

INDUSTRIAL SAFETY and HEALTH

4th June 2021

TOTAL TIME 90 minutes (PART 1 + Part 2)

Signalize just one answer to each questions. In the case two answers are signalized quotation will be zero. Quotation for each correct answer to multiple choices questions is one.

BE AWARE - You will receive **PART 2**, after deliver **PART 1**

PART 1

1 - Hazardous substances are those that:

- Find a receptor in the human body or environment and disturb their normal performance
- Can cause intoxication or death
- Are responsible for malaise of workers and environmental modifications
- Are responsible for professional diseases.

2 - P-statement means:

- Precaution statement
- Prevention statement
- Precautionary statement
- None of the previous

3 - The TLV-TMP value for acetonitrile (CH₃CN, MW 41 g/mol) and nitrogen monoxide (NO, MW 30 g/mol) are respectively 67 and 61 mg/m³. Identify the correct sentence.

- At the workplace, CH₃CN represents a bigger risk than NO.
- Acetonitrile represents a lower risk than nitrogen monoxide under time average conditions.
- At the workplace, NO represents a higher risk than CH₃CN, no matter the conditions.
- It is not possible to compare because acetonitrile is a liquid and nitrogen monoxide is a gas.

4 – Increasing by 1.2 m, the actual distance (2 m) of a noisy equipment to a worker, the noise:

- Decreases by 1.2 DB
- Decreases by 9.4 DB
- Decreases by 4.1 DB
- Decreases by 1.6 DB

5 - Safety at warehouses for chemicals is based on existing:

- Guidelines, labels and pictograms
- Safety plan, good practices and formation
- General organization and quantity of chemicals
- Type of circulation areas and formation of workers

6 - Colorimetric tubes are used to:

- Analyze the quality of the air
- Analyze and quantify specific substances in the air
- Quantify unknown substances in the air
- Quantify unknown substances in the sea water

7 –The half time for ethanol elimination is 6h 20 min. After 8 h upon exposure to 0.12 mg of ethanol the amount (mg) that still remains in the body is:

- 0.050
- 0.11
- 0.016
- 0.095

8 – Sick Building Syndrome detection is based on symptoms:

- Increase during day and decrease during weekend
- Increase during day, remain during night and disappear at the weekend
- Increase during the workday and decreases at night and disappear during the weekend
- None of those mentioned

9 - Directive on Equipment and Protective Systems (2014/34/EU) is also known as

- ATEX 95
- ATEX Equipment
- ATEX Workplace
- ATEX Product

10 - Under the point of view of safety, incompatible substances are those that:

- React in a non-desired way
- React very slowly
- Explode
- Cause major accidents

11 – Safety management systems strategy is based on:

- Risk assessment and mitigation as a prevention strategy
- Hazards and risk identification
- Plan for emergency
- Establishment of a safety policy, promotion and assurance of procedures

12 –According to ADR identification of vehicles carrying hazardous substances includes:

- Red plates divided in sections referring the EC number and class of risk
- Red plates divided in sections referring the UN number and class of hazard
- Orange plates divided in sections referring to the UN number and class of hazard
- One orange plate divided in sections referring to the UN number and class of risk

13 – HACCP is a safety management system directed to:

- Workplace safety
- Risk assessment and mitigation
- Assessment of industrial risks
- [None of the answers](#)

INDUSTRIAL SAFETY and HEALTH

4th June 2021

PART 2

Problem 1 (3 val)

HAZOP and FMEA are risk assessment methodologies.

