Name:	
Enrolment No:	UPES

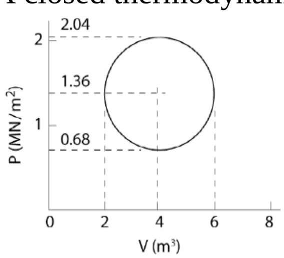
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

END Semester Examination, December 2019

Programme Name: M.Tech-Energy System **Semester : I**
Course Name : Thermodynamics and Heat Transfer Systems **Time : 03 hrs**
Course Code : EPEC7028 **Max. Marks: 100**
Nos. of page(s) : 3
Instructions:

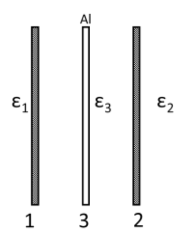
i. *There are three sections viz. Section A, Section B and Section C. Section A carries 20 marks, Section B carries 40 marks and Section C carries 40 marks*
ii. *Attempt all the questions in Section A, B and any two in section C*
iii. *Make appropriate assumptions wherever required*

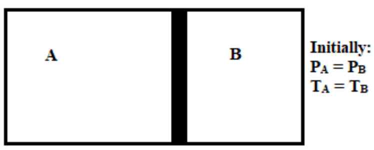
SECTION A – 20 Marks

S. No.		**Marks**	**CO**
Q 1	A closed thermodynamic system employs the cycle shown in the figure below:  If the system performs as a heat engine and the heat transfer to the low temperature heat reservoir is 50 MJ, determine the thermal efficiency of the cycle	**5**	**CO4**
Q 2	It is impossible to construct a heat engine working on single reservoir. Interpret?	**5**	**CO4**
Q 3	An object is initially at a temperature above that of its surroundings. We have seen that many kinds of convective process will bring the object into equilibrium with its surroundings. Describe the characteristic of a process that will do so with the least net increase of the entropy of the universe.	**5**	**CO4**
Q.4	Is it possible to increase the heat transfer from a convectively cooled isothermal sphere by adding insulation? Explain fully.	**5**	**CO1**

SECTION-B (40 Marks)

Q 6	Humans are able to control their heat production rate and heat loss rate to maintain a nearly constant core temperature of T_c = 37 ^{0}C under a wide range of environmental conditions. This process is called thermoregulation. From perspective of calculating heat transfer between a human body and its surroundings, we focus on a layer of skin	**10**	**CO1**

	and fat, with its outer surface exposed to the environment and its inner surface at a temperature slightly less than the core temperature, T_i = 35 ^{0}C = 308 K. Consider a person with a skin/fat layer of thickness L = 3 mm and effective thermal conductivity k = 0.3 W/mK. The person has a surface area A = 1.8 m^2 and is dressed in a bathing suit. The emissivity of skin is ε = 0.95. (a) When the person is in still air at T_∞ = 297 K, What is the skin surface temperature and rate of heat loss to the environment? Convective heat transfer to the air is characterized by a free convection coefficient of h = 2 W/m^2K. (b) When the person is in water at T_∞ = 297 K, what is the skin surface temperature and heat loss rate? Heat transfer to the water is characterized by a convective coefficient of h = 200 W/m^2k		
Q 7	Consider a concentric tube heat exchanger with hot and cold-water inlet temperature of 200^{0}C and 35^{0}C respectively. The flow rate of hot and cold fluids is 42 and 84 kg/h, respectively. Assume the overall heat transfer coefficient is 180 W/m^2K. What is the maximum heat transfer rate that could be achieved for the prescribed inlet conditions? If the exchanger is operated in counter flow with heat transfer area of 0.33 m^2. Determine the outlet fluid temperature.	**10**	**CO3**
Q.8	Calculate the net radiant heat exchange per m^2 area for two large parallel plates at temperatures of 427^0 C and 27^{0}C. ε (hot plate) = 0.9 and ε (cold plate) = 0.6. If a polished aluminum shield is placed between them, Compute the % reduction in the heat transfer ε (shield) = 0.4  	**10**	**CO1**
Q.9	A heat engine receives heat from a source at 1500 K at a rate of 700 kJ/s, and it rejects the waste heat to a medium at 320 K. The measured power output of the heat engine is 320 kW, and the environment temperature is 25°C. Determine (a) the reversible power, (b) the rate of irreversibility, and (c) the second-law efficiency of this heat engine.	**10**	**CO5**
	SECTION C (40 Marks)- Attempt any two		
Q 10	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.)	**20**	**CO1**

	b.) Calculate the change in internal energy if the bar is cooled to a uniform temperature of $T_f = 20°C$. c.) Calculate the change in entropy of the bar for the process in part (b). d.) What is the change in exergy of the bar for the process in part (b) given a large heat sink at 20°C? e.) What is the maximum thermal efficiency at which work could be produced for the conditions in part (d)?		
Q. 11	The sketch below shows an ideal experiment done in a perfectly insulated, rigid container with compartments separated by a frictionless piston. The two compartments contain different amounts of the same gas ($m_A = 1.2\ m_B$). The piston is nonadiabatic (heat can be transferred) and moves very slowly. Compartment A is initially at a higher temperature than compartment B ($T_A > T_B$) but the pressure in the two compartments is the same. Assume an ideal gas with constant c_p and c_v.  a) Which way, if at all, does the piston move? Indicate by an arrow on the drawing and give an explanation (5 Marks). b) Evaluate final temperatures and volumes in compartments A and B? Express your answer in terms of given properties (10 Marks). c) Evaluate net work done in the experiment (5 Marks)?	**20**	**CO4**
Q.12	The side of a building of height H = 7 m and length W = 30 m is made entirely of glass. Estimate the heat loss through this glass (Ignore the thermal resistance of the glass) when the temperature of the air inside the building is 20 ^{0}C, the outside air temperature is -15 ^{0}C and a wind of 15 m/s blows parallel to the side of the building. Select the appropriate correlation from those listed below of local Nusselt number to estimate the average heat transfer coefficient. For air take: $\rho = 1.2\ kg/m^3$, $\mu = 1.8x10^{-5}$ kg/m s, $C_p = 1$ kJ/kg K and Pr = 0.7 • Free convection in air, laminar ($Gr_x < 10^9$): $Nu = 0.3\ Gr_x^{1/4}$ • Free convection in air, turbulent ($Gr_x > 10^9$): $Nu = 0.09\ Gr_x^{1/3}$ • Forced convection, laminar ($Re_x < 10^5$): $Nu = 0.33\ Re_x^{0.5}\ Pr^{1/3}$ • Forced convection, turbulent ($Re_x > 10^5$): $Nu = 0.029\ Re_x^{0.8}\ Pr^{1/3}$	**20**	**CO2**