Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

III SEMESTER B.TECH. (AERONAUTICAL/AUTOMOBILE ENGINEERING)

END SEMESTER EXAMINATIONS, NOVEMBER 2019

SUBJECT: THERMODYNAMICS [AAE 2158]

REVISED CREDIT SYSTEM
(26/11/2019)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Thermodynamics data hand book is allowed.

1A. A certain mass of gas is compressed as per a reversible polytropic process from 80 kPa, 0.4 m^3 to 0.4 MPa, 0.3 m^3. Determine the magnitude and the direction of the work done and heat transfer during the process for 1 kg of gas. Given: For the gas, the specific gas constant 'R' is 1/3rd of the specific heat at constant volume 'c_v'. **(04)**

1B. A tank has a single inlet pipe of diameter 2.5 cm and a single outlet pipe. The outlet pipe has a cross-sectional area two times that of the inlet pipe. Liquid water enters at 45ºC at a rate of 270 kg per hour. A cooling coil is immersed in the water which removes energy at a rate of 7.6 kW. The water is well mixed by a paddle wheel which consumes 0.6 kW of power. The pressures at the inlet and outlet are equal. Neglecting the changes in PE, determine (i) Exit temperature of water (ii) Inlet and Exit velocities. **(04)**

1C. Identify the thermometric properties along with their SI units in the following cases: **(02)**

a) In an experiment, a Wheatstone bridge is being used for measurement of temperature.

b) A bi-metallic coil is used to measure the temperature of the hot air exiting from the radiator.

c) A doctor using a clinical thermometer for measuring the temperature of patients.

d) Thermal radiation thermometers used for non-contact type of temperature measurement.

2A. A heat pump is thermodynamically advantageous as compared to an electrical heater. Justify. **(02)**

2B. Consider an engine in outer space which operates on the Carnot cycle. The only way in which heat can exit from the engine is by radiation. The rate at which heat is radiated is proportional to the fourth power of the absolute temperature of the sink, 'T_2' and to the area of the radiating surface, 'A'. Show that for a given power output and a given source temperature T_1, the area of the radiator will be a minimum when $T_2=0.75T_1$. **(04)**

2C. A closed system contains air at a pressure of 2 bar, temperature 500 K and volume of 0.02 m^3. The system undergoes the following processes in series as **(04)**

i. Constant volume heat addition till pressure becomes 6 bar
ii. Constant pressure cooling
iii. Heating to initial state as per polytropic process $pV^2=constant$.

Represent the complete cycle on a P-V plot and calculate the change in entropy for each process. Take c_p=1.005 kJ/kgK, R=0.287kJ/kgK

3A. Sketch and explain the P-v-T surface for a substance that expands on freezing. **(04)**

3B. Steam at 10 bar and 250ºC expands to a final pressure of 1 bar as per a polytropic process $pv^{1.2}=constant$. Determine the final specific volume, the final temperature and the heat transferred per kg of steam. **(03)**

3C. A spherical aluminium vessel with an inside diameter of 0.3 m and wall thickness 0.62 cm contains water at 25ºC which is 1% dry. The vessel is heated till the water inside becomes dry saturated vapor. Find the total heat transfer to the combined system of water and vessel. Density of Aluminium is 2700 kg/m^3, specific heat of Aluminium is 0.9 kJ/kgK. **(03)**

4A. Three separate insulated tanks contain different gases as shown in the **Table 4A**. **(03)**

Table 4A. Description of gases in the tanks

Gas	m (kg)	p (kPa)	T (K)
N_2	1	350	300
CO_2	3	400	400
O_2	2	700	500

If the tanks are interconnected, determine the final pressure and temperature of the resulting mixture at equilibrium.

4B. State the law of corresponding states. Using this law, determine the compressibility factor for steam at 40 bar and 300ºC. **(03)**

4C. A hall of size 15×15×35 m^3 contains air at 25°C and 101 kPa at a relative humidity of 82%. Determine **(04)**

a) Partial pressure of dry air

b) Specific humidity

c) Enthalpy per unit mass of dry air

d) Masses of dry air and water vapor in the room

e) Dew point of the air

5A. Sketch the T-s and P-v plots for an Ideal Dual cycle. **(02)**

5B. A dense air refrigeration system is required to provide 10 tons of load, with a cooler pressure of 50 N/cm^2 and refrigerator pressure of 15 N/cm^2. Air is cooled in the cooler to a temperature of 60°C and the temperature of air at the entry to compressor is -30°C. Assume theoretical cycle with isentropic compression and expansion and no heat losses. Determine (i) COP of the plant (ii) Mass of air in circulation. **(04)**

5C. In an air standard Otto cycle, the compression ratio is 7. Compression begins at 35ºC, 0.1 MPa. The maximum temperature of the cycle is 1100ºC. Determine (a) the temperature and pressure at each of the four states of the cycle. (b) the heat supplied per kg of air (c) work done per kg of air (d) cycle efficiency. **(04)**