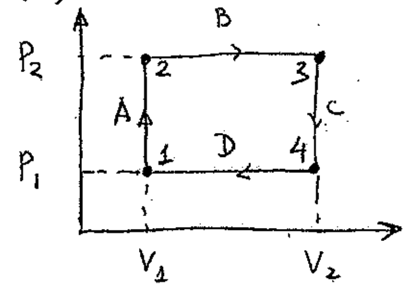
HW #2 | 3760

Problem # 1.

(a)



A, B, C, D define pathes
1, 2, 3, 4 define points in PV diagram.

$dU = đQ - đW$ $\quad$ $đW = PdV$ – work done by the system in quasistatic process.

$PV = NkT$ gas is ideal

$U = \frac{5}{2}NkT$ diatomic molecule with translational and rotational d.of.f active.

$U = \frac{5}{2}PV$ for each P, V we may find U.

A-path $\Delta V = 0 \Rightarrow \Delta W = 0$ $\quad$ $\Delta U = \frac{5}{2}V_1(P_2 - P_1)$

gas is heated up at constant volume. (heat is added)

B-path $\Delta U = \frac{5}{2}P_2(V_2 - V_1)$

$\Delta W_s = \int PdV = P_2(V_2 - V_1)$ – work done by system is positive.

$\Delta W_{ext} = -\Delta W_s = P_2(V_1 - V_2)$ – work done on system.

$\Delta Q = \Delta U + \Delta W_s = \frac{5}{2}P_2(V_2 - V_1) + P_2(V_2 - V_1) > 0$

gas expands, heat is added to the gas, temperature of the gas increases.

C-path

$\Delta V = 0 \quad \Delta W = 0$

$\Delta U = \frac{5}{2} P_2 - \frac{5}{2} P V_2 = \frac{5}{2} V_2 (P_1 - P_2) < 0$

$\Delta Q = \Delta U < 0$ system releases the heat.

D-path

$\Delta U = \frac{5}{2} P_1 (V_1 - V_2) < 0$ Temperature goes down

$W_s = \int P dV = P_1 (V_1 - V_2) < 0$

$W_{ext} = -W_s > 0$ work done on system is positive.

$\Delta Q = \Delta U + \Delta W_s = \frac{7}{2} P_1 (V_1 - V_2) < 0$ System releases the heat.

Total change in $U = \Delta U_a + \Delta U_b + \Delta U_c + \Delta U_d = 0$. as expected.

Total work $\Delta W_s = \Delta W_a + \Delta W_b + \Delta W_c + \Delta W_d = (P_2 - P_1)(V_2 - V_1) > 0$

total work done by the system is positive.

$\Delta W_s = \Delta Q$ - over cycle.

Total heat added to the system is positive.

the System converts heat into work.

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Problem #2.

$CO_2 + H_2 = CO + H_2O + 40.1$ kJ/mole.

Find $\frac{P_f}{P_i}$

$P_f = P_{H_2O} + P_{CO} = 2 P_{CO}$. / because we have one mole of each gas.

$P_i = P_{CO_2} + P_{H_2} = 2 P_{CO_2}$

$P_{CO} = \frac{1}{V} \cdot R \cdot T_f$ $P_{CO_2} = \frac{1}{V} \cdot R\, T_i$

$\frac{P_f}{P_i} = \frac{T_f}{T_i}$ $T_i = 800$ K.

T_f - ?, $U_f = U_i + Q$ – no work was done.

$U_i = C_{CO_2} \cdot T_i + C_{H_2} \cdot T_i$ $U_f = C_{CO} \cdot T_f + C_{H_2O}\, T_f$.

$$C_{CO_2} = \frac{1}{2} f_{CO_2} R = \frac{1}{2} R \Big(\overset{\text{TR}}{3} + \underset{\text{Rot. (}CO_2\text{ is axial mol}}{2} + 2 \cdot \overset{\text{vibrational modes}}{4} \Big) = \frac{13}{2} \cdot R$$

$$C_{H_2} = \frac{1}{2} R (3 + 2 + 2 \cdot 1) = \frac{7}{2} R$$

$$C_{CO} = \frac{1}{2} R (3 + 2 + 2 \cdot 1) = \frac{7}{2} R$$

$$C_{H_2O} = \frac{1}{2} R (3 + 3 + 2 \cdot 3) = \frac{12}{2} R.$$

$$T_f = \frac{\left(\frac{13}{2} + \frac{7}{2}\right) R \cdot T_i + Q}{\left(\frac{7}{2} + \frac{12}{2}\right) R} = \frac{10\, R T_i + Q}{9.5\, R} = \frac{66480 + 40100}{78.9} = 1350\text{K}.$$

$P_f / P_i = 1.688$