Name: **Enrolment No:**	

UPES

End Semester Examination, December 2024

Programme Name : B.Tech (Fire and Safety Engineering) **Semester :** V

Course Name : Chemical Engineering II (Unit Operations) **Time : 03** hrs

Course Code : HSFS 3026 **Max. Marks:** 100

Nos. of page(s) : Two

Instructions: Assume suitable data wherever necessary. Your answer should be precise and to the point.

SECTION A

(6 Marks *5 = 30 Marks)

S. No.		Marks	CO
Q 1	i. What is a unit operation? ii. List out three types of unit operations.	3+3	CO1
Q 2	i. Briefly explain with an example of mass transfer in daily life. ii. What is the function of a heat exchanger? iii. Convert a pressure of 1.5 atm into kPa.	2+2+2	CO1
Q 3	Water enters a heat exchanger at 20°C and is heated to 70°C using steam. The mass flow rate of water is 2 kg/s and the specific heat capacity of water is 4.18 kJ/kg K. Find the heat transferred to the water.	6	CO1
Q 4	Briefly explain Plastics, Fiber-Reinforced Plastics (FRP) and adhesives.	2+2+2	CO1
Q 5	A safety valve in a fire suppression system is calibrated to open at an absolute pressure of 220 kPa. If the local atmospheric pressure is 90 kPa (at high altitude), what is the gauge pressure at which the valve will open?	6	CO1

SECTION B

(15 Marks * 3 = 45 Marks)

Q 6	(a) A fire-rated door has a thermal conductivity of 0.5 W/m·K and a thickness of 10 cm. If one side is exposed to a temperature of 700°C and the other side is at 30°C, calculate the rate of heat transfer through the door if the area is 2 m² (b) A certain set of crushing rolls has rolls of 1000 mm diameter by 375 mm width of face. They are set so that the crushing surfaces are 12 mm apart at the narrowest point. The angle of nip is 30o. What is the maximum permissible size of feed?	8 7	CO2 CO2
Q 7	a. In a chemical plant, oxygen diffuses through a thin polymer film of thickness 0.005 m. The oxygen concentration on one side of the film is 0.2 mol/m3, and on the other side, it is 0.05 mol/m3. The diffusion coefficient for oxygen through the polymer is 1×10^{-9} m2/s. Calculate the diffusion flux of oxygen through the film using Fick's Law as given by: $J= -D\, dc/dx$	7	CO3

	Where: • J = Diffusion flux (mol/m2/s) • D = Diffusion coefficient (m2/s) • dc = Concentration difference across the film (mol/m3) • dx= Thickness of the film (m) b. How knowledge of diffusion rates helps fire safety engineers to design proper ventilation systems. c. Differentiate leaching with crystallization?	**4** **4**	
Q8	(a) What are the codes and standards commonly used in Fire Safety Engineering applications? (b) A tragic fire occurred on the night of November 15, 2024, at the Neonatal Intensive Care Unit (NICU) of Maharani Laxmi Bai Medical College in Jhansi, Uttar Pradesh, resulting in the deaths of at least 10 newborns and injuries to 16 others. Based on the knowledge and your understanding of this incidence, highlight your thoughts on the following: i. What were the main causes of the fire at the Jhansi Hospital? ii. In the context of Fire Safety Engineering, how can hospitals better implement a fire safety risk assessment process?	**5** **5+5**	**CO5**
SECTION C **(25 Marks * 1 = 25 Marks)**			
Q 9	Case Study: In a chemical manufacturing plant, a fire broke out in the **distillation column area** due to an uncontrolled exothermic reaction in the upstream reactor. The plant processes flammable organic compounds to manufacture solvents. Key unit operations involved include **reactor operation**, **distillation**, and **storage of flammable chemicals**. Please explain the following: a. How can distillation columns contribute to fire risks in chemical plants? b. Why did the pressure relief valve fail, and what preventive measures could have been taken? c. What are the key hazards associated with exothermic reactions in reactors? d. What role did inadequate maintenance play in the fire scenario? e. How can automatic shutdown systems improve safety in chemical industries?	**5 x 5**	**CO4**