Code No: R1621033 **R16** SET - 1

II B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019
THERMODYNAMICS
(Com to ME, AE and AME)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

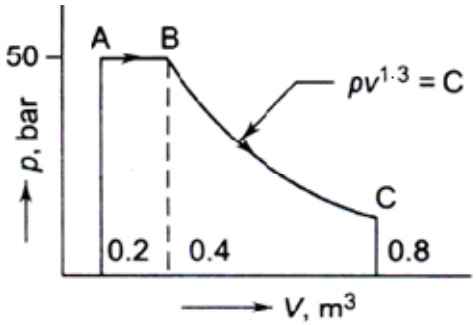
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PART –A

1. a) What are the conditions for thermodynamic equilibrium? (2M)
   b) What are the limitations of first law of thermodynamics? (3M)
   c) What is the difference between a heat pump and a refrigerator? (2M)
   d) Explain the terms, Degree of super heat, degree of sub-cooling. (2M)
   e) What are the important psychrometric process? (2M)
   f) Why carnot cycle cannot be realised in practice for vapour power cycles? (3M)

PART -B

2. a) Determine the total work done by a gas system following an expansion process as shown in Figure. (7M)



   b) Amass 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. (7M)

3. a) Show that energy is a property of a system. (7M)
   b) A mass of 8 kg gas expands within a flexible container so that the p–v relationship is of the from $pv^{1.2}$ = constant. The initial pressure is 1000 kPa and the initial volume is 1 m^3. The final pressure is 5 kPa. If specific internal energy of the gas decreases by 40 kJ/kg, find the heat transfer in magnitude and direction (7M)

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4. a) Establish the equivalence of Kelvin- Planck and Clausius statements. (7M)

   b) Two reversible heat engines *A* and *B* are arranged in series, A rejecting heat directly to *B*. Engine *A* receives 200 kJ at a temperature of 421°C from a hot source, while engine *B* is in communication with a cold sink at a temperature of 4.4°C. If the work output of *A* is twice that of *B,* find (7M)
   (i) The intermediate temperature between *A* and *B*
   (ii) The efficiency of each engine
   (iii) The heat rejected to the cold sink

5. a) Draw the phase equilibrium diagram for a pure substance on T-s plot with relevant constant property lines. (7M)

   b) Two insulated tanks, *A* and *B*, are connected by a valve. Tank *A* has a volume of 0.70 m3 and contains steam at 1.5 bar, 200°C. Tank *B* has a volume of 0.35 ^{m3} and contains steam at 6 bar with a quality of 90%. The valve is then opened, and the two tanks come to a uniform state. If there is no heat transfer during the process, what is the final pressure? Compute the entropy change of the universe. (7M)

6. An ideal gas cycle consists of the following reversible processes: (14M)
   (i) isentropic compression, (ii) constant volume heat addition, (iii) isentropic expansion, and (iv) constant pressure heat rejection.
   Show that the efficiency of this cycle is given by
   $$\eta = 1 - 1/r^{\gamma-1}[\gamma (a^{1/\gamma} -1)/a-1]$$
   Where k r is the compression ratio and *a* is the ratio of pressures after and before heat addition.
   An engine operating on the above cycle with a compression ratio of 6 starts the compression with air at 1 bar, 300 K. If the ratio of pressures after and before heat addition is 2.5, calculate the efficiency and the m.e.p. of the cycle. Take $\gamma = 1.4$ and c v = 0.718 kJ/kg K.

