

**INDUSTRIAL SAFETY AND HAZARD ANALYSIS
(CHEN 3142)**

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

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

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) The first layer of safety protection is
 - (a) inclusion of control system
 - (b) inclusion of interlocks
 - (c) the process sdesign
 - (d) inclusion of safety shutdown system.
- (ii) Below the lower flammability limit
 - (a) Vapor-air mixture will burn spontaneously
 - (b) Vapor-air mixture will not burn
 - (c) Vapor-air mixture will burn if the pressure is increased
 - (d) Vapor-air mixture will burn spontaneously if pressure is reduced.
- (iii) 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) none of the above.
- (iv) Hazop:
 - (a) Generates a record that a recognized form of hazard analysis has been applied to the project
 - (b) Provides proof that a recognized form of hazard analysis has been applied to the project
 - (c) Both (a) and (b)
 - (d) None of the above.
- (v) The OR 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.

- (vi) 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) $P = A \cdot B \cdot C$
 (c) $P = A \cdot B + C$ (d) $P = A + B \cdot C$
- (vii) Basic rules for combination of frequencies of two events by OR gate is given by
 (a) $\lambda_A - \lambda_B$ (b) $\lambda_A + \lambda_B$
 (c) $\lambda_A \lambda_B$ (d) None of the above.
- (viii) Disaster management plans are
 (a) Monolayer (b) Bilayer
 (c) Multilayered (d) None of the above.
- (ix) The Bhopal accident, one of the major disasters in chemical industries, is linked with
 (a) MIC leakage on 3rd December, 1984
 (b) killed 2000 civilians and injured an estimated 20,000 more
 (c) 25 tons of toxic MIC vapor released
 (d) all of the above.
- (x) For control of air borne toxic material the most preferred method of choice is
 (a) Scrubbing (b) Ventilation
 (c) ESP (d) All of the above.

Fill in the blanks with the correct word

- (xi) An outstanding safety program prevents the _____ of safety hazards.
- (xii) The OSHA incidence rate is based on cases per _____ worker years.
- (xiii) The term HAZOP originates from _____.
- (xiv) Ventilation is based on _____ principle/s
- (xv) Mitigation means actions taken to eliminate a _____ or reduce its potential impact.

Group - B

2. (a) Define Runaway reactions. [[CO1](Remember/LOCQ)]
 (b) Distinguish between good and outstanding safety program. [[CO1](Remember/LOCQ)]
 (c) What do you understand by Inherent Safety? Discuss in details the major approaches to inherently safer process designs. [[CO1](Remember/LOCQ)]
2 + 4 + 6 = 12
3. (a) Write the empirical equations used for evaluating LFL and UFL for the following reaction:

$$C_m H_x O_y + z O_2 = m CO_2 + \frac{x}{2} H_2 O$$
[[CO2](Apply/HOCQ)]
- (b) A fuel air gas mixture containing 2% CH₄, 0.5% C₂H₄ 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. of the mixture.

Component	LFL (vol%)	UFL (vol%)
CH ₄	5.3	15.0
C ₂ H ₄	3.1	32.0
C ₆ H ₁₄	1.2	7.5

[[CO2) (Apply/HOCQ)]
5 + 7 = 12

Group - C

4. Describe in detail the procedure followed in HAZOP study. [[CO3)(Remember/IOCQ)]
12
5. (a) State the principles of Quantitative Risk Analysis (QRA). [[CO3)(Analyse/IOCQ)]
(b) Discuss briefly the logic tree approach followed in Quantitative Risk Analysis with special reference to Fault Tree Analysis and Event Tree Analysis. [[CO4)(Analyse/IOCQ)]
4 + 8 = 12

Group - D

6. 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. [[CO4)(Apply/HOCQ)]
12

7. (a) Two potentially dangerous but independent events occur at frequencies λ_A and λ_B respectively with duration D_A and D_B , show that the combined frequency of

the two dangerous events is given by $\lambda_{AB} = \lambda_A \lambda_B (D_A + D_B)$, and average duration for coincidence of the two recurring events is $D_{AB} = \frac{D_A D_B}{D_A + D_B}$. [[CO4](Apply/HOCQ)]

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

Data: $\lambda_A = 4yr^{-1}$, $\lambda_B = 1yr^{-1}$, $D_A = 0.75hr$, $D_B = 0.5hr$

Prove the formulas used for solving the problem.

[[CO2](Apply/HOCQ)]

6 + 6 = 12

Group - E

8. Xylene is used as a solvent in paint. A certain painting operation evaporates an estimated 0.02 Kg/min 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, the TLV-TWA. Also, compute the air required if the operation is carried out in an enclosed hood with an opening of 4.65 m² and a face velocity of 30.48 m / min. 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. Deduce the formula you have used.

[[CO3](Apply/IOCQ)]

(8 + 4) = 12

9. Explain in detail how emergency management is organized?

[[CO3](Apply/IOCQ)]

12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	37.5	25	37.5