Given

Data for pressure, temperature, and specific volume

Find

(a) Specific volume $\left(\frac{m^3}{kg}\right)$ for 7 bar and 60°C

(b) Specific volume $\left(\frac{m^3}{kg}\right)$ for 7.4 bar and 50°C

(c) Specific volume $\left(\frac{m^3}{kg}\right)$ for 7.4 bar and 60°C

System

N/A

Assumptions

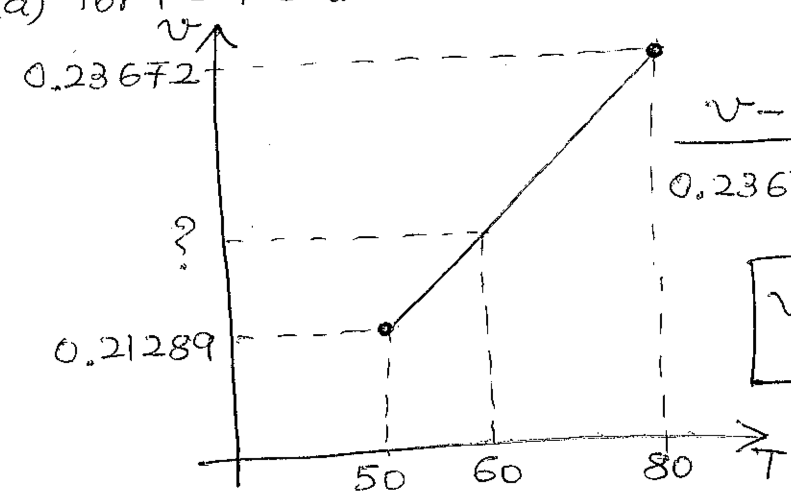
- Linear interpolation

Basic Equations

N/A

Solution

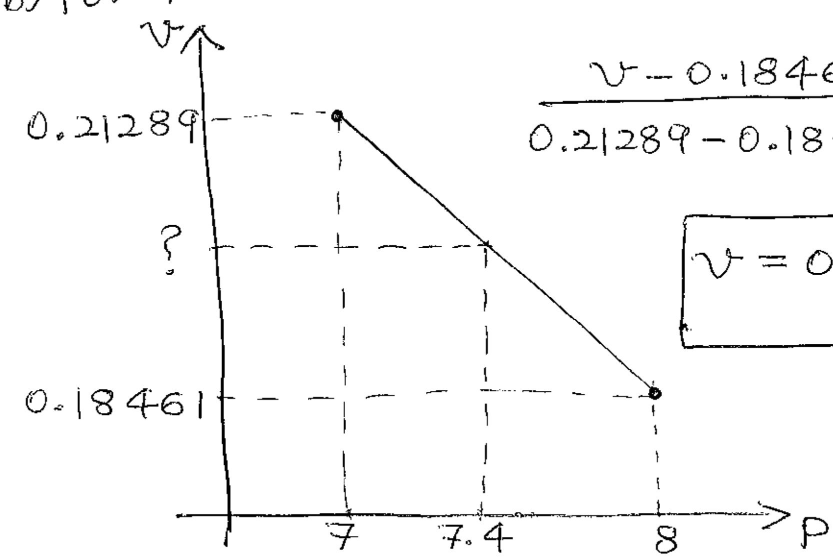
(a) For P = 7 bar



$$\frac{v - 0.21289}{0.23672 - 0.21289} = \frac{60-50}{80-50}$$

$$\boxed{v = 0.22083 \ \frac{m^3}{kg}}$$

(b) For T = 50°C

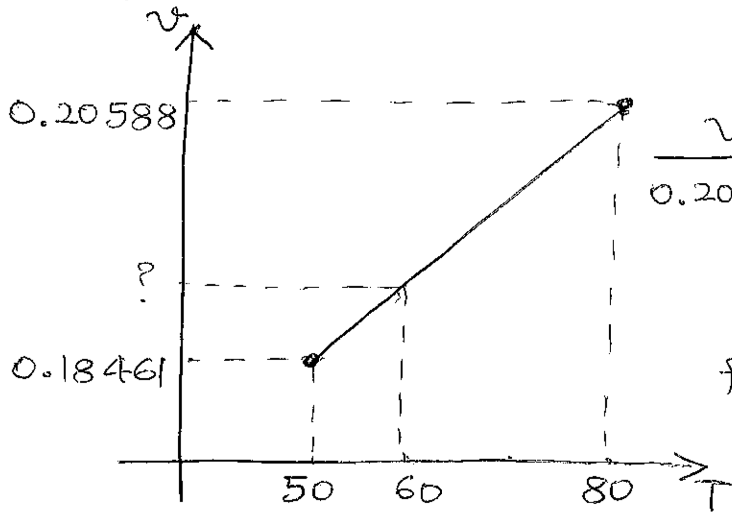


$$\frac{v - 0.18461}{0.21289 - 0.18461} = \frac{7.4 - 8}{7 - 8}$$

$$\boxed{v = 0.20158 \ \frac{m^3}{kg}}$$

(c) From (a) $v = 0.22083 \frac{m^3}{kg}$ for $P = 7$ bar, $T = 60°C$

For $P = 8$ bar



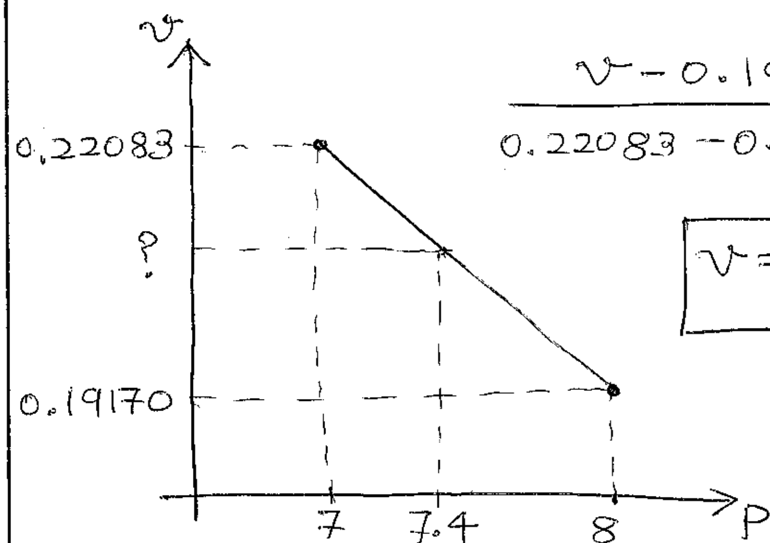
$$\frac{v - 0.18461}{0.20588 - 0.18461} = \frac{60-50}{80-50}$$

$$v = 0.19170 \frac{m^3}{kg}$$

for $P = 8$ bar, $T = 60°C$

Interpolating again:

For $T = 60°C$



$$\frac{v - 0.19170}{0.22083 - 0.19170} = \frac{7.4-8}{7-8}$$

$$\boxed{v = 0.20918 \frac{m^3}{kg}}$$

Given

