, what is the volume of the container that the gas is in?

n = 7.7 mol, P = 0.09 atm, T = 56°C = 329 K, V = ?

$PV = nRT$

$(0.09\,atm)V = (7.7\,mol)(0.0821\,\frac{L\cdot atm}{K\cdot mol})(329\,K)$

$V = \frac{(7.7\,mol)(0.0821\,\frac{L\cdot atm}{K\cdot mol})(329\,K)}{0.09\,atm} = 2310.93\,L$

5) If I have 17 moles of gas at a temperature of 67 ^{0}C, and a volume of 88.89 liters, what is the pressure of the gas?

n = 17 mol, T = 67°C = 340 K, V = 88.89 L, P = ?, $R = 0.0821\,\frac{L\cdot atm}{K\cdot mol}$

$PV = nRT$

$P(88.89\,L) = (17\,mol)(0.0821\,\frac{L\cdot atm}{K\cdot mol})(340\,K)$

$P = \frac{(17\,mol)(0.0821\,\frac{L\cdot atm}{K\cdot mol})(340\,K)}{88.89\,L} = 5.34\,atm$

6) If I have an unknown quantity of gas at a pressure of 0.5 atm, a volume of 25 liters, and a temperature of 300 K, how many moles of gas do I have?

P = 0.5 atm, V = 25 L, T = 300 K, n = ?

$PV = nRT$

$(0.5\,atm)(25\,L) = n(0.0821\,\frac{L\cdot atm}{K\cdot mol})(300\,K)$

$n = \frac{(0.0821\,\frac{L\cdot atm}{K\cdot mol})(300\,K)}{(0.5\,atm)(25\,L)} = 1.97\,mol$

KEY

7) If I have 21 moles of gas held at a pressure of 78 atm and a temperature of 900 K, what is the volume of the gas?

n = 21 mol
P = 78 atm
T = 900 K
V = ?

$PV = nRT$

$(78\,atm)V = (21\,mol)(0.0821\,\frac{L \cdot atm}{K \cdot mol})(900\,K)$

$V = \frac{(21\,mol)(0.0821\,\frac{L \cdot atm}{K \cdot mol})(900\,K)}{78\,atm} = 19.89\,L$

8) If I have 1.9 moles of gas held at a pressure of 5 atm and in a container with a volume of 50 liters, what is the temperature of the gas?

n = 1.9 mol
P = 5 atm
V = 50 L
T = ?

$PV = nRT$

$(5\,atm)(50\,L) = (1.9\,mol)(0.0821\,\frac{L \cdot atm}{K \cdot mol})T$

$T = \frac{(5\,atm)(50\,L)}{(1.9\,mol)(0.0821\,\frac{L \cdot atm}{K \cdot mol})} = 1602.67\,K$

9) If I have 2.4 moles of gas held at a temperature of 97 ^{0}C and in a container with a volume of 45 liters, what is the pressure of the gas?

n = 2.4 mol
T = 97°C = 370 K
V = 45 L
P = ?

$PV = nRT$

$P(45\,L) = (2.4\,mol)(0.0821\,\frac{L \cdot atm}{K \cdot mol})(370\,K)$

$P = \frac{(2.4\,mol)(0.0821\,\frac{L \cdot atm}{K \cdot mol})(370\,K)}{45\,L} = 1.62\,atm$

10) If I have an unknown quantity of gas held at a temperature of 1195 K in a container with a volume of 25 liters and a pressure of 560 atm, how many moles of gas do I have?

n = ?
T = 1195 K
V = 25 L
P = 550 atm

$PV = nRT$

$(550\,atm)(25\,L) = n(0.082\,\frac{L \cdot atm}{K \cdot mol})(1195\,K)$

$n = \frac{(550\,atm)(25\,L)}{(0.0821\,\frac{L \cdot atm}{K \cdot mol})(1195\,K)} = 140.15\,mol$

11) If I have 0.275 moles of gas at a temperature of 75 K and a pressure of 1.75 atmospheres, what is the volume of the gas?

n = 0.275 mol
T = 75 K
P = 1.75 atm
V = ?

