RE: modified 26/3/21

CBCS SCHEME

USN | | | | | | | | | | |

18ME33

# Third Semester B.E. Degree Examination, Jan./Feb. 2021
## Basic Thermodynamics

Time: 3 hrs. Max. Marks: 100

*Note:* **1.** ***Answer any FIVE full questions, choosing ONE full question from each module.***
**2.** ***Use of thermodynamic data handbook is permitted.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

### Module-1

1 a. Explain microscopic and macroscopic approaches to thermodynamics. **(06 Marks)**

b. State and explain Zeroth law of thermodynamics. What is diathermal and adiabatic wall? **(06 Marks)**

c. The temperature t on a Celsius thermometer scale is defined in terms of property P by the relation $P = e^{\frac{(t-B)}{A}}$ where A and B are constants. At ice point and steam points the value of P is 1.86 and 6.81 respectively. Find the value of 't' for P = 2.5. **(08 Marks)**

**OR**

2 a. With examples distinguish between:
(i) Intensive and extensive property
(ii) Point and path function
(iii) Thermodynamic equilibrium **(10 Marks)**

b. In 1709m Newton proposed a linear temperature scale where ice point and normal human body temperature are maintained as two fixed points of 0°N ad 12°N respectively. The temperature of human body on the Celsius scale is 36°C. Obtain relation between Newton scale and Celsius scale. **(10 Marks)**

### Module-2

3 a. Obtain the expression for displacement adiabatic work. **(06 Marks)**

b. Define heat and work with reference to thermodynamic point of view and also the sign convention of heat and work. **(06 Marks)**

c. A cylinder contains 1 kg of certain fluid at an initial pressure of 20 bar. The fluid is allowed to expand reversibly behind a piston according to law $PV^2$ = constant until the volume is doubled. The fluid is then cooled reversibly at constant pressure until the piston regains its original position. Heat is then supplied reversibly with the piston firmly locked in position until the pressure rises to its original value of 20 bar. Calculate the net work done by the fluid for an initial volume of 0.05 $m^3$. **(08 Marks)**

**OR**

4 a. Apply steady flow energy equation to each of the following:
(i) Boiler (ii) Nozzle (iii) Centrifugal pump
(iv) Throttling device (v) Turbine **(10 Marks)**

b. The working fluid in a steady flow process flows at the rate of 220 kg/min. the fluid rejects 100 kJ/s of heat passing through the system. The fluid enters at a velocity of 320 m/s, pressure of 6 bar, internal energy 2000 kJ/kg, specific volume of 0.36 $m^3$/kg and leaves the system at a velocity of 140 m/s, pressure of 1.2 bar, internal energy 1400 kJ/kg, specific volume of 1.3 $m^3$/kg. Determine the power output in MW. The change in potential energy is neglected. **(10 Marks)**

## Module-3

5 a. Prove that Kelvin-Planck statement and clausius statements of second law of thermodynamic are equivalent. **(10 Marks)**

b. A reversible heat engine operates between two reservoirs at temperature of 600°C and 40°C. The engine drives a reversible refrigerator which operates between reservoirs at temperature of 40°C and –20°C. The heat transfer to the heat engine is 2000 kJ and net work output of combined engine refrigerator plant is 360 kJ. Evaluate the heat transfer to the refrigerant and net heat transfer to the reservoir at 40°C. **(10 Marks)**

**OR**

6 a. Show that entropy is a property of the system. **(04 Marks)**

b. Derive the maximum work attainable from a finite body and a thermal energy reservoir. **(10 Marks)**

c. A lump of steel of mass 10 kg at 627°C is dropped in 100 kg of oil at 30°C. The specific heats of steel and oil are 0.5 kJ/kgK and 3.5 kJ/kgK respectively. Calculate the entropy change of steel, the oil and the universe. **(06 Marks)**