Definite integrals

Find

(a) $I_1 = \int_5^{10} \frac{dx}{x}$

(b) $I_2 = \int_{0.1}^{0.3} \frac{dx}{x^{1.5}}$

System

N/A

Assumptions

N/A

Basic Equations

N/A

Solution

(a) $I_1 = \int_5^{10} \frac{dx}{x} = [\ln x]_5^{10} = \ln 10 - \ln 5 = \ln \frac{10}{5}$

$$\boxed{I_1 = \ln 2 = 0.693}$$

(b) $I_2 = \int_{0.1}^{0.3} \frac{dx}{x^{1.5}} = \left[\frac{x^{-1.5+1}}{-1.5+1}\right]_{0.1}^{0.3}$

$$= \frac{(0.3)^{-0.5} - (0.1)^{-0.5}}{-0.5}$$

$$\boxed{I_2 = 2.673}$$

Given

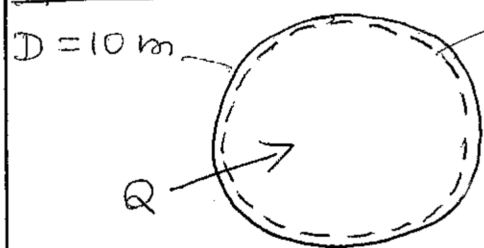
A spherical balloon containing helium gas

Find

(a) Mass (kg) of the gas

(b) Final absolute pressure (bar) of the gas

System



Helium gas inside the balloon is the system

$M_{He} = 4 \frac{kg}{kmol}$

$P_1 = 5$ bar, $T_1 = 20°C$

$\downarrow$

$T_2 = 150°C$

Assumptions

- Mass and volume remain constant
- Helium is an ideal gas

Basic Equations

N/A

Solution

(a) $P_1 V_1 = m_1 R_{He} T_1$

$V_1 = \frac{4}{3}\pi R^3 = \frac{\pi}{6} D^3 = 523.6\ m^3$

Mass of helium gas : $m_1 = \frac{P_1 V_1}{R_{He} T_1}$

$R_{He} = \frac{\bar{R}}{M_{He}} = \frac{8.314 \frac{kJ}{kmol\text{-}K}}{4 \frac{kg}{kmol}} = 2.079 \frac{kJ}{kg\text{-}K}$

