Exam question 1

Heat release rate per unit area of polymeric materials

Explain: Difference of thermoplastics and thermosets in fire behaviour

Explain: Fire point

Explain: Upper and lower flammability limits as safety criteria

Explain what is meant by fire resistance of structures and what are the characteristics.

2. **Combustion chemistry** **(25 p)**

a) Fuel gas with chemical formula C_5H_{12} and molar mass of 72.15 g/mol combusts in air. Write the **reaction formula** and derive its **coefficients** for incomplete combustion with carbon monoxide yield of 1.94 % (mass basis). Assume CO's molar mass = 28 g/mol. (9 p)

b) Calculate the heat of combustion for the reaction (8 p).
Use the known heats of formation:

$$\Delta H_{f,CO2}^{298} = -393.5\ \text{kJ/mol} \qquad \Delta H_{f,H2O}^{298} = -241.8\ \text{kJ/mol}$$
$$\Delta H_{f,CO}^{298} = -110.5\ \text{kJ/mol} \qquad \Delta H_{f,C5H12}^{298} = -147.0\ \text{kJ/mol}$$

c) Calculate the **adiabatic flame temperature** at initial temperature of 20 °C using the reaction and heat from tasks a and b, respectively. **List the assumptions** made. (8 p)

Specific heat capacities at 1000 K

c_p (CO) = 33.2 J/mol.K	c_p (CO_2) = 54.3 J/mol.K
c_p (H_2O) = 41.2 J/mol.K	c_p (N_2) = 32.7 J/mol.K
c_p (O_2) = 34.9 J/mol.K	c_p (C_5H_{12}) = 120 J/mol.K

3. Thermal radiation from pool fire

A pool of crude oil (diameter = 8 m) burns steadily.

a) Calculate the radiative emission power (MW). Present and justify input data. (10 p)
b) Calculate radiative heat flux to a vertical, ground-level target at 15 m distance from the pool centre, using a point source method (5 p)
c) Calculate radiative heat flux as above, but assuming a cylindrical emitter with base diameter equal to the pool, and cylinder height equal to flame height. (5 p)
d) Assess the effect of the heat flux on humans and building materials? (5 p)

4. FDS simulation (25 p)

Fire ignites in the middle of a $4 \times 4 \times 2.5$ (height) m^3 room with two open doors (1×2 (height) m^2 doors to ambient at opposite walls. Fire source is a 1×1 m^2 ethanol pool fire with ultra-fast growth rate (t^2-fire) and maximum HRR of 1 MW. Soot yield of 1 %.

All other solid surfaces are made of 13 mm thick plywood ($\rho = 450$ kg m^{-3}, $c = 1500$ J $kg^{-1}K^{-1}$, $k = 0.2$ $Wm^{-1}K^{-1}$, $\varepsilon = 1.0$) with insulated backing.

Simulate the fire using FDS from 0 to 300 s. Enclose the input file.
a) Show a plot of HRR. (10 p)
b) Plot the plywood surface temperature in the middle of the ceiling. Assuming a charring temperature of 300 °C, when would the ceiling start to char? Is the middle point the first point of the ceiling to char? (10 p)
c) How would you describe the spatial resolution of your simulation? (5 p)