

Dougherty Valley HS Chemistry

Gay-Lussac's Law, Combined Gas Law,
and Ideal Gas Law

Name:

Date:

Period:

KEY

Gay-Lussac's Law, the Combined Gas Law, and the Ideal Gas Law are the remaining three gas laws we are going to use.

Use them just like Boyle's Law or Charles' Law.

- Read the entire problem
- Write down what the variables are (are we dealing with temp, or volume, or pressure, etc?)
- Pick the equation that has those variables in them.
- Plug the numbers into the equation and solve for the unknown value.

P = pressure

V = volume

T = temperature

n = # of moles

R = the ideal gas constant = $8.31 \frac{\text{L} \cdot \text{kPa}}{\text{K} \cdot \text{mol}}$ ← (those are the units. The dot is just a multiplication sign)

Gay-Lussac's Law

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \quad \text{Pressure increases as temperature increases. Directly proportional.}$$

Combined Gas Law

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

Ideal Gas Law

$PV = nRT$ * Make sure to convert your pressure to kPa, volume to Liters, and temperature to Kelvin!
If you don't do this then your units in your ideal gas constant (R) won't cancel out right and you won't get the right answer!!

Practice Problems

Answer the following problems.

SHOW YOUR WORK!

Don't forget to **convert all temperatures to Kelvins** before you start the calculations!

PUT A BOX AROUND YOUR FINAL ANSWER!

Gay-Lussac's Law Problems:

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

1) At 120 °C, the pressure of a sample of nitrogen is 1.07 atm. What will the pressure be at 205 °C?

$$P_1 = 1.07 \text{ atm}$$

$$T_1 = 120^\circ\text{C} + 273 = 393 \text{ K}$$

$$P_2 = ?$$

$$T_2 = 205^\circ\text{C} + 273 = 478 \text{ K}$$

$$\frac{1.07 \text{ atm}}{393 \text{ K}} = \frac{P_2}{478 \text{ K}}$$

$$P_2 = 1.3 \text{ atm}$$

2) A sample of oxygen gas is at 27 °C and 1.00 atm. What will the pressure be at -70 °C?

$$P_1 = 1.00 \text{ atm}$$

$$T_1 = 27^\circ\text{C} + 273 = 300 \text{ K}$$

$$P_2 = ?$$

$$T_2 = -70^\circ\text{C} + 273 = 203 \text{ K}$$

$$\frac{1.00 \text{ atm}}{300 \text{ K}} = \frac{P_2}{203 \text{ K}}$$

$$P_2 = 0.68 \text{ atm}$$

3) A sample of gas is at -73°C and 1.4 atm . What will the final temperature be if the pressure is doubled?

$$P_1 = 1.4\text{ atm}$$

$$T_1 = -73^{\circ}\text{C} + 273 = 200\text{ K}$$

$$P_2 = (1.4) \times (2) = 2.8\text{ atm}$$

$$T_2 = ?$$

$$\frac{1.4\text{ atm}}{200\text{ K}} = \frac{2.8\text{ atm}}{T_2}$$

$$\frac{T_2 \times 1.4\text{ atm}}{1.4\text{ atm}} = \frac{2.8\text{ atm} \times 200\text{ K}}{1.4\text{ atm}} \quad T_2 = 400\text{ K}$$

Combined Gas Law

4) The volume of a gas-filled balloon is 30.0 L at 313 K and 153 kPa . What would the volume be at 273 K and 101.3 kPa ? (273 K and 101.3 kPa is called "standard temperature and pressure" which is usually abbreviated as STP)

$$\left(\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2} \right)$$

$$P_1 = 153\text{ kPa}$$

$$V_1 = 30\text{ L}$$

$$T_1 = 313\text{ K}$$

$$P_2 = 101.3\text{ kPa}$$

$$V_2 = ?$$

$$T_2 = 273\text{ K}$$

$$\frac{(153\text{ kPa}) \times (30\text{ L})}{313\text{ K}} = \frac{(101.3\text{ kPa}) \times V_2}{273\text{ K}}$$

$$V_2 = 39.5\text{ L}$$

5) A gas at 155 kPa and 25°C has an initial volume of 1.00 L . The pressure of the gas increases to 605 kPa as the temperature is raised to 125°C . What is the new volume?

$$P_1 = 155\text{ kPa}$$

$$V_1 = 1\text{ L}$$

$$T_1 = 25^{\circ}\text{C} + 273 = 298\text{ K}$$

$$P_2 = 605\text{ kPa}$$

$$V_2 = ?$$

$$T_2 = 125^{\circ}\text{C} + 273 = 398\text{ K}$$

$$\frac{(155\text{ kPa}) \times (1\text{ L})}{298\text{ K}} = \frac{(605\text{ kPa}) \times V_2}{398\text{ K}}$$

$$V_2 = 0.34\text{ L}$$

6) A 5.00 L air sample has a pressure of 107 kPa at a temperature of -50°C . If the temperature is raised to 102°C and the volume expands to 7.00 L , what will the new pressure be?

$$P_1 = 107\text{ kPa}$$

$$V_1 = 5\text{ L}$$

$$T_1 = -50^{\circ}\text{C} + 273 = 223\text{ K}$$

$$P_2 = ?$$

$$V_2 = 7\text{ L}$$

$$T_2 = 102^{\circ}\text{C} + 273 = 375\text{ K}$$

$$\frac{(107\text{ kPa}) \times (5\text{ L})}{223\text{ K}} = \frac{P_2 \times (7\text{ L})}{375\text{ K}}$$

$$P_2 = 128\text{ kPa}$$

Ideal Gas Law Problems: don't forget to use the ideal gas constant (R)!