## Module-4

7 a. Explain the concept of available and unavailable energy. **(04 Marks)**

b. Write Maxell relations and explain the terms involved. **(06 Marks)**

c. A vessel of volume 0.04 $m^3$ contains a mixture of saturated water and saturated steam of a temperature of 250°C. The mass of liquid present is 9 kg. Find the pressure, mass, specific volume, enthalpy and internal energy. **(10 Marks)**

**OR**

8 a. With a neat sketch, explain the working of combined separating and throttling calorimeter. **(10 Marks)**

b. Steam at 10 bar and dry state is cooled under constant pressure until it becomes 0.85 dry. Using steam tables, find the work done, change in enthalpy, heat transferred and change in entropy. **(10 Marks)**

## Module-5

9 a. Determine the Vander Waal's constant in terms of critical properties. **(08 Marks)**

b. Explain the following:
(i) Generalized compressibility chart
(ii) Law of corresponding state
(iii) Compressibility factor **(04 Marks)**

c. Determine the pressure exerted by carbon dioxide in a container of 1.5 $m^3$ capacity when it contains 5 kg at 27°C using (i) Ideal gas equation (iii) Vander Waal's equation. Take Vander Waal's constant for $CO_2$ as a = 364.3 $kNm^4/kgmol^2$, b = 0.0427 $m^3/kgmol$. **(08 Marks)**

**OR**

10 a. Explain Dalton's law if partial pressure and Amagat's law of additive volumes with reference to ideal gas mixture. **(08 Marks)**

b. Derive an expression for internal energy and enthalpy of gaseous mixtures. **(04 Marks)**

c. A mixture of gases contains 1 kg of $CO_2$ and 1.5 kg and $N_2$. The pressure and temperature of the mixture are 3.5 bar and 27°C. Determine for the mixture :
(i) The mass and mole fraction of each constituent gas
(ii) Average molecular weight
(iii) The partial pressure **(08 Marks)**

* * * * *

## [SPAM] Re: Sir, Regarding Discrepancy in the question paper(18ME33)

"virupaxi bagodi" <virupaxibagodi@yahoo.com> March 26, 2021 11:50 AM

To: boe@vtu.ac.in

Dear Sir,

The corrections are correct and approved.

Thanking you with warm regards.

Sincerely,
Dr. Virupaxi Bagodi
Principal
Government Engineering College,
TALAKAL - 583238, India
E-mail: virupaxibagodi@yahoo.com
Cell: +91 94 49 973293

> On Friday, 26 March, 2021, 11:38:47 am IST, <boe@vtu.ac.in> wrote:

" APPROVED "
Registrar (Evaluation)
Visvesvaraya Technological University
BELAGAVI - 590018

Basic Thermodynamics – 18ME33.

Q9.c → To determine the pressure exerted by $CO_2$ using (i) Ideal gas eqⁿ (ii) Vander Waal's eqⁿ

The solution shows that by

(i) Ideal gas eqⁿ $P = \frac{mRT}{V}$

$P = 1.889$ bar or $188.9$ kPa

(ii) vander waals eqⁿ

$P = 3.6$ bar – which is incorrect –

The correct answer is.

$P = 1.870$ bar or $187.0$ kPa

$$P = \frac{RT}{\bar{v} - b} - \frac{a}{\bar{v}^2}$$

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Kindly correct the scheme & solution.

Dr. K. M. AKKoli

Dr Ratan patil

Prof Manik. R

Approved as suggested by Chairman BoE

"APPROVED"

26/03/2021

Registrar (Evaluation)

Visvesvaraya Technological University

BELAGAVI - 590018

# [SPAM] Fw: Scheme and solutions

"virupaxi bagodi" <virupaxibagodi@yahoo.com>

March 23, 2021 8:07 AM

To: boe@vtu.ac.in, boe@vtu.ac.in

Dear Sir,

Subject: Basic thermodynamics and Subject code: 18ME33, scheme and solutions are found correct.

Thanking you with warm regards.

