Seat No.: _____ Enrolment No.______

GUJARAT TECHNOLOGICAL UNIVERSITY

B. E. Semester-IV- Examination June- 2011

Subject code: 141903

Subject Name: Engineering Thermodynamics

Date: 06/06/2011 **Time : 10:30 am to 1:00 pm**

Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Define the followings. **07**

i) Thermodynamic equilibrium
ii) Reversible and irreversible processes
iii) One Pascal pressure and one bar pressure
iv) Dithermal boundary of a thermodynamic system
v) Point function and Path function
vi) Critical points of pure substance
vii) Availability of system at given state

(b) Write down the Van der Waal's real gas state equation. Explain the reduced properties of gas and obtain the Van der Waal's equation in reduced form i.e. $\left(\mathrm{P_r}+\frac{3}{V_r^2}\right)(3V_r-1)=8T_r$. **07**

Where P_c, V_c, T_c are critical property values and $P_r=P/P_c$, $V_r=V/V_c$, $T_r=T/T_c$.

Q.2 **(a)** State and write the 1st Law of thermodynamics for a thermodynamic process and explain the conventional meanings for positive ness and negative ness for heat and work interactions between thermodynamic system and its surroundings across the system boundary. **07**

(b) Write down any two statements for the 2nd law of thermodynamics. Also state the Carnot theorem and its corollary. **07**

OR

(b) Derive all the Maxwell's relations. Also work out the second Tds equation i.e. $Tds = C_p dT - T\left(\frac{\partial V}{\partial T}\right)_p dP.$ **07**

Q.3 **(a)** Plot the Otto cycle and semi Diesel cycle on P-V as well as T-S diagrammes. Explain the difference between these cycles. **07**

(b) In a gas turbine plant, operating on the Brayton cycle, the air compressor compresses the surrounding air to a pressure ratio of 6.0.The maximum temperature at inlet to the compressor is at 0.1MPa, 30˚C, the pressure ratio is 6.0. The maximum temperature of the cycle is maintained at 1000˚C..Surrounding air is at 0.1 MPa and 30 ˚C. **07**

Find (i) the turbine work and compressor work

(ii) the plant efficiency. Assume compression and expansion are friction less adiabatic ,for air $\gamma=\frac{C_p}{C_v}=1.4$ and $C_p=1.005$ kJ/kg..

OR

Q.3 **(a)** Define/ explain the following terms; **07**

i) adiabatic flame temperature
ii) stoichio metric air
iii) high and low calorific values of fuels
iv) stoichiometric equation for fuel
v) rich air fuel ratio

(b) Write down the combustion reaction equations for complete combustion of the following fuels and also work out the stoichio metric air required for each of these fuels by mass as well as volume analysis. **07**

i) Hydrogen-H_2
ii) Carbon -C
iii) Methane –CH_4

Q.4 **(a)** Write down the expressions for working out the total enthalpy and total entropy of superheated steam as well as for wet steam with dryness fraction 'x'. **07**

Determine the total enthalpy and total entropy for following qualities of steam.

i) per kg of super heated steam at pressure 20 bar and 350˚C
ii) per kg of wet steam at pressure 0.075bar with dryness fraction of 0.85.

From steam table :

i) At 20 bar saturation enthalpy=2574.8kJ/kg , saturation entropy=6.3408 kJ/kg-K , saturation temperature =212.42˚C and C_p for super heated steam=2.453 kJ/kg-K.

ii) At 0.075 bar, saturation enthalpy=2574.8kJ/kg, saturation entropy=8.2514 kJ/kg-K, saturation temperature =40.29˚C ,h_{fg}=2406.0 kJ/kg-K and ,h_f=168.77.kJ/kg-K , s_{fg}=7.6751 kJ/kg-K and ,s_f=0.5763kJ/kg-K and Sp. Volume of saturated water is 0.001005m^3/kg.

(b) Steam at 20 bar, 350˚C is expanded in a steam turbine to 0.075 bar. It then enters a condenser, where it is condensed to liquid water. The pump feeds back the water into boiler. **07**

i) Assuming ideal processes, find per kg of steam the net work and
ii) The cycle efficiency.

The above data for super heated and wet steams can be made use of if desired.

OR

Q.4 **(a)** Define the following terms: **07**

i) Elements of irreversibility
ii) Maximum work
iii) Dead state of a given system
iv) Availability
v) Irreversibility
vi) Second law of efficiency
vii) Availability function.

(b) Derive the expression for Availability in a closed system at a given state. Mention clearly the assumptions made. **07**

Q.5 **(a)** In an Otto cycle air at start of isentropic compression is at 20˚C and 110kPa. If clearance volume is 20% of the swept volume and temperature at end of constant volume heat addition is 1400˚C, find the air standard efficiency and mean effective pressure in kPa. Take C_p/C_v=1.4. **07**

(b) In an air standard Diesel cycle the compression ratio is 14 and the beginning of isentropic compression is at 110kPa and 30˚C. If the fuel cut off takes place at 5% of stroke, find the air standard efficiency and mean effective pressure. Take γ =1.4, C_v=0.718kJ/kg-K and R=0.287 kJ/kg-K. **07**

OR

Q.5 **(a)** Write a steady flow energy equation for steam flowing through an inclined constant diameter pipe, where steam looses heat at a rate 'Q' kJ/kg . **07**

For driving a steam turbine, steam flows from boiler to steam turbine, through a horizontal steam pipe of constant diameter of 0.25m. The steam conditions at boiler and turbine entrance are as under:

At boiler	At turbine entrance
Pressure= 3.5 MPa	Pressure= 3.25 MPa
Temperature=500˚C	Temperature=490˚C
Total enthalpy=3450.9kJ/kg-K	Total enthalpy=3440.0kJ/kg-K
Sp.volume= 0.11324m^3/kg.	Sp.volume= 0.1204m^3/kg.

There occurs a heat loss of 9.0 kJ/kg from pipe line.

Calculate the steam flow rate.

(b) The air compressor takes in air steadily at the rate of 0.6 kg/sec from the surroundings with pressure of 100.0kPa and density of 1.0526 kg/m^3. The air entry velocity is 7.0 m/sec.The pressure ratio of air compressor is 7.0. The leaving air has density of 5.26315kg/m3 and leaves with velocity of 5.0 m/sec.The internal energy of the leaving air is 100.0kJ/kg more than that at entering. Cooling water in the compressor jackets absorbs heat from air at the rate of 65.0 KW. **07**

i) Compute the rate of shaft work to air

ii) Find the ratio of inlet pipe diameter to outlet pipe diameter.

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