Modified

CBCS SCHEME

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

18ME33

Third Semester B.E. Degree Examination, Feb./Mar. 2022
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 thermodynamics charts and tables are permitted.***

Module-1

1 a. Distinguish between:
(i) Macroscopic and microscopic approaches
(ii) Intensive and extensive properties **(10 Marks)**

b. Define the following terms:
(i) System (ii) State (iii) Property
(iv) Quasi-static process (v) Thermodynamic cycle **(10 Marks)**

OR

2 a. Define Thermodynamic Equilibrium. Also explain Mechanical, Chemical and Thermal equilibrium. **(10 Marks)**

b. A constant volume gas thermometer containing helium gives readings of gas pressure 'P' as 1000 and 1366 mm of mercury at ice point and steam point respectively. Assuming a linear relationship of the form $t = a + bP$, express the gas thermometer celsius temperature 't' in terms of gas pressure P. What is the temperature recorded by the thermometer, when it registers a pressure of 1074 mm of mercury? **(10 Marks)**

Module-2

3 a. Compare work and heat. **(10 Marks)**

b. A fluid contained in a horizontal cylinder fitted with a frictionless leak proof piston is continuously agitated by a stirrer passing through the cylinder cover. The diameter of the cylinder is 40 cm and piston is held against the fluid due to atmospheric pressure equal to 100 kPa. The stirrer turns 7000 revolutions with an average torque of 1 Nm. If the piston slowly moves outwards by 50 cm determine the network transfer to the system. **(10 Marks)**

OR

4 a. With a neat diagram, explain Joule's experiments. Also state the first law of thermodynamics. **(10 Marks)**

b. A centrifugal compressor delivers 20 kg/min of air. Air enters the compressor of 5 m/s, 100 kPa and leaves at 9 m/s, 600 kPa. Heat lost to the surroundings during this process is 10 kJ/s. If the increase in enthalpy of the fluid is 180 kJ/kg and inlet and outlet specific volume of air are 0.5 m^3/kg and 0.16 m^3/kg respectively, determine the power of the motor to drive the compressor. Also calculate the ratio of inlet pipe diameter to the outlet pipe diameter. Assume zero elevation difference. **(10 Marks)**

Module-3

5 a. Describe the limitations of first law of thermodynamics. Also explain Kelvin-Plank and Clausius statements of second law of thermodynamics with representative diagrams. **(10 Marks)**

b. Two Carnot engines A and B are connected in series between two thermal reservoirs maintained at 1000 K and 100 K respectively. Engine A receives 1680 kJ of heat from high temperature reservoir and rejects heat to the Carnot engine B. Engine B takes in heat rejected by engine A and reject heat to the low temperature reservoir. If engines A and B have equal thermal efficiencies, determine:
(i) The heat rejected by engine B.
(ii) Temperature at which heat is rejected by engine A.
(iii) Work done by engine A and B. **(10 Marks)**

OR

6 a. Define entropy and explain the principle of increase of entropy. **(10 Marks)**
b. A closed system contains air at pressure 1 bar, temperature 290 K and volume 0.02 m^3. This system undergoes a thermodynamic cycle consisting of the following three process:
Process 1-2: Constant volume heat addition till pressure becomes 4 bar.
Process 2-3: constant pressure cooling.
Process 3-1: Isothermal heating to initial state. Evaluate the change in entropy for each process. Take C_V = 0.718 kJ/kgK, R = 287 J/kgK. Also represent the cycle on T-S and P-V plot. **(10 Marks)**

Module-4

7 a. Explain the concept of availability and unavailable energy by deducing suitable relevant equation. **(10 Marks)**
b. Superheated steam at 40 bar and 300°C expands to 4 bar and 0.97 dry in a turbine. Determine: (i) Availability (ii) Actual work done (iii) Loss in availability. Assume t_0 = 28°C. **(10 Marks)**