Sincerely,
Dr. Virupaxi Bagodi
Principal
Government Engineering College,
TALAKAL - 583238, India
E-mail: virupaxibagodi@yahoo.com
Cell: +91 94 49 973293

----- Forwarded message -----
**From:** Shanakara naik <shankarnaiksb@gmail.com>
**To:** virupaxi bagodi <virupaxibagodi@yahoo.com>; Virupaxi Bagodi <virupaxibagodi@gmail.com>
**Sent:** Monday, 22 March, 2021, 10:08:38 pm IST
**Subject:** Scheme and solutions

Respected sir:

Subject: **Basic thermodynamics** and Subject code: **18ME33**, scheme and solutions are found correct.
--
Dr. Shankara Naik
Department of Mechanical Engineering
Government Engineering College
Haveri-581110
Karnataka

" APPROVED "
Registrar (Evaluation)
Visvesvaraya Technological University
BELAGAVI - 590018

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## Scheme & Solution

Signature of Scrutinizer

Subject Title : Basic Thermodynamics

Subject Code : 18ME33

| Question Number | Solution | Marks Allocated |
|---|---|---|
| 1a. | Microscopic Approach & Macroscopic Approach<br>It considers the behaviour of every molecule by using statistical Methods. In Macroscopic approach we are concerned with the gross or average effects of many molecules infractions. These effects can be measured such as Pressure and temperature can be perceived by our senses. These approach greatly reduces the problem of complexity and this is known as classical thermodynamics.<br>Large number of Variables is needed to describe Microscopic approach whereas only few properties are needed in Macroscopic approach.<br>The behaviour of system is found by using Statistical Method whereas analysis of Macroscopic System requires simple Mathematical formulae. | 06 Marks |
| b. | Statement:<br>When a body A is in thermal equilibrium with body B and body B is in thermal equilibrium with body C then body A & C are in thermal equilibrium. | |

| Question Number | Solution | Marks Allocated |
|---|---|---|
| | A diathermal wall is one that heat can pass through. It is made from a thermal conductor. It is essentially a thermal wall. | 01 Marks |
| | An adiabatic wall is one that heat cannot pass through. It is made from a thermal insulator | |
| c. | Given | |
| | $p = e^{\frac{t-B}{A}}$ | |
| | Taking ln on both sides | |
| | $\ln p = \frac{t-B}{A} \Rightarrow t = A \ln p + B$ | 1 Mark |
| | $p_i = 1.86 \quad p_s = 6.81$ | |
| | $°c \rightarrow t_i = 0°c$, $t_s = 100°c$ | 1 Mark |
| | $t_i = A \ln p + B$ — (1) | |
| | $0 = A \ln 1.86 + B$ — (2) | |
| | $100 = A \ln 6.81 + B$ — (3) | |
| | (3) - (2) $\Rightarrow$ $A = 77.04$ | |
| | $B = -47.79$ | 4 Marks |
| | Sub the value of A & B in equ (1) | |
| | $t = A \ln p + B$ | |
| | $t = 77.04 \ln 2.5 - 47.79$ | 2 Marks |
| | $t = 22.80°C$ | |

| Question Number | Solution | Marks Allocated |
|---|---|---|
| 2. a. | i) Intensive - Independent of Mass Ex: Pressure<br>Extensive - Depend on the Mass Ex: Volume<br>ii) Point function - Properties can be located as point in the coordinate axis Ex: Temperature<br>Path function: Can't be located as point but can be represented as Area Ex: Work<br>iii) Thermodynamic equilibrium states that when the pressure and temperature at all points are same and there is no velocity gradient then the system is said to be thermodynamic equilibrium | 10 Marks |
| b. | $t = ax + b$ — (1)<br>$t_N = ax_i + b$     $t_C = ax + b$ — (3a)<br>$t_i = 0N$   $t_s = 12N$     $t_iC = 0$   $t_s = 36$ | 01 Mark |
| | $0 = ax_i + b$ — (2)     $0 = ax_i + b$ — (4)<br>$12 = ax_s + b$ — (3)     $36 = ax_s + b$ — (5)<br>(3) − (2) ⇒ $12 = a(x_s - x_i)$     (5) − (2) ⇒ $36 = a(x_s - x_i)$<br>$a = \frac{12}{x_s - x_i}$     $a = \frac{36}{x_s - x_i}$ | 02 Marks |
| | Sub a in equ (2)     Sub a in equ (4)<br>$b = \frac{-12x_i}{x_s - x_i}$     $b = \frac{-36x_i}{x_s - x_i}$ | 02 Marks |
| | Sub value of a & b in equ (1)     Sub value of a & b in equ 3a<br>$t = \frac{12}{x_s - x_i}x - \frac{12x_i}{x_s - x_i}$     $t = \frac{36}{x_s - x_i}x - \frac{36x_i}{x_s - x_i}$<br>$t_N = 12\frac{x - x_i}{x_s - x_i}$     $t_C = 36\frac{x - x_i}{x_s - x_i}$ | 02 Marks |

