MCG2130 - Solutions to Mid-term Exam F2011

Version A:

2. (a) $x_1 = m_{g1} / (m_{f1} + m_{g1})$

$m_{f1} = V_{f1} / v_{f1}$; $m_{g1} = V_{g1} / v_{g1}$

$V_{f1} = 0.0025$ m^3, $V_{g1} = 0.4975$ m^3, from table $v_{f1} = 0.001534$ m^3 / kg, $v_{g1} = 0.4181$ m^3 / kg

then $m_{f1} = 1.630$ kg, $m_{g1} = 1.190$ kg, and $\mathbf{x_1 = 0.422}$.

(b) Constant volume process, therefore $v_2 = v_1 = V / (m_{f1} + m_{g1}) = 0.1773$ m^3 / kg

At T_2, this value of v places the final state in the superheat region, and interpolation gives

P_2 = 775 kPa.

(c) First law: $Q_{12} = W_{12} + m (u_2 - u_1)$

$W_{12} = 0$ (constant volume).

$u_1 = u_{f1} + x_1 u_{fg1} = 134 + 1175.2 x_1 = 629.9$ kJ/kg; $u_2 = 1359.3$ kJ/kg by interpolation

and **Q_{12} = 2056 kJ** (positive, heat transferred to system).

3. (a) Assume that the piston hits the stops, then the final total volume $V_2 = 0.55$ m^3, and

$P_2 = mRT_2 / V_2$, where $m = m_{A1} + m_{B1}$

m_{A1} is given; $m_{B1} = P_{B1} V_{B1} / R T_{B1} = 0.595$ kg, and m = 1.595 kg.

then **P_2 = 243.8 kPa**.

This is less than P_{A1}, confirming that the piston does indeed hit the stops.

(b) Work is done in cylinder only, and there it is a constant pressure process.

$W_{12} = P_{A1} (V_{A2} - V_{A1})$; $V_{A1} = m_{A1} R T_{A1} / P_{A1} = 0.1681$ m^3

W_{12} = -59.1 kJ - negative, therefore work done ON system.

(c) First law: $Q_{12} = W_{12} + m (u_2 - u_1)$

Since temperature does not change, u is also constant, so that $Q_{12} = W_{12}$ - heat is transferred out during the process.

Version B:

1. (a) Assume that the piston hits the stops, then the final total volume $V_2 = 0.90\ m^3$, and

$P_2 = mRT_2 / V_2$, where $m = m_{A1} + m_{B1}$

m_{A1} is given; $m_{B1} = P_{B1} V_{B1} / R T_{B1} = 5.95$ kg, and m = 6.95 kg.

then $\mathbf{P_2 = 649}$ **kPa**.

This is greater than P_{A1}, confirming that the piston does indeed hit the stops.

(b) Work is done in cylinder only, and there it is a constant pressure process.

$W_{12} = P_{A1} (V_{A2} - V_{A1})$; $V_{A1} = m_{A1} R T_{A1} / P_{A1} = 0.280\ m^3$

$\mathbf{W_{12} = 35.9}$ **kJ** - positive, therefore work done BY system.

(c) First law: $Q_{12} = W_{12} + m (u_2 - u_1)$

Since temperature does not change, u is also constant, so that $Q_{12} = W_{12}$ - heat is transferred in during the process.

2. (a) $x_1 = m_{g1} / (m_{f1} + m_{g1})$

$m_{f1} = V_{f1} / v_{f1}$; $m_{g1} = V_{g1} / v_{g1}$

$V_{f1} = 0.008\ m^3$, $V_{g1} = 0.792\ m^3$, from table $v_{f1} = 0.000722\ m^3 / kg$, $v_{g1} = 0.22402\ m^3 / kg$

then $m_{f1} = 11.08$ kg, $m_{g1} = 3.535$ kg, and $\mathbf{x_1 = 0.242}$.

(b) Constant volume process, therefore $v_2 = v_1 = V / (m_{f1} + m_{g1}) = 0.0547\ m^3 / kg$

At T_2, this value of v places the final state in the superheat region, and interpolation gives

$\mathbf{P_2 = 421}$ **kPa.**

(c) First law: $Q_{12} = W_{12} + m (u_2 - u_1)$

$W_{12} = 0$ (constant volume).

$u_1 = u_{f1} + x_1 u_{fg1} = 161.06 + 199.67 x_1 = 209.4$ kJ/kg; $u_2 = 400.1$ kJ/kg by interpolation

and $\mathbf{Q_{12} = 2788}$ **kJ** (positive, heat transferred to system).

Version C:

1. (a) Initial state superheated. Constant volume process, therefore $v_2 = v_1 = 0.0745\ m^3 / kg$
This is < v_g at T_2, therefore final state is saturated: $P_2 = P_{SAT} = 269.6$ kPa.

$v_2 = v_{f2} + x_2\ v_{fg2} = 0.000781 + 0.09392\ x_2$

solve: $\mathbf{x_2 = 0.7847}$

(b) $V_{f2} = m\ (1 - x_2)\ v_{f2}$; $V_{g2} = V - V_{f2}$; $m = V / v_1 = 6.713$ kg

$V_{f2} = 0.0011$, and **volume fraction of liquid is 0.226%**.

(c) First law: $Q_{12} = W_{12} + m\ (u_2 - u_1)$

$W_{12} = 0$ (constant volume).

$u_2 = u_{f2} + x_2\ u_{fg2} = 13.78 + 228.23\ x_2 = 192.9$ kJ/kg; $u_1 = 290.6$ kJ/kg by interpolation

and $\mathbf{Q_{12} = -656.1}$ **kJ** (negative, heat transferred from system).

3. (a) Assume that the piston rises from the stops, then the final pressure $P_2 = 500$ kPa, and

$V_{A2} = V_2 - V_B$; $V_2 = mRT_2 / P_2$, where $m = m_{A1} + m_{B1}$

m_{A1} is given; $m_{B1} = P_{B1}\ V_{B1} / R\ T_{B1} = 4.757$ kg, and m = 4.857 kg.

then $V_2 = 0.817\ m^3$ and $\mathbf{V_{A2} = 0.417\ \ m^3}$.

This is greater than V_{A1}, confirming that the piston does indeed rise from the stops.

(b) Work is done in cylinder only, and there it is a constant pressure process.

$W_{12} = P_{A2}\ (V_{A2} - V_{A1})$

$\mathbf{W_{12} = 183.4}$ **kJ** - positive, therefore work done BY system.

(c) First law: $Q_{12} = W_{12} + m\ (u_2 - u_1)$

Since temperature does not change, u is also constant, so that $Q_{12} = W_{12}$ - heat is transferred in during the process.