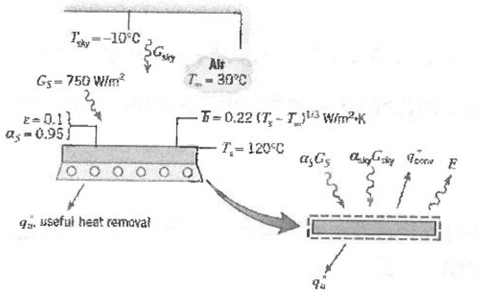
HTO-CHE-2253

Q.P. IV Sem

Type: DES

Q1. A flat-plate solar collector with no cover plate has a selective absorber surface of emissivity 0.1 and solar absorptivity 0.95. At a given time of day the absorber surface temperature *Ts* is 120°C when the solar irradiation is 750 W/m2, the effective sky temperature is -10°C, and the ambient air temperature T_∞ is 30°C. Assume that the heat transfer convection coefficient for the calm day conditions can be estimated from $\bar{h} = 0.22(T_s - T_\infty)^{1/3}\ \mathrm{W/m^2 \cdot K}$.



Calculate the useful heat removal rate (W/m²) from the collector for these conditions. What is the corresponding efficiency of the collector? Consider α_{sky}= 0.1 (4)

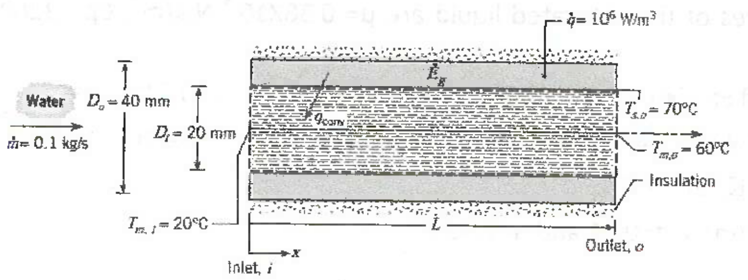
Q2. A glass window's inner and outer surface temperatures of 5 mm thick are 15 and 5°C. What is the heat loss through a window that is 1 m by 3 m on a side? The thermal conductivity of glass is 1.4 W/m. K. Define Conduction, convection, and radiation. (3)

Q3. Derive the Equation that is used to compute the temperature reached by the solid at some time *t*. (3)

Q4.

A system for heating water from an inlet temperature of $T_{m,i} = 20°C$ to an outlet temperature of $T_{m,o} = 60°C$ involves passing the water through a thick-walled tube having inner and outer diameters of 20 and 40 mm. The outer surface of the tube is well insulated, and electrical heating within the wall provides for a uniform generation rate of $\dot{q} = 10^6\ \mathrm{W/m^3}$.

1. For a water mass flow rate of $\dot{m}$ = 0.1 kg/s, how long must the tube be to achieve the desired outlet temperature?
2. If the inner surface temperature of the tube is $T_s = 70°C$ at the outlet, what is the local convection heat transfer coefficient at the outlet?



Consider the Cp for water as 4179J/kg.K. (5)

Q5. Define Radiosity, the total hemispherical emissive power and spectral, directional emissivity. (3)

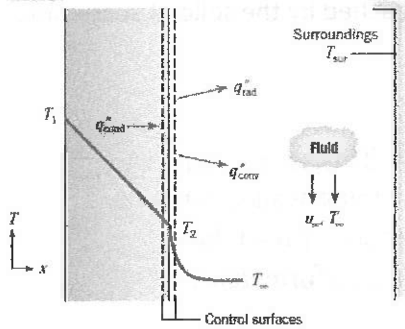
Q6. Explain any two ways to increase the heat transfer coefficient. (2)

Q7. The engine oil at 150 C is cooled to 80 C in a parallel flow heat exchanger by water entering at 25C and leaving at 60C. Estimate the exchanger's effectiveness and the number of transfer units. (4)

Q8. Define the Capacity and economy of evaporators. Describe the working of the short-tube and falling film evaporators with the help of a neat diagram. (3)

Q9. Consider a plane composite wall that is composed of two materials of thermal conductivities k_A= 0.1 W/m. K and k_B = 0.04 W/m. K and thicknesses L_A= 10 mm and L_B= 20 mm. The contact resistance at the interface between the two materials is known to be 0.30 m^2. K/W. Material A adjoins a fluid at 200°C for which h=10 W/m^2.K and material B adjoins a fluid at 40°C for which h= 20 W/m^2. K. What is the rate of heat transfer through a wall that is 2 m high by 2.5 m wide? (3)

Q10. Write the energy balance for the system shown in the diagram.