Subject Title : Basic Thermodynamics    Subject Code : 18ME33

| Question Number | Solution | Marks Allocated |
|---|---|---|

$\frac{t^\circ N}{12} = \frac{t^\circ C}{36}$

$\boxed{3 t^\circ N = t^\circ C}$ — 03 Marks

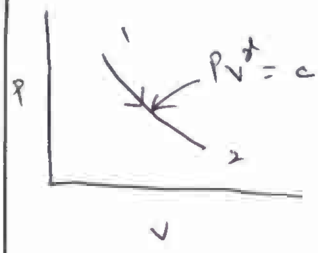
**3a.**

$W = \int P\,dV$

Adiabatic $PV^\gamma = c$

$P = \frac{c}{V^\gamma}$

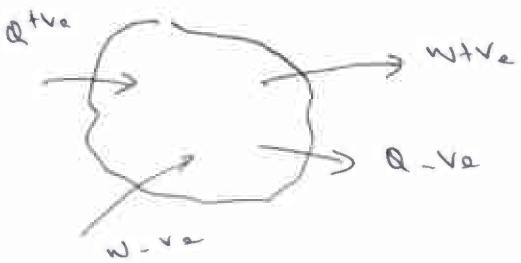
$W = \int_{V_1}^{V_2} \frac{c}{V^\gamma}\,dV \Rightarrow \frac{c}{-\gamma+1}\left[V^{-\gamma+1}\right]_{V_1}^{V_2} \Rightarrow \frac{P_2 V_2^\gamma\left[V_2^{-\gamma+1}\right] - P_1 V_1^\gamma\left[V_1^{-\gamma+1}\right]}{-\gamma+1}$ — 06 Marks




$\Rightarrow \frac{P_2V_2 - P_1V_1}{-\gamma+1} = \frac{P_1V_1 - P_2V_2}{\gamma-1}$

**b.** Work - Sole effect could be reduced by rising up of weight external to the surroundings — 06 Marks

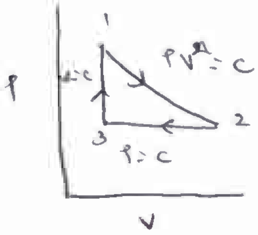
Heat : Measure of degree of coldness (or) hotness




