Ref. No. (IEBE/PE/T/122 (OLD)/2019)

B. IE ENGINEERING 1ST YEAR SECOND SEMESTER (OLD)EXAMINATION 2019

*SUBJECT: **APPLIED THERMODYNAMICS***

Time: Three Hours **Full Marks: 100**

Answer any 5

1.

a. Define heat and work. State the first law of thermodynamics for a closed system. What do you mean by PMM I.? **10**

b. A piston-cylinder arrangement shown in Fig 1 initially contains air at 200 kPa and 600 K. The set-up is allowed to cool to the ambient temperature of 300 K. (a) Will the piston be resting on the stops in the final state? What will be the final pressure in the cylinder? (b) What will be the specific work done by the air during the process? **10**

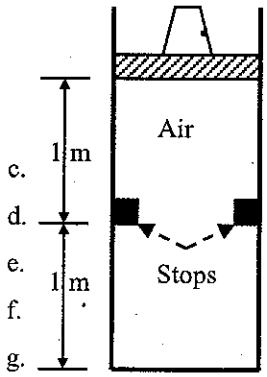

Fig 1 (P1b)

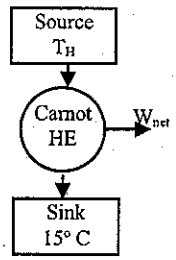

Fig 2 (P2a)

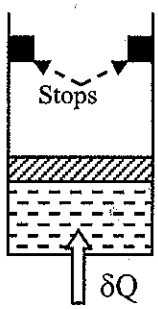

Fig 3 (P2b)

2.

a. A heat engine is operating on Carnot cycle and has a thermal efficiency of 55%. The waste heat from this engine is rejected to a nearby lake at 15°C at a rate of 800 kJ/min (see **Fig. 2**). Determine (a) the power output of the engine and (b) the temperature of the source. **10**

b. 5 kg of water at 15°C is contained in a vertical cylinder by a frictionless piston of a mass such that the pressure of the water is 700 kPa (**see Fig 3**). Heat is transferred slowly to the water, causing the piston to rise until it reaches the stops at which point the volume inside the cylinder is 0.5 m^3. More heat is transferred to the water until it exists as dry vapor. Find (a) the final pressure in the cylinder, (b) the heat transfer and work done during the process. (c) Show the process on T-s diagram. **10**

3.

a. Write down the First Law of thermodynamics for an open system and derive the steady flow energy equation from it **5**

b. Steam enters a turbine at 100 bar and 450 °C and expands to 0.1 bar. The turbine has an isentropic efficiency of 90%. Calculate the mass flow rate through the turbine if it delivers 100 MW of internal power. **15**

4.

a. Write down the Kelvin Planck and Clausius statements. **4**

b. Define COP of heat pump and refrigerator. Show that $[(COP)_{HP} - (COP)_R] = 1$ **6**

c. A house in winter loses heat at a rate of 5400 kJ/h per °C between the indoor and outdoor. A reversible heat pump requires a power input of 6 kW for maintaining the indoor temperature at 21°C. Determine the outdoor temperature. **10**

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5.

a. An ideal air-standard diesel engine cycle has air before compression at 285K and 85 kPa. The highest temperature is 2200 K, and the highest pressure is 6 MPa. Find the volumetric compression ratio and thermal efficiency. **10**

b. Consider an ideal air standard Brayton cycle in which the air into the compressor is at 100 kPa and 27°C, and the pressure ratio across the compressor is 12:1. The maximum operating temperature of the cycle is 1100°C, and the airflow rate is 10 kg/s. Determine the net work output, the work ratio and cycle efficiency. **10**

6.

a. What do you mean by 1 T of refrigeration? **2**

b. Refrigerant 134a is the working fluid in an ideal vapor-compression refrigeration cycle that communicates thermally with a cold region at 0 °C and a warm region at 30 °C. Saturated vapor enters the compressor at 0°C and saturated liquid leaves the condenser at 30 °C. Plot the process on representative T-s and p-h diagrams. The mass flow rate of the refrigerant is 0.08 kg/s. Determine (a) the compressor power, in kW, (b) the refrigeration capacity, in tons, (c) the coefficient of performance, and (d) the coefficient of performance of a Carnot refrigeration cycle operating between warm and cold regions at 30 and 0 °C, respectively. Use the enclosed property chart for R-134. **18**

7.

a. Hot air at 100°C is blown over a 2m × 2m flat plate maintained at 0°C. If the average heat transfer coefficient is 20 W/m^{2}K, determine the rate of heat transfer to the plate. **5**

b. The wall of a refrigerator is constructed of fiberglass insulation (k=0.035 W/m.K) sandwiched between two layers of 1-mm-thick sheet metal (k=15.1 W/m.K). The refrigerated space is maintained at 3° C, and the average heat transfer coefficients at the inner and outer surfaces of the wall are 4 W/m^{2}K and 9 W/m^{2}K K, respectively. The kitchen temperature averages 25°C. It is observed that the outer surface temperature of the refrigerator is to 10°C. Determine the thickness L of fiberglass insulation. **15**

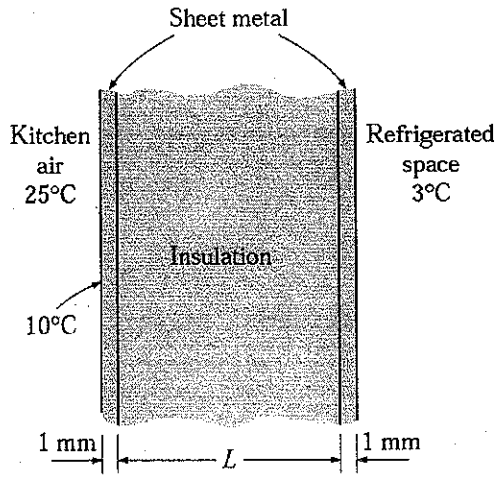

Fig. 7b

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