Mid-Term Exam

Subject:- Chemical Engineering Thermodynamics-I

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(Q.NO.1)

1. System:-

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

e.g The gas in the container is system.

2. Surroundings:-

we define surroundings as the part of the universe other than the system. It interacts with the system.

e.g The walls of the container are part of the surroundings.

3. Adiabatic process:-

In the adiabatic process, no heat passes through boundaries of the system.

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4. Isolated System:-

A system in which both mass and energy cannot flow across the system boundary.

5. Extensive Property:-

The property of the system which depends upon the mass of the system.
We will use capital letter For the extensive property.

e.g Mass, Volume, Internal energy etc.

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(Q. NO. 2)

Given Data:-

$P = 7$ bar

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

Required:-

$x = ?$

$\hat{V} = ?$

$\hat{u} = ?$

Solution:-

Now, we find x as.

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

putting values, we get.

$2600 = 697.1 + x(2064.9)$

$2600 - 697.1 = x(2064.9)$

$1902.9 = x(2064.9)$

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

$$\boxed{x = 0.921}$$

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Now,

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

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

$$= 696.3 + (0.921)(1874.8)$$

$$= 696.3 + 1726.6908$$

$$\boxed{\hat{u} = 2420 \ KJ/Kg}$$

also, For $\hat{v}$

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

$$= 0.001108 + (0.921)(0.273 - 0.001108)$$

$$= 0.001108 + (0.921)(0.271892)$$

$$= 0.001108 + 0.25041$$

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

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—(Q. NO. 3)—

Given Data:-

$m = 10\ Kg$

$P_1 = 20\ bar$

$V_1 = 1.0\ m^3$

$P_2 = 100\ bar$

Required:-

(a) $\hat{w} = ?$

(b) $\hat{q} = ?$

(a) $\hat{w} = ?$

$$P_2 = \frac{100\ bar \mid 100\ KPa}{\mid 1\ bar} = 10,000\ KPa = 10\ MPa$$

$\hat{V}_2 = ?$

Since,

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

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

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

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$$\hat{V}_2 = \left((0.2 \times 10.1)^{1.5}\right)^{1/1.5} m^3/Kg$$

$$= (0.2 \times 0.0316)^{1/1.5} m^3/Kg$$

$$= (0.2 \times 0.0316)^{0.667}$$

$$\boxed{\hat{V}_2 = 0.0342 \, m^3/Kg}$$

$$\hat{\omega} = \int_{0.1}^{0.0342} PE.d\hat{V} = -\int_{0.1}^{0.0342} p.d\hat{V}$$

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

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

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

$$\hat{\omega} = -\int_{0.1}^{0.0342} \frac{0.0632}{\hat{V}^{1.5}} d\hat{V}$$

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

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

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$$= \frac{0.2838\,MPa.m^3}{Kg} \left| \frac{1000\,KPa}{1\,MPa} \right| \frac{1\,KN}{1\,KPa.m^2}$$

$$\boxed{\hat{\omega} = 283.8\ KJ/Kg}$$

(b) $\hat{q} = ?$

since,

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

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

$\hat{u}_1 = ?$

$\hat{u}_1$ (KJ/Kg)	T (°C)
2600.3	212.4
u_1	213.6
2628.3	225

After Interpotation, we get

$$\boxed{\hat{u}_1 = 2602.97\ KJ/Kg}$$

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At State 2 , $P_2 = 10\,MPa$, $\hat{V}_2 = 0.0342\ m^3/Kg$

$\hat{U}_2$ (KJ/Kg)	$\hat{V}_2$ (m^3/Kg)
3045.8	0.0328
$\hat{U}_2$	0.0342
3144.5	0.0356

After interpolation, we get

$$\boxed{\hat{U}_2 = 3095.15\ KJ/Kg}$$

Since,

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

$$= (3095.15 - 2602.97)\ KJ/Kg$$

$$\boxed{\Delta\hat{U} = 492.18\ KJ/Kg}$$

putting values, we get

$$\Delta\hat{U} = \hat{q} + \hat{\omega}$$

$$\hat{q} = \Delta\hat{U} - \hat{\omega}$$

$$\hat{q} = (492.18 - 283.8)\ KJ/Kg$$

$$\boxed{\hat{q} = 208.38\ KJ/Kg}$$