**c.** Given

$m = 1\,kg$, $P_1 = 20\,bar$, $V_1 = 0.05\,m^3$

$V_2 = 2V_1 = 0.1\,m^3$



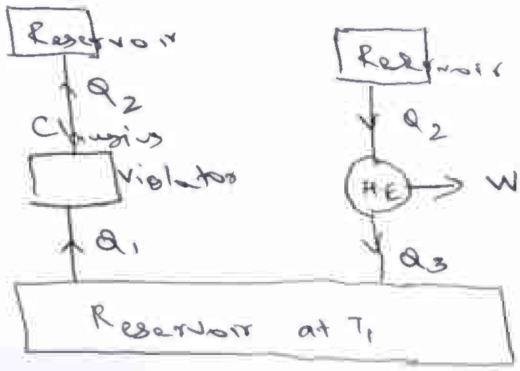
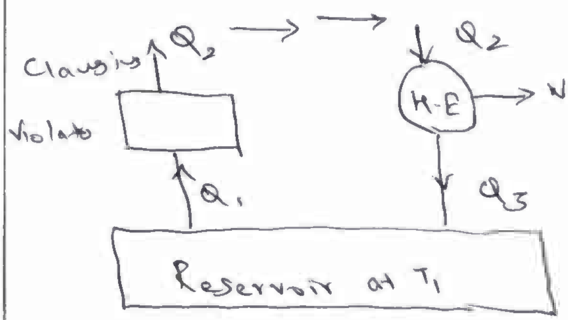
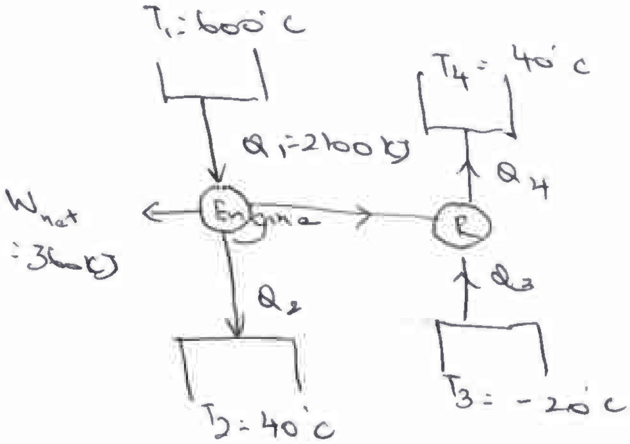

02 Marks

**Subject Title :** Basic Thermodynamics **Subject Code :** 18ME33

| Question Number | Solution | Marks Allocated |
|---|---|---|
| | Process 1-2 Polytropic | |
| | $P_1 V_1^n = P_2 V_2^n$ | |
| | $P_2 = P_1 (V_1/V_2)^n = 20\left[\frac{1}{2}\right]^2 = 5$ bar | |
| | $W.D = \frac{P_1V_1 - P_2V_2}{n-1} = \frac{(20\times10^2 \times 0.05) - (5\times10^2\times0.1)}{2-1}$ | 02 Marks |
| | $W.D = 50$ KJ | |
| | 2-3 → Constant Pressure | |
| | $W.D = P_3V_3 - P_2V_2 = P_2(V_3 - V_2) = P_2(V_1 - V_2)$ $= 5\times10^2 \times (0.05 - 0.1)$ $= -25$ KJ | 02 Marks |
| | 3-1 → Constant Volume = W.D = 0 | |
| | $W_{net} = {}_1W_2 + {}_2W_3 + {}_3W_1 \Rightarrow 50 - 25 + 0 \Rightarrow 25$ KJ | 02 Marks |
| 4a. | SFEE | |
| | $\left[u_1 + P_1v_1 + \frac{V_1^2}{2} + gz_1\right] + Q = \left[u_2 + P_2v_2 + \frac{V_2^2}{2} + gz_2\right] + W$ | |
| | <u>Boiler</u> ⇒ | |
| | $\Delta V = 0$, $\Delta$ Elevation $= 0$, Work $= 0$ | |
| | $Q = \Delta h$ | |
| | $Q = m\Delta h = m(h_{in} - h_{out})$ | |
| | <u>Nozzle</u> | |
| | $\Delta$Elevation $= 0$, $Q = 0$, $W = 0$ | |
| | $h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2}$ | |
| | <u>Centrifugal Pump</u> | |
| | $\Delta$velocity, Elevation, $Q = 0$   $W = \Delta H = m\Delta h$ | |
| | $W = m[h_{in} - h_{out}]$ | |

