B.E. (Fire Engineering) Sixth Semester (C.B.S.)

Elective - I : Fire & Smoke Dynamics

P. Pages : 3 **NIR/KW/18/3962**

Time : Three Hours * 1 4 2 3 * Max. Marks : 80

Notes :
1. All questions carry marks as indicated.
2. Solve Question 1 OR Questions No. 2.
3. Solve Question 3 OR Questions No. 4.
4. Solve Question 5 OR Questions No. 6.
5. Solve Question 7 OR Questions No. 8.
6. Solve Question 9 OR Questions No. 10.
7. Solve Question 11 OR Questions No. 12.
8. Due credit will be given to neatness and adequate dimensions.
9. Assume suitable data whenever necessary.
10. Diagrams and chemical equations should be given whenever necessary.
11. Illustrate your answers whenever necessary with the help of neat sketches.
12. Use of non programmable calculator is permitted.
13. Use graph paper wherever necessary.

1. a) What do you mean by critical thickness of insulation ? Explain its concept with help of material and surface resistance. **4**

b) A sealed 1.2 m^3 spherical chamber is used to establish the maximum pressure increase resulting from the combustion of a flammable gas mixture. The chamber operates at ambient temperature (20ºC) and the volume occupied by a mole of gas at ambient temperature and pressure ($P_{initial}$ = 1atm) is 24 liters. The chamber is filled with a mixture of propane (C_3H_8) and air until the pressure inside the chamber is ambient. The composition of air is 71% nitrogen and 29% oxygen by volume and 528 gram of propane are introduced in the chamber. The specific heat of the mixture can be assumed as C_p = 1600 J/kg-k and heat of complete combustion of propane is 16 MJ/kg. **10**

i) Find the mass of air in the mixture before combustion.
ii) Find the equivalence ratio of the mixture
iii) Determine the time required for the combustion, if the laminar flame speed is 25 cm/sec.
iv) If the combustion can be assumed to be complete, what will be the adiabatic temperature of the combustion gases after all the fuel has reacted ? Assume chamber is well insulated.

OR

2. a) A steam pipe (inear diameter = 150 mm and outer diameter = 160 mm) having thermal conductivity 58 W/mºC is covered with two layers of insulation, of thickness 30 mm and 50 mm respectively and thermal conductivities 0.18 W/mºC and 0.09 W/mºC respectively. The temperature of inner surface of steam pipe is 320ºC and that of the outer surface of the insulation layer is 40ºC. **11**

i) Determine the quantity of heat loss per meter length of steam pipe and layer contact temperature.
ii) If the condition of steam is dry and saturated, find the quality of the steam coming out of one meter pipe assuming the quantity of steam flowing is 0.32 kg/min.

Properties of steam at 320ºC are :
h_f = 1463 kJ/kg ; h_{fg} = 1240 kJ/kg, h_g = 2703 kJ/kg-k.

b) Calculate the vapour pressure of the following pure liquids at 20ºC. **3**
   a) n-pentane [E = 6595.1 ; F = 7.4879]
   b) Toluene [E = 8580.5 ; F = 7.7194]
   c) Methanol [E = 8978.8 ; F = 8.6398]

3. a) What is limit of flammability ? How it is measured using US Bureau of mines apparatus. **6**

b) What is the UFL of a gas mixture composed of 1% methane, 2% ethane and 3% propane by volume at 50ºC and 2 atmospheres : **7**
Data :

Component	MW	Heat of combustion (k cal/mol)
Methane	16.04	212.79
Ethane	30.07	327.81
Propane	44.09	256.75

OR

4. a) What is flammability diagram ? Explain the construction of flammability diagram. Use 5 points (MOC = 12%, LFL (O_2) = 3%, UFL (O_2) = 52% ; LFL (air) = 3% ; UFL (air) = 12.5%. **7**

b) A mixture has methane / propane (20:80 mole%) altogether 5.6% the rest is nitrogen. It is flammable in air ? **6**
Take $T_{Ci} = 8.7$ (methane)
$T_{Ci} = 3.7$ (propane)

5. a) Explain : Deflagration, Explosion and Detonation. **7**

b) Calculate the flame height of the benzene stored in a container of 2n diameter and 0.5 m high. (Take $\Delta H_{C(benzene)}$ = 54.02 MJ/kg) $\rho_{(Benzene)} = 610\ kg/m^3$. **6**

OR

6. a) Explain the structure of non-premixed flame. **6**

b) Calculate the length of the turbulent diffusion flame formed when pure propane is released at high pressure through a nozzle 0.1 m in diameter. Assume that flame temperature of propane is 1870ºC and ambient temperature is 25ºC. What would be the length if nozzle fluid consisted of 50% propane in air. **7**

7. a) Explain : **6**
   i) Smouldering combustion
   ii) Glowing combustion

b) What is thermally thick and thermally thin ? Explain its effect on flame spread velocity. **7**

OR

8. a) Explain the process of Burning of wood. **5**

b) A wooden plank of length 1.5 m is exposed to radiant heat of around 20 kW/m^2 for 300 seconds. If the ambient temperature is 20ºC, find the ignition temperature of wood and velocity of flame spread. **8**

Take :

$k_{wood} = 0.22\ W/m^oC$

$\rho_{wood} = 160\ kg/m^3$

$C_{P(wood)} = 2000\ J/kg-k$

9. a) Explain how HRR is determined using cone calorimeter. **6**

b) 60 kg/m^2 of timber is placed as fuel load density in the compartment of 3m wide, 4m long and 2m height and having a ven^t of 1m x 2m. Find the maximum temperature of the fully developed fine and make an estimate of the duration of fine. **8**

OR

10. a) A designer is to analyse the possible design fire in a room of dimension 8m long, 4m wide and 4m high (H_o) The entrainment rate is given by : **14**

$$\dot{n}_a = 0.0416\ (H)^{3/2} \cdot (\dot{Q})^{1/2}$$

The fire can be described as $\dot{Q} = \alpha t^2$

where α = 0.0029 kW/sec^2

Estimate the thickness of smoke layer and smoke temperature after 50 seconds (ΔT=10sec)

(Take : T_a = 300 k ; $\rho_A = 1.2\ kg/m^3$; $C_p = 1\ kJ/kg-k$)

11. a) What do you mean by RSET and ASET ? Explain its significance in life safety. **6**

b) Explain the effect of wind on the movement of smoke. **7**
Calculate the mean wind speed for a 38 storey building at lower, middle and top floors (height = 4m, 55 m and 112 m), if the wind for an arbitrary selected gradient is 20 km/hr

OR

12. a) Explain stack effect in movement of smoke. **6**

b) Explain HVAC systems. **7**

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