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# B.M.S. College of Engineering, Bengaluru-560019

**Autonomous Institute Affiliated to VTU**

## January / February 2025 Semester End Main Examinations

**Programme: B.E.** **Semester: III**

**Branch: Mechanical Engineering** **Duration: 3 hrs.**

**Course Code: 23ME3PCETD / 22ME3PCETD** **Max Marks: 100**

**Course: Engineering Thermodynamics**

**Instructions**: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Use of thermodynamic data handbook is permitted
3. Missing data, if any, may be suitably assumed.

**Important Note:** Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.



| | | **UNIT - I** | *CO* | *PO* | **Marks** |
|---|---|---|---|---|---|
| 1 | a) | Define the following.<br>(i) Closed and open system, (ii) Thermodynamic equilibrium, (iii) Intensive and extensive property, (iv) Zeroth Law of Thermodynamics. | *CO1* | *PO1* | **08** |
| | b) | What is quasistatic process and what is the significance of quasistatic process. | *CO1* | *PO1* | **04** |
| | c) | A mass of gas is compressed in a quasi-static process from 80 kPa, 0.1 $m^3$ to 0.4 MPa, 0.03 $m^3$. Assuming that the pressure and volume are related by $Pv^n$ = constant, find the work done by the gas system. | *CO1* | *PO2* | **08** |
| | | **OR** | | | |
| 2 | a) | Derive an expression for displacement work for isothermal and polytropic processes. | *CO1* | *PO1* | **08** |
| | b) | Compare the heat and work transfer. | *CO1* | *PO1* | **04** |
| | c) | If a gas of volume 6000 $cm^3$ and at pressure of 100 kPa is compressed quasistatically according to $PV^2$ = constant until the volume becomes 2000 $cm^3$, determine (i) final pressure and (ii) the work transfer. | *CO1* | *PO2* | **08** |
| | | **UNIT - II** | | | |
| 3 | a) | State the first law of thermodynamic for cyclic and non-cyclic process. | *CO2* | *PO1* | **06** |
| | b) | Show that energy is a property of the system. | *CO2* | *PO1* | **06** |
| | c) | A gas undergoes a thermodynamic cycle consisting of the following processes:<br>(i) Process 1-2: Constant pressure P = 1.4 bar, $V_1$ = 0.028 $m^3$, $W_{12}$ = 10.5kJ. | *CO2* | *PO2* | **08** |

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| | | | (ii) Process 2-3: Compression with PV = constant, $U_3 = U_2$<br>(iii) Process 3-1: Constant volume, $U_1 - U_3 = -26.4$ kJ. There are no significant changes in KE and PE.<br>(a) Sketch the cycle on a *P-v* diagram.<br>(b) Calculate the net work for the cycle in kJ.<br>(c) Calculate the heat transfer for process 1-2<br>(d) Show that $\sum Q_{cycle} = \sum W_{cycle}$. | | | |
| | | | **OR** | | | |
| | 4 | a) | Reduce the steady flow energy equation for the following devices with suitable assumptions:<br>(i) Turbine.<br>(ii) Throttling device.<br>(iii) Nozzle. | *CO2* | *PO1* | **06** |
| | | b) | What is PMM1? Why it is impossible? | *CO2* | *PO1* | **04** |
| | | c) | Air flows steadily at the rate of 0.5 kg/s through an air compressor, entering at 7m/s velocity, 100 kPa pressure, and 0.95 $m^3$ /kg volume, and leaving at 5 m/s, 700 kPa, and 0.19 $m^3$ /kg. The internal energy of the air leaving is 90 kJ/kg greater than that of the air entering. Cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kW. Compute the rate of shaft work input to the air in kW. | *CO2* | *PO2* | **10** |
| | | | **UNIT – III** | | | |
| | 5 | a) | Show that Kelvin-Planck and Clausius statements of second law of thermodynamics are equivalent. | *CO3* | *PO1* | **08** |
| | | b) | Show that COP of heat pump is greater than COP of refrigerator by unity. | *CO3* | *PO1* | **04** |
| | | c) | A reversible heat engine operates between two reservoirs at temperatures of 600°C and 40°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40°C and - 20°C. The heat transfer to the heat engine is 2000 kJ and the network output of the combined engine refrigerator plant is 360 kJ. Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C. | *CO3* | *PO2* | **08** |
| | | | **OR** | | | |
| | 6 | a) | State and prove Clausius inequality. | *CO3* | *PO1* | **08** |
| | | b) | Explain principle of increase of entropy of universe. | *CO3* | *PO1* | **04** |
| | | c) | One kg of ice at - 5°C is exposed to the atmosphere which is at 20°C. The ice melts and comes into thermal equilibrium with the atmosphere. (i) Determine the entropy increase of the universe. | *CO3* | *PO2* | **08** |
| | | | **UNIT – IV** | | | |
| | 7 | a) | Derive an expression for entropy change for ideal gas during polytropic process. | *CO4* | *PO1* | **06** |

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| | | b) | Explain universal and particular gas constants. | *CO4* | *PO1* | **04** |
| | | c) | A certain gas with $C_p$ = 1.968 kJ/kgK and $C_v$ =1.507 kJ/kgK in a constant volume chamber of 0.3m$^3$ capacity has a mass of 2 kg at 5 $^0$C. The heat is transferred to the gas until the temperature is 100 $^0$C. find (i) Molecular weight of gas (ii) Gas constant, (iii) Work done, (iv) Heat transferred, (v) Change in internal energy, (vi) Change in enthalpy and (vii) Change in entropy. | *CO4* | *PO2* | **10** |
| | | | **OR** | | | |
| | 8 | a) | Explain the following:<br>(i) Law of corresponding states.<br>(ii) Compressibility factor.<br>(iii) Reduced properties. | *CO4* | *PO1* | **06** |
| | | b) | Differentiate between ideal and real gases. | *CO4* | *PO1* | **04** |
| | | c) | One kg of $CO_2$ has a volume of 1m$^3$ at 100 $^0$C. compute the pressure by:<br>(i) Van der Waal's equation.<br>(ii) Perfect gas equation. | *CO4* | *PO2* | **10** |
| | | | **UNIT – V** | | | |
| | 9 | a) | With the help of *T-h* diagram explain the following terms:<br>(i) Sensible heat of water.<br>(ii) Latent heat of vaporization.<br>(iii) Dryness fraction.<br>(iv) Enthalpy of wet steam.<br>(v) Enthalpy of superheat steam. | *CO5* | *PO1* | **10** |
| | | b) | Steam initially at 1.5 MPa, 300 $^0$C expands reversibly and adiabatically in a steam turbine to 40 $^0$C. determine the ideal work output of the turbine per kg of steam. | *CO5* | *PO2* | **10** |
| | | | **OR** | | | |
| | 10 | a) | Explain the simple Rankine cycle with the help of schematic diagram and *h-s* diagrams for ideal case and obtain an expression for cycle efficiency. | *CO5* | *PO2* | **10** |
| | | b) | A simple Rankine cycle works between pressure of 28 bar and 0.06 bar, the initial condition of steam being dry saturated. Calculate the cycle efficiency. | *CO5* | *PO2* | **10** |

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