



CHEMISTRY

GAS LAWS - PART 3

Combined Gas Law

Recall: The average pressure taken at sea level and is found to be $760 \text{ mm Hg} = 760 \text{ torr} = 1 \text{ atm} = 101.3 \text{ kPa}$. This is called **Standard Pressure**.

Standard Temperature is said to be 0°C or 273 K .

Standard Temperature and Pressure (STP) are the environmental conditions that exist at *standard pressure* and *standard temperature*.

Gas Laws:

Boyle's	Charles'	Gay-Lussac
$P_1V_1 = P_2V_2$	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Using algebra, one can combine all these laws together to create what's called the **Combined Gas Law**.





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Ex: You are having a birthday party on a mild winter's day. The weather changes and a high-pressure (103.0 kPa) cold front (-25°C) rushes into town. The original air temperature was -2°C and the pressure was 100.8 kPa. What will happen to the volume of the 4.2 L balloons that were tied to the front of the house?

*Ex: 10.1 mL of nitrogen gas is at **STP** (Standard Temperature and Pressure). What would the temperature be in °C if the volume was increased to 12.0 mL and 780 torr?*



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Practice Problems

1. A sample of argon gas, Ar(g), occupies a volume of 2.0 L at -35°C and 0.5 atm. What would its Celsius temperature be at 2.5 atm if its volume was decreased to 1.5 L?
2. A chemical researcher produces 15.0 mL of a new gaseous substance in a laboratory at a temperature of 298 K and pressure of 100.0 kPa. Calculate the volume of this gas if the temperature was changed to 273 K and the final pressure was 101.325 kPa.
3. A sample of air in a syringe exerts a pressure of 1.02 atm at 295 K. The syringe is placed in a boiling water bath at 373 K. The pressure is increased to 1.23 atm and the volume becomes 0.224 mL. What was the initial volume?
4. Helium gas, He(g), in a 1.0×10^2 L weather balloon is under a pressure of 25 atm at 20.0°C . If the helium balloon expands to 2400 L at 1.05 atm of pressure, what would the temperature of the helium gas be?
5. A 30.00 mL gas syringe was at a pressure of 100.0 kPa at 30.0°C . On the following day, the temperature dropped to 25.0°C and the new volume was 28.5 mL. What was the atmospheric pressure on this day?
6. A 2.7 L sample of nitrogen gas, $\text{N}_2(\text{g})$, is collected at a temperature of 45.0°C and a pressure of 0.92 atm. What pressure would have to be applied to the gas to reduce its volume to 2.0 L at a temperature of 25.0°C ?
7. A scuba diver is swimming 30.0 m below the ocean surface where the pressure is 4.0 atm and the temperature is 8.0°C . A bubble of air with a volume of 5.0 mL is emitted from the breathing apparatus. What will the volume of the air bubble be when it is just below the surface of the water, where the pressure is 101.3 kPa and the water temperature is 24.0°C ?
8. A 5.0×10^2 mL sample of oxygen, $\text{O}_2(\text{g})$, is kept at 950 mmHg and 21.5°C . The oxygen expands to a volume of 700 mL and the temperature is adjusted until the pressure is 101.325 kPa. Calculate the final temperature of the oxygen gas.
9. A sample of Freon-12, $\text{CF}_2\text{Cl}_2(\text{g})$, formerly used in refrigerators, is circulated through a series of pipes for refrigeration. If the gas occupies 350 cm^3 at a pressure of 150 psi and a temperature of 15°C , what volume of gas will be released if there is a break in the line where the external temperature is 25°C and the external pressure is 102 kPa?
10. A crack in the floor of the ocean at a depth where the pressure is 16 atm releases 350 m^3 of methane gas. The temperature of the water at this depth is 8°C . If the surface temperature is 40°C and the pressure is 758 mmHg, what volume of methane is released at the surface?

1. 620°C
2. 13.6 ml
3. 0.214 mL
4. 22°C
5. 104 kPa
6. 1.2 atm
7. 21 mL
8. 57°C
9. $3.7 \times 10^3 \text{ cm}^3$
10. $6 \times 10^3 \text{ m}^3$