| Question Number | Solution | Marks Allocated |
|---|---|---|
| | Throttling Device | |
| | $\Delta$velocity = 0 , $\Delta$ Elevation = 0 , Q = 0 , W = 0 | 5×2 = 10 Marks |
| | $\Delta H = 0$ $H_{in} = H_{out}$ $\Rightarrow$ $h_{in} = h_{out}$ | |
| | Turbine | |
| | $\Delta$velocity , $\Delta$ Elevation , Q = 0 | |
| | $W = \Delta H = m\Delta h$ $W = m[h_{in} - h_{out}]$ | |
| b. | Given | |
| | m = 220 kg/min Q = −100 kJ/s | |
| | $V_1$ = 320 m/s $V_2$ = 140 m/s | |
| | $P_1$ = 6 bar $P_2$ = 1.2 bar | |
| | $u_1$ = 2000 kJ/kg $u_2$ = 1400 kJ/kg | |
| | $v_1$ = 0.36 m³/kg $v_2$ = 1.3 m³/kg | |
| | $\left[u_1 + P_1v_1 + \frac{V_1^2}{2} + gZ_1\right] + Q = \left[u_2 + P_2v_2 + \frac{V_2^2}{2} + gZ_2\right] + W$ | 02 Marks |
| | $W = \left[(u_1 - u_2) + \frac{P_1v_1 - P_2v_2}{2\times1000} + \frac{V_1^2 - V_2^2}{\times 1000}\right] \times \frac{220}{60} - 100$ | |
| | $W = \frac{220}{60}\left[600 + \frac{6\times10^5\times0.36 - 1.2\times10^5\times1.3}{2000} + \frac{320^2 - 140^2}{2000}\right] - 100$ | 04 Marks |
| | $3.67\,[600 + 30 + 41.4] - 100$ | 02 Marks |
| | P = 681.98 kW = 0.6 MW | 02 Marks |

Subject Title : Basic Thermodynamics    Subject Code : 18ME33

| Question Number | Solution | Marks Allocated |
| --- | --- | --- |
| 5a | Equivalence of Kelvin - Planck and Clausius Statements | |
| |  | 05 Marks |
| |  Equivalence of Clausius and Kelvin Planck Statement | 05 Marks |
| b. |  | 02 Marks |
| | $\eta = \frac{T_1 - T_2}{T_1} = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$ | |
| | $\Rightarrow \frac{2100 - Q_2}{2100} = \frac{873 - 313}{873}$ | |
| | $Q_2 = 752.92$ kJ | 04 Marks |

Subject Title : Basic Thermodynamics Subject Code : 18ME33

| Question Number | Solution | Marks Allocated |
|---|---|---|

Then

$W_1 = Q_1 - Q_2 = 2100 - 752.9 = 1347.1 \text{ kJ}$

$W_{net} = W_1 - Q_5$

$Q_5 = W_1 - W_{net} = 1347.1 - 360 = 987.1 \text{ kJ}$ — 02 Marks

In case of refrigeration

$W_{in} = Q_4 - Q_3 = Q_5$

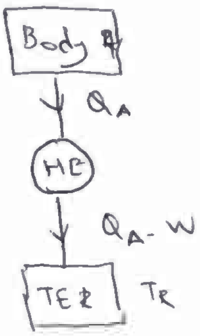
$$\varepsilon_R = \frac{T_3}{T_4 - T_3} = \frac{253}{313 - 253} = 4.21$$

$Q_3 = \varepsilon_R \times W_{in} = \varepsilon_R \times Q_5$ — 02 Marks

$Q_3 = 4.21 \times 987.1 = 4162.27 \text{ kJ}$

6. a. Entropy is a property and it does not follow the path it depends on the initial and final points. with P-V diagram — 04 Marks.

