B.TECH/BT/CE/7TH SEM/CHEN 4181/2018

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

(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) 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.

(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 the above.

(vi) 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.

(vii) The Risk Management Plan document is updated when
(a) there is a serious accident in the plant
(b) the process or chemistry changes
(c) a government audit requests an update
(d) both (b) and (c).

(viii) 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}.

(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) 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.

Group – B

2. (a) Runaway reactions have been the immediate cause of a number of the most notorious chemical process incidents. Stating the common causes of runaway reactions, explain critically the theory of runaway reactions.

(b) Distinguish between:
(i) fire and explosion
(ii) flash point and fire point
(iii) lower and upper flammability points

6 + 6 = 12

3. (a) A fuel air gas mixture containing 5% CH_4, 2% C_2H_4 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

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

7 + 5 = 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. (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 10^6hours 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.

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 to 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 to shut	0.001/demand
Low flow trip failure	0.01/demand
High temperature trip failure	0.01/demand

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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 derails 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 ($year^{-1}$) 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^{-4} ,$year^{-1}$

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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 26.67^0C 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. Discuss in details the case history of the following accident.
Seveso (Italy) accident on July 10, 1976

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