7. What are the main steps in the creation of event tree? Enumerate the advantages of Event Tree Analysis in Quantitative Risk Assessment. Explain briefly how analysis of failure data is carried out.

4 + 4 + 4 = 12

Group – E

8. (a) Why ventilation is done in chemical process industry? State the principles on which ventilation is based.

(b) An open toluene container in an enclosure is weighed as a function of time and it is determined that the average evaporation rate is 0.1 gm/min. The ventilation rate is 2.832 m^3/min. The temperature is 26.67^{0}C and the pressure is 1 atm. Estimate the concentration of toluene vapour in the enclosure.
Data: The non ideal mixing factor (k) = 0.5.

(3 + 3) + 6 = 12

9. (a) Discuss in details the case history of the following accident.
Seveso (Italy) accident on July 10, 1976

(b) State the precautions to be taken while working in chemical laboratory.

7 + 5 = 12

INDUSTRIAL SAFETY & HAZARD ANALYSIS (CHEN 4142)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Safety program needs a system
(a) to record what needs to be done to have an outstanding safety program
(b) to do what needs to be done
(c) to record that the required tasks are done
(d) all of (a), (b) & (c).

(ii) OSHA stands for
(a) Organization of Safety and Health Administration
(b) Occupational Safety and Health Administration
(c) Organization of Safety and Health Agency
(d) Occupational Safety and Health Agency.

(iii) The first layer of safety protection is
(a) Inclusion of control system
(b) Inclusion of interlocks
(c) The process design
(d) Inclusion of safety shut down system.

(iv) The best approach to prevent accidents is to
(a) add process design features to prevent hazardous situations
(b) add interlocks and safety shutdown systems
(c) emergency response plans
(d) all of (a), (b) & (c).

(v) A process has a reported FAR of 2. If an employee works a standard 8 hr shift 300 days per year, the death per person per year will be
(a) 4.8×10^{-5} (b) 2.4×10^{-5}
(c) 1.2×10^{-5} (d) 2.4×10^{-6}.

(vi) Lower Flammability Limit of a mixture is given by

(a) $LFL_{mix} = \frac{1}{\sum \frac{y_i}{LFL_i}}$ (b) $LFL_{mix} = \sum \frac{y_i}{LFL_i}$

(c) $LFL_{mix} = \sum \frac{LFL_i}{y_i}$ (d) none of (a), (b) & (c).

(vii) The relation between upper flammability limit (UFL) and stoichiometric coefficient (C_{st}) is given by

(a) LFL = 3.0 C_{st} (b) LFL = 0.5 C_{st}

(c) LFL = 1.5 C_{st} (d) LFL = 0.55 C_{st}.

(viii) Detonation is an explosion in which the reaction front

(a) is stationary (b) moves with a supersonic speed

(c) moves with a subsonic speed (d) none of (a), (b) & (c).

(ix) If two basic events A and B having probabilities of failure respectively 0.01 and 0.13 are connected by OR gate, the probability (P) of the final event will be

(a) P = 0.0013 (b) P = 0.14

(c) P = 0.1387 (d) P = 0.1413.

(x) Events A and B occur at frequencies and durations respectively $\lambda_A, \lambda_B, D_A$ and D_B. The combined frequency of the two events (λ_{AB}) is equal to

(a) $\lambda_A \lambda_B$ (b) $\lambda_A D_A + \lambda_B D_B$

(c) $\lambda_A \lambda_B (D_A + D_B)$ (d) none of (a), (b) & (c).

Group – B

2. (a) Estimate the lower flammability limit and upper flammability limit for hexane for the following stoichiometric reaction:

$$C_6H_{14} + zO_2 \rightarrow mCO_2 + \frac{x}{2} H_2O$$

(b) Define:

(i) Hazard
(ii) Detonation
(iii) Flash point
(iv) Combustion
(v) Flammability limit.

7 + 5 = 12

3. (a) Estimate the Limiting Oxygen Concentration (LOC) for butane (C_4H_{10}) given that the LFL of butane is 1.9% by volume.

(b) A fuel air gas mixture containing 2% CH_4, 0.5% C_2H_4 and 0.8 % hexane and rest air by volume is used in a chemical process industry. From the data given below find its LFL and UFL.

Component	LFL (vol%)	UFl (vol%)
CH_4	5.3	15.0
C_2H_4	3.1	32.0
C_6H_{14}	1.2	7.5

5 + 7 =12

Group – C

4. (a) State the objective of HAZOP. What are the documentations required for HAZAOP?

(b) Briefly describe the procedure followed for HAZOP.

(2 + 4) + 6 = 12

5. With the help of a flow chart describe in detail the procedure for calculation of Dow Fire and Explosion Index. State the factors considered for general process hazards and special process hazards in Dow F & EI.

6 + 6 = 12

Group – D

6. A reactor effecting an exothermic reaction is at risk of thermal runway in the event of coolant failure. Its protective trip system is intended to open a dump valve which empties the reactor if low coolant flow or high reaction temperature is detected. Draw a fault tree which summarizes the failure logic analysis given below.

Failure Logic Analysis: Runway reaction occurs if cooling water failure occurs whilst the protective system is inoperative. Cooling water failure can occur because of pump failure, line blockage or an exhausted water supply. The protective system may be inoperative when either the shutdown system fails because the dump valve fails shut, or because the detection system fails. Calculate also the approximate frequency of the runaway reaction from the following data:

Failure	Failure rate (hr^{-1})
Pump failure	0.2
Line blocked	0.01
Supply tank empty	0.1
Dump valve fails shut	0.001/demand
Low flow trip failure	0.01/demand
High temperature trip failure	0.01/demand

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