ASSIGNMENT PHYSICS 2

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Q1) $Q = -100J$

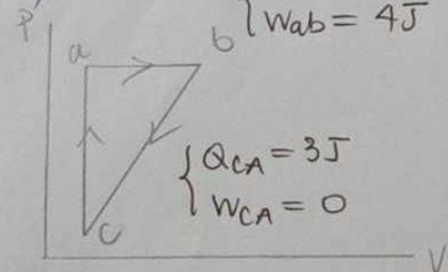
$W = p\Delta V = 100\times 10^{3}(200\times 10^{-6} - 400\times 10^{-6}) = -20(J)$

$\Delta E = Q - W = -100 + 20 = -80(J)$

$\Rightarrow$ The change in internal energy of gas is $-80(J)$

Q3)

$\begin{cases} Q_{ab} = 5J \\ W_{ab} = 4J \end{cases}$



$\begin{cases} Q_{CA} = 3J \\ W_{CA} = 0 \end{cases}$

$+ \; W_{abca} = 2J$

a) $\Delta E_{ab} = ?$

$\Delta E_{ab} = Q_{ab} - W_{ab} = 5 - 4 = 1(J)$

$\Rightarrow$ The change in internal energy along path ab is $1J$

b) $Q_{bc} = ?$

+) $W_{abca} = W_{ab} + W_{bc} + W_{ca} \Leftrightarrow 2 = 4 + W_{bc} + 0$

$\Rightarrow W_{bc} = -2(J)$

+) $\Delta E_{bc} = -(\Delta E_{ca} + \Delta E_{ab}) = -(3+1) = -4J$

+) $Q_{bc} = \Delta E_{bc} + W_{bc} = -4 - 2 = -6(J)$

$\Rightarrow$ The heat transfer out from the gas is $6J$

Q4) For isothermal process: $Q = nRT\ln\frac{V_f}{V_i}$

$\Leftrightarrow 2000 = 0.9\times 8.31\times T\times \ln\frac{0.4}{0.2}$

$\Rightarrow T = 385.7989\,(K)$

$\Rightarrow$ The temperature of the gas is $385.7989\,K$

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(2) $W = \frac{1}{2}\Delta p \, \Delta V = \frac{1}{2} \times (25 - 10) \times (5 - 1) = 30 J$

Because clockwise $\Rightarrow W > 0 \Leftrightarrow W = +30 J$

(5) Mean Free path $\lambda = \dfrac{1}{\sqrt{2}\pi d^2 N/V}$

we have $PV = NKT \Rightarrow N = \dfrac{PV}{KT} \Rightarrow \lambda = \dfrac{KT}{\sqrt{2}\pi d^2 p}$

$$= \frac{(1.38 \times 10^{-23}) \times 20}{\sqrt{2}\pi (15 \times 10^{-9})^2 \times (1 \times 10^{-5})}$$

$$= 27.6 m$$

(6) $\overline{K} = \frac{3}{2} KT$

we have $PV = NKT \Rightarrow KT = \dfrac{PV}{N}$

$$\Rightarrow \overline{K} = \frac{3PV}{2N} = \frac{3PV}{2nN_A} = \frac{3 \times (3 \times 10^{-3}) \times (5 \times 10^{6})}{2 \times 2 \times (6.02 \times 10^{23})} = 1.86 \times 10^{-20} J$$

(7) For an adiabatic expansion of an ideal gas : $T_i V_i^{\gamma-1} = T_f V_f^{\gamma-1}$

Since $T_f = \frac{1}{3} T_i$

$$\Rightarrow \frac{T_i}{T_f} = \left(\frac{V_f}{V_i}\right)^{\gamma-1} \Leftrightarrow \frac{T_i}{\frac{1}{3}T_i} = \left(\frac{V_f}{V_i}\right)^{\gamma-1} \Leftrightarrow 3 = \left(\frac{V_f}{V_i}\right)^{1.4-1}$$

$$\Leftrightarrow \frac{V_f}{V_i} = 15.6 \Rightarrow V_f = 15.6 V_i$$

therefore , the factor does the volume change

$\Delta V = V_f - V_i = 15,6 V_i - V_i = 14,6 V_i$

Question 8: An Ideal monatomic gas undergoes an adiabatic compression From State 1 with pressure $P_1 = 1$ atm, volume $V_1 = 8L$, Temperature $T_1 = 300K$ to State 2 with pressure $P_2 = 32$ atm, volume $V_2 = 1L$

a) What is the temperature of gas in State 2? $T_2 = ?$ (K)

$$\frac{PV}{T} = \text{const}$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow T_2 = \frac{T_1 P_2 V_2}{P_1 V_1} = \frac{300 \times 32 \times 1}{1 \times 8} = 1200 \text{ (K)}$$

Thus, the temperature of gas in state 2, $T_2 = 1200$ (K).

b) How many moles of gas are present?