OR

8 a. Draw and explain the salient features of P-T diagram with water as an example. **(08 Marks)**
b. The following data were obtained with a separating and throttling calorimeter pressure in steam main = 15 bar, mass of water drained from the separator = 0.55 kg. Mass of steam condensed after passing through the throttle valve = 4.20 kg. Pressure and temperature after throttling is 1 bar and 120°C. Evaluate the dryness fraction of steam in the main. **(12 Marks)**

Module-5

9 a. Define and explain Dalton's law of partial pressures and Amagat's law of additive volumes. **(10 Marks)**
b. It is required to evacuate hydrogen gas from a 8 m^3 capacity tank form atmospheric pressure of 101.325 kPa to a pressure of 98.125 kPa vacuum at 400 K. Determine the mass of Hydrogen pumped out and pressure in kPa if the temperature of hydrogen left in the tank falls to 290 K. **(10 Marks)**

OR

10 a. Define and explain: (i) Dew Point temperature (ii) Relative humidity (iii) Humidity ratio (iv) Wet Bulb temperature (v) Degree of saturation **(10 Marks)**
b. One kg of carbon monoxide has a volume of 2 m^3 at 80°C. Determine its pressure using:
(i) Ideal gas equation (ii) Vander Waal's equation
Constants for Vander Waal's equations:
$a = 147.90$ kN-m^4/(kgmol)^2 and $b = 0.0393$ m^3/kgmol. **(10 Marks)**

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18ME33

Re: Sir, regarding Out of syllabus

"Dr M S Govinde Gowda" <msggowda1964@gmail.com> May 18, 2022 10:12 AM

To: boe@vtu.ac.in

Dear Sir,
A warm greetings of the day.
With regard to the out of syllabus in 18ME33-BTD question paper, I hereby declare that it is not out of syllabus (Please refer the syllabus copy attached herewith by highlighting the topic) since the "**Air-Water mixtures and related properties**" is nothing but the Psychrometry. Of course in the syllabus, it is not mentioned directly as **Psychrometry**. Opinion is also taken from the subject experts by posting this question in whatsapp group and they are also of the opinion that the **Air-Water mixtures and related properties**" is nothing but the **Psychrometry**.
With regards

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Dr. M.S.Govinde Gowda
Chairman, BOE, Mechanical Board, VTU
and
Dean(Academics)
ATME College of Engineering
13th Kilometer, Mysore-Bannur-Bangalore Road
MYSORE -570 028, Karnataka State
Mob: 9972940201 / 9008097764
Web: www.atme.in

On Mon, May 16, 2022 at 11:08 AM <boe@vtu.ac.in> wrote:

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

Re: Sir, Regarding Modification of Scheme and Solutions

"Dr M S Govinde Gowda" <msggowda1964@gmail.com>

May 18, 2022 3:58 PM

To: boe@vtu.ac.in

Dear Sir,
PFA for the corrected and approved scheme and solution of 18ME33, 18ME34, 18ME35A and 18ME35B and they are being forwarded for further needful from your end
With regards

Dr. M.S.Govinde Gowda
Chairman, BOE, Mechanical Board, VTU
and
Dean(Academics)
ATME College of Engineering
13th Kilometer, Mysore-Bannur-Bangalore Road
MYSORE -570 028, Karnataka State
Mob: 9972940201 / 9008097764
Web: www.atme.in

On Fri, May 13, 2022 at 9:25 AM <boe@vtu.ac.in> wrote:

