

**INDUSTRIAL SAFETY AND HAZARDS
(CHEN 3222)**

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) In FAR calculation, the employees are assumed to work:
(a) A total of 50 years (b) A total of 60 years
(c) A total of 55 years (d) A total of 65 years.
- (ii) Autoignition temperature (AIT) is
(a) A fixed temperature above which adequate energy is available in the environment to provide an ignition source
(b) A fixed temperature below which adequate energy is available in the environment to provide an ignition source
(c) A fixed temperature below which adequate energy is available in the environment to provide an ignition source
(d) None of the above.
- (iii) A BLEVE occurs if a vessel that contains:
(a) A liquid at a temperature above its atmospheric pressure boiling point ruptures.
(b) A gas above atmospheric pressure ruptures
(c) A liquid at a temperature below its atmospheric pressure boiling point ruptures
(d) A gas below atmospheric pressure ruptures.
- (iv) 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 (a), (b) & (c).
- (v) 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).

- (vi) Fault trees are
(a) A logical method for identifying ways in which hazards can lead to accidents
(b) A deductive method for identifying ways in which hazards can lead to accidents
(c) Combination of both logical and deductive methods for identifying ways in which hazards can lead to accidents
(d) None of the above.
- (vii) 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.
- (viii) 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.
- (ix) Mond index takes account of circumstances other than processing, such a storage, loading and unloading
(a) True (b) False
(c) Not always true (d) None of (a), (b) & (c).
- (x) 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) $LFL = 0.55 C_{st}$.

Group- B

2. (a) Define:
i. Unknown risk
ii. Predictable risks
iii. Temporary risks. [(CO1)(Remember/LOCQ)]
- (b) Describe in detail the salient features of runaway reaction encountered in chemical process industry. [(CO2)(Analyze/IOCQ)]
- (c) Write short notes on BLEVE. What is fire triangle? [(CO1)(Analyze/IOCQ)]
- 3 + 4 + 5 = 12**
3. (a) Distinguish between:
i. Explosion and Detonation
ii. OSHA and FAR
iii. Flash point and fire point. [(CO2)(Remember/LOCQ)]
- (b) Estimate the minimum oxygen concentration for propane. Given that the lower flammability limit for propane is 2.2 %. By volume. [(CO3)(Evaluate/HOCQ)]
- (c) A fuel air gas mixture containing 2% CH_4 , 1.0% C_2H_6 and 0.5 % C_3H_8 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 ₆	3.0	12.5
C ₃ H ₈	2.2	9.5

[(CO3)(Analyse/IOCQ)]

3 + 4 + 5 = 12

Group - C

4. (a) What are the documentation requirements for a typical HAZOP study? Describe in detail the procedure followed in HAZOP study. [(CO3)(Analyze/IOCQ)]
 (b) Define Material Factor. Discuss in detail the procedure followed in calculating the Mond fire, explosion, and toxicity index. [(CO3)(Analyze/IOCQ)]
 6 + 6 = 12
5. (a) 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. [(CO3)(Understand/LOCQ)]
 (b) What are general process hazards and special process hazards? [(CO3)(Understand/LOCQ)]
 6 + 6 = 12

Group - D

6. A reactor effecting an exothermic reaction is at risk of thermal runaway 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 and calculate 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

Failure Logic Analysis: Runaway 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. [(CO4)(Evaluate/HOCQ)]

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7. A car traveller wishes to have cold drink while driving. So he reached near to a country club. This public house has a car park and two cold drink counters, public and lounge, each with their cold drink supply system and counter staffs. Note that the two systems

are totally separate and identical except for the staff. The undesired event is “no cold drink for the car traveller”. Make a fault tree analysis for this case.

[(CO4)(Analyze/IOCQ)]

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Group - E

8. (a) Discuss in details the safety precautions to be taken during working in laboratory. [(CO3)(Understand/LOCQ)]
 (b) Name the different types of disaster and explain them. [(CO3)(Remember/LOCQ)]
8 + 4 = 12

9. (a) Prove that the working exposure to toxic vapour is given by:

$$C_{ppm} = \frac{Q_m R_g T}{k Q_v P M} \times 10^6$$

Where the notations bear their usual meanings. [(CO2) (Evaluate/HOCQ)]

- (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 10^{-4} kg/min. The ventilation rate is 2,83 m³/min. The temperature is 27.6°C and the pressure is 1 atm. Estimate the concentration of toluene vapor in the enclosure. [(CO2) (Evaluate/HOCQ)]
 (c) Discuss in details the cause and effect of any one major accident in chemical industry. [(CO2)(Analyze/IOCQ)]
4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	31.25	43.75	25

Course Outcome (CO):

- Ability to use important technical fundamentals of chemical process safety and to impart basic knowledge that allows the students to evaluate occupational safety and health hazards in the workplace.
- Ability to analyze the effects of workplace exposures, injuries and illnesses, fatalities.
- Ability to use safety programs to prevent or mitigate damage or losses and to develop preventative measure to avoid accident.
- Ability to use logic based quantitative risk analysis

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.