- a) List the main steps to follow on application of FMEA methodology.
 - b) List three differences between FMEA and HAZOP.
 - c) Aiming at sustainable development, which of the upper risk assessment methods do you recommend for a settled chemical industry? Justify your answer.
- a) Study and definition of the process; Identification of all possible failures; Identification of the failure consequences (severity); Identification of failure causes (frequency); Control methods (detection); action plan.
- b) FMEA involves:
- 1- identification of failures at a node, so it can encompass risk quantification involving workers, processes and environment;
 - 2- considers existing detection controls and the eventual need for improvement;
 - 3- risk priority number
- HAZOP involves:
- 1- Guide-Words and Parameters to foresee possible failures of a process / equipment;
 - 2- Drifts identification
 - 3- No simultaneous quantification of the risk for worker, environment process.
- c) FMEA because it allows a combined assessment of severity for workers, process and environment

Problem 2 (2 val)

A leak in the gas transport pipeline, created an atmosphere with 2% ethylene and 1% ethane (% vol.) The average temperature at the was 25 °C. **Comment on risk of explosion and what should be done.** Support your answer with the calculations. For calculations, consider the following properties of pure compounds at 1 atm and 25 °C:

Compound	$\Delta H_{\text{combustion}}$ (kcal/mol)	LFL (%)	UFL (%)
Ethylene	337.01	2.75	28.6
Ethane	372.8	3	12.4

Consider that in a mixture of flammable liquids, LFL and UFL can be calculated from the value for each pure compound, by the Chatelier relation:

$$LFL_{mix} = 1/\sum(y_i / LFL_i) \quad UFL_{mix} = 1/\sum(y_i / UFL_i)$$

The values of the compounds (see table) can be corrected for temperature by the equations:

$$LFL_t = LFL_{25}(1 - 0.75(T - 25) / \Delta H_c) \quad UFL_t = UFL_{25}(1 + 0.75(T - 25) / \Delta H_c)$$

and UFL can be corrected in relation to pressure by the equation (p in MPa abs):

$$UFL_p = UFL_{atm} + 20.6(\log_{10} p + 1)$$

	LFL(25°C)	UFL(25°C)		
Ethylene	2.75	28.6	337.01	kcal/mol
Ethane	3	12.4	372.8	kcal/mol
Combustible base				
yEti=	2	0.666667	Total combustible	
yEta=	1	0.333333	3	

Temperature correction UFL

t=	25	°C
yEti=	28.60	%
yEta=	12.40	%

Temperature correction LFL

2.75	%
3.00	%

Pressure correction UFL

p=	0.1	MPa
yEti=	28.6	%
yEta=	12.4	%

Calculation mixture

UFL=	19.9236	%	LFL=	2.828571	%
------	---------	---	------	----------	---

The composition of the mixture in the air is 3% (2% ethylene + 1 % ethane). The values LFL and UFL calculated are respectively 2.8% e 19.9%, for the gases in that proportion - mixture. Thus the risk of fire is very high if an ignition source exists. Required actions are: improve ventilation to a faster decrease of the combustible in the air till value is lower than LFL. Just after that action repair of the leak should begin.

Problem 3 (2 val)

After an incident at a store of chemicals, the evaluation of the indoor air quality showed the results bellow.

Substance	MW (g/mole)	Concentration (mg/m ³)	TLV-TWA	TLV-STEL
Ethylene	28	100	200 ppm	600 ppm
Propane	44	500	1000 ppm	7200 mg/m ³

Toluene	92	5	20 ppm	560 mg/m ³
---------	----	---	--------	-----------------------

The cleaning team needs ¼ of hour to accomplish the cleaning process and leave. Check if under the toxicological point of view any actions are needed concerning safety of the cleaning team and in the affirmative case, say which. Support your affirmation with values.

For a process that takes 15 minutes the relevant parameter is TLV-STEL.

Ethylene TLV-STEL (600x28) /24.45 = 687 mg/m³

Since, for safety

$$\sum \frac{C_A}{TLV_A} + \frac{C_B}{TLV_B} + \dots + \frac{C_N}{TLV_N} \leq 1$$

It is necessary to apply the equation and calculate the value:

$$100/687 + 500/7200 + 5/560 = 0.22 \text{ mg/m}^3$$

Value is clearly lower than 1, thus no safety concerns exist.