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Subject: Chemical Engineering Thermodynamics - I

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Q No 1:-

i) Define system:-

Any thing which we take underconsideration is known as system.

ii) Surroundings:-

Every thing except system is known as surrounding.

iii) Adiabatic process:-

An adiabatic process is defined as the thermodynamic process in which there is no exchange of heat from system to surrounding neither during expansion nor during compression. The adiabatic process can be either reversible or irreversible.

iv) Isolated system:-

An isolated system is a thermodynamic system that cannot exchange either energy or matter outside the boundaries of the system. Means does not interact with its surroundings Thermo Flask

v) Extensive Property:-

An extensive property is a physical quantity whose value is proportional to the size of the system. It describe the quantity of matter in the system. Mass of sample in extensive quantity depends on the amount of substance.

Q No2:-

Find specific volume and specific internal energy of steam at 7 bar and specific enthalpy 2600 KJ/kg.

Given data:

$P = 7$ bar

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

Required:-

$x = ?$

$\hat{v} = ?$

$\hat{u} = ?$

Solution

$$\hat{h} = hf + xhfg$$

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

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

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

$$\boxed{x = 0.921}$$

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ii)

$\hat{v} = v_f + x f_g$

$\hat{v} = 0.001108 + (0.921)(0.273 - 0.001108)$

$\hat{v} = 0.001108 + (0.921)(0.271892)$

$\hat{v} = 0.001108 + 0.25041$

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

iii)

$\hat{u} = u_f + x f_g$

$\hat{u} = 696.3 + (0.921)(2571.1 - 696.3)$

$\hat{u} = 696.3 + (0.921)(1874.8)$

$\hat{u} = 696.3 + 1726.6908$

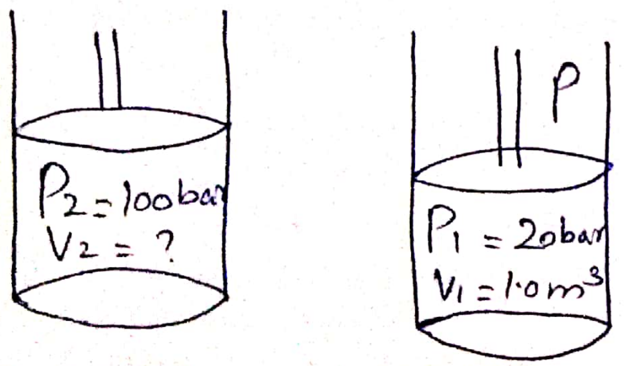
$\boxed{\hat{u} = 2420 \ \frac{kJ}{kg}}$

Q No 3:-

$Pv^{1.5} = \text{constant}$

calculate the work done and heat transferred during this process.

Diagram:-



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Given:

Mass = m = 10 kg

Find:

Work done = ?

Heat transfer = ?

Solution:

$$P\hat{v}^{1.5} = \text{constant}$$

As we know that

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

$$\hat{v}_1 = ?$$

$$\hat{v}_1 = \frac{v_1}{m} = \frac{1}{0.1}$$

$$\boxed{\hat{v}_1 = 0.1 \ m^3/kg}$$

Now

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

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

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

$$\hat{v}_2 = \left(\frac{2 \times (0.1)^{1.5}}{10}\right)^{1/1.5}$$

$$\boxed{\hat{v}_2 = 0.0341 \ m^3/kg}$$

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

$$\hat{w} = -\int_{0.1}^{0.0342} \frac{P_1 \hat{v}_1^{1.5}}{\hat{v}^{1.5}}\, d\hat{v}$$

$$\hat{w} = 2 P_1 \hat{v}_1^{1.5} \left[\frac{1}{\hat{v}_2^{1.5}} - \frac{1}{\hat{v}_1^{0.5}} \right]_{0.1}^{0.0342}$$

$$\boxed{\hat{w} = 284 \text{ kJ/kg}}$$

Apply 1st law

$$q = \Delta u - w$$

$$u_1 = 2600.3 \text{ kJ/kg}$$

For u_2

$$\frac{u_2 - u(T=500)}{u(T=500) - u(T=550)} = \frac{v_2 - v(500^\circ C)}{v(T=550) - v(T=500)}$$

$$u_2 = u(T=500) + \left[[u(T=500)] - u[T=500] \right]$$

$$u_2 = \left[\frac{v_2 - v(T=500)}{v(T=550) - v(T=500)} \right]$$

$$u_2 = 3045.8 + \left[31445.5 - 3045.8 \right] \left[\frac{0.0342 - 0.03279}{0.03564 - 0.03279} \right]$$

$$\boxed{u_2 = 3094.6 \text{ kJ/kg}}$$

$$q = \Delta u - w$$

$$q = (u_2 - u_1) - w$$

$$\boxed{q = 210 \text{ kJ/kg}}$$

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'Q' is Postive so heat transfer from system to surroundings.

So value of heat is given as

$$\boxed{Q = 210 \text{ kJ/kg}}$$

and work is given as

$$\boxed{W = 284 \text{ kJ/kg}}$$