7. a) Two engines are to operate on Otto and Diesel cycles with the following data: Maximum temperature 1400 K, exhaust temperature 700 K. State of air at the beginning of compression 0.1 MPa, 300 K. Estimate the compression ratios, the maximum pressures, efficiencies, and rate of work outputs (for 1 kg/min of air) of the respective cycles. (7M)

   b) How is a reversed Brayton cycle used for a refrigeration? (7M)

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PART –A

1. a) Prove that for an isolated system, there is no change in internal energy? (2M)
   b) Indicate the practical application of steady flow energy equation. (2M)
   c) What do you understand by the entropy principle? (2M)
   d) Explain the term critical point, critical temperature and critical pressure. (3M)
   e) Explain Dalton's law of partial pressure. (3M)
   f) What is meant by work ratio? What is the importance of work ratio in vapour cycles? (2M)

PART -B

2. a) A mass of 1.5 kg of air is compressed in a quasi-static process from 0.1 MPa to 0.7 MPa for which pv = constant. The initial density of air is 1.16 kg/m^3. Find the work done by the piston to compress the air. (7M)
   b) Show that work is a path function and not a property. (7M)

3. a) Which property of a system increases when heat is transferred: i). at constant volume, ii).at constant pressure? (7M)
   b) The properties of a certain fluid are related as follows: (7M)
   $u = 196 + 0.718t$
   $pv = 0.287\ (t + 273)$
   Where u is the specific internal energy (kJ/kg), t is in °C, p is pressure (kN/m^2), and v is specific volume (m^3/kg). For this fluid, find cv and cp.

4. a) In a steam generator, water is evaporated at 260°C, while the combustion gas (cp = 1.08 kJ/kg K) is cooled from 1300°C to 320°C. The surroundings are at 30°C. Determine the loss in available energy due to the above heat transfer per kg of water evaporated (Latent heat of vaporization of water at 260°C = 1662.5 kJ/kg). (7M)
   b) Calculate the entropy change of the universe as a result of the following processes: (7M)
   (i) A copper block of 600 g mass and with Cp of 150 J/K at 100°C is placed in a lake at 8°C.
   (ii) The same block, at 8°C, is dropped from a height of 100 m into the lake.
   (iii) Two such blocks, at 100 and 0°C, are joined together.

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5. Steam at 10 bar, 250°C flowing with negligible velocity at the rate of 3 kg/min mixes adiabatically with steam at 10 bar, 0.75 quality, flowing also with negligible velocity at the rate of 5 kg/min. The combined stream of steam is throttled to 5 bar and then expanded isentropically in a nozzle to 2 bar. Determine (14M)
   (a) The state of steam after mixing
   (b) The state of steam after throttling
   (c) The increase in entropy due to throttling
   (d) The velocity of steam at the exit from the nozzle
   (e) The exit area of the nozzle. Neglect the K.E. of steam at the inlet to the nozzle.

6. A gaseous mixture contains 21% by volume of nitrogen, 50% by volume of hydrogen, and 29% by volume of carbon-dioxide. Calculate the molecular weight of the mixture, the characteristic gas constant *R* for the mixture and the value of the reversible adiabatic index γ. (At 10ºC, the c p values of nitrogen, hydrogen, and carbon dioxide are l.039, 14.235, and 0.828 kJ/kg K respectively.) A cylinder contains 0.085 m^3 of the mixture at 1 bar and 10°C. The gas undergoes a reversible non-flow process during which its volume is reduced to one-fifth of its original value. If the law of compression is $pv^{1.2}$ = constant, determine the work and heat transfer in magnitude and sense and the change in entropy. (14M)

7. a) Explain the the effect of pressure ratio on the net output and efficiency of a Brayton cycle. (7M)
   b) In a gas turbine plant working on the Brayton cycle the air at the inlet is at 27°C, 0.1 MPa. The pressure ratio is 6.25 and the maximum temperature is 800°C. The turbi- ne and compressor efficiencies are each 80%. Find (i) the compressor work per kg of air, (ii) the turbine work per kg of air, (iii) the heat supplied per kg of air, (iv) the cycle efficiency, and (v) the turbine exhaust temperature. (7M)

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PART –A

1. a) When a system will be in a state of thermodynamic equilibrium? (2M)
   b) Define perpetual motion machine (PMM) of first kind (2M)
   c) Define available energy and unavailable energy. (2M)
   d) Explain heat of super heat or super heat enthalpy. (2M)
   e) What are the assumptions made on the analysis of ideal Rankine cycle? (3M)
   f) Represent the following Psychrometric process using skeleton Psychrometric chart? i. Cooling and dehumidification
      ii. Evaporative cooling. (3M)

