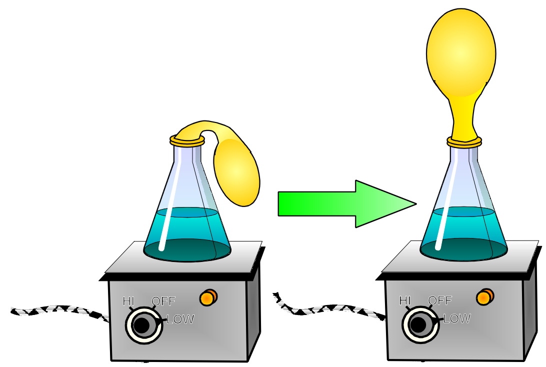
Using the Combined Gas Law

If a balloon is pulled over the neck of a flask, and the setup is placed on a hot plate, the balloon blows up as it heats up. This happens even though no additional air can get into the balloon. As the air heats up, it expands. The air can be squeezed back into a smaller space by increasing the pressure on it. This is what causes the diver in a Cartesian diver to sink when pressure is put on its container. The relationship between the temperature, pressure, and volume of a gas is known as the combined gas law.



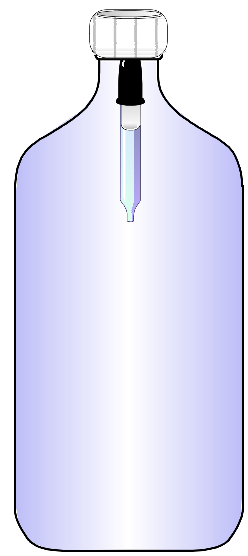
THE LAW

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

Where:

P_1 = initial pressure
V_1 = initial volume
T_1 = initial temperature (K)

P_2 = final pressure
V_2 = final volume
T_2 = final temperature (K)



The equation has six variables. Generally, five variables must be provided in order to solve for the sixth. If either temperature, pressure, or volume is constant, they cancel out, making an equation of four variables.

Sample Problem

A gas with a volume of 250. mL at 35°C and 101.3 kPa is heated to 57°C and the pressure is increased to 151.3 kPa. What is its new volume?

- $T_1 = 35 + 273 = 308K;\ T_2 = 57 + 273 = 330K$
- $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
- $V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{(101.3kPa)(250mL)(330K)}{(308K)(151.3kPa)} = 179mL$

(Continue ☞)

Fill in the blanks in the table below by using the combined gas law to find the unknown variable in each row.

	Initial			Final		
	volume	***pressure***	***temperature***	***volume***	***pressure***	***temperature***
1.	80.0 mL	96 kPa	27°C		99.0 kPa	0.0°C
2.	36 mL	SP*	ST*		96.6 kPa	35.0°C
3.	2.0 L	95.3 kPa	–45°C		SP*	ST*
4.	4.5 L	1.035 atm	375 K		1.100 atm	350. K
5.		0.980 atm	30.0°C	185 mL	0.900 atm	28.0°C
6.	16.5 mL	107.3 kPa	26.5°C	18.0 mL	104.4 kPa	
7.	14.8 mL	1.123 atm	75.5°C	16.5 mL		70.2°C
8.	5.322 L		100.0°C	4.895 L	104.2 kPa	98.5°C
9.	1.0 0L	SP	ST		SP	27.3 K
10.	2.50 L	SP	ST		111.4 kPa	87°C

*SP = Standard Pressure (101.3 kPa *or* 1.0 atm)
ST = Standard Temperature (0°C *or* 273 K)