*Ref. No:* **Ex/EE/ES/B/ME/T/216/2024**

**B.E. ELECTRICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAM 2024**

**ENGINEERING THERMODYNAMICS & HEAT POWER**

**Time: Three hours** **Full Marks 100**

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| | **All parts of the same question must be answered together. Assume any unfurnished data suitably**<br>**Use of Thermodynamic Tables and Charts permitted** | |
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| | **Group I**<br>**Answer any one question** | |
| Q:1.(a) | What is the difference between intensive and extensive properties? | |
| (b) | Explain reversibility and irreversibility | |
| (c) | What is the difference between gauge pressure and absolute pressure? | 10 |
| (d) | What is the difference between heat pump and refrigerator? | |
| (e) | A rigid tank with a volume of 2.5 $m^3$ contains 15 kg of saturated liquid–vapor mixture of water at 75°C. Now the water is slowly heated. Determine the temperature at which the liquid in the tank is completely vaporized. Also, show the process on a T-v diagram with respect to saturation lines. | 10 |
| Q:2(a) | What is point and path functions? Give some examples. | 4 |
| (b) | Liquid water is heated, so it becomes superheated vapor. Can specific heat be used to find the heat transfer? Explain. | 3 |
| (c) | A room is heated by an iron that is left plugged in. Is this a heat or work interaction? Take the entire room, including the iron, as the system. | 3 |
| (d) | A vertical piston with freely propagating piston contains 0.1 kg air at 1.2 bar and a small electrical resistor. The resistor is wired to an external 12 volt battery. When a current of 1.5 amps is passed through the resistor for 90 seconds, the piston sweeps a volume of 0.01 $m^3$.<br>Assume<br>(i) Piston and cylinder are insulator<br>(ii) Air behaves as an ideal gas with $C_v$ = 700 J/kg K<br>Find the rise in temperature of gas. | 10 |
| | **Group II**<br>**Answer any three questions** | |
| Q:3.(a) | What is the difference between the critical point and the triple point? | 3 |
| (b) | What is the difference between $R$ and $R_u$? How are these two related? | 3 |

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| (c) | Steam at 0.6 MPa and 200°C enters an insulated nozzle with a velocity of 50 m/s. It leaves at a pressure of 0.15 MPa and a velocity of 600 m/s. Determine the final temperature if the steam is superheated in the final state and the quality if it is saturated. | 14 |
| Q.4.(a) | In the absence of any friction and other irreversibilities, can a heat engine have an efficiency of 100 percent? Explain. | 4 |
| (b) | A Carnot heat engine receives heat from a reservoir at 900°C at a rate of 800 kJ/min and rejects the waste heat to the ambient air at 27°C. The entire work output of the heat engine is used to drive a refrigerator that removes heat from the refrigerated space at -5°C and transfers it to the same ambient air at 27°C. Determine (*a*) the maximum rate of heat removal from the refrigerated space and (*b*) the total rate of heat rejection to the ambient air. | 16 |
| Q:5 (a) | Prove that the COP of a reversible heat pump operating between two given temperatures is the maximum. | 10 |
| (b) | An inventor claims to have developed a refrigeration unit which maintains the refrigerated space at –10°C while operating in a room where the temperature is 25°C, and which has a COP of 8.5. How do you evaluate his claim? How would you evaluate his claim of a COP of 7.5? | 10 |
| Q:6 (a) | Show that through one point there can pass only one adiabatic. | 4 |
| (b) | A system undergoes a process between two fixed states first in a reversible manner and then in an irreversible manner. For which case is the entropy change greater? Why? | 4 |
| (c) | Two bodies of equal mass m and heat capacity $C$ are at temperatures $T_1$ and $T_2$ respectively ($T_1 > T_2$). If the first body is used as the source of heat for a reversible engine and the second as sink, show that the maximum work obtainable from such an arrangement is $mC(\sqrt{T1} - \sqrt{T2})^2$. | 12 |
| | **Group III**<br>**Answer any one questions** | |
| Q:7.(a) | Why is the Carnot cycle not suitable as an ideal cycle for all power-producing cyclic devices? | 3 |
| (b) | What is the difference between spark-ignition and compression-ignition engines? | 4 |
| (c) | Derive the expression of thermal efficiency of Otto cycle in terms of compression ratio. | 13 |
| 8. (a) | What four processes make up the simple ideal Rankin cycle? | 3 |
| (b) | Consider a simple ideal Rankine cycle with fixed turbine inlet conditions. What is the effect of lowering the condenser pressure on? | 4 |
| (c) | The power output of an adiabatic steam turbine is 5 MW, and the inlet and the exit conditions of the steam are as indicated in following figure | |

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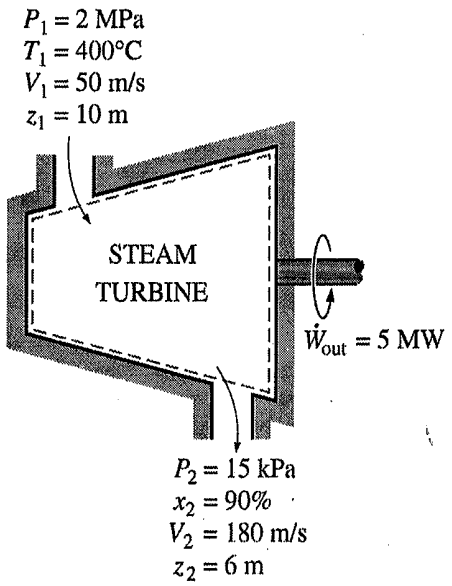
| |  <br>(a) Compare the magnitudes of Δh, Δke, and Δpe.<br>(b) Determine the work done per unit mass of the steam flowing through the turbine.<br>(c) Calculate the mass flow rate of the steam. | 13 |
| 9.(a) | Air goes through a polytropic process from 125 kPa and 325K to 300 kPa and 500 K. Find the polytropic exponent **n** and the specific work in the process. | 10 |
| (b) | In an Otto cycle air at $17^0$C and 1 bar is compressed adiabatically until the pressure is 15 bar. Heat is added at constant volume until the pressure rises to 40 bar. Calculate the air-standard efficiency, the compression ratio and mean effective pressure for the cycle. Assume $C_v$=0.716 kJ/kg K and R=8.314kJ/kmol K. | 10 |