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PRACTICE - Gas Laws

1. A 50.0 cm^3 sample of nitrogen gas is collected at 101.3 kPa . If the volume is reduced to 5.0 cm^3 , and the temperature remains constant, what will the final pressure of the nitrogen be?
2. A weather balloon has a volume of 1000 L at a pressure of 740.0 torr . The balloon rises to a height of 1000 m where the atmospheric pressure is measured as 450.0 torr . Assuming there is no change in temperature, what is the final volume of the weather balloon?
3. A 45.0 cm^3 sample of nitrogen gas is collected at 1.0 atm . The nitrogen is compressed to a pressure of 10.0 atm . What is the final volume of the nitrogen if the temperature remains constant?
4. A 45.6 mL sample of gas at 490 torr is compressed to a certain volume at 3 atm . What is the new volume, in litres?
8. A sample of nitrogen gas surrounding a circuit board occupies a volume of 300 mL at 17°C and 100 kPa . What volume will the nitrogen occupy at 100.0°C if the pressure remains constant?
9. A 2.5 L balloon is completely filled with helium indoors at a temperature of 24.2°C . The balloon is taken out on a cold winter day (-17.5°C). What will the volume of the balloon become, assuming a constant pressure?
10. 10.0 L of neon at 20.0°C is expanded to a volume of 30.0 L . If the pressure remains constant, what must the final temperature be (in $^\circ\text{C}$)?
11. A 14.5 cm^3 sample of oxygen gas at 24.3°C is drawn into a syringe with a maximum volume of 60 cm^3 . What is the maximum change in temperature that the oxygen can be subjected to before the plunger pops out of the syringe?
12. Methane gas can be condensed by cooling and increasing the pressure. A 600 L sample of methane gas at 25°C and 100 kPa is cooled to -20°C . In a second step, the gas is compressed until the pressure is quadrupled. What will the final volume be? (Hint: Use both Boyle's law and Charles' law to answer this question.)
13. An unknown gas is collected in a 250.0 mL flask and sealed. Using electronic devices, it is found that the gas inside the flask exerts a pressure of 135.5 kPa at 15°C . What pressure will the gas exert if the temperature (in Kelvins) is doubled?

Practice Problems: 1. $1.0 \times 10^3 \text{ kPa}$ 2. 1644 L 3. 4.5 cm^3
 4. 0.01 L 5.(a) 298 K (b) 310 K (c) 423 K 6.(a) 100°C
 (b) -175°C (c) 152°C 8. $3.86 \times 10^2 \text{ mL}$ 9. 2.1 L 10. 606°C
 11. 957°C 12. 127 L 13. $2.71 \times 10^2 \text{ kPa}$ 14. 18.8 atm



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PRACTICE - Gas Laws

14. At 18°C, a sample of helium gas stored in a metal cylinder exerts a pressure of 17.5 atm. What will the pressure become if the tank is placed in a closed room where the temperature increases to 40°C?
15. A gaseous refrigerant, enclosed in copper tubes, surrounds the freezer in a small refrigerator. The gas is found to exert a pressure of 110 kPa at 45°C. The refrigerant is allowed to expand through a nozzle into an expansion chamber such that the exerted pressure decreases to 89 kPa. What is the temperature inside the freezer?
16. Before leaving on a trip to Florida, you measure the pressure inside the tires of your car at a gas station. At -7.5°C the tire pressure is found to be 206.5 kPa. When you arrive in Florida, you stop for dinner. Before leaving, you once again measure the tire pressure at a gas station beside the restaurant. Most pressure gauges in the United States are calibrated in psi. You find the tire pressure to be 34.3 psi. What is the approximate temperature in Florida? (Hint: See the MathLink on page 428 to find out how to convert psi to kPa.)
17. A sample of gas has a volume of 150 mL at 260 K and 92.3 kPa. What will the new volume be at 376 K and 123 kPa?
18. A cylinder at 48 atm pressure and 290 K releases 35 mL of carbon dioxide gas into a 4.0 L container at 297 K. What is the pressure inside the container?
19. In a large syringe, 48 mL of ammonia gas at STP is compressed to 24 mL and 110 kPa. What must the new temperature of the gas be?
20. A 100 W light bulb has a volume of 180.0 cm³ at STP. The light bulb is turned on and the heated glass expands slightly, changing the volume of the bulb to 181.5 cm³ with an internal pressure of 214.5 kPa. What is the temperature of the light bulb (in °C)?
21. Sulfur hexafluoride, SF_{6(g)}, is used as a chemical insulator. A 5.0 L sample of this gas is collected at 205.0°C and 350 kPa. What pressure must be applied to this gas sample to reduce its volume to 1.7 L at 25°C?
11. 957°C 12. 127 L 13. 2.71 × 10² kPa 14. 18.8 atm
 15. -16°C 16. 31°C 17. 163 mL 18. 0.43 atm 19. 148 K
 20. 310°C 21. 6.4 × 10² kPa 22. 300.6 kPa 23. 14 kPa,