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NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA

(An Autonomous Institute Affiliated to AKTU, Lucknow)

B.Tech.

SEM: III - THEORY EXAMINATION (2022 - 2023)

Subject: Basic Thermodynamics

Time: 3 Hours Max. Marks: 100

General Instructions:

IMP: Verify that you have received the question paper with the correct course, code, branch etc.

1. This Question paper comprises of three Sections -A, B, & C. It consists of Multiple Choice Questions (MCQ's) & Subjective type questions.
2. Maximum marks for each question are indicated on right -hand side of each question.
3. Illustrate your answers with neat sketches wherever necessary.
4. Assume suitable data if necessary. Use of steam tables & charts is permitted.
5. Preferably, write the answers in sequential order.
6. No sheet should be left blank. Any written material after a blank sheet will not be evaluated/checked.

SECTION A 20

1. Attempt all parts:-

1-a. Measurement of temperature is based on which law of thermodynamics? (CO1) 1

(a) First law of thermodynamics

(b) Second law of thermodynamics

(c) Third law of thermodynamics

(d) Zeroth law of thermodynamics

1-b. The cyclic integral of point function is (CO1) 1

(a) Zero

(b) One

(c) Infinity

(d) Two

1-c. Kelvin-Planck's law deals with (CO2) 1

(a) conservation of energy

(b) conservation of heat

(c) conversion of work into heat

(d) conversion of heat into work

1-d. Perpetual Motion Machine of Type 2 (PMM2) violates.................... of thermodynamics. (CO2) 1

(a) Zeroth law

(b) First law

(c) Second law

(d) Third law

1-e. Which of the following is the correct criteria for a spontaneous process? (CO3) 1

(a) $\Delta S_{system} - \Delta S_{surrounding} > 0$

(b) $\Delta S_{system} + \Delta S_{surrounding} > 0$

(c) $\Delta S_{surrounding} > 0$ only

(d) $\Delta S_{system} > 0$ only

1-f. Availability function for a closed system is given by .... (CO3) 1

(a) u - p.v - T.s

(b) u + p.v + T.s

(c) u + p.v - T.s

(d) u - p.v + T.s

where, u is specific internal energy, p is pressure, v is specific volume, T is absolute temperature and s is specific entropy

1-g. In Rankine cycle the work output from the turbine is given by (CO4) 1

(a) change of internal energy between inlet and outlet

(b) change of enthalpy between inlet and outlet

(c) change of entropy between inlet and outlet

(d) change of temperature between inlet and outlet

1-h. Choose the correct answer. (CO4) 1

(a) The slope of vapourisation curve is always negative

(b) The slope of vapourisation curve is always positive

(c) The slope of sublimation curve is negative for all pure substances

(d) The slope of fusion curve is positive for all pure substances

1-i. Clausius Clapeyron equation applies to the process (CO5) 1

(a) Sublimation

(b) Melting

(c) Vaporisation

(d) All of he mentioned

1-j. Clapeyron equation is a relation between (CO5) 1

(a) temperature, pressure and enthalpy

(b) specific volume and enthalpy

(c) temperature and enthalpy

(d) temperature, pressure, and specific volume

2. Attempt all parts:-

2.a. Explain briefly the Zeroth law of thermodynamics. (CO1) 2

2.b. What is importance of Steady Flow Energy equation? (CO2) 2

2.c. What do you understand by the 'dead state'? (CO3) 2

2.d. Explain the difference between Critical point and Triple point. (CO4) 2

2.e. Define the terms compression ratio and mean effective pressure. (CO5) 2

SECTION B 30

3. Answer any five of the following:-

3-a. What is the value of 27°C in Kelvin ? A gas at 65 kPa, 200°C is heated in a closed, rigid vessel till it reaches to 400°C. Determine the amount of heat required for 0.5 kg of this gas if internal energy at 200°C and 400°C are 26.6 kJ/kg and 37.8 kJ/kg respectively. (CO1) 6

3-b. During one cycle the working fluid in an engine engages in two work interactions: 20 kJ to the fluid and 50 kJ from the fluid, and three heat interactions, two of which are known: 80 kJ to the fluid and 45 kJ from the fluid. Evaluate the magnitude and direction of the third heat interaction. (CO1) 6

3-c. If a refrigerator is used for heating purposes in winter so that the atmosphere becomes the cold body and the room to be heated becomes the hot body, how much heat would be available for heating for each kW input to the driving motor? The COP of the refrigerator is 5, and the electromechanical efficiency of the motor is 90%. (CO2) 6

