B.TECH/CHE/7TH SEM/ CHEN 4142/2017

INDUSTRIAL SAFETY AND 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) 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.

(ii) 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

(iii) 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}.

(iv) Events A and B occur at a frequency λ_A and λ_B per year respectively and their duration respectively are D_A and D_B. The combined frequency is given by

(a) $\lambda_{AB} = \lambda_A D_A + \lambda_B D_B$ (b) $\lambda_{AB} = \lambda_A D_A - \lambda_B D_B$

(c) $\lambda_{AB} = \lambda_A \lambda_B (D_A + D_B)$ (d) $\lambda_{AB} = \lambda_A \lambda_B (D_A - D_B)$.

(v) In the HAZOP study team

(a) the chairman must be a trained HAZOP leader
(b) the sectary must be a trained HAZOP leader
(c) the process design engineer must be a trained HAZOP leader
(d) no trained HAZOP leader is necessary.

(vi) Deflagration 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 the above.

(vii) The relation between lower flammability limit (LFL) 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) Lower Flammability Limit of a mixture is given by

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

(c) $LFL_{mix} = \sum \dfrac{LFL_i}{y_i}$ (d) none of the above.

(ix) 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 the above.

(x) A mixture is flammable only when

(a) the composition is below LFL
(b) the composition is above UFL
(C) the composition is in between LFL and UFL
(d) the composition is above UFL.

Group – B

2. (a) Estimate the Lower flammability limit and Upper Flammability limit for hexane for following stoichiometric reaction:

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

(b) Distinguish between fire and explosion. Briefly discuss about BLEVE.

6 + 6 = 12

3.(a) Define the term Process Safety. State the major approaches to inherent safety in process industry.

(b) Describe in detail the inherent safety techniques used in process industry.

(2 + 4) + 6 = 12

Group – C

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

(b) Discuss briefly the procedure followed for HAZOP.

(2 + 4) + 6 = 12

5. (a) State briefly the steps involved in the methodology of Failure Mode and Effect Analysis.

(b) Two basic events having mean failure rates 12 and 25 per 10^6 hours are connected by an OR gate to constitute a combination event. Find the probability of the combination event.

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. Calculate the frequency of the runway reaction.
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.

Failure	Failure rate
Pump failure	0.2 yr^{-1}
Line blocked	0.01 yr^{-1}
Supply tank empty	0.1 yr^{-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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7. A distillation unit is used for handling flammable material operating at an elevated pressure. The column bottoms system includes a liquid cooling train and the liquid is discharged to a tank which is not designed to withstand full column pressure. Under normal operation a liquid seal is maintained in the column base and the bottom product is let down through a control valve linked to liquid level in the column. In the event of failure of control system and its associated back up, it is possible for high pressure gas to break through in the low pressure system. Using the probability data given below, construct Event Tree for the consequence of break through and estimate the probability of fatal injury. The plant is run continuously and operated by a single process worker on a shift basis. Each shift worker will work 250 eight hour shifts per year. Calculate also the maximum frequency of liquid break through and estimate the probability to satisfy operating company safety criteria.
Data:

System	Probability
Cooling system fractures	0.02
Vapour cloud ignites	1.00
Operator present in the vapour cloud area	0.80
Operator escapes before ignition	0.25
Operator burned but survives	0.50

The operating company has a target FAR of 0.4 for a single incident.

12

Group – E

8. Discuss in details the case history of the accident at Pasadena, Texas, on October 23, 1989.

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9. (a) 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

(b) State the safety Precautions to be taken in laboratory classes.

7 + 5 = 12