b. Maximum work attainable from a finite Body and a thermal Energy Reservoir




$$\Delta S_A = \int_{T_A}^{T_R} c_p \frac{dT}{T} = c_p \ln \frac{T_R}{T_A}$$

$\Delta S_{H.E} = \oint dS = 0$ — 10 Marks

$$\Delta S_{TER} = \frac{Q_A - W}{T_R}$$

$$\Delta S_{universe} = c_p \ln \frac{T_R}{T_A} + \frac{Q_A - W}{T_R}$$

Solving $W_{max} = c_p \left[ (T_A - T_R) + T_R \ln \frac{T_R}{T_A} \right]$

| Question Number | Solution | Marks Allocated |
|---|---|---|
| c. | Energy lost by lump of Steel = Energy gained by the oil | |
| | $(mC_s\,\Delta T)_{steel} = (m\,c_o\,\Delta T)_{oil}$ | |
| | $m_s c_s (T_s - T_f) = m_o c_o (T_f - T_o)$ | |
| | $10 \times 0.5 (900 - T_f) = 100 \times 3.5 (T_f - 303)$ | |
| | $900 - T_f = 70 T_f - 21210$ | |
| | $T_f = 311.408\ K$ | 02 Marks |
| | Entropy change in Steel = $\Delta S_s = m_s c_s \ln \frac{T_f}{T_s}$ | |
| | $= 10 \times 0.5 \times \ln \frac{311.408}{900}$ | |
| | $= -5.301\ kJ/k$ | 01 Mark |
| | Entropy change in oil = $\Delta S_o = m_o c_o \ln \frac{T_f}{T_o}$ | |
| | $= 100 \times 3.5 \times \ln \frac{311.408}{303}$ | |
| | $= 4.16\ kJ/k$ | 01 Mark |
| | $(\Delta S)_{Universe} = \Delta S_{steel} + \Delta S_{oil}$ | |
| | $= -1.1405\ kJ/k$ | 02 Marks |
| 7. a. | Definition / Concept of available & Unavailable Energy | 4 Marks |
| b. | Maxwell relations | |
| | $\left(\frac{\partial T}{\partial V}\right)_s = -\left(\frac{\partial P}{\partial s}\right)_V = \frac{\partial^2 U}{\partial S \partial V}$ | |
| | $\left(\frac{\partial T}{\partial P}\right)_s = \left(\frac{\partial V}{\partial s}\right) = \frac{\partial^2 H}{\partial S \partial P}$ | |

| Question Number | Solution | Marks Allocated |
|---|---|---|
| | $\left(\frac{\partial s}{\partial v}\right)_T = \left(\frac{\partial p}{\partial T}\right)_v = \frac{-\partial^2 f}{\partial T \partial v}$ | |
| | $-\left(\frac{\partial s}{\partial p}\right)_T = \left(\frac{\partial v}{\partial T}\right)_p = \frac{\partial^2 G}{\partial T \partial p}$ | 06 Marks |
| c. | $V = 0.04 m^3$ <br> $t_s = 250°C$ <br> $m_f = 9 kg$ | |
| | from steam table @ 250°c $P_s = 39.73$ bar | 01 Mark |
| | $v_f = 0.0012512 \, m^3/kg$ $v_g = 0.05013 \, m^3/kg$ <br> $h_f = 1085.36$ $h_{fg} = 1716.2 \, kJ/kg$ $S_f = 2.7927 \, kJ/kg\,K$ <br> $S_{fg} = 3.2802 \, kJ/kg\,K$ | 01 Mark |
| | $V_g$ = Volume of dry steam $= V - V_f$ <br> $= V - m_f (v_f)$ <br> $= 0.04 - 9 \times 0.0012512$ <br> $= 0.02874 \, m^3$ | 01 Mark |
| | Mass of dry steam $= \frac{0.02874}{0.05013} = 0.5733 kg$ | |
| | Mass of steam $= m_g + m_f = 0.5733 + 9 = 9.5733$ | 01 Mark |
| | Specific Volume $= v = v_f + x v_{fg}$ <br> $x = \frac{m_g}{m_g + m_f} = \frac{0.5733}{0.5733+9} = 0.06$ | |

