Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2019

Course: Chemical Process & Plant Safety — **Semester: 8**
Program: CE-RP — **Time 03 hrs.**
Course Code: CHCE315 — **Max. Marks: 100**

Instructions:

SECTION A

S. No.	
Q 1	It is reported that about 5000 Indians are killed by lightning each year. The current population of India is 2.5 billion. Which accident index is suitable for this information: FAR, OSHA incidence rate or fatality rate (deaths per person per year)? Why? Calculate the value of the selected index. [**4**] [**CO1**]
Q 2	Air contains 5 ppm of diethylamine (TLV-TWA = 5 ppm), 20 ppm of cyclohexanol (TLV-TWA = 50 ppm) and 10 ppm of propylene oxide (TLV-TWA = 2 ppm). Calculate the mixture TLV-TWA and has this limit been exceeded. [**4**] [**CO3**]
Q 3	Briefly describe the different ways in which the toxicants enter a living organism. [**4**] [**CO2**]
Q 4	Define a probit variable. How does it help to model a response curve? [**4**] [**CO2**]
Q 5	Discuss briefly the two commonly used neutrally buoyant dispersion models. [**4**] [**CO5**]

SECTION B

Q 6	A storage tank containing acrolein (maximum permissible limit = 0.05 ppm) is located 1500 m from a residential area. Estimate the constant rate at which acrolein must be continuously released at the ground level to produce a concentration equal to the permissible limit at the location of the residential area at steady state. Assume that the eddy diffusivity model is valid in this case with $K_x^* = K_y^* = K_z^* = 0.1$ cm^2/sec and zero wind velocity. [**10**] [**CO5**]
Q 7	The following equation provides a mass balance for the evolution of volatile material in an enclosure. $V\frac{dC}{dt}=Q_m-k\,Q_V\,C$ Integrate the above expression to obtain the following expression for concentration at any time $t > 0$. $\frac{Q_M/V-C/\tau}{Q_M/V-C_0/\tau}=e^{-t/\tau}$ Find an expression for the time constant τ. [**10**] [**CO3**]
Q 8	A 0.2 mm hole forms in a tank containing oxygen (γ = 1.4) at 30 MPa gauge pressure and 40 °C. Determine the mass flow rate through this leak. Assume an orifice discharge coefficient of 1.0. The flow rate of an ideal gas through an orifice is given by, $Q_m=C_0 A P_0\sqrt{\frac{2g_c M}{R_g T_0}\frac{\gamma}{\gamma-1}\left[\left(\frac{P}{P_0}\right)^{2/\gamma}-\left(\frac{P}{P_0}\right)^{(\gamma+1)/\gamma}\right]}$

where,
C_0 = Discharge coefficient, A = Area of the hole, P_0, T_0 = pressure and temperature of the gas in the tank, M = molecular weight of the gas, γ = ratio of specific heats, R_g= Ideal gas constant = 8.314 J/mol.K

[10] [CO4]

Q 9 Derive the governing equation for concentration levels for neutrally buoyant dispersion models of both puff and plume releases. **[10] [CO5]**

SECTION-C

Q 10 A tank with a drain pipe is shown in Figure 1 below. The tank contains crude oil, and there is a concern that the drain pipe might shear off below the tank, allowing the tank contents to leak out.

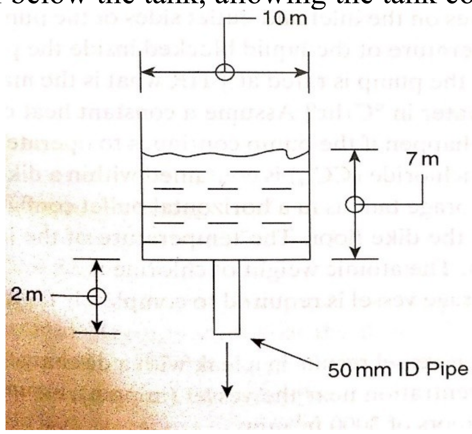

Figure 1

If the drain pipe shears 2 m below the tank, and the oil level is 7 m at the time, estimate the initial mass flow rate of material out of the drain pipe. The crude oil has a density of 928 kg/m^3 and a viscosity of 0.004 kg/m. Assume that the interior of the pipe is smooth and that the following relationships hold for the Fanning friction factor.

$$f=\frac{16}{\Re}\ \Re<2000$$

$$\frac{1}{\sqrt{f}}=-4\log\left(\frac{1}{3.7}\frac{\epsilon}{d}+\frac{1.255}{\Re\sqrt{f}}\right)\ \Re>4000$$

where,
Re = Reynolds' number, f = Fanning friction factor, ε = Roughness factor, d = Internal diameter of pipe.

