4. Oxygen gas is at a temperature of 40°C when it occupies a volume of 2.3 L. To what temperature in Celsius should it be raised to occupy a volume of 6.5 dm³?

<table>
<thead>
<tr>
<th>GIVEN</th>
<th>GAS LAW</th>
<th>WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1 = 40 + 273$</td>
<td>Gay-Lussac</td>
<td>$\frac{2.3}{313} = \frac{6.5}{T_2}$</td>
</tr>
<tr>
<td>$V_1 = 2.3 \text{L}$</td>
<td>FORMULA</td>
<td>$2.3 T_2 = 6.5 (313)$</td>
</tr>
<tr>
<td>$V_2 = 6.5 \text{L}$</td>
<td></td>
<td>$T_2 = 885 \text{K}$</td>
</tr>
<tr>
<td>$t_2 =$ ?</td>
<td></td>
<td>ANSWER: $885 \text{K}$</td>
</tr>
</tbody>
</table>

5. Fluorine exerts a pressure of 90.0 kPa. When the pressure is changed to 150 kPa, its volume is 250 mL. What was the original volume?

<table>
<thead>
<tr>
<th>GIVEN</th>
<th>GAS LAW</th>
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</tr>
</thead>
<tbody>
<tr>
<td>$P_1 = 90 \text{kPa}$</td>
<td>Boyle's</td>
<td>$90 (V_1) = 150 (250)$</td>
</tr>
<tr>
<td>$P_2 = 150 \text{kPa}$</td>
<td>FORMULA</td>
<td>$V_1 = 417 \text{mL}$</td>
</tr>
<tr>
<td>$V_2 = 250 \text{mL}$</td>
<td></td>
<td>ANSWER: $417 \text{mL}$</td>
</tr>
<tr>
<td>$V_1 =$ ?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. The volume of a gas is 200.0 mL at 275 K and 92.1 kPa. Find its volume at STP.

<table>
<thead>
<tr>
<th>GIVEN</th>
<th>GAS LAW</th>
<th>WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_1 = 200 \text{mL}$</td>
<td>combined</td>
<td>$\frac{92.1 (200)}{275} = \frac{101.3 (V_2)}{273}$</td>
</tr>
<tr>
<td>$T_1 = 275 \text{K}$</td>
<td>FORMULA</td>
<td>$66.98 = 0.371 V_2$</td>
</tr>
<tr>
<td>$P_1 = 92.1 \text{kPa}$</td>
<td></td>
<td>$180.5 \text{mL} = V_2$</td>
</tr>
<tr>
<td>$V_2 =$ ?</td>
<td></td>
<td>ANSWER: $180.5 \text{mL}$</td>
</tr>
<tr>
<td>$T_2 = 273 \text{K}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_2 = 101.3 \text{kPa}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. A sample of N₂ occupies a volume of 250 mL at 25°C. What volume will it occupy at 95°C?

<table>
<thead>
<tr>
<th>GIVEN</th>
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</tr>
</thead>
<tbody>
<tr>
<td>$V_1 = 250 \text{mL}$</td>
<td>Gay-Lussac's</td>
<td>$\frac{250}{298} = \frac{V_2}{368}$</td>
</tr>
<tr>
<td>$t_1 = 25 + 273$</td>
<td>FORMULA</td>
<td>$250 (368) = 298 V_2$</td>
</tr>
<tr>
<td>$V_2 =$ ?</td>
<td></td>
<td>$308 \text{mL} = V_2$</td>
</tr>
<tr>
<td>$t_2 = 95 + 273$</td>
<td></td>
<td>ANSWER: $308 \text{mL}$</td>
</tr>
</tbody>
</table>
Gas Laws – Boyle’s, Charles’s, Gay-Lussac’s, and Combined

Boyle’s Law
1. A sample of oxygen gas occupies a volume of 250 mL at 740 torr. What volume will it occupy at 800 torr if the temperature is held constant?
   \[ P_1 V_1 = P_2 V_2 \]
   \[ 740 \text{ torr} \times 250 \text{ mL} = 800 \text{ torr} \times V_2 \]
   \[ \frac{740}{800} \times 250 = V_2 \]
   \[ V_2 = 237.5 \text{ mL} \]

2. A 2.0 liter container of nitrogen had a pressure of 3.2 atm. What volume would be necessary to decrease the pressure to 1.0 atm if the temperature is held constant?
   \[ P_1 V_1 = P_2 V_2 \]
   \[ 3.2 \text{ atm} \times 2.0 \text{ L} = 1.0 \text{ atm} \times V_2 \]
   \[ \frac{3.2}{1.0} \times 2.0 = V_2 \]
   \[ V_2 = 6.4 \text{ L} \]