Subject Title : Basic Thermodynamics

Subject Code : 18ME33

| Question Number | Solution | Marks Allocated |
|---|---|---|
| | $v = 0.0012512 + 0.06\,(0.5013 - 0.0012512)$ | |
| | $= 0.0041839\ m^3/kg$ | 01 Mark |
| | Specific enthalpy $= h_f + x h_{fg} = 1188.332\ kJ/kg$ | 02 Marks |
| | Specific entropy $= s_f + x s_{fg} = 2.9895\ kJ/kg\,K$ | 02 Marks |
| | Specific Internal energy $u = h - pv$ | |
| | $= 1171.709\ kJ/kg$ | 01 Mark |
| 8a. | Working of Combined Separating and Throttling Calorimeter | |
| | Diagram | 5 Marks |
| | Explanation & Equation | |
| | $x_1 = \dfrac{M}{m+M}$ | |
| | $x_2 = \dfrac{h_{sup.C} - h_{f.B}}{h_{fg.B}}$ | |
| | $X = \dfrac{M \cdot x_2}{m+M}$ | 05 Marks |
| b. | $P = 10$ bar | |
| | $x = 0.15$ | |
| | $W.D = P(v_2 - v_1)$ | |
| | Using steam tables | |

Subject Title : Basic Thermodynamics Subject Code : 18ME33

| Question Number | Solution | Marks Allocated |
|---|---|---|
| | finding<br>change in enthalpy<br>Heat transfered<br>change in entropy | 10 Marks |
| a. a | Vanderwaal's equation / constant in terms of critical properties<br>$\left(P + \frac{a}{v^2}\right)(v - b) = RT$<br>$\frac{v_c}{b} = 3$ $T_c = \frac{8a}{27Rb}$ $a = 3 v_c^2 P_c$ | 08 Marks |
| b. | Definition Of Generalized compressibility chart | 4 Marks |
| c. | $V = 1.5\ m^3$ $m = 5\ kg$ $T = 300\ k$<br>Ideal gas<br>$PV = mRT$<br>$P = \frac{mRT}{V} = \frac{5 \times \frac{8314}{44} \times 300}{1.5} = 1.889$ bar<br>Vanderwaal's eqn<br>$P = \frac{RT}{\bar{v} - b} - \frac{a}{\bar{v}^2} = \frac{8314 \times 300}{6.82 - 0.0427} - \frac{364.3 \times 10^3}{(6.82)^2}$<br>$\bar{v} = \frac{1.5 \times 44}{10} = 6.82\ m^3/kgmol$<br>$\Rightarrow = 368022.6 - 7832.3$<br>3.6 bar | |

10.

a. Dalton's & Amagat's law Definition — 08 Marks

b. Expression for I.E and Enthalpy — 04 Marks

c. 1 kg – $CO_2$

1.5 kg – $N_2$

P = 3.5 bar  T = 27°C

(i) Mole fraction

$n = \frac{m}{M}$  $n_{CO_2} = \frac{1}{44} = 0.022$

$n_{N_2} = \frac{1.5}{28} = 0.053$

$X_{CO_2} = \frac{0.022}{0.022+0.053} = 0.2933$

$X_{N_2} = \frac{0.053}{0.022+0.053} = 0.7066$

(ii) Partial Pressures

$P_{CO_2}V = n_{CO_2} R_0 T$

$P_{CO_2} = \frac{n_{CO_2} R T}{V} = \frac{0.022 \times 8.314 \times 10^3 \times 300}{V}$

$V = \frac{mRT}{P} = \frac{2.5 \times \bar{R} \times 300}{M \times 3.5 \times 10^5}$  $M = \frac{n_{CO_2} M_{CO_2} + n_{N_2} M_{N_2}}{n_{CO_2} + n_{N_2}}$

$= \frac{2.5 \times 8.314 \times 300}{32.69 \times 3.5 \times 10^5}$  $= \frac{0.022 \times 44 + 0.053 \times 28}{0.022 + 0.053}$

$= \frac{2.5 \times 0.254 \times 10^3 \times 300}{~~32.69~~ \times 3.5 \times 10^5}$  $= \boxed{32.69 = M}$

$= 0.5442 \ m^3$

$P_{CO_2} = 1.0083$ bar  $P_{N_2} = 2.491$ bar

10 Marks

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