Chapter 12

Exploring the Gas Laws

Section 12.1The Combined Gas Law

Solutions for Practice Problems

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1. Practice Problem (page 542)

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?

What Is Required?

You need to find the Celsius temperature, T_2, of the argon gas under the new conditions of volume and pressure.

What Is Given?

You know the initial pressure, volume, and temperature:
P_1 = 0.5 atm
V_1 = 2.0 L
T_1 = –35°C
You also know the final volume and pressure:
V_2 = 1.5 L
P_2 = 2.5 atm

Plan Your Strategy

Convert the temperature from the Celsius scale to the Kelvin scale.
The combined gas law states that the pressure and volume of a given amount of gas are inversely proportional to each other, and directly proportional to the Kelvin temperature of the gas: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
Rearrange the combined gas law expression to isolate the variable T_2.
Substitute the given data into the expression and solve for T_2.
Convert the temperature from the Kelvin scale to the Celsius scale.

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Act on Your Strategy
Initial temperature conversion:

$$T_1 = -35°\text{C} + 273.15$$
$$= 238.15 \text{ K}$$

Isolation of the variable T_2:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$
$$P_1V_1T_2 = P_2V_2T_1$$
$$\frac{\cancel{P_1V_1}T_2}{\cancel{P_1V_1}} = \frac{P_2V_2T_1}{P_1V_1}$$
$$T_2 = \frac{P_2V_2T_1}{P_1V_1}$$

Substitution to solve for T_2:

$$T_2 = \frac{P_2V_2T_1}{P_1V_1}$$
$$= \frac{(2.5 \cancel{\text{atm}})(1.5 \cancel{\text{L}})(238.15 \text{ K})}{(0.5 \cancel{\text{atm}})(2.0 \cancel{\text{L}})}$$
$$= 893.062 \text{ K}$$

Final temperature conversion:

$$T_2 = 893.062 \text{ K} - 273.15$$
$$= 619.912°\text{C}$$
$$= 620°\text{C}$$

The temperature of the argon gas under the new conditions of volume and pressure would be 620°C.

Alternative Solution

Plan Your Strategy
Convert the initial temperature from the Celsius scale to the Kelvin scale.
You know that the temperature decreases when the volume decreases.
Determine the ratio of the initial volume and the final volume that is less than 1.
You know that the temperature increases when the pressure increases.
Determine the ratio of the initial pressure and the final pressure that is greater than 1.

Multiply the initial temperature by the volume and pressure ratios determined to obtain the final temperature.
Convert the final temperature from the Kelvin scale to the Celsius scale.

Act on Your Strategy

Initial temperature conversion:

$$\begin{aligned} T_1 &= -35°\text{C} + 273.15 \\ &= 238.15\ \text{K} \end{aligned}$$

Volume ratio:

$V_1 = 2.0$ L
$V_2 = 1.5$ L

volume ratio < 1 is $\dfrac{1.5\ \text{L}}{2.0\ \text{L}}$

Pressure ratio:

$P_1 = 0.5$ atm
$P_2 = 2.5$ atm

pressure ratio > 1 is $\dfrac{2.5\ \text{atm}}{0.5\ \text{atm}}$

Substitution to solve for T_2:

$$\begin{aligned} T_2 &= T_1 \times \text{volume ratio} \times \text{pressure ratio} \\ &= 238.15\ \text{K} \times \frac{1.5\ \text{L}}{2.0\ \text{L}} \times \frac{2.5\ \text{atm}}{0.5\ \text{atm}} \\ &= 893.062\ \text{K} \end{aligned}$$

Final temperature conversion:

$$\begin{aligned} T_2 &= 893.062\ \text{K} - 273.15 \\ &= 619.912^\circ\text{C} \\ &= 620^\circ\text{C} \end{aligned}$$

The temperature of the argon gas under the new conditions of volume and pressure would be 620°C.

Check Your Solution

The large increase in pressure causes a large temperature increase. The volume change decreases the temperature but by a much smaller amount. The large increase in temperature seems reasonable. The answer correctly shows two significant digits.

The volume of the gas under the new conditions of temperature and pressure would be 13.6 mL.

