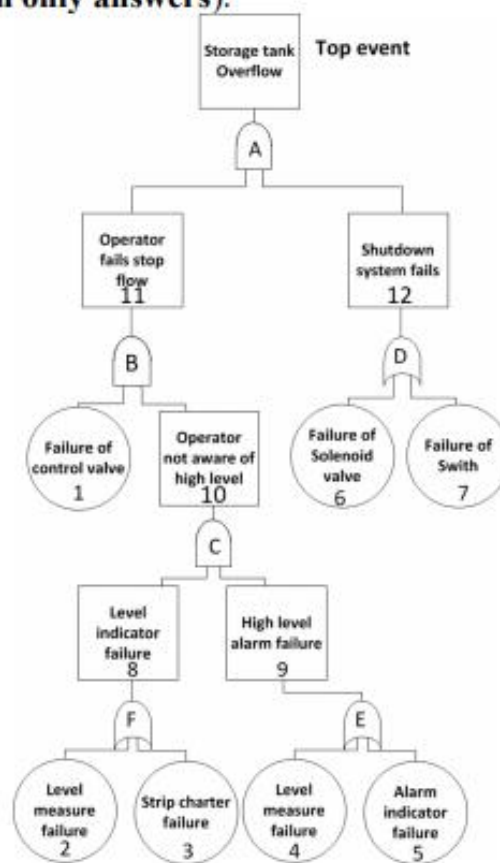


Question 1 (3 marks)

Determine the minimal cut sets in the following diagram (Write down the analysis process. No mark will be given with only answers).



Question 2 (5 marks)

In a ventilation process occurring in the painting evaporation using the toluene as the solvent, an approximate 5 gal of toluene was evaporated within an 8-hr shift. The ventilation process is rated as poor. (a) Determine the quantity of required air for the dilution ventilation to maintain the toluene concentration below 200 ppm, the TLV-TWA. (b) Calculate the required air if the operation is performed in an enclosed hood with an opening of 60 ft² and a face velocity of 150 ft/min. The temperature is 79 °F and the pressure is 1 atm. The specific gravity of the toluene is 0.867, and its molecular weight is 92.

Nonideal mixing factor for dilution ventilation conditions

Vapor concentration/ppm	Dust concentration/mppcf	Mixing factor: Ventilation condition			
		Poor	Average	Good	Excellent
over 500	50	1/7	1/4	1/3	1/2
101-500	20	1/8	1/5	1/4	1/3
0-100	5	1/11	1/8	1/7	1/6

Question 3 (4 marks)

Hazard analysis is being carried out on the following design, to estimate the risk of no flow from valve D. As shown in Figure 3.1A, three pumps (A, B and C) have separated power supply (PS). During annual operation, the probabilities of failure in power supply, pump and valve are 0.1, 0.15 and 0.2, respectively. (a) If the design proceeds as shown in Figure 3.1A, what is the probability of no flow from valve D (**Draw the Fault Tree and show the calculation process**)? (b) What would be the probability of no flow from valve D if all three pumps have a common power supply (Figure 3.1B, **Draw the Fault Tree and show the calculation process**)?

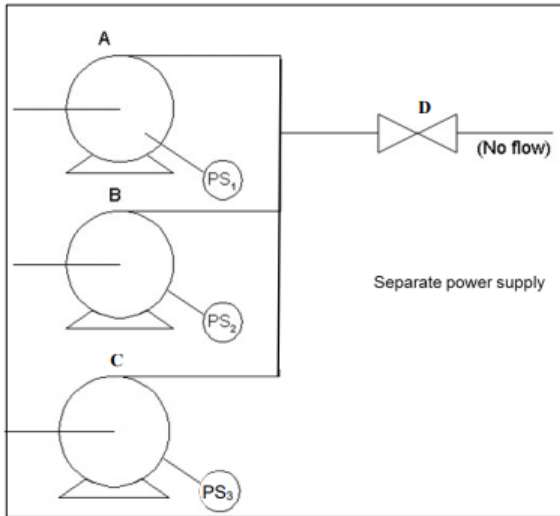


Figure 3.1A

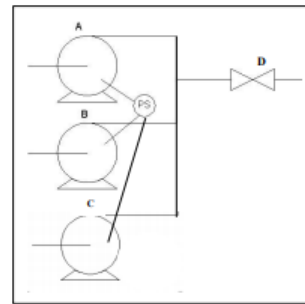


Figure 3.1B

Question 4 (8 marks)

Based on the knowledge learned in the unit, discuss the effect of heavy metal ions on biological organisms (at least 1000 words). You can use but no limit to the following aspects in the discussion. For example, (1) Types of heavy metal ions, (2) How the metal ions enter the organisms, (3) What is the effect? (4) How to eliminate?