3. Chlorine gas occupies a volume of 1.2 liters at 720 torr. What volume will it occupy at 1 atm pressure?
   \[ P_1 V_1 = P_2 V_2 \]
   \[ 720 \text{ torr} \times 1.2 \text{ L} = 1 \text{ atm} \times V_2 \]
   \[ \frac{720}{1} \times 1.2 = V_2 \]
   \[ V_2 = 864 \text{ L} \]

4. Fluorine gas exerts a pressure of 900 torr. When the pressure is changed to 152 kPa, its volume is 250 mL. What was the original volume?
   \[ P_1 V_1 = P_2 V_2 \]
   \[ 900 \text{ torr} \times 250 \text{ mL} = 152 \text{ kPa} \times V_2 \]
   \[ \frac{900}{152} \times 250 = V_2 \]
   \[ V_2 = 317 \text{ mL} \]

Charles’s Law
5. A sample of nitrogen occupies a volume of 250 mL at 25°C. What volume will it occupy at 95°C if the pressure of the gas is held constant?
   \[ \frac{V_1}{T_1} = \frac{V_2}{T_2} \]
   \[ \frac{250}{25} = \frac{V_2}{95} \]
   \[ V_2 = 309 \text{ mL} \]

6. Chlorine gas occupies a volume of 25 mL at 300 K. What is the new temperature of the gas if the volume changes to 50 mL and the pressure of the gas remains the same?
   \[ \frac{V_1}{T_1} = \frac{V_2}{T_2} \]
   \[ \frac{25}{300} = \frac{50}{T_2} \]
   \[ T_2 = 600 \text{ K} \]

7. A sample of argon gas is cooled and its volume went from 0.380 L to 250 mL. If its final temperature was 5°C, what was its original temperature?
   \[ \frac{V_1}{T_1} = \frac{V_2}{T_2} \]
   \[ \frac{0.380}{300} = \frac{250}{5} \]
   \[ T_1 = 499 \text{ K} \]

8. Hydrogen gas was cooled from 150°C to 50°C. Its new volume is 75 mL. What was its original volume?
   \[ \frac{V_1}{T_1} = \frac{V_2}{T_2} \]
   \[ \frac{V_1}{323} = \frac{75}{323} \]
   \[ V_1 = 98 \text{ mL} \]

Gay-Lussac’s Law
9. A gas held in a rigid container (constant volume) has a pressure of 4.0 atm at 100°C. To what temperature would you have to heat gas to get the pressure to reach 9.5 atm?
   \[ \frac{P_1}{T_1} = \frac{P_2}{T_2} \]
   \[ \frac{4.0}{373} = \frac{9.5}{T_2} \]
   \[ T_2 = 886 \text{ K} \]

10. When a gas is heated to 90°C, it exerts a pressure of 350 kPa on its 5-liter container. If the temperature is decreased to 50°C, what is the new pressure exerted on the container?
    \[ \frac{P_1}{T_1} = \frac{P_2}{T_2} \]
    \[ \frac{350}{363} = \frac{323}{311} \]
    \[ P_2 = 311 \text{ kPa} \]
Combined Gas Law

11. A gas at a pressure of 1.5 atm occupies 3.0 L at 20°C. If the pressure is increased to 2.5 atm and the temperature is increased to 30°C, find the new volume.

\[ \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \]

\[ V_2 = \frac{P_2}{P_1} \cdot \frac{V_1}{T_2} \]

\[ V_2 = 1.86 L \]

12. A gas at unknown pressure occupies 750 mL at 0°C. When this gas occupies 0.5 L at 25°C, it has a pressure of 2.0 atm. Find the original pressure.

\[ V_1 = 750 mL \]
\[ T_1 = 0 + 273 = 273 K \]
\[ V_2 = 0.5 L \]
\[ T_2 = 25 + 273 = 298 K \]

\[ \frac{P_1 (750)}{2.0 atm} = 273 \]

\[ P_1 = 1.22 atm \]

13. The pressure of a gas at 22°C is 600 mmHg when it occupies 2.5 L. If the gas is compressed to 1.8 L and the pressure changes to 760 mmHg, what is its new temperature in Celsius?

\[ P_1 = 600 \text{ mmHg} \]
\[ V_1 = 2.5 L \]
\[ T_1 = 22 + 273 = 295 K \]
\[ P_2 = 760 \text{ mmHg} \]
\[ V_2 = 1.8 L \]

\[ \frac{600}{295} = \frac{760}{1.8} \]

\[ t_2 = -3.96°C \]

14. A gas at a temperature of 100°C has a pressure of 650 torr. When the temperature of the gas is increased to 150°C and the pressure of the gas changes to 1.2 atm, the gas occupies 225 mL. Find the original volume of the gas.

