Reg. No. | | | | | | | | | |

M.E. / M.TECH. DEGREE EXAMINATIONS, MAY/JUNE 2017
FIRST SEMESTER
INTERNAL COMBUSTION ENGINEERING
IC16102 – ADVANCED THERMODYNAMICS

(Use of relevant Thermodynamic data books, tables and charts permitted)

(Regulation 2016)

Q. Code: 851000

Time: Three Hours **Maximum : 100 Marks**

Answer **ALL** questions

PART A - (10 X 2 = 20 Marks)

1. What are the thermodynamic potentials?
2. What is Clausius-Clapeyron equation? Mention its application.
3. What is three parameter theorem of corresponding states?
4. Define fugacity and fugacity coefficient.
5. What is irreversibility? What are its causes?
6. Define second law efficiency and relate it with first law efficiency.
7. What is exergy based performance analysis of IC engines?
8. Write availability equation for steady flow process and non-flow process.
9. What is adiabatic flame temperature?
10. Write equation of reaction equilibrium. What is its purpose?

PART B - (5 X16 = 80 Marks)

11. (a) (i) Derive Maxwell relations. **(8)**

(ii) Derive an expression for $C_p - C_v$ in terms of volume expansivity and isothermal compressibility. **(8)**

(OR)

(b) (i) Derive an expression for Joule-Thomson coefficient and prove that it is zero for ideal gas. **(8)**

(ii) Obtain generalized relations for changes in internal energy and enthalpy. **(8)**

12. (a) Ethane is compressed from 32ºC and 19.5 bars to 185ºC and 98 bars in a steady flow process. The molar specific heat at zero pressure in kJ/kmol-K is given by $c_{p,0} = 16.8 + 0.123T$, where T is in Kelvin. Determine the enthalpy change of the gas in kJ/kmol, if a) the gas is an ideal gas, b) generalized two parameter data are used and c) generalized three parameter data are used. **(16)**

(OR)

(b) (i) The specific volume of R134a at 80ºC is 0.01435 m^3/kg. Determine the pressure in bars by means of i) the ideal gas equation, ii) the Van der Waals equation and iii) the two parameter corresponding states principle. **(10)**

(ii) Determine the value of fugacity and fugacity coefficient for nitrogen at 200 K and 100 bars by i) employing tabular superheat data ii) employing Lee-Kesler three parameter data. **(6)**

13. (a) Air expands through a turbine from 500 kPa, 520ºC to 100 kPa, 300ºC. During expansion, 10 kJ/kg of heat is lost to the surroundings which is at 98 kPa, 20ºC. Neglecting the K.E. and P.E. changes, determine per kg of air a) the decrease in availability, b) the maximum work, c) the irreversibility. For air, take c_p = 1.005 kJ/kgK, h = c_pT where c_p is constant and pV = mRT where p is pressure in kPa, V is volume in m^3, m is mass in kg, R is gas constant equal to 0.287 kJ/kgK and T is temperature in K. **(16)**

(OR)

(b) Perform availability analysis for the following: i) simple refrigeration cycle, ii) Steam power cycle. Draw suitable diagrams. **(16)**

14. (a) Discuss in detail the available energy referred to a cycle with diagrams. **(16)**

(OR)

(b) Suggest ideal models for engine processes with assumptions. Analyse each process in detail with diagrams. **(16)**

15. (a) (i) The combustion of CH_4 with air leads to the following volumetric analysis of the product gases on a dry basis: 10.10% CO_2, 0.21% CO and 2.58% O_2. Determine Stoichiometric and actual air-fuel ratios. Also find % excess air used and equivalence ratio. **(8)**

(ii) Ethane (C_2H_6) is burned in a steady flow system with 30% excess air, both originally at 25ºC and complete products of combustion are cooled to 700 K, determine the heat transfer from the product gases, in kJ/kmol of fuel. **(8)**

(OR)

(b) (i) Ethane gas (C_2H_6) is burned in a steady flow process with 30% excess air, with both reactants initially at 25ºC. Determine the maximum combustion temperature, in Kelvin for the steady flow process. **(10)**

(ii) Consider the gas phase reaction at 2000 K: CO(g) + ½O_2(g) ↔ CO_2(g). Determine the equilibrium constant K_0 by using 1) enthalpy of formation data at 298 K and enthalpy, entropy data 2) $\log_{10}K_P$ of formation data. **(6)**