$T_1 = 20°C = (20 + 273.15)\ K = 293.15\ K$

$m_1 = \frac{(5 \times 100)\ \cancel{kPa} * 523.6\ \cancel{m^3}}{2.079\ \frac{\cancel{kJ}}{kg\text{-}\cancel{K}} * 293.15\ \cancel{K}}$

$m_1 = m_2 = m$

$\boxed{m = 429.6\ kg}$

(b) Initial state : $P_1 V_1 = m_1 R_{He} T_1$

Final state : $P_2 V_2 = m_2 R_{He} T_2$

$\Rightarrow \frac{P_2 \cancel{V_2}}{P_1 \cancel{V_1}} = \frac{\cancel{m_2} \cancel{R_{He}} T_2}{\cancel{m_1} \cancel{R_{He}} T_1} \Rightarrow P_2 = P_1 * \frac{T_2}{T_1}$

$T_2 = 150°C = (150 + 273.15)\ K = 423.15\ K$

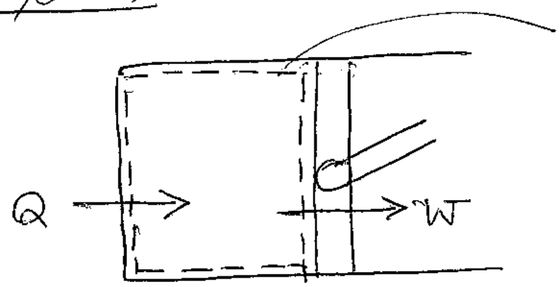
$\boxed{P_2 = 7.22\ bar}$

Final pressure of helium gas : $P_2 = 5\,bar * \frac{423.15\ K}{293.15\ K}$

Given
Air inside a closed piston-cylinder system

Find
(a) Specific volume $\left(\frac{m^3}{kg}\right)$ of air
(b) Effect of heating on specific volume of air
(c) Effect of heating on pressure of air

System



Air inside the cylinder is the system

$M_{air} = 28.97 \frac{kg}{kmol}$

$P_1 = 100\ kPa,\ T_1 = 27^\circ C$

Assumptions
- Closed system (m = constant)
- Quasi-equilibrium process
- Air is an ideal gas

Basic Equations

N/A

Solution

(a) $P_1 V_1 = m_1 R_{air} T_1 \Rightarrow P_1 v_1 = R_{air} T_1$

Specific volume of air: $v_1 = \frac{R_{air} T_1}{P_1}$

$$R_{air} = \frac{\overline{R}}{M_{air}} = \frac{8.314 \frac{kJ}{kmol-K}}{28.97 \frac{kg}{kmol}} = 0.287 \frac{kJ}{kg-K}$$

$T_1 = 27^\circ C = (27 + 273.15)\ K = 300.15\ K$

$$v_1 = \frac{0.287 \frac{kJ}{kg-\cancel{K}} * 300.15\cancel{K}}{100\ kPa}$$

$1\ kJ = 1\ kPa * 1\ m^3$

$$\boxed{v_1 = 0.861 \frac{m^3}{kg}}$$

(b) Closed system: $m_1 = m_2$

Since volume doubles $V_2 = 2V_1$

$$v_1 = \frac{V_1}{m_1} \quad \text{and} \quad v_2 = \frac{V_2}{m_2} = \frac{2V_1}{m_1} = 2v_1$$

$\Rightarrow$ $\boxed{\text{Specific volume of air increases when air is heated at constant temperature}}$

(c) Initial state: $P_1 V_1 = m_1 R_{air} T_1$

Final state: $P_2 V_2 = m_2 R_{air} T_2$

closed system: $m_1 = m_2$

Since temperature remains constant $T_1 = T_2$

$$\Rightarrow P_1 V_1 = P_2 V_2 \quad \Rightarrow \quad P_2 = P_1 * \frac{V_1}{V_2} = P_1 * \frac{V_1}{2V_1}$$

$\Rightarrow$ $\boxed{\text{Pressure of air decreases when air is heated at constant temperature}}$