$$(PV = nRT)$$

7) Determine the volume occupied by 0.582 mol of a gas at 15°C if the pressure is 81.8 kPa .

$$P = 81.8\text{ kPa}$$

$$V = ?$$

$$n = 0.582\text{ mol}$$

$$R = 8.31\text{ (L} \cdot \text{kPa) / (K} \cdot \text{mol)}$$

$$T = 15^{\circ}\text{C} + 273 = 288\text{ K}$$

$$(81.8\text{ kPa}) \times V = (0.582\text{ mol}) (8.31) (288\text{ K})$$

$$V = \frac{(0.582)(8.31)(288)}{(81.8)}$$

$$V = 17\text{ L}$$

8) What pressure is exerted by 0.450 mol of a gas at 25°C if the gas is in a 0.650 L container?

$$P = ?$$

$$V = 0.650\text{ L}$$

$$n = 0.450\text{ mol}$$

$$R = 8.31$$

$$T = 25^{\circ}\text{C} + 273 = 298\text{ K}$$

$$\frac{P(0.650)}{0.650} = \frac{(0.450)(8.31)(298)}{0.650}$$

$$P = 1714\text{ kPa}$$

9) A 1.5 L flask contains 5 moles of a gas at 27°C . What is the pressure of the gas?

$$P = ?$$

$$V = 1.5\text{ L}$$

$$n = 5\text{ mol}$$

$$R = 8.31$$

$$T = 27^{\circ}\text{C} + 273 = 300\text{ K}$$

$$\frac{P(1.5)}{1.5} = \frac{(5)(8.31)(300)}{1.5}$$

$$P = 8310\text{ kPa}$$

Mixed Gas Law Problems:

These problems require you to use either Boyle's Law, Charles' Law, Gay-Lussac's Law, the Combined Gas Law, or the Ideal Gas Law. Write down the name of the gas law you need to use for each problem and then solve the problem.

- 10) A gas occupies 30.5 L at 1 atm. At what pressure will the gas occupy at 45.9 L? Temperature is held constant.

Name of Gas Law Used: Boyle's Law $P \propto V$

$$P_1 V_1 = P_2 V_2$$

$$P_1 = 1 \text{ atm} \quad P_2 = ?$$

$$V_1 = 30.5 \text{ L} \quad V_2 = 45.9 \text{ L}$$

$$(1 \text{ atm})(30.5 \text{ L}) = P_2 (45.9 \text{ L})$$

$$P_2 = 0.66 \text{ atm}$$

- 11) At 84 °C a gas in a container exerts a pressure of 0.503 atm. Assuming the size of the container has not changed, at what temperature would the pressure be 1.20 atm?

Name of Gas Law Used: Gay-Lussac's $P \propto T$

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

$$P_1 = 0.503 \text{ atm}$$

$$T_1 = 84^\circ\text{C} + 273 = 357 \text{ K}$$

$$P_2 = 1.20 \text{ atm}$$

$$T_2 = ?$$

$$\frac{0.503 \text{ atm}}{357 \text{ K}} = \frac{1.20 \text{ atm}}{T_2}$$

$$T_2 = 852 \text{ K}$$

- 12) A 14.2 L sample of gas is at 42 °C. What temperature will the gas exert if its volume is reduced to 8.53 L?

Name of Gas Law Used: Charles' Law $V \propto T$

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

$$V_1 = 14.2 \text{ L}$$

$$T_1 = 42^\circ\text{C} + 273 = 315 \text{ K}$$

$$V_2 = 8.53 \text{ L}$$

$$T_2 = ?$$

$$\frac{14.2 \text{ L}}{315 \text{ K}} = \frac{8.53 \text{ L}}{T_2}$$

$$T_2 = 189 \text{ K}$$

- 13) When the temperature of a rigid hollow sphere containing 658 L of helium gas is held at 621 K, the pressure of the gas is 1.89×10^3 kPa. How many moles of helium does the sphere contain?

Name of Gas Law Used: ideal gas law $P \propto V \propto T \propto \text{moles}$

$$PV = nRT$$

$$P = 1.89 \times 10^3 \text{ kPa}$$

$$V = 658 \text{ L}$$

$$n = ?$$

$$R = 8.31$$

$$T = 621 \text{ K}$$

$$(1.89 \times 10^3)(658) = n(8.31)(621)$$

$$n = 241 \text{ moles}$$

- 14) A given mass of air is at 37 °C, has a volume of 6.00 L, and is at 101 kPa. What volume will the gas occupy if you increase the pressure to 162 kPa, and the temperature to 50 °C?

Name of Gas Law Used: Combined $P \propto T \propto V$

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

$$P_2 = 162 \text{ kPa}$$

$$V_2 = ?$$

$$T_2 = 50^\circ\text{C} + 273 = 323 \text{ K}$$

$$\frac{(101)(6)}{310} = \frac{(162)V_2}{323}$$

$$V_2 = 3.9 \text{ L}$$

- 15) A child's lungs can hold 2.20 L. How many moles of air do her lungs hold at a pressure of 102 kPa and a body temperature of 37 °C?

Name of Gas Law Used: ideal gas law $V \propto P \propto T \propto \text{moles}$

$$PV = nRT$$

$$P = 102 \text{ kPa}$$

$$R = 8.31$$

$$V = 2.20 \text{ L}$$

$$T = 37 + 273 = 310 \text{ K}$$

$$n = ?$$

$$(102 \text{ kPa})(2.20 \text{ L}) = n(8.31)(310 \text{ K})$$

$$n = 0.087 \text{ moles}$$

