National Exams - May 2019

18-Env-B5, Industrial & Hazardous Waste Management

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.

   Any non-communicating calculator is permitted.

3. Marks are indicated beside each question for a total of 100 marks .

4. Clarity and organization of the answer are important.

Q.1. **(10 points)**
All of the statements below are false. Discuss why they are false and correct them.

1. The thermal process that implies the splitting of organic substances into gaseous, liquid, and solid fractions in an oxygen free atmosphere is called gasification
2. In order to protect the microorganisms from excessive heat exposure, the temperature in the body of the composting pile should not exceed 95 °C
3. Chemicals with high values of octanol-water partition coefficient (K_{ow} > 10) tend to be hydrophilic, remain in aqueous phase, and are generally more mobile in the environment.
4. In biological treatment of waste, electron acceptor is usually the organic waste.
5. POHCs, Principal Organic Hazardous Constituents are defined as constituents that are detected in emissions and identified in the incoming waste stream at concentration greater than 1000 mg/kg

Q.2. **(5 points)**
The following table is a section from the compatibility chart for storage of hazardous waste. List the materials that can be stored together without causing any hazard.

Reactivity group						
No	Name					
1	Acids, minerals, non-oxidizing	1				
2	Acids, minerals, oxidizing		2			
3	Acids organic		G H	3		
4	Alcohols & glycols	H	H F	H P	4	
5	Aldehydes	H P	H F	H P		5

Q.3. **(5 points)**
In a TCLP test, the concentrations of all tested contaminates were found to be below the maximum permissible level. Under Ont. Regulation 347, explain if this information is enough to define if the waste is hazardous or not?

Q.4. (5 points)

A 200 m^3 recycled bioreactor receives an industrial wastewater at a rate of 400 m^3/d. The settled biomass of concentration 15 g/L is wasted at a rate of is 300 kg/d. Discuss the expected performance of the reactor and improvement measures based on hydraulic and solid retention times calculation.

Q.5. (5 points)

Considering a first-order decay rate $\frac{d_c}{d_t} = -k_T C$, determine the time required for the concentrations of toluene (30 mg/L) in a treatment pond to be reduced to one half of its initial values. Assume the first order removal constants (k_T) for toluene is 0.067/hr.

Q.6. (10 points)

Benzene at 25 °C, find:

a. Henry's constant in water
b. Calculate H', dimensionless constant
c. How can you leverage this information (Henry's constant) to decide for a remediation method?

Q.7. (15 points)

Use the following half-reactions to discuss the possible reduction of nitrobenzene using iron (II). Base your discussion on the calculated standard electrode potential and standard free energy change.

$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$ $\quad E^0 = +0.77$ V

Q.8. **(15 points)**

A ground water aquifer is contaminated with benzene at a concentration of 150 mg/L. Design an air stripping process using the following data:

KLa = 0.015 sec^{-1},
Flow rate = 2.19 L/sec
Temperature = 25 °C
Henrys Constants: A = -3.19x 10^3 and B = 5.53
Column diameter = 0.765 m
Air to water ratio (Q_A/Q_W) = 50
The concentration has to be reduced to 130 µg/L

Q.9. **(15 point)**

A company is faced with the decision of selecting either hazardous waste minimization process A or B. Process A involves purchasing machinery that costs $1.2 million with annual maintenance expenses of $150,000 for the first 10 years and $180,000 for the following 10 years. Process B calls for buying machinery that costs $1.5 million and has maintenance charges of $100,000 for the 20-year period. Both sets of machinery have zero salvage value. Which process is more economical for the company at a 15 % rate of interest?

Q.10. **(15 points)**

100 m^3 of benzene was spilled on soil of an area of 300 m^2. Use Hartley's method to estimate the time required to volatilize the entire amount of benzene. Use an estimated diffusion coefficient of 0.087 cm^2/s. The following data is provided:

- Benzene saturation in air = 319 g/m^3
- Diffusion coefficient = 0.087 cm^2/sec
- Humidity = 0.3; Temperature = 20 °C
- Latent heat of vaporization = 9.53 Kcal/mol
- Thickness of stagnant boundary layer = 3 mm
- Density of benzene = 878.6 kg/m^3