PART -B

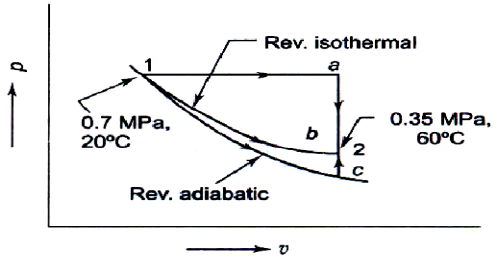
2. a) What do you understand by flow work? It is different from displacement work? (7M)
   b) If a gas of volume 6000 $cm^3$and at pressure of 100 kPa is compressed quasistatically according to pV^2= constant until the volume becomes 2000 cm^3, determine the final pressure and the work transfer. (7M)

3. a) What is a PMM1? Why is it impossible? (4M)
   b) A gas undergoes a thermodynamic cycle consisting of the following processes: (10M)
   (I) Process 1–2: Constant pressure p = 1.4 bar, V1 = 0.028 m^3, W12 = 10.5 kJ
   (II) Process 2–3: Compression with pV = constant, U3 = U2
   (III) Process 3–1: Constant volume, U1 – U3 = – 26.4 kJ.
   There are no significant changes in KE and PE.
   (i) Sketch the cycle on a *p–V* diagram
   (ii) Calculate the net work for the cycle in kJ
   (iii) Calculate the heat transfer for process 1–2
   (iv) Show that $\Sigma Q_{cycle} = \Sigma W_{cycle}$.(4M+10M)

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4. a) 0.2 kg of air at 300°C is heated reversibly at constant pressure to 2066 K. Find the available and unavailable energies of the heat added. Take *T*0 = 30°C and *cp* = 1.0047 kJ/kg K. (4M)

   b) One kg of air initially at 0.7 MPa, 20°C changes to 0.35 MPa, 60°C by the three reversible non-flow processes, as shown in Figure. Process 1: *a*-2 consists of a constant pressure expansion followed by a constant volume cooling, process 1: *b*-2 an isothermal expansion followed by a constant pressure expansion, and process 1: *c*-2 an adiabatic (10M)



   Expansion followed by a constant volume heating. Determine the change of internal energy, enthalpy, and entropy for each process, and find the work transfer and heat transfer for each process.
   Take *cp* = 1.005 and c v= 0.718 kJ/kg K and assume the specific heats to be constant. Also assume for air *pv* = 0.287 T, where *p* is the pressure in kPa, *v* the specific volume in m^3/kg, and *T* the temperature in K.

5. a) What do you understand by triple point? Give the pressure and temperature of water at its triple point. (7M)

   b) A rigid vessel contains 1 kg of a mixture of saturated water and saturated steam at a pressure of 0.15 MPa. When the mixture is heated, the state passes through the critical point. Determine (7M)
   (i) The volume of the vessel
   (ii) The mass of liquid and of vapour in the vessel initially

6. a) Define the terms Specific humidity, Relative humidity and Degree of saturation. (7M)

   b) The specific heat at constant pressure for air is given bycp = 0.9169 + 2.577 + 10^{-4}T - 3.974 * 10^{-8}T2 kJ/kg K Determine the change in internal energy and that in entropy of air when it undergoes a change of state from 1 atm and 298 K to a temperature of 2000 K at the same pressure. (7M)

7. a) Mention the merits and demerits of the Stirling and Ericsson cycles. (7M)

   b) An ideal air cycle consists of isentropic compression, constant volume heat transfer, isothermal expansion to the original pressure, and constant pressure heat transfer to the original temperature. Deduce an expression for the cycle efficiency in terms of volumetric compression ratio *r k,* and isothermal expansion ratio, *r k* In such a cycle, the pressure and temperature at the start of compression are 1 bar and 40°C, the compression ratio is 8, and the maximum pressure is 100 bar. Determine the cycle efficiency and the m.e.p. (7M)