$$PV = nRT$$

$$P_1V_1 = nRT_1 \Rightarrow n = \frac{P_1V_1}{RT_1} = \frac{1 \times 1.01 \times 10^5 \times 8 \times 10^{-3}}{8.31 \times 300}$$

$$= 0.324 \text{ (mole)}$$

Thus, the present moles of gas is: $n = 0.324$ mol

c) What is the average translational kinetic energy per mole before and after the compression? $\bar{K}_1 = ?$ (J), $\bar{K}_2 = ?$ (J)

The average translational kinetic energy per mole:

$$\bar{K} = \frac{3}{2}nRT = \frac{3}{2} \times 1 \times R \times T = \frac{3}{2}RT$$

Before compression: $\bar{K}_1 = \frac{3}{2}RT_1 = \frac{3}{2} \times 8.31 \times 300 = 3739.5$ (J)

After compression: $\bar{K}_2 = \frac{3}{2}RT_2 = \frac{3}{2} \times 8.31 \times 1200 = 14958$ (J)

d) What is the ratio of the squares of the rms speeds before and after the compression? $\frac{v^2_{rms_1}}{v^2_{rms_2}} = ?$

Root mean square speed equation: $v_{rms} = \sqrt{\frac{3RT}{M}}$ (m/s)

$\Rightarrow v^2_{rms} = \frac{3RT}{M}$ (m^2/s^2)

$$\frac{v^2_{rms_1}}{v^2_{rms_2}} = \frac{3RT_1 \; M}{3RT_2 \; M} = \frac{T_1}{T_2} = \frac{300}{1200} = \frac{1}{4}$$

Thus, the ratio of the squares of the rms speeds before and after compression is $\frac{1}{4}$.

e) If we do not know that the ideal gas here is monatomic, demonstrate that the gas is truly monoatomic.

Due to adiabatic process: pV^γ = constant

$$p_1V_1^\gamma = p_2V_2^\gamma$$

$$\Leftrightarrow \left(\frac{V_1}{V_2}\right)^\gamma = \frac{p_2}{p_1}$$

$$\Leftrightarrow 8^\gamma = 32$$

$$\Leftrightarrow 2^{3\gamma} = 2^5 \quad \Leftrightarrow \gamma = \frac{5}{3}.$$

$$\gamma = \frac{5}{3} = \frac{C_p}{C_v} = \frac{C_v + R}{C_v} = \frac{\frac{F}{2}+1}{\frac{F}{2}} = \frac{F+2}{F}$$

$\Rightarrow F = 3$: monatomic

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Question 9: A 2.0 mol sample of an ideal monatomic gas undergoes a reversible process at a constant volume, increasing it temperature from 400K to 600K. What is the entropy change of the gas?

$n = 2.0$ mol , $T_i = 400$ K , $T_F = 600$ K , $\Delta S = ?$ (J/K)

Equation of the entropy change of the gas at constant volume.

$$\Delta S = n C_v \ln \frac{T_F}{T_i}$$

Due to the monatomic gas:

$$C_v = \frac{3}{2} R$$

$$\Delta S = \frac{3}{2} R n \ln \frac{T_F}{T_i} = \frac{3}{2} \times 8.31 \times 2.0 \times \ln \frac{600}{400} = 10.1 \left(\frac{J}{K}\right)$$

Thus, the entropy change of the gas: $\Delta S = 10.1$ (J/K).

Question 10: Calculate the change in entropy of gases in the following cases

a) A 3.0 mol sample of an ideal gas expands reversibly and isothermally at 350K until it volume doubles?

$n = 3.0 mol$ $T_F = T_i$; $V_F = 2V_i$, $\Delta S_a = ?$ (J/K)

Equation of entropy change of the gas

$$\Delta S_a = nC_v \ln \frac{T_F}{T_i} + nR \ln \frac{V_F}{V_i}$$

Due to the isothermal;

$$\Delta S = nR \ln \frac{V_F}{V_i} = 3.0 \times 8.31 \times \ln \frac{2V_i}{V_i}$$

$$= 3.0 \times 8.31 \times \ln 2$$

$$= 17.3 \text{ (J/K)}$$

b) The temperature of 1.0 mol of an ideal monatomic gas is raised reversibly from 200K to 300K with its volume keep constant.

~~Equa~~ $n = 1.0 mol$, $T_i = 200K$, $T_F = 300K$, $\Delta S_b = ?$ (J/K)

Equation of entropy change of ideal monatomic gas at constant volume

$$\Delta S_b = nC_v \ln \frac{T_F}{T_i} = n \times \frac{3}{2} R \times \ln \frac{T_F}{T_i}$$

$$= 1.0 \times \frac{3}{2} \times 8.31 \times \ln \frac{300}{200} = 5.05 \text{ (J/K)}$$

Thus, $\Delta S_a = 17.3$ (J/K)

$\Delta S_b = 5.05$ (J/K)

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