21장 기체의 운동론

1. (a) $V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi (0.150\ \mathrm{m})^3 = 1.41 \times 10^{-2}\ \mathrm{m}^3$

$PV = nRT$에서,

$$n = \frac{PV}{RT} = \frac{(1.013 \times 10^5\ \mathrm{N/m^2})(1.41 \times 10^{-2}\ \mathrm{m^3})}{*8.314\ N \cdot \mathrm{m/mol} \cdot \mathrm{K})(293\ \mathrm{K})} = 0.588\ \mathrm{mol}$$

분자의 수는 $N = nN_A$ 이다.

$$N = nN_A = (0.588\ \mathrm{mol})(6.02 \times 10^{23}\ \mathrm{molecuels/mol})$$

$$= 3.54 \times 10^{23}\ \mathrm{helium\,atoms}$$

(b) $\overline{K} = \frac{1}{2}m_o\overline{v^2} = \frac{3}{2}k_b T$

$$= \frac{3}{2}(1.38 \times 10^{-23}\ \mathrm{J/K})(293\ \mathrm{K}) = 6.07 \times 10^{-21}\ \mathrm{J}$$

(c) He원자의 질량 $m_o = \frac{M}{N_A} = \frac{4.0026\ \mathrm{g/mol}}{6.02 \times 10^{23}\mathrm{molecules/mol}}$

$$= 6.65 \times 10^{-24}\ \mathrm{g} = 6.65 \times 10^{-27}\ \mathrm{kg}$$

$$v_{rms} = \sqrt{\overline{v^2}} = \sqrt{\frac{2\overline{K}}{m_o}}\ ; = \sqrt{\frac{2 \times 6.07 \times 10^{-27}\ \mathrm{J}}{6.65 \times 10^{-27}\ \mathrm{kg}}} = 1.35\ \mathrm{km/s}$$

4. 압력과 분자 운동 에너지와의 관계식 (21.15 참고) : $P = \frac{2N}{3V}\left(\frac{m_o\overline{v^2}}{2}\right)$

$\overline{K} = \frac{1}{2}m_o\overline{v^2} = \frac{3PV}{2N}$ 에서 $N = nN_A$

$$\overline{K} = \frac{3PV}{2nN_A} = \frac{3(8.00\ \mathrm{atm})(1.013 \times 10^5\ \mathrm{Pa/atm})(5.00 \times 10^{-3}\ \mathrm{m^3})}{2(2\ \mathrm{mol})(6.02 \times 10^{23}\ \mathrm{molecuels/mol})}$$

$$= 5.05 \times 10^{-21}\ \mathrm{J}$$

10. (a) $Q = nC_p \triangle T$ 이용, $\triangle T = 420\ \text{K} - 300\ \text{K} = 120\ \text{K}$

$Q = nC_P \triangle T = (1.00\ \text{mol})(28.8\ \text{J/mol} \cdot \text{K})(420\ \text{K} - 300\ \text{K}) = 3.46\ \text{kJ}$

(b) $\triangle E_{\text{int}} = \text{nC}_\text{V} \triangle \text{T} = (1.00\ \text{mol})(20.4\ \text{J/mol} \cdot \text{K})(120\ \text{K}) = 2.45\ \text{kJ}$

(c) $\triangle E_{\text{int}} = \text{Q} + \text{W}$에서

$W = -Q + \triangle E_{\text{int}} = -3.46\ \text{kJ} + 2.45\ \text{kJ} = -1.01\ \text{kJ}$

14. (a) 이상기체의 단열과정에서 P와 V의 관계에서,

$P_i V_i^\gamma = P_f V_f^\gamma$ 이용

$$P_f = P_i \left(\frac{V_i}{V_f} \right)^\gamma = (5.00\ \text{atm}) \left(\frac{12.0}{30.0} \right)^{1.40} = 1.39\ \text{atm}$$

(b) $$T_i = \frac{P_i V_i}{nR} = \frac{5.00\,(1.013 \times 10^5\ \text{Pa})(12.0 \times 10^{-3}\ \text{m}^3)}{(2.00\ \text{mol})(8.314\ \text{J/mol} \cdot \text{K})} = 366\ \text{K}$$

$$T_f = \frac{P_f V_f}{nR} = \frac{1.39\,(1.013 \times 10^5\,\text{Pa})(30.0 \times 10^{-3}\ \text{m}^3)}{(2.00\ \text{mol})(8.314\ \text{J/mol} \cdot \text{K})} = 253\ \text{K}$$

(c) 단열과정에서 $Q = 0$

(d) $\triangle E_{int} = nC_V \triangle T$ 에서, $C_V = \dfrac{R}{\gamma - 1} = \dfrac{2}{5} R$

$$\triangle E_{int} = nC_V \triangle T = (2.00\,\text{mol}) \left[\frac{2}{5} (8.314\,\text{J/mol} \cdot \text{K}) \right] (253\ \text{K} - 366\ \text{K})$$

$= -4.66\ \text{kJ}$

(e) $W = \triangle E_{int} - Q = -4.66\ \text{kJ} - 0 = -4.66\ \text{kJ}$