INDUSTRIAL SAFETY AND HAZARDS 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. Symbols are of usual significance

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(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 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}

(iii) 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.

(iv) 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.

(v) Disaster management plans are
(a) Monolayered (b) Bilayered
(c) Multilayered (d) None of the above.

(vi) The Dow F&EI is designed for rating the relative hazards
(a) with the storage materials
(b) with the handling of flammable materials
(c) with the processing of explosive materials
(d) all of the above.

(vii) 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.

(viii) 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.

(ix) 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 at which adequate energy is available in the environment to provide an ignition source
(d) none of the above.

(x) A fault tree
(a) gives the probability of an untoward incident
(b) examines the possible consequences of an untoward incident.
(c) gives the probability of an untoward incident as well as examines the possible consequences of that incident.
(d) none of the above.

Fill in the blanks with the correct word

(xi) 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 P = _____

(xii) Hazard is a chemical or physical condition that has the potential to cause_____

(xiii) An inherently safe plant relies on_____to prevent accidents.

(xiv) The principal document/s for a Hazop is _____

(xv) The flash point generally increases with _____.

Group - B

2. (a) Distinguish between:
(i) Fire and explosion.
(ii) Flash point and fire point
(iii) Lower and Upper flammability point. *[(CO1) (Remember/LOCQ)]*

(b) A fuel air gas mixture containing 2% CH_4, 0.5% C_2H_4 and 0.8 % hexane and rest air by volume is used in a chemical process industry. From the data given below find its LFL.

Component	LFL (vol%)	UFl (vol%)
CH_4	5.3	15.0
C_2H_4	3.1	32.0
C_6H_{14}	1.2	7.5

[(CO2)(Analyze/IOCQ)]

(c) What is the upper flammability of the above gas mixture? *[(CO1)(Analyze/IOCQ)]*

6 + 4 + 2 = 12

3. (a) What do you understand by Inherent Safety? *[(CO2) (Remember/LOCQ)]*
   (b) Discuss in details the major approaches to inherently safer process designs. *[(CO2) (Remember/LOCQ)]*
   (c) Estimate the minimum oxygen concentration for methane for the reaction
   $C_2H_4 + 3O_2 = 2CO_2 + 2H_2O$
   Given that the lower flammability limit for ethylene is 3.1 volume%.
   [(CO3)(Analyse/IOCQ)]

2 + 6 + 4 = 12

Group - C

4. (a) What do you understand by the term HAZOP and its objective? *[(CO3)(Analyze/IOCQ)]*
   (b) State the composition of a typical HAZOP team for a new project. *[(CO3)(Analyze/IOCQ)]*
   (c) Discuss briefly the methodologies followed during FMEA. *[(CO3)(Analyze/IOCQ)]*

3 + 3 + 6 =12

5. (a) Define Material Factor. *[(CO3)(Understand/LOCQ)]*
   (b) Discuss in detail the procedure followed in calculating the Mond fire, explosion, and toxicity index. *[(CO3)(Understand/LOCQ)]*
   (c) Write a brief note on general process hazards and special process hazards. *[(CO3)(Understand/LOCQ)]*

2 + 4 + 6 = 12

Group - D

6. (a) Enumerate the advantages of Event Tree Analysis in Quantitative Risk Assessment. *[(CO4) (Analyze/IOCQ)]*
   (b) 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 $\lambda_{AB} = \lambda_A \lambda_B (D_A + D_B)$. *[(CO4)(Analyze/IOCQ)]*
   (c) Find the average duration for coincidence of the two recurring events described above'. *[(CO4)(Analyze/IOCQ)]*

4 + 5 + 3 = 12

7. (a) Define the term Fault Tree Analysis. *[(CO4)(Analyze/IOCQ)]*
   (b) 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.

Data:

Probability that a derailed train overturns	0.5
Probability that an overturned train catches fire	0.1
Probability that fire engulfsLPG 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} ,$year^{-1}$

Draw a Fault Tree for the undesired event explosion of the LPG storage installation. *[(CO4)(Analyze/IOCQ)]*

(c) Estimate the frequency of explosion ($year^{-1}$) of the LPG storage installation from the data given above. *[(CO4)(Analyze/IOCQ)]*

2 + 7 + 3 = 12

Group - E

8. (a) Explain the detail how emergency management is organized. *[(CO3)(Remember/HOCQ)]*

(b) Describe in detail any one major accident that took place in chemical industry. *[(CO2)(Evaluate/HOCQ)]*

(c) Suggest a plan of action to mitigate such accident. *[(CO2)(Evaluate/HOCQ)]*

4 + 6 + 2 = 12

9. (a) Explain in detail how emergency management is organized. *[(CO3)(Remember/HOCQ)]*

(b) An open container containing a volatile solvent in an enclosure is weighed as a function of time and it is determined that the average evaporation rate is 980 mg/min. The ventilation rate is 2.53 m^3 / min. The temperature is 28^0C and the pressure is 1 atm. Estimate the concentration of the solvent in the enclosure.
Data: The non-ideal mixing factor (k) = 0.48. *[(CO2)(Evaluate/HOCQ)]*

(c) Deduce the formula you have used. *[(CO2)(Evaluate/HOCQ)]*

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	27.08	47.92	25

Course Outcome (CO):

After the completion of the course students will be able to

1. 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.
2. Ability to analyze the effects of workplace exposures, injuries and illnesses, fatalities.
3. Ability to use safety programs to prevent or mitigate damage or losses and to develop preventative measure to avoid accident.
4. Ability to use logic based quantitative risk analysis.

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