Check Your Solution
Both the change in temperature and the change in pressure will cause the volume to decrease. The small decrease in volume seems reasonable. The answer correctly shows three significant digits.

3. Practice Problem (page 542)
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?

What Is Required?
You need to find the initial volume, V_1, of the gas under the original conditions of temperature and pressure.

What Is Given?
You know the initial temperature and pressure:
$T_1 = 295$ K
$P_1 = 1.02$ atm
You also know the final volume, temperature, and pressure:
$V_2 = 0.224$ mL
$T_2 = 373$ K
$P_2 = 1.23$ atm

Plan Your Strategy
The combined gas law states that the pressure and volume of a given amount of gas are inversely proportional to each other, and directly proportional to the Kelvin temperature of the gas:

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

Rearrange the combined gas law expression to isolate the variable V_1.
Substitute the given data into this expression and solve for V_1.

Act on Your Strategy
Isolation of the variable V_1:

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

$$P_1V_1T_2 = P_2V_2T_1$$

$$\frac{\cancel{P_1}V_1\cancel{T_2}}{\cancel{P_1T_2}} = \frac{P_2V_2T_1}{P_1T_2}$$

$$V_1 = \frac{P_2V_2T_1}{P_1T_2}$$

Substitution to solve for V_1:

$$\begin{aligned} V_1 &= \frac{P_2V_2T_1}{P_1T_2} \\ &= \frac{(1.23\ \cancel{\text{atm}})(0.224\ \text{mL})(295\ \cancel{\text{K}})}{(1.02\ \cancel{\text{atm}})(373\ \cancel{\text{K}})} \\ &= 0.21363\ \text{mL} \\ &= 0.214\ \text{mL} \end{aligned}$$

The initial volume of the gas was 0.214 mL.

Alternative Solution

Plan Your Strategy
You know that the volume increases when the temperature increases. For the volume to increase, T_2 is greater than T_1. Determine the ratio of the initial temperature and the final temperature that is less than 1.
You know that the volume decreases when the pressure increases. For the volume to decrease, P_2 is greater than P_1. Determine the ratio of the initial pressure and the final pressure that is greater than 1.
Multiply the final volume by the temperature and pressure ratios determined to obtain the initial volume.

Act on Your Strategy
Temperature ratio:
$T_1 = 295\ \text{K}$
$T_2 = 373\ \text{K}$
temperature ratio < 1 is $\frac{295\ \text{K}}{298\ \text{K}}$

Pressure ratio:
$P_1 = 1.02$ atm
$P_2 = 1.23$ atm
pressure ratio > 1 is $\frac{1.23 \text{ atm}}{1.02 \text{ atm}}$

Substitution to solve for V_1:
$V_1 = V_2 \times$ temperature ratio × pressure ratio

$$= 0.224 \text{ mL} \times \frac{295 \cancel{\text{K}}}{298 \cancel{\text{K}}} \times \frac{1.23 \cancel{\text{atm}}}{1.02 \cancel{\text{atm}}}$$

$$= 0.21363 \text{ mL}$$

$$= 0.214 \text{ mL}$$

The initial volume of the gas was 0.214 mL.

Check Your Solution
The initial volume will be increased by the increase in temperature and will be decreased by the increase in pressure. The change in temperature is a greater factor than the change in pressure. It is reasonable that the initial volume will be smaller than the final volume. The answer correctly shows three significant digits.

4. Practice Problem (page 542)
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?

What Is Required?
You need to find the final temperature, T_2, of the helium gas under the new conditions of volume and pressure.

What Is Given?
You know the initial pressure, volume, and temperature:
$P_1 = 25$ atm
$V_1 = 1.0 \times 10^2$ L
$T_1 = 20.0$°C
You also know the final volume and pressure:
$V_2 = 2400$ L
$P_2 = 1.05$ atm

Plan Your Strategy
Convert the initial temperature from the Celsius scale to the Kelvin scale.

Check Your Solution
The temperature will increase when the volume increases. The temperature will decrease when the pressure decreases. The volume change is a greater factor than the pressure change, and the temperature increases by a small amount overall. The answer correctly shows two significant digits.

5. **Practice Problem (page 542)**
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?

What Is Required?
You need to find the final pressure, P_2, of the gas under the new conditions of volume and temperature.