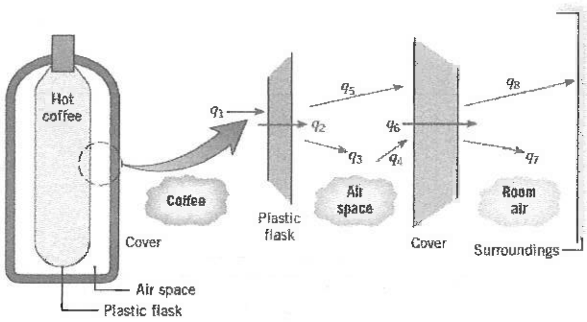
Define Absorptivity and irradiation. (2)

Q11. Saturated ethylene glycol at 1 atm is heated by a horizontal chromium-plated surface which has a diameter of 200 mm and is maintained at 480K. Estimate the heating power requirement and the rate of evaporation. The properties of the saturated liquid are μ= 0.38X10^{-3} N.s/m^2, Cp= 3280 J/Kg.K, and Pr=8.7.

PROPERTIES: *Table A-5*, Saturated ethylene glycol (1atm): T_{sat} = 470K, h_{fg} = 812 kJ/kg, ρ_f = 1111 kg/m^3, σ = 32.7 × 10^{-3} N/m; Saturated ethylene glycol (given, 470K): ρ_v = 1.66kg/m^3, μ_ℓ = 0.38 × 10^{-3} N-s/m^2, $c_{p,\ell}$ = 3280 J/kg-K, Pr_ℓ = 8.7.

The saturated vapor density is 1.66 kg/m^3. $C_{s,f}$=0.01 and n=1. (5)

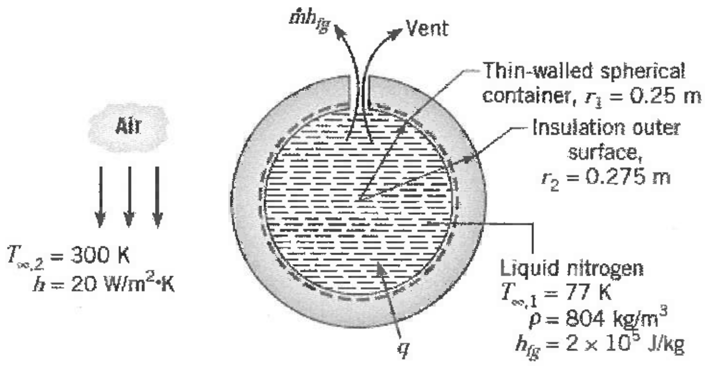
Q12. A closed container filled with hot coffee is in a room whose air and walls are at a fixed temperature. Identify all heat transfer processes that contribute to the cooling of the coffee.



(3)

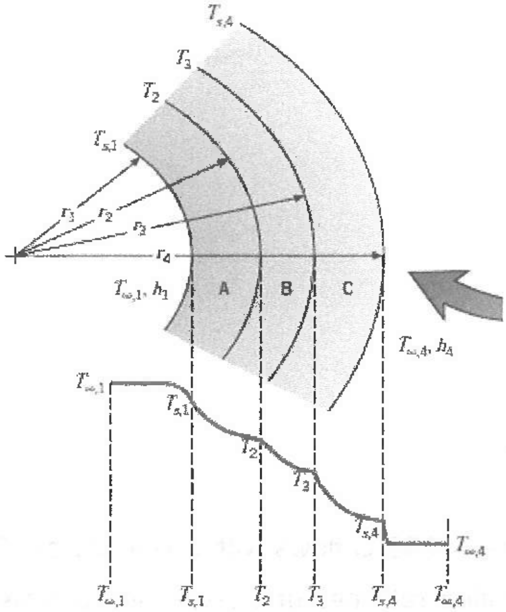
Q13. Air at a pressure of 6 kN/m² and a temperature of 300°C flows with a velocity of 10 m/s over a flat plate 0.5 m long. Estimate the cooling rate per unit width of the plate needed to maintain it at a surface temperature of 27°C. Pr=0.687, $u=5.21X10^{-4}$ m²/s, $k=36.4X10^{-3}$W/m.K (3)

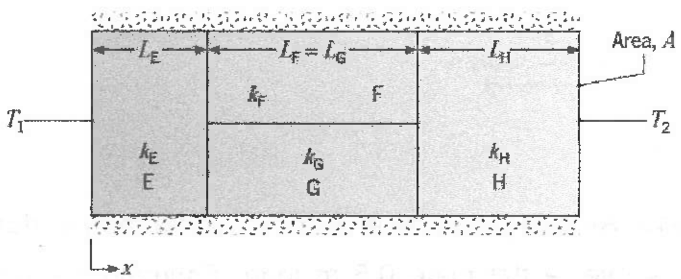
Q14. A spherical, thin-walled metallic container is used to store liquid nitrogen at 77 K. The container has a diameter of 0.5 m and is covered with evacuated, reflective insulation composed of silica powder. The insulation is 25 mm thick, and its outer surface is exposed to ambient air at 300 K. The convection coefficient is known to be 20 W/m²K. The latent heat of vaporization and the density of liquid nitrogen are $2X10^5$ J/kg and 804 kg/m³, respectively.



What is the rate of heat transfer to the liquid nitrogen? What is the rate of liquid boil-off per day? (4)

Q15. For the composite systems shown in the diagram, express the heat transfer rate for the cylindrical system and draw the thermal circuits (series and parallel) for the composite wall.





(3)