Reg.No.									

INTERNATIONAL CENTRE FOR APPLIED SCIENCES

(Manipal University)

THIRD SEMESTER B.S. DEGREE EXAMINATION – OCT. / NOV. 2017

SUBJECT: PRINCIPLES OF THERMODYNAMICS (ME 231)

(BRANCH: MECHANICAL)

Friday, 10 November 2017

Time: 3 Hrs. **Max.Marks: 100**

- **Answer any FIVE full questions.**
- **Use of Thermodynamic data handbook is permitted.**
- **Missing data if any may be suitably assumed.**

1A. Differentiate the following terms with suitable examples.

a. System and Surrounding.

b. Open system and Isolated system

c. Statistical thermodynamics and Classical thermodynamics

d. Intensive and Extensive properties.

1B. Explain the state of thermodynamic equilibrium of a system.

1C. The relationship between pressure and volume for a non-flow reversible process is given by **P = [8 - 4V]** where P in bar, V is in m^3. The initial volume is 0.5 m^3. If 130 kJ of work is supplied to the system. Calculate final pressure and volume of the system.

(4+6+10)

2A. Explain Joule's experiment of I^{st} law of thermodynamics applied to a closed system executes a complete cycle.

2B. Explain the first law of thermodynamics applied to a closed system executing a cyclic process and an open system executing a process.

2C. Nitrogen of 0.001 kg is contained in a cylinder executes the following sequence of following quasi-static process,

(i). An adiabatic expansion which follows the law $\mathbf{PV^{1.3} = C}$ and volume gets doubles.

(ii) A constant pressure cooling which reduces volume to its initial value.

(iii) With piston in the firmly locked position, heat is supplied to rise the pressure to its initial pressure value. The nitrogen is initially at 160^0C temperature and pressure 5 bar pressure. Calculate the net work done by the fluid and show the processes on P-V diagram. Take R= 297 J/kg.K.

(6+4+10)

3A. Obtain an expression for work transfer in the following cases and show the processes on P-V diagram. (i) Polytropic process ii) Isothermal process iii) Adiabatic process.

3B. State and explain the zeroth law of thermodynamics. Explain how this law is the basis for temperature measurement.

3C. In a rotary compressor air flow steadily at a rate of 1.5 kg/s. The air enters with a velocity of 80 m/s and leaves at 4.5 m/s. The specific volume at inlet is 0.9 m^3/ kg and at the exit is 0.4 m^3/kg. As the air passes through the compressor, the specific enthalpy of air is increased by 110 kJ/kg and losses heat of 20 kJ/kg. Determine, a) The inlet and exit areas of the compressor in m^2 and, b) The power required to drive the compressor in kW.

(6+4+10)

4A. Define the two parallel statements of second law of thermodynamics and show that violation of kelvin-plank statement equally violates the Clausius statement.

4B. Derive the relationship between COP of Refrigerator and Heat pump.

4C. A gas occupies 0.3 m^3 at 2 bar. It executes a complete cycle consisting of processes

(i) 1-2 constant pressure process with work transfer of 15 kJ.

(ii) 2-3 compression process which follows law PV = C and $U_3 = U_2$.

(iii) 3-1 constant volume and change in internal energy $U_1 - U_3 = -50$ kJ.

Neglect changes in KE and PE. Draw P-V diagram for the above processes and determine network heat transfer for the cycle. Also show that first law is obeyed by the cycle.

(6+4+10)

5A. Define Carnot's theorem and prove that the efficiency of a reversible heat engine is always greater than the efficiency of an irreversible heat engine.

5B. A reversible heat engine operates between two reservoirs at temperature of 820^0C and 27^0C. The engine drives a reversible refrigerator which operates between reservoirs at 27^0 C and -15^0C. The heat transfer to the heat engine is 2000 kJ and the network available for the combined engine refrigerator system is 300 kJ. Evaluate i) Heat transfer to the refrigerant and the net heat transfer to the reservoir at 27^0C. **(8+12)**

6A. What are the limitations of separating and throttling calorimeters when they are used alone for the measurement of dryness fraction and explain the working principle of combined calorimeter.

6B. Steam at a pressure of 15 bar and 250^0 C expands according to law $\mathbf{PV^{1.25} = C}$ to a pressure of 1.5 bar. Evaluate the final conditions, work done, heat transfer and change in entropy. The mass of steam is 0.8 kg. **(8+12)**

7A. Define thermodynamic temperature scale and show that thermodynamic scale is given by $\mathbf{Q_1/Q_2 = T_1/T_2}$.

7B. Explain and prove Clausius inequality of the second law of thermodynamics.

7C. Define the following terms and draw T_S diagram of: : a. Sensible heat b. Latent heat of vaporization c. Dryness fraction d. Triple point e. Critical pressure and temperature f. Degree of Super heat. **(6+6+8)**

8A. Define the following terms applied to a mixture of ideal gases.

i) Mole fraction ii) Volume fraction iii) Mass fraction iv) Partial pressure ratio.

8B. Derive expression for gas constant R and molecular weight M of mixture of gases

8C. During the polytropic expansion of 1 kg of air the pressure reduces from 8 bar to 1 bar following equation $PV^{1.2} = C$. If the initial temperature of air is 350 K, determine (i) The volume and temperature after expansion (ii) Change of internal energy, work done and heat interaction, (iii) Change of entropy. Take R = 287 J/kg.k and $\gamma = 1.4$.

(4+8+8)