What Is Given?
You know the initial pressure, volume, and temperature:
$P_1 = 100.0$ kPa
$V_1 = 30.0$ mL
$T_1 = 30.0$°C
You also know the final volume and temperature:
$V_2 = 28.5$ mL
$T_2 = 25.0$°C

Plan Your Strategy
Convert the temperatures from the Celsius scale to the Kelvin scale.
The combined gas law states that the pressure and volume of a given amount of gas are inversely proportional to each other, and directly proportional to the Kelvin temperature of the gas:

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

Rearrange the combined gas law expression to isolate the variable P_2.
Substitute the given data into the expression and solve for P_2.

Act on Your Strategy
Initial temperature conversion:
$T_1 = 30.0°\text{C} + 273.15$
$\quad = 303.15$ K

Final temperature conversion:
$T_2 = 25.0°\text{C} + 273.15$
$\quad = 298.15$ K

Isolation of the variable P_2:

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

$$\frac{P_1V_1}{T_1}\left(\frac{T_2}{V_2}\right) = \frac{P_2\cancel{V_2}}{\cancel{T_2}}\left(\frac{\cancel{T_2}}{\cancel{V_2}}\right)$$

$$P_2 = \frac{P_1V_1T_2}{V_2T_1}$$

Substitution to solve for P_2:

$$\begin{aligned}P_2 &= \frac{P_1V_1T_2}{V_2T_1} \\ &= \frac{(100.0\ \text{kPa})(30.0\ \cancel{\text{ml}})(298.15\ \cancel{\text{K}})}{(28.5\ \cancel{\text{mL}})(303.15\ \cancel{\text{K}})} \\ &= 103.527\ \text{kPa} \\ &= 104\ \text{kPa}\end{aligned}$$

The atmospheric pressure on the following day was 104 kPa.

Alternative Solution

Plan Your Strategy

Convert the temperatures from the Celsius scale to the Kelvin scale.
You know that the pressure increases when the volume decreases. Determine the ratio of the initial volume and the final volume that is greater than 1.
You know that the pressure decreases when the temperature decreases. Determine the ratio of the initial temperature and the final temperature that is less than 1.
Multiply the initial pressure by the volume and temperature ratios determined to obtain the final pressure.

Act on Your Strategy

Initial temperature conversion:

$$\begin{aligned}T_1 &= 30.0°\text{C} + 273.15 \\ &= 303.15\ \text{K}\end{aligned}$$

Final temperature conversion:

$$\begin{aligned}T_2 &= 25.0°\text{C} + 273.15 \\ &= 298.15\ \text{K}\end{aligned}$$

Volume ratio:
$V_1 = 30.0$ mL
$V_2 = 28.5$ ml
volume ratio > 1 is $\frac{30.0 \text{ mL}}{28.5 \text{ mL}}$

Temperature ratio:
$T_1 = 303.15$ K
$T_2 = 298.15$ K
temperature ratio < 1 is $\frac{298.15 \text{ K}}{303.15 \text{ K}}$

Substitution to solve for P_2:
$P_2 = P_1 \times$ volume ratio × temperature ratio

$$= 100.0 \text{ kPa} \times \frac{30.0 \cancel{\text{mL}}}{28.5 \cancel{\text{mL}}} \times \frac{298.15 \cancel{\text{K}}}{303.15 \cancel{\text{K}}}$$
$$= 103.527 \text{ kPa}$$
$$= 104 \text{ kPa}$$

The atmospheric pressure on the following day was 104 kPa.

Check Your Solution
The final atmospheric pressure will increase because of the decrease in volume, and the final atmospheric pressure will decrease because of the decrease in temperature. The small net increase in pressure seems reasonable. The answer correctly shows three significant digits.

6. Practice Problem (page 542)
A 2.7 L sample of nitrogen gas, N_2(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?

What Is Required?
You need to find the final pressure, P_2, that must be applied to a gas under the new conditions of volume and temperature.

