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Chen 19/1/0013
Chemical engineering

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① No: 3

$m_1 = 10.0 kg$

$P_1 = 20\ bar$

$V_1 = 1.0 m^3$

$P_2 = 100 bar$

$PV\ relation = PV^{1.5} = constant$

a) $\hat{w} = ?$

$$P = \frac{100\ bar \left| \frac{100 Kpa}{1 bar} \right.}{} = 10 Mpa$$

$\hat{V}_2 = ?$

$$P_1 \hat{V}_1^{1.5} = P_2 \hat{V}_2^{1.5} \Rightarrow \hat{V}_2^{1.5} = \frac{P_1 \hat{V}_1^{1.5}}{P_2}$$

$$\hat{V}_2 = \left| \frac{2 MPa \left| \left(\frac{0.1 m^3}{1 kg} \right)^{1.5} \right|}{10 Mpa} \right|^{1.5} \Rightarrow \hat{V}_2 = \left((0.2 \times 10.1)^{1.5} \right) m^3/kg$$

$$= (0.0 \times 0.0316)^{1/1.5} = (0.2 \times 0.0316)^{0.663}$$

$$\hat{V}_2 = 0.0342\ m^3/kg$$

$$\hat{w} = \int_{0.1}^{0.0342} P_2 \cdot d\hat{V} = -\int_{0.1}^{0.0342} P \cdot d\hat{V}$$

$$P\hat{v}^{1.5} = P_1 v_1^{1.5} \Rightarrow P = \frac{P_1 v_1^{1.5}}{\hat{v}^{1.5}}$$

$$P = \frac{2\,MPa \left| \left(\frac{0.1\,m^3}{kg}\right)^{1.5} \right| \left(\frac{kg}{\hat{v}\,m^3}\right)^{1.5}}{}$$

$$P = \frac{0.0632}{\hat{v}^{1.5}}\ MPa$$

$$\hat{w} = \int_{0.1}^{0.0342} \frac{0.0632}{\hat{v}^{1.5}}\, d\hat{v}$$

$$= \frac{-0.0632}{-0.5} \left| \frac{1}{\hat{v}^{0.5}} \right|_{0.1}^{0.0342}$$

$$= \frac{-0.0632}{-0.5} \left[\frac{1}{0.0342^{0.5}} - \frac{1}{0.1^{0.5}} \right]$$

$$= \frac{0.2838\ MPa \cdot m^3 \left| \frac{1000\,kPa}{1\,MPa} \right| \frac{1\,kN}{1\,kPa \cdot m^2}}{kg}$$

$$\hat{w} = 283.8\ kJ/kg$$

b) $q = ?$

$$\Delta\hat{u} = q + \hat{w}$$

At state 1, $P_1 = 2\,MPa$, $T_1 = 213.6^{\circ}C$

$u_1 = ?$

$u_1 = (kJ/kg)$	$T(^{\circ}C)$
2600.3	212.4
u_1	213.6
2628.3	215

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a) $\hat{w} = ?$

$$P = \frac{100 bar \left| \frac{100 Kpa}{1 bar} \right.}{} = 10 Mpa$$

$\hat{V}_2 = ?$

$$P_1 V_1^{1.5} = P_2 \hat{V}_2^{1.5} \Rightarrow \hat{V}_2^{1.5} = \frac{P_1 \hat{V}_1^{1.5}}{P_2}$$

$$\hat{V}_2 = \left| \frac{2 MPa \left| \left(\frac{0.1 m^3}{1 kg} \right)^{1.5} \right| \frac{1}{10 Mpa}}{} \right|^{1.5} \Rightarrow \hat{V}_2 = \left((0.2 \times 10.1)^{1.5} \right) m^3/kg$$

$$= (0.0 \times 0.0316)^{1/1.5} = (0.2 \times 0.0316)^{0.683}$$

$$\hat{V}_2 = 0.0342\ m^3/kg$$

$$\hat{w} = \int_{0.1}^{0.0342} P_2 \cdot d\hat{V} = -\int_{0.1}^{0.0342} P \cdot d\hat{V}$$

$$P\hat{v}^{1.5} = P_1 v_1^{1.5} \Rightarrow P = \frac{P_1 v_1^{1.5}}{\hat{v}^{1.5}}$$

$$P = \frac{2\,MPa \;\Big|\; \left(\frac{0.1\,m^3}{kg}\right)^{1.5} \;\Big|\; \left(\frac{1\,kg}{\hat{v}\,m^3}\right)^{1.5}}{}$$