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PART –A

1. a) What is Quasi – Static process? (2M)
   b) Name and explain the two types of properties. (2M)
   c) What are the Corollaries of Carnot theorem? (2M)
   d) Define heat of vapourisation. (2M)
   e) How does humidity affect human comfort? (3M)
   f) Compare Carnot and Rankine cycles (3M)

PART -B

2. a) What is a quasi-static process? What is its characteristic feature? (4M)
   b) A system of volume *V* contains a mass *m* of gas at pressure *p* and temperature *T*. The macroscopic properties of the system obey the following relationship: (10M)
   $(p + a/V^2)(V - b) = mRT$
   Where *a, b,* and *R* are constants.
   Obtain an expression for the displacement work done by the system during a constant-temperature expansion from volume *V*1 to volume *V*2. Calculate the work done by a system which contains 10 kg of this gas expanding from 1 m^3 to 10 m^3 at a temperature of 293 K. Use the values
   $a = 15.7 \times 10$ Nm^4, $b = 1.07 \times 10^{-2}$ m^3, and R = 0.278 kJ/kg-K.

3. a) Define enthalpy. Why does the enthalpy of an ideal gas depend only on temperature? (4M)
   b) A gas of mass 1.5 kg undergoes a quasi-static expansion which follows a relationship $p = a + bV$, where *a* and *b* are constants. The initial and final pressures are 1000 kPa and 200 kPa respectively and the corresponding volumes are 0.20 m^3 and 1.20 m^3. The specific internal energy of the gasis given by the relation, $u = 1.5\,pv - 85$ kJ/kg (10M)
   Where *p* is the kPa and *v* is in m^3/kg. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion.

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4. a) Give expressions for availabilities of a closed system and a steady flow open system. (7M)

   b) A heat pump working on the Carnot cycle takes in heat from a reservoir at 5°C and delivers heat to a reservoir at 60°C. The heat pump is driven by a reversible heat engine which takes in heat from a reservoir at 840°C and rejects heat to a reservoir at 60°C. The reversible heat engine alsodrives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ/s from the 5°C reservoir, determine (7M)
   (i) The rate of heat supply from the 840°C source
   (ii) The rate of heat rejection to the 60°C sink.

5. Boiler steam at 8 bar, 250°C, reaches the engine control valve through a pipeline at 7 bar, 200°C. It is throttled to 5 bar before expanding in the engine to 0.1 bar, 0.9 dry. Determine per kg of steam (14M)
   (a) The heat loss in the pipeline
   (b) The temperature drop in passing through the throttle valve
   (c) The work output of the engine
   (d) The entropy change due to throttling
   (e) The entropy change in passing through the engine.

6. a) Define the terms Dry bulb temperature, Wet bulb temperature, Dew point temperature and Thermodynamic wet bulb temperature. (7M)

   b) Methane has a specific heat at constant pressure given by p c = 17.66 +0.06188 T kJ/kg mol K when 1 kg of methane is heated at constant volume from 27 to 500°C. If the initial pressure of the gas is 1 atm, calculate the final pressure, the heat transfer, the work done and the change in entropy. (7M)

7. a) An air standard limited pressure cycle has a compression ratio of 15 and compression begins at 0.1 MPa, 40°C. The maximum pressure is limited to 6 MPa and the heat added is 1.675 *MJ/kg*. Compute (10M)
   (i) the heat supplied at constant volume per kg of air,
   (ii) the heat supplied at constant pressure per kg of air,
   (iii) the work done per kg of air,
   (iv) the cycle efficiency,
   (v) the temperature at the end of the constant volume heating process,
   (vi) the cut-off ratio, and
   (vii) them.e.p. of the cycle.

   b) How does the actual vapour compression cycle differ from the ideal one? (4M)

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