\[ t_1 = 100 + 273 = 373 K \]
\[ V_2 = 225 mL \]
\[ P_1 = 650 \text{ torr} \]
\[ t_2 = 150 + 273 = 423 K \]
\[ P_2 = 1.2 \text{ atm} \times 760 \text{ torr atm}^{-1} = 912 \text{ torr} \]

\[ \frac{650V_1}{373} = \frac{912 (225)}{423} \]

\[ V_1 = 278 mL \]

Mixed Problems

15. Fluorine gas at 300 K occupies a volume of 500 mL. To what temperature should it be lowered to bring the volume to 300 mL?

\[ V_1 = 500 mL \]
\[ t_1 = 300 K \]
\[ V_2 = 300 mL \]

\[ \frac{300}{300} = \frac{t_2}{300} \]

\[ t_2 = 90 K \]

16. Ammonia gas occupies a volume of 450 mL at a pressure of 720 mmHg. What volume will it occupy at standard pressure?

\[ V_1 = 450 mL \]
\[ P_2 = 720 \text{ mmHg} \]
\[ \text{Same at } 1 \text{ atm} \]

\[ \frac{720 (450)}{760} = 426 mL = V_2 \]

17. Helium occupies a volume of 3.8 liters at -45°C. What will its temperature be if it occupies 5.3 L?

\[ V_1 = 3.8 L \]
\[ t_1 = -45 + 273 = 228 K \]
\[ V_2 = 5.3 L \]

\[ \frac{3.8}{228} = \frac{5.3}{t_2} \]

\[ t_2 = 318 K \]

18. A gas has a pressure of 720 torr when it occupies 256 mL at 25°C. What is its new pressure at 50°C if it now has a volume of 250 mL?

\[ P_1 = 720 \text{ torr} \]
\[ t_1 = 25 + 273 = 328 K \]
\[ V_1 = 256 mL \]
\[ V_2 = 250 mL \]
\[ t_2 = 50 + 273 = 323 K \]

\[ \frac{720 (256)}{298} = \frac{P_2 (250)}{323} \]

\[ 799 \text{ torr} = P_2 \]

19. The pressure of a gas is 5.6 atm when at 60°C. If the pressure is increased to 942 kPa, what is the new temperature of the gas?

\[ P_1 = 5.6 \text{ atm} \]
\[ t_1 = 60 + 273 = 333 K \]
\[ P_2 = 942 \text{ kPa} \times \frac{1 \text{ atm}}{101.3 \text{ kPa}} = 9.3 \text{ atm} \]

\[ \frac{5.6}{333} = \frac{9.3}{t_2} \]

\[ t_2 = 553 K \]
The Gas Laws

1. The gas left in a used aerosol can is at a pressure of 1 atm at 27°C. If this can is thrown into a fire, what is the internal pressure of the gas when its temperature reaches 927°C?

<table>
<thead>
<tr>
<th>GIVEN</th>
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</tr>
</thead>
<tbody>
<tr>
<td>$p_1 = 1 \text{ atm}$</td>
<td>Charles</td>
<td>$\frac{1}{300} = \frac{p_2}{1200}$</td>
</tr>
<tr>
<td>$t_1 = 27 + 273 = 300 \text{ K}$</td>
<td></td>
<td>$1200 = 300p_2$</td>
</tr>
<tr>
<td>$t_2 = 927 + 273 = 1200 \text{ K}$</td>
<td></td>
<td>$4 \text{ atm} = p_2$</td>
</tr>
</tbody>
</table>

**ANSWER:** 4 atm

2. A sample of carbon dioxide occupies a volume of 3.50 L at 125 kPa. What pressure would the gas exert if the volume were decreased to 2.00 L?

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>$V_1 = 3.50 \text{ L}$</td>
<td>Boyle's</td>
<td>$125(3.50) = p_2 (2.00)$</td>
</tr>
<tr>
<td>$p_1 = 125 \text{ kPa}$</td>
<td></td>
<td>$218.75 \text{ kPa} = p_2$</td>
</tr>
<tr>
<td>$V_2 = 2.00 \text{ L}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ANSWER:** 218.75 kPa

3. A sample of propane occupies 250.0 L at 125 kPa and 38°C. Find its volume at 100.0 kPa and 95°C.

<table>
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<tr>
<td>$V_1 = 250 \text{ L}$</td>
<td>Gay-Lussac's</td>
<td>$\frac{250(125)}{311} = \frac{100V_2}{368}$</td>
</tr>
<tr>
<td>$t_1 = 38 + 273 = 311 \text{ K}$</td>
<td></td>
<td>$370 L = V_2$</td>
</tr>
<tr>
<td>$V_2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_2 = 95 + 273 = 368 \text{ K}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p_1 = 125 \text{ kPa}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p_2 = 100 \text{ kPa}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ANSWER:** 370 L