$$P = \frac{0.0632}{\hat{v}^{1.5}}\ MPa$$

$$\hat{w} = \int_{0.1}^{0.0342} \frac{0.0632}{\hat{v}^{1.5}}\, d\hat{v}$$

$$= \frac{-0.0632}{-0.5} \;\Big|\; \frac{1}{\hat{v}^{0.5}} \;\Big|_{0.1}^{0.0342}$$

$$= \frac{-0.0632}{-0.5}\left[\frac{1}{0.0342^{0.5}} - \frac{1}{0.1^{0.5}}\right]$$

$$= \frac{0.2838\ MPa\cdot m^3 \;\Big|\; 1000\,kPa \;\Big|\; 1\,kN}{kg \;\Big|\; 1\,MPa \;\Big|\; 1\,kPa\cdot m^2}$$

$$\hat{w} = 283.8\ kJ/kg$$

b) $q = ?$

$$\Delta\hat{u} = q + \hat{w}$$

At state 1, $P_1 = 2\,MPa$, T_1 213.6 C

$u_1 = ?$

$u_1 = (kJ/kg)$	$T(^\circ C)$
2600.3	212.4
u_1	213.6
2628.3	215

$\hat{u}_1 = 2602.96 \text{ kJ/kg}$ $\quad \hat{v}_2 = 0.0342 \text{ m}^3/\text{kg}$

At state 2, $P_2 = 10 \text{ MPa}$

$\hat{u}_2$ (kJ/kg)	$\hat{v}_2$ (m³/kg)
3045.8	0.0328
$\hat{u}_2$	0.0342
3144.5	0.0356

$$\hat{u}_2 = 3095.15 \text{ kJ/kg}$$

$$\Rightarrow \Delta\hat{u} = \hat{u}_2 - \hat{u}_1$$

$$= (3095.15 - 2602.97)\frac{\text{kJ}}{\text{kg}}$$

$$\Delta\hat{u} = 492.18 \text{ kJ/kg}$$

$$\Delta \hat{u} = q + \hat{w}$$

$$\hat{q} = \Delta\hat{u} + \hat{w}$$

$$\hat{q} = (492.18 - 283.8) \text{ kJ/kg}$$

$$\hat{q} = 492.38 \frac{\text{kJ}}{\text{kg}}$$

$$\hat{q}_{11} = 208.38 \text{ kJ/kg}$$

Q. No. 2

$P = 7 bar$

$h = 2600 \ kJ/kg$

$v = ?$

$\hat{v} = ?$

$\hat{u} = ?$

Sol

(1) $\hat{h} = h_f + x.h_{fg}$

$2600 = 697.1 + x(2064.9)$

$2600 - 697.1 = x(2064.9)$

$\frac{1902.9}{2064.9} = x$

$x = 0.921$

(2) $\hat{v} = v_f + x.v_{fg}$

$= 0.001108 + (0.921)(0.0273 - 0.001108)$

$= 0.001108 + (0.921)(0.271892)$

$= 0.001108 + 0.2504$

$= 0.2515 \ m^3/kg$

(3) $\hat{u} = u_f + x u_{fg}$

$= 696.3 + (0.921)(2571.1 - 696.3)$

$= 6963 + (0.921)(1874.8)$

$= 6963 + 1726.6908$

$= 2420 \ kJ/kg$

(4) So,

$\hat{v} = 0.2515 \ m^3/kg$

$\hat{u} = 2480 \ kJ/kg$

Q. No. 1

1) System

System refess to the subject matter of analysis. Thermodynamic system or system refer to definite quantity of matter, enclosed by a boundary on which we focus our attention for thermodynamic analysis

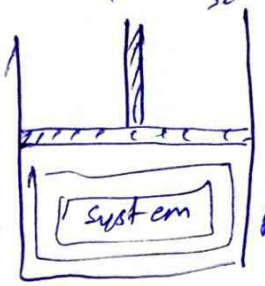

Fig. 0.1

2) Surroundings

This part of the universe other than the system is called surroundings. As shown Fig 0.1.

3) Adiabatic process

No heat transfer through bondries of the system.

4) Isolated process

No mass or heat energy transfer with environment.

5) Extensive property

Depend upon the mass of system e.g mass, volume, internal energy Enthalpy, Entropy.