Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

END Semester Examination, December 2019

Programme Name: B.Tech- Mechanical **Semester : III**
Course Name : Thermodynamics **Time : 03 hrs**
Course Code : MECH 2020 **Max. Marks : 100**
Nos. of page(s) : 3

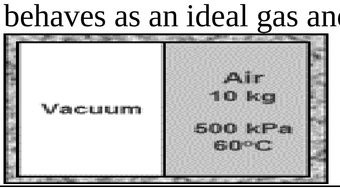
Instructions:

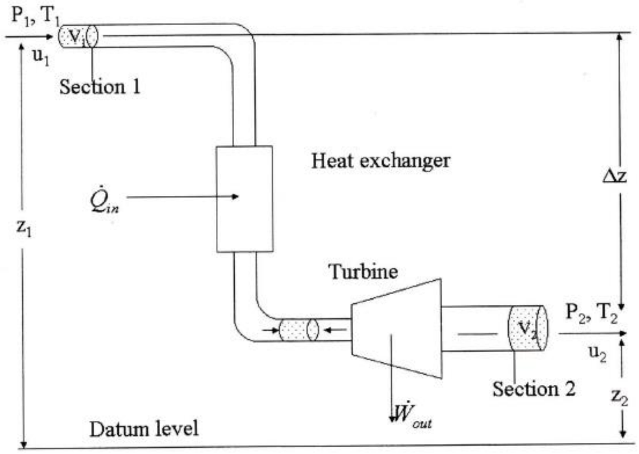
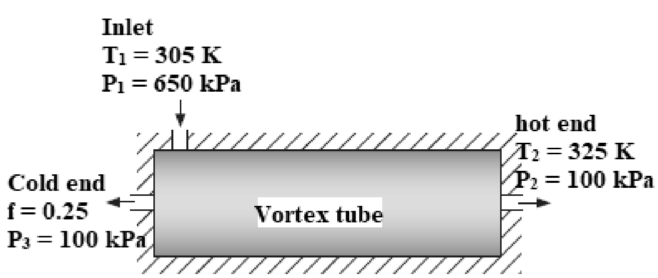
i. *There are three sections viz. Section A, Section B and Section C. Section A carries 20 marks, Section B carries 40 marks and Section C carries 40 marks*
ii. *Attempt all the questions in Section A, B and any two in section C*
iii. *Make appropriate assumptions wherever required*

SECTION A – 20 Marks

S. No.		**Marks**	**CO**
Q 1	An inventor claims that he has developed a heat engine, which absorbs 1200 kJ and 800 kJ from reservoir at 800 K and 600 K respectively and rejects 600 kJ and 200 kJ as heat to reservoirs at 400 K and 300 K respectively. It delivers 1200 kJ work. Analyze whether the heat engine is theoretically possible or not.	**5**	**CO3**
Q 2	A finite thermal system having heat capacity, C = 0.04 T^2, J/K initially at 600 K. Estimate the maximum work obtainable from the thermal system if the surrounding is at 300 K.	**5**	**CO4**
Q 3	Brayton cycle is less efficient than Carnot cycle. Explain?	**5**	**CO1**
Q.4	One kg of ice at 0^0C is completely melted into water at 0^0C at 1 bar pressure. The latent heat of fusion of water is 333 kJ/kg and the densities of water and ice at 0^0C are 999 kg/m^3 and 916 kg/m^3, respectively. Identify approximate values of the work done and energy transferred as heat for the process, respectively?	**5**	**CO1**

SECTION B-40 Marks

Q 6	A large vessel contains steam at a pressure of 20 bar and a temperature of 350 ^{0}C. This large vessel is connected to a steam turbine through a valve followed by a small initially evacuated tank with a volume of 0.8 m^3. During emergency power requirement, the valve is opened and temperature of the tank is then 400 ^{0}C. Assume that the filling process takes place adiabatically and the changes in potential and kinetic energies are negligible. By drawing the control volume, compute the amount of work developed by the turbine in kJ. ***OR*** The tank, shown below, has two chambers of equal volume. The left side holds 10 kg of air at 500 kPa and 60oC. The right side is completely evacuated. When the wall that separates the two chambers within the tank is removed, the air expands to fill the right side of the tank. Calculate the final temperature and pressure in the tank. Assume air behaves as an ideal gas and the process is adiabatic because the tank is well insulated. 	**10**	**CO2**