What Is Given?
You know the initial pressure, volume, and temperature:
$P_1 = 0.92$ atm
$V_1 = 2.7$ L
$T_1 = 45.0$°C

Substitution to solve for P_2:
$P_2 = P_1 \times$ volume ratio × temperature ratio

$$= 0.92 \text{ atm} \times \frac{2.7 \cancel{\text{L}}}{2.0 \cancel{\text{L}}} \times \frac{298.15 \cancel{\text{K}}}{318.15 \cancel{\text{K}}}$$

$$= 1.1639 \text{ atm}$$

$$= 1.2 \text{ atm}$$

Pressure of 1.2 atm would have to be applied to the gas to reduce its volume to 2.0 L at a temperature of 25.0°C.

Check Your Solution
The final pressure will increase because of the decrease in volume, and the final pressure will decrease because of the decrease in temperature. The change in volume is a slightly larger factor than the change in pressure factor. The small increase in pressure seems reasonable. The answer correctly shows two significant digits.

7. Practice Problem (page 542)
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?

What Is Required?
You need to find the volume, V_2, of a gas bubble under the new conditions of temperature and pressure.

What Is Given?
You know the initial volume, temperature, and pressure:
$V_1 = 5.0$ mL
$T_1 = 8.0$°C
$P_1 = 4.0$ atm
You also know the final temperature and pressure:
$T_2 = 24.0$°C
$P_2 = 101.3$ kPa

Plan Your Strategy
Convert the temperatures from the Celsius scale to the Kelvin scale.
Convert the units for the initial temperature to kilopascals.

The combined gas law states that the pressure and volume of a given amount of gas are inversely proportional to each other, and directly proportional to the Kelvin temperature of the gas:

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

Rearrange the combined gas law expression to isolate the variable V_2.
Substitute the given data into this expression and solve for V_2.

Act on Your Strategy

Initial temperature conversion:

$$\begin{aligned} T_1 &= 8°\text{C} + 273.15 \\ &= 281.15 \text{ K} \end{aligned}$$

Final temperature conversion:

$$\begin{aligned} T_2 &= 24.0°\text{C} + 273.15 \\ &= 297.15 \text{ K} \end{aligned}$$

Initial pressure conversion:

$$\begin{aligned} P_1 &= 4.0 \cancel{\text{atm}} \times \frac{101.325 \text{ kPa}}{1.0 \cancel{\text{atm}}} \\ &= 405.3 \text{ kPa} \end{aligned}$$

Isolation of the variable V_2:

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

$$\frac{P_1V_1}{T_1}\left(\frac{T_2}{P_2}\right) = \frac{\cancel{P_2}V_2}{\cancel{T_2}}\left(\frac{\cancel{T_2}}{\cancel{P_2}}\right)$$

$$V_2 = \frac{P_1V_1T_2}{P_2T_1}$$

Substitution to solve for V_2:

$$\begin{aligned} V_2 &= \frac{P_1V_1T_2}{P_2T_1} \\ &= \frac{(405.3 \cancel{\text{kPa}})(5.0 \text{ mL})(297.15 \cancel{\text{K}})}{(101.3 \cancel{\text{kPa}})(281.15 \cancel{\text{K}})} \\ &= 21.1433 \text{ mL} \\ &= 21 \text{ mL} \end{aligned}$$

The volume of the air bubble under the new conditions of temperature and pressure will be 21 mL.

Alternative Solution

Plan Your Strategy
Convert the temperatures from the Celsius scale to the Kelvin scale.
Convert the units for the initial temperature to kilopascals.
You know that the volume increases when temperature increases. Determine the ratio of the initial temperature and the final temperature that is greater than 1.
You know that the volume increases when the pressure decreases. Determine the ratio of the initial pressure and the final pressure that is greater than 1.
Multiply the initial volume by the temperature and pressure ratios determined to obtain the final volume.