Visvesvaraya Technological University
Belagavi, Karnataka - 590 018

Scheme & Solution

Signature of Scrutinizer

Subject Title : Basic Thermodynamics   Subject Code : 18ME33

Question Number	Solution	Marks Allocated
	MODULE 1	
1 (a)	(i) Macroscopic View – effect of many molecules fundamental measurable properties.	05
	Microscopic – Analysis at molecular level. Statistical	05
	(ii) Intensive & Extensive properties – Independent of Mass & dependance on mass – Explanation	(10)
(b)	System, state, property, Quasi-static process, cycle – Definition	02×05 = (10)
2 (a)	Definition of thermodynamic Eqm – (02)	
	Mechanical, Chemical, & Thermal Eqm – (08)	10
(b)	$t = a + bP$	
	At $t = 0$, $P = 1000 \Rightarrow 0 = a + 1000b$ – (i)	
	At $t = 100$, $P = 1366 \Rightarrow 100 = a + 1366b$ – (ii)	
	Solving $a = -273.24$, $b = 0.27324$ – (05)	
	Now $t = -273.24 + 0.27324P$	
	When $P = 1074$	
	$t = -273.24 + 0.27324 \times 1074$ $= 20.22°C$ (Ans) – (05)	10
	MODULE 2	
3 (a)	Work & Heat → Similarities (05)	
	Work & Heat → Dissimilarities (05)	10

* APPROVED *

Registrar (Evaluation)
Visvesvaraya Technological University
BELAGAVI - 590018

Subject Title : **Subject Code :**

Question Number	Solution	Marks Allocated
3 (b)	Work done by stirrer / paddle work	
	$W_p = 2\pi N T = -2\pi \times 7000 \times 1 = -43.98\ kJ$	— (03)
	Displacement work of piston	
	$W_D = p\,dV = P A L = 100 \times \frac{\pi}{4}(0.4)^2 \times 0.5$	
	$= 6.28\ kJ$	— (04)
	Net Work Transfer	
	$W_{net} = W_p + W_D = -43.98 + 6.28$	
	$= -37.69\ kJ$	— (03)
	Note: Paddle work is negative	10
4 (a)	Diagram of Joule's Experiment	— (02)
	Explanation of Experiment $W = JQ$	— (05)
	Fext law of thermodynamics	— (03)
		10
(b)	Applying SFEE	
	${}_1W_2 = {}_1Q_2 - m\left[(h_2 - h_1) + \frac{V_2^2 - V_1^2}{2 \times 1000} + g(z_2 - z_1)\right]$	-2M
	$= {}_1Q_2 - m\left[(h_2 - h_1) + \frac{V_2^2 - V_1^2}{2 \times 1000} + 0\right]$	
	$= -10 - \frac{20}{60}\left[180 + \frac{9^2 - 5^2}{2 \times 1000}\right]$	
	$= -$ ~~50~~ 70 kJ/s $= -$ ~~50~~ 70 kW	~~(05)~~ -6M
	$\frac{d_1}{d_2} = \sqrt{\frac{V_2 \times v_1}{V_1 \times v_2}} = \sqrt{\frac{9 \times 0.5}{5 \times 0.16}} = 2.372$	~~(05)~~ -2M
	Here $v_1, v_2 \rightarrow$ sp. volumes	
	$V_1, V_2 \rightarrow$ velocities.	10

Subject Title : Subject Code :

Question Number	Solution	Marks Allocated

Module 3

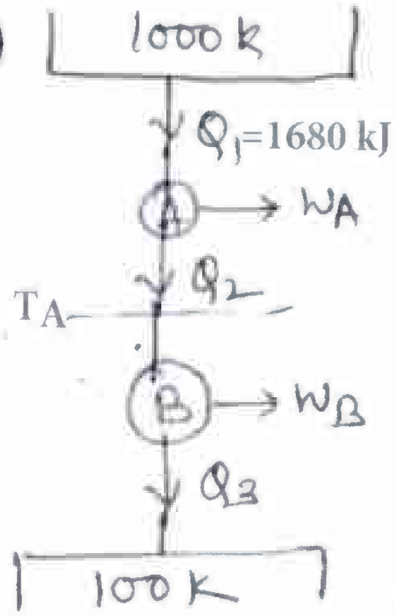
5 (a) Limitations of first law of TD — (2)

Kelvin Planck statement & explanation with Diagram (04)

Clausius statement with Diagram (04)

10

5 (b)



$\eta_A = \frac{W_A}{Q_1} = \frac{1000 - T_A}{1000}$

$\frac{W_A}{1680} = \frac{1000 - T_A}{1000}$

$\eta_B = \frac{W_B}{Q_2} = \frac{W_B}{Q_3 + W_B}$

$= \frac{T_A - 100}{T_A}$

As $\eta_A = \eta_B$

i.e, $T_A = \sqrt{1000 \times 100} = 316.2$ K -2M

$\frac{T_A - 100}{T_A} = \frac{1000 - T_A}{1000}$ $\Rightarrow T_A = 316.22$ K Ans