Q 7	 Apply energy balance, entropy balance and exergy balance equation for the figure shown above.	**10**	**CO2**
Q.8	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. Calculate (a) the thermal efficiency of this power plant, (b) the thermal efficiency if steam is superheated to 600 °C instead of 350 °C, and (c) the thermal efficiency if the boiler pressure is raised to 15 MPa while the turbine inlet temperature is maintained at 600 °C.	**10**	**CO3**
Q.9	In a gas turbine, hot combustion product with the specific heat C_p = 0.98 kJ/kg-K and C_v = 0.7538 kJ/kg-K enter the turbine at 20 bar, 1500 K exit at 1 bar. The isentropic efficiency of the turbine is 0.94. Calculate work developed by the turbine per kg of gas flow?	**10**	**CO3**
	SECTION C- 40 Marks		
Q 10	Figure illustrates a "vortex tube".  According to the company that makes the vortex tube, the device takes in high-pressure air at pressure P_1 = 650 kPa and temperature T_1 = 305 K and splits it into two streams of air that both leave at lower pressure, $P_2 = P_3$ = 100 kPa. One of the streams exits through the cold end of the device at a low temperature, T_3, and the other exits through the warm end at a high temperature, T_2 = 325 K. The fraction of the entering mass that leaves through the cold end is f = 0.25. The vortex tube operates at steady state, it is adiabatic and there is no work done on or by the device. Model air as an ideal gas with R = 287 J/kg-K and constant C_p = 1004 J/kg-K. a) Evaluate temperature of the air leaving through the cold end, T_3?20 b) Is this device possible? Justify your answer. ***OR***	**20**	**CO4**

	A vapor-compression refrigeration system circulates Refrigerant 134a at rate of 6 kg/min. The refrigerant enters the compressor at -10 ^{0}C, 1.4 bar, and exits at 7 bar. The isentropic compressor efficiency is 67%. There are no appreciable pressure drops as the refrigerant flows through the condenser and evaporator. The refrigerant leaves the condenser at 7 bar, 24 ^{0}C. Ignoring heat transfer between the compressor and its surroundings, evaluate (a) The coefficient of performance. (b) The refrigerating capacity, in tons. (c) The irreversibility rates of the compressor and expansion valve, each in kW (d) The changes in specific flow availability of the refrigerant passing through the evaporator and condenser, respectively, each in kJ/kg. Let T_o = 21 ^{o}C, P_o = 1 bar		
Q. 11	At a particular instant of time, a square metal bar has an axial temperature distribution given by: $T(x) = 50(1+ 8x^2)$ where x is the distance (in meters) measured from one end and T is the local temperature (in °C). Due to its high thermal conductivity, the temperature in the bar may be assumed uniform at any cross-section. The cross-section of the bar has width W = 2.5 cm and the length of the bar is L = 0.3 m. The density and specific heat of the metal are ρ = 2700 kg/m3 and c = 0.90 J/kg-K, respectively. a.) Is the average bar temperature rising or falling at this instant of time? (Assume that the bar can only transfer energy at its end points; i.e., the sides are insulated.) b.) Compute change in internal energy if the bar is cooled to a uniform temperature of T_f = 20°C. c.) Compute change in entropy of the bar for the process in part (b). d.) Compute change in exergy of the bar for the process in part (b) given a large heat sink at 20°C? e.) Compute maximum thermal efficiency at which work could be produced for the conditions in part (d)?	**20**	**CO2**
Q.10	A cold fluid cannot be stored for long periods because thermal gains inevitably occur, even in a Dewar (a vacuum-insulated container). An alternative is to store a high-pressure gas (e.g., air) and then release it as needed to generate the cold source. In a particular application, air at P_1 = 100 atm is stored at T_1 = 25 ^{0}C in a V = 15 liter tank. a) Identify exergy of the air in the tank? b) Identify maximum possible cooling (in J) that can be provided at Tc = 0 ^{0}C? c) Indicate how this cooling might be accomplished. ***OR***	**20**	**CO3**
	Air enters the compressor of an ideal air standard Brayton cycle at 100 kPa, 25 ° C, with a volumetric flow rate of 8 m ^{3} /s. The compressor pressure ratio is 12. The turbine inlet temperature is 1100 ° C. (a) Analyze entropy generation of the system and comment on possibility and impossibility of the system (a) Calculate Exergetic efficiency of the cycle	**20**	