

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular), November 2017

M. Tech Thermal Engineering, Semester I

Roll No.....

COURSE CODE: TEMTECH 101

Time: 3 hours

Max. Marks: 100

COURSE TITLE: Advance Thermodynamics

Instructions to students:

1. Do not write anything other than your roll number on question paper.
 2. Assume suitable data wherever required and mention it clearly.
 3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.
 4. Use steam table
-

Q.1 Objective type multiple choice questions (10 questions @ 1 mark) 10

- i. Real processes proceed in:
 - a. One direction
 - b. Two direction
 - c. All of the above
 - d. None of the above
- ii. Work can be converted to heat
 - a. In totality
 - b. partially
 - c. never
 - d. All of the above
- iii. In real processes entropy always:
 - a. Decrease
 - b. Increase
 - c. Been constant
 - d. none of the above
- iv. Ideal gas equation considers :
 - a. No intermolecular forces
 - b. Finite size of molecules
 - c. Intramolecular forces
 - d. all of the above
- v. Constants of Beattie-Bridgeman equation are :
 - a. Experimental values
 - b. Derived from critical constants
 - c. Empirical values
 - d. None of the above
- vi. Combustion is an example of :
 - a. Ideal gas behaviour
 - b. Real gas behaviour
 - c. Reactive system
 - d. None of the above
- vii. Correct Maxwell equation is:
 - a. $\frac{\partial T}{\partial v} = -\frac{\partial P}{\partial s}$

$$b. \frac{\partial u}{\partial v} = -\frac{\partial P}{\partial s}$$

$$c. \frac{\partial s}{\partial v} = -\frac{\partial P}{\partial s}$$

d. None of the above

viii Joule Kelvin constant is always :

- a. Positive
- b. Negative
- c. zero
- d. All of the above

ix Rankine cycle considers :

- a. Phase change
- b. Same phase
- c. Sometimes phase change and sometimes no phase change
- d. All of the above

x Work output in Brayton cycle is :

- a. Through temperature drop
- b. Through entropy drop
- c. Through phase change
- d. None of the above

Q.2 Short answer type questions

10

- a. Define type of thermal reservoirs. Define Thermal efficiency and coefficient of performance considering reservoirs and the significance of these parameters
- b. Describe availability and derive expression for availability transfer associated with heat transfer

Q.3(a) A heat engine receives 600 kJ of heat from high temperature source of 1000 K during a cycle. It converts 150 kJ of this heat in to network and rejects the remaining 450 kJ to a low temperature sink at 300 K. Determine if this heat engine violates the second law of thermodynamics on the basis of

15

- a. Clausius inequality
- b. Carnot cycle

(b) Derive for ideal gas:

15

$$S_2 - S_1 = C_p \ln\left(\frac{T_2}{T_1}\right) - R \ln\left(\frac{P_2}{P_1}\right)$$

Q.4 A heat transfer of 100 kJ occurs between reservoirs of 1000 K and 300 K and $T_0 = 300$ K.

25

- (i) Determine the effectiveness of heat transfer process
- (ii) Also find out the effective ness of heat transfer if the heta is used for heating a space at 40°C, process steam generation at 200°C and furnace operation at 420°C

OR

Q.4 A mixture of Oxygen (O₂), Carbon Di Oxide (CO₂) and Helium (He) gases with mass fraction of 0.0625, 0.0625 and 0.3125 respectively enter an an adiabatic turbine at 1000 kPa and 600 K steadily and expand to 100 kPa and 600 K. The isentropic efficiency of the turbine is 0.9. For gas component assuming constant specific heats at room temperature. Determine:

25

- a. Work output per unit mass of mixture

b. Second law efficiency

Specific heats of gases:

Oxygen : $C_v = 0.658 \text{ kJ/kg-K}$; $C_p = 0.918 \text{ kJ/kg-K}$

Carbon di Oxide : $C_v = 0.657 \text{ kJ/kg-K}$; $C_p = 0.846 \text{ kJ/kg-K}$

Helium: $C_v = 3.1156 \text{ kJ/kg-K}$; $C_p = 5.1926 \text{ kJ/kg-K}$

Q.5 Coal contains the following components: 25

C : 84.36%, H₂: 1.89%, O₂: 4.40%, N₂: 0.63%, S : 0.89%, Ash : 7.83%

Is burnt with the theoretical amount of air. Disregarding the ash content, determine the mole fraction of the products and the apparent molar mass of the product gases. Also determine the air fuel ratio required for this combustion processes. Atomic weight of elements are :

Carbon : 12 Hydrogen : 1 Oxygen : 16 Nitrogen ; 14 Sulfur ; 32
OR

Q.5 a. Using the ideal gas equation of state, verify : 25

i. The cyclic relation

ii. The reciprocity relation at constant P

b. A gas turbine power plant operating on an Ideal Brayton cycle has a pressure ration of 8. The gas temperature is 300 K at compressor inlet and 1300 K at turbine inlet. Using the standard assumptions, Determine:

i. the gas temperature at the exits of the compressor and turbine

ii. The back work ratio

iii. the thermal efficiency

$C_p = 1.0 \text{ kJ/kg-K}$ and $\gamma = 1.4$