$PV = nRT$

$(1.75\,atm)V = (0.275\,mol)(0.0821\,\frac{L \cdot atm}{K \cdot mol})(75\,K)$

$V = \frac{(0.275\,mol)(0.0821\,\frac{L \cdot atm}{K \cdot mol})(75\,K)}{1.75\,atm} = 0.97\,L$

12) If I have 72 liters of gas held at a pressure of 3.4 atm and a temperature of 225 K, how many moles of gas do I have?

V = 72 L
P = 3.4 atm
T = 225 K
n = ?

$PV = nRT$

$(3.4\,atm)(72\,L) = n(0.0821\,\frac{L \cdot atm}{K \cdot mol})(225\,K)$

$n = \frac{(3.4\,atm)(72\,L)}{(0.0821\,\frac{L \cdot atm}{K \cdot mol})(225\,K)} = 13.25\,mol$

$R = 0.0821 \frac{L \cdot atm}{K \cdot mol} = 8.31 \frac{L \cdot kPa}{K \cdot mol}$

KEY

The Ideal and Combined Gas Laws

Use your knowledge of the ideal and combined gas laws to solve the following problems. Hint: Figuring out which equation you need to use is the hard part!

1) If four moles of a gas at a pressure of 5.4 atmospheres have a volume of 120 liters, what is the temperature?

$n = 4 mol$, $P = 5.4 atm$, $V = 120 L$, $T = ?$

$PV = nRT$

$(5.4 atm)(120 L) = (4 mol)(0.0821 \frac{L \cdot atm}{K \cdot mol})T$

$T = \frac{(5.4 atm)(120 L)}{(4 mol)(0.0821 \frac{L \cdot atm}{K \cdot mol})} = \boxed{1973.20 K}$

2) If I initially have a gas with a pressure of 84 kPa and a temperature of 35^0 C and I heat it an additional 230 degrees, what will the new pressure be? Assume the volume of the container is constant.

$P_1 = 84 kPa$, $T_1 = 35°C = 308 K$, $T_2 = (35 + 230) = 265°C$, $T_2 = 538 K$, $P_2 = ?$

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

$\frac{84 kPa}{308 K} = \frac{P_2}{538 K}$

$(308 K)P_2 = (84 kPa)(538 K)$

$P_2 = \frac{(84 kPa)(538 K)}{308 K} = \boxed{146.73 kPa}$

3) My car has an internal volume of 2600 liters. If the sun heats my car from a temperature of 20^0 C to a temperature of 55^0 C, what will the pressure inside my car be? Assume the pressure was initially 760 mm Hg.

$V_1 = 2600 L$, $T_1 = 20°C = 293 K$, $T_2 = 55°C = 328 K$, $P_1 = 760 mmHg = 1 atm$, $P_2 = ?$

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

$\frac{760 mm Hg}{293 K} = \frac{P_2}{328 K}$

$(293 K)P_2 = (760 mm Hg)(328 K)$

$P_2 = \frac{(760 mm Hg)(328 K)}{293 K} = \boxed{850.78 mm Hg = 1.12 atm}$

4) How many moles of gas are in my car in problem #3?

$n = ?$, $P = 1 atm$, $V = 2600 L$, $T = 293 K$

$PV = nRT$

$(1 atm)(2600 L) = n(0.081 \frac{L \cdot atm}{K \cdot mol})(293 K)$

$n = \frac{(1 atm)(2600 L)}{(293 K)(0.0821 \frac{L \cdot atm}{K \cdot mol})} = \boxed{108.08 mol}$

5) A toy balloon filled with air has an internal pressure of 1.25 atm and a volume of 2.50 L. If I take the balloon to the bottom of the ocean where the pressure is 95 atmospheres, what will the new volume of the balloon be? How many moles of gas does the balloon hold? (Assume T = 285 K)

$P_1 = 1.25 atm$, $V_1 = 2.50 L$, $P_2 = 95 atm$, $V_2 = ?$, $T = 285 K$

$P_1 V_1 = P_2 V_2$

$(1.25 atm)(2.50 L) = (95 atm)V_2$

$V_2 = \frac{(1.25 atm)(2.50 L)}{(95 atm)}$

$V_2 = 0.033 L$

$PV = nRT$

$(1.25 atm)(2.50 L) = n(0.0821 \frac{L \cdot atm}{K \cdot mol})(285 K)$

$n = \frac{(1.25 atm)(2.50 L)}{(0.0821 \frac{L \cdot atm}{K \cdot mol})(285 K)} = \boxed{0.13 mol}$