# Contents



# 1 Chapter 18 - Thermal Properties of Matter

Avogadro's number

$$N_A = 6.02 \times 10^{23}\,\text{mol} \tag{1}$$

## 1.1 The Ideal Gas Law

**Ideal gas**: a collection of atoms or molecules that move randomly and exert no long-range forces on each other.

Number of moles

$$n = \frac{N}{N_A} = \frac{m_{particle}N}{m_{particle}N_A} = \frac{m}{M} \tag{2}$$

The **molar mass** $M$ **(molecular weight)** is the mass per mole. The total mass of $n$ moles is $m_{total} = nM$.

Ideal-gas equation

$$pV = nRT \tag{3}$$

Universal gas constant

$$R = 8.31\,\text{J}\,\text{mol}^{-1}\,\text{K}^{-1} = 0.0821\,\text{L}\,\text{atm}\,\text{mol}^{-1}\,\text{K}^{-1} \tag{4}$$

The volume occupied by 1 mol of any ideal gas at atmospheric pressure and at 0 °C is 22.4 L.

### 1.1.1 Question

$$\begin{aligned} V &= 22.4 \times 10^{-3}\,\text{L} \\ T &= 273.15\,\text{K} \\ p &= 1.013 \times 10^{5}\,\text{Pa} = 1.0\,\text{atm} \\ n &= ? \end{aligned}$$

$$
\begin{aligned}
pV &= nRT \\
n &= \frac{pV}{RT} \\
n &= \frac{(1.0\ \text{atm})(22.4\,\text{L})}{(0.0821\,\text{L atm mol}^{-1}\,\text{K}^{-1})(273.15\,\text{K})} \\
n &= 1.000\,\text{mol}
\end{aligned}
$$

### 1.1.2 18.3

$$
\begin{aligned}
V_0 &= 0.110\,\text{m}^3 \\
p_0 &= 0.355\,\text{atm} \\
V_1 &= 0.390\,\text{m}^3 \\
T &= \text{constant} \\
p_1 &= ?
\end{aligned}
$$

$$
\begin{aligned}
p_0V_0 &= p_1V_1 \\
p_1 &= \frac{p_0V_0}{V_1} \\
p_1 &= \frac{(0.355\,\text{atm})(0.110\,\text{m}^3)}{0.390\,\text{m}^3} \\
p_1 &= 0.1001\,\text{atm}
\end{aligned}
$$

### 1.1.3 18.4

$$
\begin{aligned}
V_0 &= 3.00\,\text{L} \\
p_0 &= 3.00\,\text{atm} \\
T_0 &= 20.0\,^\circ\text{C} = 293\,\text{K} \\
p_1 &= 1.00\,\text{atm}
\end{aligned}
$$

**(a)**

$$
\begin{aligned}
pV &= nRT \\
\frac{p}{T} &= \frac{nR}{V} \\
\frac{p_0}{T_0} &= \frac{p_1}{T_1} \\
T_1 &= \frac{p_1T_0}{p_0} \\
T_1 &= \frac{(1.00\,\text{atm})(293\,\text{K})}{3.00\,\text{atm}} \\
T_1 &= 97.7\,\text{K} = -175.3\,^\circ\text{C}
\end{aligned}
$$

### 1.1.4 18.7

$$
\begin{aligned}
V_0 &= 499\,\mathrm{cm}^3 = 499 \times 10^{-6}\,\mathrm{m}^3 \\
p_0 &= 1.01 \times 10^5\,\mathrm{Pa} \\
T_0 &= 27.0\,^\circ\mathrm{C} = 300\,\mathrm{K} \\
V_1 &= 46.2\,\mathrm{cm}^3 = 46.2 \times 10^{-6}\,\mathrm{m}^3 \\
p_1 &= 2.72 \times 10^6\,\mathrm{Pa} + 1\,\mathrm{atm} = 2.821 \times 10^6\,\mathrm{Pa} \\
T_1 &= ?
\end{aligned}
$$

$$
\begin{aligned}
p_0 V_0 &= nrT \\
\frac{p_0 V_0}{T_0} &= \frac{p_1 V_1}{T_1} \\
T_1 &= \frac{p_1 V_1 T_0}{p_0 V_0}
\end{aligned}
$$