$W_A = 1680\left(\frac{1000 - T_A}{1000}\right) = 1148.75$ kJ Ans -2M

$\eta_A = \frac{W_A}{1680} = \frac{1148.75}{1680} = 0.6838$ -2M

Now $Q_2 = Q_1 - W_A = 1680 - 1148.75 = 531.25$ kJ -2M

$\eta_B = 0.6838 = \frac{W_B}{Q_2} = \frac{W_B}{531.25}$

$W_B = 363.27$ kJ -1M Ans 05

Heat rejected by Engine B

$\eta_B = 0.6838 = \frac{W_B}{Q_3 + W_B} = \frac{363.27}{Q_3 + 363.27}$

Subject Title :   Subject Code :

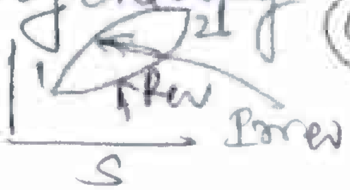
Question Number	Solution	Marks Allocated

$Q_3 = 167.98$ kJ -1M Ans   10

6 (a) Definition of Entropy   03

Principle of Increase of entropy   07

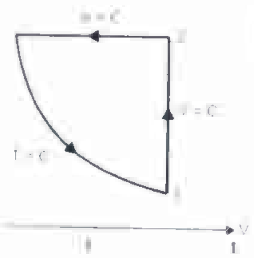
Proof $dS \geq \delta Q / T$



10

6 (b) Mass of air

$$m = \frac{P_1 V_1}{R T_1} = \frac{1\times10^5 \times 0.02}{287 \times 290} = 0.024 \text{ kg}$$ -1M



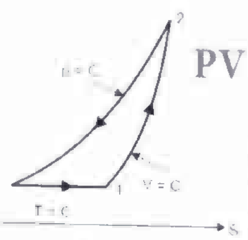
Process 1-2 ⇒ $T_2 = \frac{P_2}{P_1} T_1 = \frac{4}{1} \times 290 = 1160$ K -1M

Entropy change

$$S_2 - S_1 = m C_v \ln\left(\frac{T_2}{T_1}\right)$$

$$= 0.024 \times 0.718 \ln(4)$$

$$= 0.024 \text{ kJ/kg}$$ -2M ~~04~~



PV & TS diagram=2M

Process 2-3 ⇒ $T_3 = T_1 = 290$ K

$$S_3 - S_2 = m C_p \ln(T_3/T_2) = m(C_v + R)\ln(T_3/T_2)$$

$$= 0.024(0.718 + 0.287)\ln\left(\frac{290}{1160}\right)$$

$$= -0.0334 \text{ kJ/kg}$$ -2M ~~03~~

Process 3-1 ⇒ $P_3 = P_2 = 4$ bar

S_1-S_3

$$\cancel{S_3 - S_1} = m R \ln(P_3/P_1) = 0.024 \times 0.287 \times \ln(4/1)$$

$$= 0.0095 \text{ kJ/kg}$$ -2M ~~03~~   10

MODULE 4

7 (a) Availability & Unavailability relation

$$\left.\begin{aligned} {}_1(AE)_2 &= {}_1Q_2 - T_0(S_2 - S_1) \\ {}_1(UE)_2 &= T_0(S_2 - S_1) \end{aligned}\right\}\text{Proof}$$ 08