Act on Your Strategy
Initial temperature conversion:

$$\begin{aligned} T_1 &= 8°\text{C} + 273.15 \\ &= 281.15\text{ K} \end{aligned}$$

Final temperature conversion:

$$\begin{aligned} T_2 &= 24.0°\text{C} + 273.15 \\ &= 297.15\text{ K} \end{aligned}$$

Initial pressure conversion:

$$\begin{aligned} P_1 &= 4.0\,\cancel{\text{atm}} \times \frac{101.325\text{ kPa}}{1.0\,\cancel{\text{atm}}} \\ &= 405.3\text{ kPa} \end{aligned}$$

Temperature ratio:
$T_1 = 281.15$ K
$T_2 = 297.15$ K

$$\text{temperature ratio} > 1 \text{ is } \frac{297.15\text{K}}{281.15\text{K}}$$

Pressure ratio:
$P_1 = 405.3$ kPa
$P_2 = 101.3$ kPa

$$\text{pressure ratio} > 1 \text{ is } \frac{405.3\text{kPa}}{101.3\text{kpa}}$$

Substitution to solve for V_2:

$$V_2 = V_1 \times \text{ temperature ratio } \times \text{ pressure ratio}$$

$$= 5.0\text{ mL} \times \frac{297.15\ \cancel{\text{K}}}{281.15\ \cancel{\text{K}}} \times \frac{405.3\ \cancel{\text{kPa}}}{101.3\ \cancel{\text{kPa}}}$$

$$= 21.1433\text{ mL}$$

$$= 21\text{ mL}$$

The volume of the air bubble under the new conditions of temperature and pressure will be 21 mL.

Check Your Solution

Both the change in temperature and the change in pressure will cause the volume to increase. The final pressure is about ¼ the original pressure and the final volume is about four times the original volume. The answer is reasonable and correctly shows two significant digits.

8. **Practice Problem (page 542)**

A 5.0×10^2 mL sample of oxygen, $O_2(g)$, 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.

What Is Required?

You need to find the final temperature, T_2, of the oxygen gas under the new conditions of volume and pressure.

What Is Given?

You know the initial pressure, volume, and temperature:

$P_1 = 950$ mmHg
$V_1 = 5.0 \times 10^2$ mL
$T_1 = 21.5$°C

You also know the final volume and pressure:

$V_2 = 700$ mL
$P_2 = 101.325$ kPa

Plan Your Strategy

Convert the initial temperature from the Celsius scale to the Kelvin scale.
Convert the units for the initial pressure to kilopascals.
The combined gas law states that the pressure and volume of a given amount of gas are inversely proportional to each other, and directly proportional to the Kelvin temperature of the gas:

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

Final temperature conversion:

$$T_2 = 330.0086 \text{ K} - 273.15$$
$$= 56.86°\text{C}$$
$$= 57°\text{C}$$

The final temperature of the oxygen gas is 57°C.

Check Your Solution
The temperature will increase when the volume increases, and the temperature will decrease when the pressure decreases. The volume change is a greater factor than the pressure change, and the temperature increases overall. The answer correctly shows two significant digits.

9. Practice Problem (page 542)
A sample of Freon-12, $CF_2Cl_2(g)$, 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?

What Is Required?
You need to find the final volume, V_2, of a Freon-12 sample under the new conditions of temperature and pressure.

What Is Given?
You know the initial volume, temperature, and pressure:
$V_1 = 350 \text{ cm}^3$
$T_1 = 15°\text{C}$
$P_1 = 150 \text{ psi}$
You also know the final temperature and pressure:
$T_2 = 25°\text{C}$
$P_2 = 102 \text{ kPa}$

Plan Your Strategy
Convert the temperatures from the Celsius scale to the Kelvin scale.
Convert the units for the initial pressure from psi to kilopascals.
The combined gas law states that the pressure and volume of a given amount of gas are inversely proportional to each other, and directly proportional to the Kelvin temperature of the gas:

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

Rearrange the combined gas law expression to isolate the variable V_2.
Substitute the given data into the expression and solve for V_2.

Act on Your Strategy

Initial temperature conversion:

$$T_1 = 15°\text{C} + 273.15$$
$$= 288.15 \text{ K}$$

Final temperature conversion:

$$T_2 = 25.0°\text{C} + 273.15$$
$$= 298.15 \text{ K}$$

Initial pressure conversion:

$$P_1 = 150 \cancel{\text{psi}} \times \frac{101.325 \text{ kPa}}{14.7 \cancel{\text{psi}}}$$
$$= 1033.928 \text{ kPa}$$

Isolation of the variable V_2:

