Ref. No. : Ex/Met/BS/B/T/225/2024

B.E. METALLURGICAL ENGINEERING SECOND YEAR SECOND SEMESTER – 2024

THERMODYNAMICS OF MATERIALS

Time : Three hours | Full marks: 100

Answer Question 1 and any four from the rest
All questions carry equal marks
Notations have their usual significance
Assume any missing data

Q.No	Question	Marks
1(a)	What is the thermodynamic definition of work?	2
1(b)	Explain : "work is a path function"	2
1(c)	Initial volume of air in a piston cylinder arrangement Is 200cc. the volume is expanded to 400cc under a constant pressure of 2 atmosphere. Calculate the work done. Is it reversible work?	2
1(d)	In a chamber 50% of its volume is occupied by air. The other 50% is kept at vacuum. The chamber is divided by a partition. Air is allowed to expand by removing the partition. Calculate work done.	2
1(e)	With a proper diagram explain non-equilibrium work.	2
1(f)	A paddle wheel adds work to a rigid container by rotation caused by dropping a 50kg weight through a distance of 2 meter from a pulley. How much heat must be transferred to result an equivalent effect. draw a suitable diagram of the process.	2
1(g)	Explain internal energy of a substance.	2
1(h)	A linear spring with spring constant 100 kN/m is stretched through a distance of 0.8 meter and attached to a paddle wheel. The paddle wheel then rotates until the spring is un-stretched. Calculate the heat transfer Necessary to return the system to its initial state.	2
1(i)	Explain a refrigeration cycle with a neat schematic drawing.	2
1(j)	Define Clausius and Kelvin-Planck statement of second law of thermodynamics.	2
2(a)	Show that the thermodynamic process involved with a Throttling valve is an isenthalpic process.	5

2(b)	Steam enters a turbine at 4000 kPa and 500 C for an inlet velocity 200m/s. Calculate turbine power output. Show that kinetic energy change is negligible. Draw a schematic of the process.
	Inlet conditions // outlet conditions:
	Inlet diameter = 50 mm // outlet diameter = 250 mm
	V1=200m/s // ?
	P=4000kPa // 80 kP
	Density = 11.5kg/m^3 // 0.5 kg/m^3
	Enthalpy = 3445 kJ/kg // 2665 kJ/kg
		15

3)	Discuss Carnot cycle with proper diagram. Derive thermal efficiency of Carnot cycle? Write three important postulates of Carnot cycle. Show that the efficiency of a Carnot cycle is the maximum possible efficiency.	20
4(a)	A Carnot engine operates between two temperature reservoirs at 200C and 20C Respectively. If the desired output of Engine is 15 kilowatt determine QH and QL.	5
4(b)	A Carnot cycle characterised by nodes 1-2-3-4 and operating between two reservoirs having temperatures 300K (connecting nodes 1-4) and 500K (connecting nodes 2-3). Conditions of following nodes are as follows, Node 1 = 80kP Node 4 = 10 m^3/kg Draw the cycle of operation on a P-v diagram. Hence based on the diagram calculate the thermal efficiency and work output per cycle of operation.	15
5(a)	A power utility Company desires to use hot groundwater from a hot spring to power a heat engine. Is the groundwater is at 95 C, determine maximum power output if a mass flux of 0.2 kg/s is possible. The atmospheric temperature is 20 C.	10
5(b)	Water at 90 C is pumped from a storage tank at a rate of 3 L/s. The motor for the pump supplies work at a rate of 1.5 kJ/s. The water goes through a heat exchanger, giving up heat at a rate of 670 kJ/s, and is delivered to a Second storage tank at an elevation 15 m above the first tank. What is the temperature of the water delivered to the second tank? Draw a schematic of the process.	10
6(a)	A 40 kg steel casting of specific heat 0.5 kJ/kg /K, at a temperature 450 C is quenched in 150kg of oil of specific heat 2.5 kJ/kg/K, at 25C. neglecting heat losses, what is the entropy change of casting, oil and both considered together.	10
6(b)	A refrigerator is rated at a COP of 4. The refrigerated space That it cools requires a peak cooling rate of 30,000 kJ/h. Calculate horsepower of electrical motor, required for the refrigerator.	10