3-d. A refrigerator is used to maintain temperature of 243K when ambient temperature is 303K. A heat engine working between high temperature reservoir of 200°C and ambient temperature is used to run this refrigerator. Considering all processes to be reversible, determine the ratio of heat transferred from high temperature reservoir to heat transferred from refrigerated space. (CO2) 6

3.e. Define the term availability in regards of the thermodynamic system. Obtain an expression 6 for availability of a closed system. (CO3)

3.f. Consider a steam power plant operating on the ideal Rankine cycle. Steam enters the turbine at 3 MPa and 350°C and is condensed in the condenser at a pressure of 10 kPa. Determine (a) the thermal efficiency of this power plant, (b) Improvement in the thermal efficiency if steam is superheated to 600°C instead of 350°C. (CO4) 6

3.g. An internal combustion engine is working on ideal Diesel cycle with a compression ratio of 8 and cut-off ratio of 5. Calculate the air-standard cycle efficiency for the engine. Assume $\gamma = 1.41$. (CO5) 6

SECTION C 50

4. Answer any <u>one</u> of the following:-

4-a. 0.15 m^3 of an ideal gas at a pressure of 15 bar and 650 K is expanded isothermally to 4 times the initial volume. It is then cooled to 290 K at constant volume and then compressed back polytropically to its initial state. Calculate the net work done and heat transferred during the cycle. (CO1) 10

4-b. State similarities between heat and work transfer. If a system returns to its original state, then what is the net change in internal energy? What are the limitations of first law of thermodynamics? (CO1) 10

5. Answer any <u>one</u> of the following:-

5-a. A diffuser is used to control air coming out of a mechanical system with a velocity of 850 m/s at 127 ºC and 2 bar pressure. Find the temperature and pressure at the exit of diffuser, if the permitted velocity at exit of the diffuser is 50 m/s. Take $\gamma = 1.41$ and C_p = 1.005 kJ/kgK (CO2) 10

5-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 also drives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ/s from the 5°C reservoir, determine: 10

(a) The rate of heat supply from the 840°C source

(b) The rate of heat rejection to the 60°C sink. (CO2)

6. Answer any <u>one</u> of the following:-

6-a. A heat engine receives reversibly 420 kJ/cycle of heat from a source at 327°C, and rejects some heat reversibly to a sink at 27°C. There are no other heat transfers. For each of the three hypothetical amounts of heat rejected, in (a), (b), and (c) below, compute the cyclic integral of dQ/T. From these results show which case is irreversible, which reversible, 10 and which is impossible:

(a) 210 kJ/cycle rejected

(b) 105 kJ/cycle rejected

(c) 315 kJ/cycle rejected (CO3)

6-b. In a thermodynamic system air contained at 20°C and 1.05 bar occupies 0.025 m^3 is heated at constant volume until the pressure becomes 4.5 bar. It is then cooled at constant pressure back to original temperature i.e. 20°C . Calculate : 10

(i) The net heat flow from the system

(ii) The net change in entropy of the system (CO3)

7. Answer any <u>one</u> of the following:-

7-a. In a steam power plant working on Rankine cycle, the steam at inlet to turbine is dry saturated at a pressure of 30 bar and after expansion the steam is rejected into a condenser at 0.25 bar. Determine : 10

(i) Dryness fraction at the end of expansion.

(ii) Thermal efficiency of plant

(iii) Power developed by the turbine (CO4)

Assume flow rate of 10 kg/s.

7-b. Define pure substance with examples. Draw T-s and h-s diagram for steam expanding in a nozzle from 10 bar 450°C to 1 bar pressure. Also find the velocity at exit, if the velocity at inlet is 40m/s . (CO4) 10

8. Answer any <u>one</u> of the following:-

8-a. In a constant volume 'Otto cycle', the pressure at the end of compression is 15 times that at the start, the temperature of air at the beginning of compression is 38°C and maximum temperature attained in the cycle is 1950°C. Determine : 10

(i) Compression ratio

(ii) maximum pressure during the cycle

(iii) Thermal efficiency of the cycle. (CO5)

Take γ for air = 1.4.

8-b. An ideal Otto cycle with air as the working fluid has a compression ratio of 8. The minimum and maximum temperatures in the cycle are 25 ^{o}C and 1000 ^{o}C respectively. Determine (a) the amount of heat transferred to the air during the heat addition process, (b) the thermal efficiency and (c) the mean effective pressure. (CO5) 10