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

$$\frac{P_1V_1}{T_1}\left(\frac{T_2}{P_2}\right) = \frac{\cancel{P_2}V_2}{\cancel{T_2}}\left(\frac{\cancel{T_2}}{\cancel{P_2}}\right)$$

$$V_2 = \frac{P_1V_1T_2}{P_2T_1}$$

Substitution to solve for V_2:

$$V_2 = \frac{P_1V_1T_2}{P_2T_1}$$
$$= \frac{(1033.928 \cancel{\text{kPa}})(350 \text{ cm}^3)(298.15 \cancel{\text{K}})}{(101.325 \cancel{\text{kPa}})(288.15 \cancel{\text{K}})}$$
$$= 3670.915 \text{ cm}^3$$
$$= 3.7 \times 10^3 \text{ cm}^3$$

The volume of gas that would be released under the given conditions of temperature and pressure would be $3.7 \times 10^3 \text{ cm}^3$.

Alternative Solution

Plan Your Strategy

Convert the temperatures from the Celsius scale to the Kelvin scale.
Convert the units for the initial pressure from psi to kilopascals.

You know that the volume increases when the temperature increases. Determine the ratio of the initial temperature and the final temperature that is greater than 1.
You know that the volume increases when the pressure decreases. Determine the ratio of the initial pressure and the final pressure that is greater than 1.
Multiply the initial volume by the temperature and pressure ratios determined to obtain the final volume.

Act on Your Strategy
Initial temperature conversion:

$$\begin{aligned} T_1 &= 15°\text{C} + 273.15 \\ &= 288.15\ \text{K} \end{aligned}$$

Final temperature conversion:

$$\begin{aligned} T_2 &= 25.0°\text{C} + 273.15 \\ &= 298.15\ \text{K} \end{aligned}$$

Initial pressure conversion:

$$\begin{aligned} P_1 &= 150\ \cancel{\text{psi}} \times \frac{101.325\ \text{kPa}}{14.7\ \cancel{\text{psi}}} \\ &= 1033.928\ \text{kPa} \end{aligned}$$

Temperature ratio:
$T_1 = 288.15$ K
$T_2 = 298.15$ K

temperature ratio > 1 is $\dfrac{298.15\ \text{K}}{288.15\ \text{K}}$

Pressure ratio:
$P_1 = 1033.928$ kPa
$P_2 = 102$ kPa

pressure ratio > 1 is $\dfrac{1033.928\ \text{kPa}}{102\ \text{kPa}}$

Substitution to solve for V_2:

$$\begin{aligned} V_2 &= V_1 \times \text{temperature ratio} \times \text{pressure ratio} \\ &= 350.0\ \text{cm}^3 \times \frac{298.15\ \cancel{\text{K}}}{288.15\ \cancel{\text{K}}} \times \frac{1033.928\ \cancel{\text{kPa}}}{102\ \cancel{\text{kPa}}} \\ &= 3670.915\ \text{cm}^3 \\ &= 3.7 \times 10^3\ \text{cm}^3 \end{aligned}$$

The volume of gas that would be released under the given conditions of temperature and pressure would be $3.7 \times 10^3\ \text{cm}^3$.

Check Your Solution
Both the change in temperature and the change in pressure will cause the volume to increase. The answer is reasonable and correctly shows two significant digits.

10. Practice Problem (page 542)
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?

What Is Required?
You need to find the final volume, V_2, of sample of methane gas under the new conditions of temperature and pressure.

What Is Given?
You know the initial volume, temperature, and pressure:
$V_1 = 350\ \text{m}^3$
$T_1 = 8°\text{C}$
$P_1 = 16\ \text{atm}$
You also know the final temperature and pressure:
$T_2 = 40°\text{C}$
$P_2 = 758\ \text{mmHg}$

Plan Your Strategy
Convert the temperatures from the Celsius scale to the Kelvin scale.
Convert the units for the final pressure from mmHg to atmospheres.
The combined gas law states that the pressure and volume of a given amount of gas are inversely proportional to each other, and directly proportional to the Kelvin temperature of the gas:

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

Rearrange the combined gas law expression to isolate the variable V_2.
Substitute the given data into the expression and solve for V_2.

Act on Your Strategy
Initial temperature conversion:

$$\begin{aligned} T_1 &= 8°\text{C} + 273.15 \\ &= 281.15\ \text{K} \end{aligned}$$