Chemical Engineering Thermodynamics-1

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## Q. no. 1

### 1- System:

Any thing under consideration that has some inputs by which some process is going and producing some output is called system.

### 2- Surroundings:

Every-thing except system and boundary is called surroundings.

### 3- Adiabatic Process:

A process in which system cannot exchange mass and heat to surroundings is called adiabatic process.

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## 4- Isolated System:

A system in which neither mass nor energy goes in or out of the system is called isolated system.

## 5- Extensive Property:

A property which depends on the size of system is called extensive system.

## Q.no.2

**Data:**

$P = 7$ bar

$\hat{h} = 2600\ kJ/kg$

$\hat{v} = ?$

$\hat{u} = ?$

**Solution:**

$$\hat{h} = h_f + x h_{fg}$$

$$2600 = 697.1 + x(2064.9)$$

$$2600 - 697.1 = x(2064.9)$$

$$x = 0.921$$

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$\hat{v} = v_f + x\, v_{fg}$

$= 0.001108 + (0.921)(0.2718)$

$= 0.001108 + 0.25041$

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

$\hat{u} = u_f + x\, u_{fg}$

$= 696.3 + (0.921)(1877.8)$

$\hat{u} = 2420 \ kJ/kg$

So, specific volume is $0.2515 \ m^3/kg$ and specific internal energy is $2420 \ kJ/kg$

## Q. no. 3

**Data:**

$m = 10 kg$ $\qquad$ $P_1 = 20 bar$

$v_1 = 1 \ m^3$ $\qquad$ $P_2 = 100 bar$

$Pv^{1.5} = const$

**Solution:**

To find: Work done and heat transferred.

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Solution

$$P_1 = \frac{20\ bar}{} \left| \frac{100\ kPa}{1\ bar} \right.$$

$$= 2000\ kPa$$

$$= 2MPa$$

$$\hat{V}_1 = \frac{1\ m^3}{10kg} = 0.1\ m^3/kg$$

At $P = 2MPa$:

$\hat{V}_2 = 0.0012$ $\hat{V}_2 = 0.0996$

Since, $\hat{V}_1 > \hat{V}_2$, so steam is superheated.

| $T$ (°C) | $\hat{V}$ ($m^3/kg$) |
|---|---|
| 212.4 | 0.0996 |
| $T$ | 0.1 |
| 225 | 0.1038 |

$$y = \left[(y_2-y_1)\left(\frac{x-x_1}{x_2-x_1}\right)\right] + y_1$$

$$T = (225-212.4)\left(\frac{0.1-0.0996}{0.1058-0.0996}\right) + 212.4$$

$$T = 213.6\ °C$$

Now,

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$$P_2 = \frac{100\ bar}{} \Big| \frac{100\ kPa}{1\ bar}$$

$$= 10000\ kPa$$

$$= 10\ MPa$$

$$P_1 \hat{v}_1^{1.5} = P_2 \hat{v}_2^{1.5}$$

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

$$\hat{v}_2 = \left( \frac{P_1 \hat{v}_1^{1.5}}{P_2} \right)^{1/1.5}$$

$$\hat{v}_2 = \left[ \frac{2MPa}{} \Big| \left(\frac{0.1\ m^3}{kg}\right)^{1.5} \Big| \frac{1}{10MPa} \right]^{1/1.5}$$

$$\hat{v}_2 = \left(0.2 \times (0.1)^{1.5}\right)^{1/1.5} \quad m^3/kg$$

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

$$\hat{w} = -\int_{0.1}^{0.0342} P_E\, d\hat{v} = -\int_{0.1}^{0.0342} P\, d\hat{v}$$

$$P \hat{v}^{1.5} = P_1 \hat{v}_1^{1.5}$$

$$P = \frac{P_1 \hat{v}_1^{1.5}}{\hat{v}^{1.5}}$$

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

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

$$\hat{W} = -\int_{0.1}^{0.0542} \frac{0.0632}{\hat{V}^{1.5}}\, d\hat{V}$$

$$= \frac{-0.0632}{-0.5}\left(\frac{1}{0.0342^{0.5}} - \frac{1}{0.1^{0.5}}\right)$$

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

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

$$\Delta\hat{U} = \hat{Q} + \hat{W}$$

| $u_1$ (kJ/kg) | $T$ (°C) |
|---|---|
| 2600.3 | 212.4 |
| $u_1$ | 213.6 |
| 2628.3 | 225 |

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$u_1 = 2602.97 \ kJ/kg$

State 2:

| $\hat{u}_2$ (kJ/kg) | $\hat{v}_2$ ($m^3$/kg) |
| --- | --- |
| 3045.8 | 0.0328 |
| $\hat{u}_2$ | 0.0342 |
| 3144.5 | 0.0352 |

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

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

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

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

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

$\hat{q} = 208.38 \ kJ/kg$

| $T_2$ | $\hat{v}_2$ |
| --- | --- |
| 500 | 0.0328 |
| T | 0.0342 |
| 550 | 0.0356 |

$T_2 = 525 \ °C$