

**SAFETY AND HAZARD ANALYSIS  
(CHEN 4181)**

**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) 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.
- (ii) In calculating the F and EI for a unit the value for the material with  
(a) lowest MF which is present in significant quantities is used  
(b) highest MF which is present in significant quantities is used  
(c) in between highest and lowest MF which is present in significant quantities is used  
(d) none of these.
- (iii) A process has a reported FAR of 0.4. If an employee works a standard 8 hr shift 300 days per year, the death per person per year will be  
(a)  $4.8 \times 10^{-5}$  (b)  $9.6 \times 10^{-6}$  (c)  $1.2 \times 10^{-5}$  (d)  $2.4 \times 10^{-6}$ .
- (iv) Events A and B occur at a frequency  $\lambda_A$  and  $\lambda_B$  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) Flash point of a liquid  
(a) increases with increase in pressure  
(b) increases with decrease in pressure  
(c) is independent of pressure  
(d) may increase or decrease with pressure depending on the type of liquid.
- (vi) The Risk Management Plan document is updated when  
(a) there is a serious accident in the plant  
(b) the process of chemistry changes  
(c) a government audit requests an update  
(d) both(b) and (c).
- (vii) The Bhopal accident, one of the major disasters in chemical industries,  
(a) is linked with MIC leakage on 3<sup>rd</sup> December, 1984  
(b) killed 2000 civilian and injured an estimated 20,000 more  
(c) released 25 tons of toxic MIC vapour  
(d) all of these.
- (viii) The AND gate in FTA describes a situation  
(a) where the next event will occur if one or more of the input events exist  
(b) where the next event requires the simultaneous existence of all the input events  
(c) of transferred events  
(d) none of the above.
- (ix) The probability of failure of an event which is dependent on the outcome of two simultaneous event occurring (of probabilities 0.1 and 0.001 respectively) is  
(a) 0.11 (b) 0.0001 (c) 0.89 (d) 0.999.
- (x) If two intermediate combination events  $Q = A + B$  and  $R = A + C$  are connected by AND gate, the probability (P) of the final event will be  
(a)  $P = A + B + C$  (b)  $P = A . B . C$   
(c)  $P = A . B + C$  (d)  $P = A . B + C$ .

**Group - B**

2. (a) Define:  
(i) Dust explosion ,(ii) Deflagration, (iii) Proof testing, (iv) Calculated risk & (v) OSHA incidence rate  
(b) Define runaway reaction. Explain the elementary theory of runaway reactions.

**5 + 7 = 12**

3. (a) Define:

(i) Hazard, (ii) Risk, (iii) FAR, (iv) Fire triangle and (v) Detonation.

(b) What are the UFL and LFL of a gas mixture composed of 0.8% hexane, 2.0% methane, 0.5% ethylene and rest air by volume? The necessary LFL and UFL data are given below:

Component	LFL (vol%)	UFL (vol%)
Hexane	1.2	7.5
Methane	5.3	15.0
Ethylene	3.1	32.0

5 + 7 = 12

**Group - C**

4. (a) Two relief valves discharge into a common header. The header has been under designed and could rupture if both valves discharge at the same time. Using the data below, estimate the frequency for the rupture of the header and the duration of discharge from the ruptured header.

Data:

$$\lambda_A = 4yr^{-1}, \lambda_B = 1yr^{-1}, D_A = 0.75hr, D_B = 0.75hr$$

(b) State the composition of HAZOP team.

8 + 4 = 12

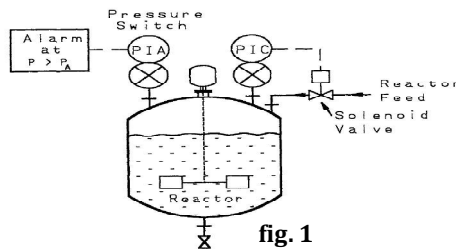
5. (a) With the help of a flow chart explain the procedure for calculating the Dow fire and explosion index and other risk analysis information.

(b) Explain the term Material Factor.

8 + 4 = 12

**Group - D**

6. Consider the alarm indicator and emergency shutdown system shown in the fig.1 below.



This reactor contains a high-pressure alarm to alert the operator in the event of dangerous reactor pressures. It consists of a pressure switch within the reactor connected to an alarm light indicator. For additional safety an automatic high-pressure reactor shutdown system is installed. This system is activated at a pressure somewhat higher than the alarm system and consists of a pressure switch connected

to a solenoid valve in the reactor feed line. The automatic system stops the flow of reactant in the event of dangerous pressures.

Estimate the probability of over pressuring of reactor from the given data:

Item	Probability of failure
Pressure switch 1	0.13
Pressure switch 2	0.13
Pressure indicator light	0.04
Solenoid valve	0.34

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7. An LPG storage tank installation is sited close to a railway line on which trains pass carrying fuel oil to a power station. If a train derailed it may either plough directly into the LPG installation or it may overturn with a consequent possibility of the fuel oil catching fire. The fire may cause the LPG installation to explode. Make Fault Tree Analysis for the undesired event explosion of the LPG storage installation and estimate the frequency of explosion (year<sup>-1</sup>) of the LPG storage installation from the data given below.

Data

Probability that a derailed train overturns	0.5
Probability that an overturned train catches fire	0.1
Probability that fire engulfs LPG tanks causing explosion	0.2
Probability that a derailed train hits the LPG installation causing an explosion	0.05
Frequency of derailment of train	3.8 × 10 <sup>-4</sup> , year <sup>-1</sup>

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**Group - E**

8. (a) State the principles on which ventilation is based. Describe in detail any one method of ventilation used in industry.

(b) Xylene is used as a solvent in paint. A certain operation evaporates an estimated 0.01m<sup>3</sup> of xylene in an 8-hr shift. The ventilation quality is rated as average. Determine the quantity of dilution ventilation air required to maintain the xylene concentration below 100 ppm, TLV-TWA. Also, compute the air required if the operation is carried out in an enclosed hood with an operating of 4.65m<sup>2</sup> and a face velocity of 30.48 m/s. The temperature is 25°C and the pressure is 1 atm. The specific gravity of the xylene is 0.864, and its molecular weight is 106.  
Data: The non ideal mixing factor (k) = 0.125

6 + 6 = 12

9. Discuss in details the case history of the following accident.

Bhopal (India) accident on December 03, 1984

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