MindVis GATE 2017 Online Preparation Course

Thermodynamics Questions

1 minute questions

Q1. Suppose 85 kJ of heat is supplied to a closed system at constant volume. During the next process, the system rejects 90 kJ of heat at constant pressure while 20 kJ of work is done on it. The system is brought to the original state by an adiabatic process. The initial internal energy is 100 kJ. Determine the quantity of work transfer during the process.

Ans: 15 kJ

Q2. A steam turbine receives steam steadily at 10 bar with an enthalpy of 3000 kJ/kg and discharges at 1 bar with an enthalpy of 2700 kJ/kg. The power output is 3.5 MW and the mass flow rate is 12 kg/s. Ignoring the changes in KE and PE, determine the rate of heat transfer from the turbine casing to the surroundings.

Ans: 100 W

Q3. An electric motor of 5 kW is subjected to a braking test for 1 hour. The heat generated by the frictional forces in the process is transferred to the surroundings at 20^0C. Calculate the entropy change in the process.

Ans: 61.43 kJ/K

Q4. If an engine of 40% thermal efficiency drives a refrigerator having a COP of 5, determine the heat input to the engine per kJ of heat removed from the cold body by the refrigerator.

Ans: 0.5 kJ

Q5. A heat pump is used to heat a house in the winter and then reversed to cool the house in the summer. The inside temperature of the house is to be maintained at 20^0C. The heat transfer through the house walls is 7.9 kJ/s and the outside temperature in winter is 5^0C. Calculate the minimum power required to drive the heat pump.

Ans: 404.43 W

Q6. The refrigerating efficiency of a refrigeration cycle is 0.8, the condenser and evaporator temperature are 51^0C and -30^0C, respectively. Calculate the work requirement for cooling capacity of 2.4 kW of the plant.

Ans: 1 kW

Q7. Experiments indicate that about 0.522 kW/m^2 of energy can be collected on a plate operating at 85^0C. This energy is to be transferred to a heat engine to produce 1 kW of

useful shaft power. The heat engine rejects heat to atmosphere at 25^0C. Determine the efficiency of the heat engine and minimum collector area of the plate.

Ans: 16.76 % and 11.43 m^2

Q8. Two moles of an ideal gas is isothermally and reversibly expanded from 10 to 1 atm. The external pressure is constant at 1 atm and the temperature is 300 K. Calculate the useful work done in the process (R = 8.3 J/mol K).

Ans: 6.984 kJ

Q9. A gas turbine develops 120 kJ of work while the compressor absorbs 60 kJ of work and the heat supplied is 200 kJ. If a regenerator which would recover 40% of the heat in the exhaust were used, determine the increase in the overall thermal efficiency.

Ans: 5.7%

Q10. Air expands from pressure P_1 to P_2 ($P_2 = P_1/10$). If the process of expansion is isothermal, the volume at the end of the expansion is 0.55 m^3. If the process of expansion is adiabatic, determine the volume at the end of the expansion.

Ans: 0.285 m^3

Numerical Answer Questions

Q1. The emf in a thermocouple with the test junction at T^0C on gas thermometer scale and reference junction at ice point is given by

$$\varepsilon = 0.2T - (5\times10^{-4})T^2\ mV$$

The mV is calibrated at ice and steam points. Calculate the emf reading at 50^0C and corresponding reading of this thermometer where the gas thermometer reads 50^0C.

Ans: 52.17^0C

Q2. In a manufacturing plant, it is required to melt iron at a rate of 1.4 kg/s, from initial temperature 25^0C to molten metal at 1700^0C. For this, an electric furnace of efficiency 80% is to be used. The melting point of iron is 1535^0C, latent heat is 270 kJ/kg and the specific heats in solid and liquid states are 0.502 kJ/kg K and 0.518 kJ/kg K respectively. The density of molten metal is 6900 kg/m^3 . The furnace volume should be three times the flow rate of the metal per hour. Calculate the kW rating of the electric furnace.

Ans: 1.948 MW

Q3. A system composed of 5 kg of a substance expands from an initial pressure 500 kPa and a volume 0.3 m^3 to a final pressure 101 kPa for which $pv^{1.2}$=constant. The internal energy (kJ) of the system is found to be a function of pressure (kPa) and volume (m^3) of the substance as

$$u = 3.6pv + 90$$

The expansion is quasi static process. Determine the net change in internal energy of the system and net heat transfer to the system.

Ans: -122.91 kJ and 47.79 kJ

Q4. A reversible heat engine operates between two temperature limits of 627^0C and 47^0C. The engine is used to drive a reversible refrigerator which operates between reservoirs at temperatures 47^0C and -23^0C. The heat transfer to the engine is 2400 kJ and the net work output of the combined plant is 450 kJ. Estimate the cooling effect of the refrigerant and the net heat transfer to the reservoir at 47^0C.

Ans: 3916.67 kJ and 4754.28 kJ

Q5. One kg of water is to be heated from an initial temperature of 25^0C to 100^0C by using thermal reservoirs. The specific heat of water is 4.186 kJ/kg. Calculate the entropy change of the universe if heating is done in single stage from 25^0C to 100^0 by a reservoir at temperature of 100^0C. What is the entropy change of the universe if heating is done in first by contact with thermal reservoir at 62^0C and then by another reservoir at temperature 100^0C?

Ans: 0.0276 kJ/K and 0.0233 kJ/K

Q6. A copper rod has a length of 2m and a diameter 0.02m. One end if the rod is at 150^0C and the other end is at 10^0C. The rod is perfectly insulated along its length and the thermal conductivity of copper is 380 W/mK. Calculate the rate of heat transfer along the rod. Also calculate the rate of entropy production due to irreversibility of the heat transfer.

Ans: 8.357 kW and 0.00969 kJ/K

Q7. A thermally insulated 100Ω resistor carries a current of 2A for 1 sec. The initial temperature of the resistor is 10^0C, its mass is 10g and its specific heat is 0.85 kJ/kg K. Calculate the entropy changes of the resistor and the universe, separately.

Ans: 1.307 kJ/K

Q8. 15 kg of water at 85^0C is mixed with 25 kg of water at 35^0C, the pressure being taken as constant and the temperature of the surroundings being maintained at 15^0C. Determine the temperatures of water after mixing, and the decrease in AE.

Ans: 130.85 kJ