Subject Title : **Subject Code :**

Question Number	Solution	Marks Allocated
	Concept of Availability — 02	10

7(b) From steam tables

At p = 40 bar and 300°C

$h_1 = 2962$ kJ/kg ; $s_1 = 6.3642$ kJ/kgK

At p = 4 bar and 0.97 dry

$h_2 = 604.7 + 0.97 \times 2132.9$

$= 2673.613$ kJ/kg

$s_2 = 1.7764 + 0.97 \times 5.1179$

$= 6.7407$ kJ/kg **Prop =2M**

Availability $= (h_1 - h_2) - T_0(s_1 - s_2)$

$= (2962 - 2673.613) - (28+273)(6.3642 - 6.7407)$

$= 401.717$ kJ -3M

Actual Work Done $= h_1 - h_2 = 2962 - 2673.613$

$= 288.387$ kJ/kg (03) marks

Loss in Availability $= 401.717 - 288.387$

$= 113.33$ kJ/kg (02) Marks

(10)

8(a) P-T Diagram showing triple pt, fusion line, vapourisation line, taking water as an example ~~10~~ 08

Diagram — (03) + Explanation ~~07~~ 05M

(b) Using steam table

At p = 1 bar, t = 120°C

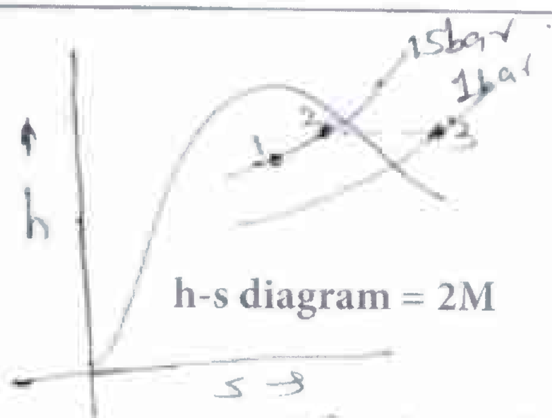
$h_3 = 2676 + \left(\frac{120-100}{150-100}\right)(2776.8 - 2676)$

$=$ ~~2742.73 kJ/kg~~ 2716.24 kJ/kg (03)

2-3 Throttling process ⇒ $h_2 = h_3$

~~2742.73~~ 2716.24 $= 844.89 + x_2 \times 1947.3$ at 15 bar

Question Number	Solution	Marks Allocated



h-s diagram = 2M

$x_2 = \frac{0.975}{0.962}$ — (05)

$x_1 = \frac{x_2 \times m_c}{m_w + m_c}$

$= \frac{0.962 \times 4.20}{(0.55 + 4.20)}$

$= 0.851$ — (02) 12

Module 5

9 (a) Definition of Dalton's & Amagat's law 05+05 = (10)

9 (b) Gas Constant $= R = \frac{8.3143}{2} = 4.157$ kJ/kgK

Initial Mass of $H_2 = m_1 = \frac{P_1 V_1}{RT_1} = \frac{101.325 \times 68}{4.157 \times 400}$

$= 0.487$ kg — (04)

Final Mass of $H_2 = m_2 = \frac{P_2 V_2}{RT_2} = \frac{98.125 \times 68}{4.157 \times 400}$

$= 0.472$ kg

Mass of H_2 Pumped $= m_1 - m_2$ $= 0.015$ kg — (04)

$m_2 = \frac{P_2 V_2}{RT_2} = \frac{P_3 V_3}{RT_3} \Rightarrow 0.472 = \frac{P_3 \times 68}{4.157 \times 290}$ = 71.13 kPa — (02) 10

10 (a) Definition of DPT, RH, Humidity Ratio, WBT and Degree of Saturation 05 × 02 (10)

(b) $pv = RT \Rightarrow p = \frac{RT}{v} = \frac{0.2971 \times (80+273)}{2}$

$= 52.438$ kN/m² — (04)

Vander Wall eqn $p = \frac{RT}{v-b} - \frac{a}{v^2}$

$v = 2 \times 28 = 56$ m³/kg-mol

$p = \frac{8318.8 \times (80+273)}{56 - 0.0393} - \frac{147.90 \times 10^3}{56^2}$

$= 52484.79$ N/m²

$= 52.484$ kN/m² — 06 (10)

Approved by

Dr. M.S. Govinde Gowda
Chairman,
BOE, Mechanical Board, VTU.

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