Marks 3

- A sample of gas is found to exert a pressure of $7.00 \times 10^4$ Pa when it is in a 3.00 L flask at 10.00 °C. Calculate the new volume if the pressure becomes $1.01 \times 10^5$ Pa and the temperature is unchanged.

**Using the ideal gas law, $PV = nRT$, the number of moles present is:**

$$n = PV/RT = (7.00 \times 10^4 \text{ Pa})(3.00 \times 10^{-3} \text{ m}^3)/(8.314 \text{ m}^3 \text{ Pa K}^{-1} \text{ mol}^{-1})(283.00 \text{ K}) = 8.925 \times 10^{-2} \text{ mol}$$

**At the new pressure, the volume occupied by this amount is:**

$$V = nRT/P = (8.925\times10^{-2} \text{ mol})(8.314 \text{ m}^3 \text{ Pa K}^{-1} \text{ mol}^{-1})(283.00 \text{ K})/(1.01 \times 10^5 \text{ Pa}) = 2.08 \times 10^{-3} \text{ m}^3 = 2.08 \text{ L}$$

**More quickly, $P_1V_1 = P_2V_2$ can be used:**

$$V_2 = P_1V_1 / P_2 = (7.00 \times 10^4 \text{ Pa})(3.00 \text{ L}) / (1.01 \times 10^5 \text{ Pa}) = 2.08 \text{ L}$$

Answer: **2.08 L**

Calculate the new pressure if the volume becomes 2.00 L and the temperature is unchanged.

**From above, $n = 8.925 \times 10^{-2}$ mol. The pressure when $V = 2.00$ L and $T = 283.00$ K is:**

$$P = nRT/V = (8.925 \times 10^{-2} \text{ mol})(8.314 \text{ m}^3 \text{ Pa K}^{-1} \text{ mol}^{-1})(283.00 \text{ K})/(2.00 \times 10^{-3} \text{ m}^3) = 1.05 \times 10^5 \text{ Pa}$$

**$P_1V_1 = P_2V_2$ can again be used without calculating $n$:**

$$P_2 = P_1V_1 / V_2 = (7.00 \times 10^4 \text{ Pa}) \times (3.00 \text{ L}) / (2.00 \text{ L}) = 1.05 \times 10^5 \text{ Pa}$$

Answer: **$1.05 \times 10^5$ Pa**

Calculate the new pressure if the temperature is raised to 50.0 °C and the volume is unchanged, *i.e.* still 3.00 L.

**From above, $n = 8.925 \times 10^{-2}$ mol. The pressure when $V = 3.00$ L and $T = 323.0$ K is:**

$$P = nRT/V = (8.925 \times 10^{-2} \text{ mol})(8.314 \text{ m}^3 \text{ Pa K}^{-1} \text{ mol}^{-1})(323.0 \text{ K})/(3.00 \times 10^{-3} \text{ m}^3) = 7.99 \times 10^4 \text{ Pa}$$

**The new pressure can be calculated directly using $P_1/T_1 = P_2/T_2$:**

$$P_2 = P_1 \times T_2/T_1 = (7.00 \times 10^4 \text{ Pa}) \times 323.0/283.0 = 7.99 \times 10^4 \text{ Pa}$$

Answer: **$7.99 \times 10^4$ Pa**