[20] [CO4]

Q 11 An alkylation unit was being started up after shutdown because of an electrical outage. When adequate circulation could not be maintained in the deisobutanizer heater circuit, it was decided to clean the strainer. Workers had depressurized the pipe and removed all but three of the flange bolts when a pressure release blew a black material from the flange followed by butane vapors. These vapors were carried to a furnace 100 ft away, where they ignited, flashing back to the flange. The ensuing fire exposed a fractionating tower and horizontal receiver drums. These drums exploded, rupturing pipelines, which added more fuel. The explosions and heat caused loss of insulation from the 8-ft × 122-ft fractionator tower, causing it to weaken and fall across two major pipelines, breaking pipes which added more fuel to fire. Extinguishment, achieved basically by isolating the fuel sources, took 2.5 hours.
The fault was traced to a 10-in valve that had been prevented from closing the last 0.75-in by a fine powder of carbon and iron oxide. When the flange was opened, this powder blew out, allowing liquid butane to be released.

	Identify the initiation, propagation and termination steps. **[20] [CO1]**

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Instructions:

	SECTION A
S. No.	
Q 1	Discuss briefly the different techniques by which toxicants are eliminated from biological organisms. **[4] [CO2]**
Q 2	Define TLV-TWA and TLV-STEL. **[4] [CO2]**
Q 3	Briefly describe the different steps of consequence modeling. **[4] [CO4]**
Q 4	If twice as many people used motorcycles for the same average amount of time each, what will happen to (a) the OSHA incidence rate, (b) the FAR and (c) the fatality rate? **[4] [CO1]**
Q 5	What should be the boundary condition at the center for a plume-type neutrally buoyant dispersion model with a continuous constant source at the center? **[4] [CO5]**
	SECTION B
Q 6	A storage tank containing acrolein (maximum permissible limit = 0.05 ppm) is located 1500 m from a residential area. Estimate the amount of acrolein that must be instantaneously released at the ground level to produce a concentration equal to the permissible limit at the location of the residential area. Assume that the eddy diffusivity model is valid in this case with $K_x^* = K_y^* = K_z^* = 0.1$ cm^2/sec and zero wind velocity. **[10] [CO5]**
Q 7	Derive the formula for the concentration C (in ppm) in an enclosure with spill area A, pressure P, and a ventilation rate of Q_v. Take the mass transfer coefficient of the spilled liquid to be K and the vapor pressure of the same to be P^{sat}. Assume the non-ideal mixing factor to be k. **[10] [CO3]**
Q 8	Derive the expression for the concentration of a pollutant in case of a steady state continuous point release with no wind. Assume a constant mass release rate Q_m and a constant eddy diffusivity, K^*, which is the same in all directions. **[10] [CO5]**
Q 9	Describe the causes of the Bhopal gas tragedy in brief. **[10] [CO1]**
	SECTION-C
Q 10	Derive an expression for the choked pressure and the choked flow rate for a gas flowing out of a tank at pressure P_0 and temperature, T_0, through an orifice with discharge coefficient 1.0 with ratio of specific heats equal to γ. Take the molecular weight of the gas to be M. **[20] [CO4]**
Q 11	Liquid chlorine is supplied to a process from a regulated pressure source 20 barg (1 bar = 100 kPa)

through 300 m of a horizontal new commercial steel pipe ($\varepsilon = 0.046$ mm) of actual inside diameter of 0.02 m. The ambient pressure is 1 atm.

If the pipe breaks off at the regulated source, estimate the flow rate through the leak, in kg/s.

If the pipe breaks off at the end of the 300-m length pipe, estimate the flow in kg/s.

Density of chlorine is 1380 kg/m^3 and viscosity is 0.328×10^{-3} Pa.s. Assume an orifice discharge coefficient of 0.61 and the following equation for the Fanning friction factor.

$$f = \frac{16}{\Re} \quad \Re < 2000$$

$$\frac{1}{\sqrt{f}} = -4\log\left(\frac{1}{3.7}\frac{\epsilon}{d} + \frac{1.255}{\Re\sqrt{f}}\right) \quad \Re > 4000$$

where,

Re = Reynolds' number

f = Fanning friction factor,

ε = Roughness factor,

d = Internal diameter of pipe. [**20**] [**CO4**]