National Examination December 2019

18-Env-B5, Industrial & Hazardous Waste Management

Duration: 3 hours

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 BOOX 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. ***(5 points)***

The two statements below are false. Discuss and explain why these statements are not correct.

a. In the process of hazardous waste identification, if a substance (A) was not listed in any of the F, K, P, U, and S lists (schedules in O.R. 347), then substance (A) is definitely not hazardous.

b. A substance (B) has to be tested according to TCLP procedure. The solid content is 0.4%. It is required that the substance should be shredded to less than 1 cm, dried and mixed with acetic acid on a ratio of 1:20.

Q.2. **(10 points)**

Explain the following mechanisms of hazardous waste treatment and give one technology example used for each mechanism.

- Microencapsulation
- Macroencapsulation

Q.3. **(10 points)**

What is the half-life of a toxic compound for which a laboratory treatability test yielded a first-order degradation rate constant of 0.02 day^{-1}?

Q.4. You are mixing two waste streams together. Using the data below, calculate:

a. Cadmium concentration of the mixed material (dry and wet). ***(5 points)***

b. Is the mixed waste a hazardous waste under TCLP (the TCLP limit for Cadmium is 5 mg/L)? ***(5 points)***

Waste	Mass (kg)	Density (kg/m^3)	MC %	Cadmium (mg/kg–wet)
A	40	120	40	370
B	30	175	50	190

Q.5. **(10 points)**

An open vat 1.25 m x 0.75 m x 0.3 m deep is used to store spent MIBK prior to distilling it for reuse. The temperature is 20 °C. Estimate the rate of volatilization across the surface of the vat. For MIBK, molecular weight = 100 g/mol and vapour pressure = 15 mm Hg.

Q.6. (10 points)

Using the standard electrode potentials for the half reactions, determine the free energy for oxidation of Fe^{2+} by MnO_2 in acid solution. Use the table below to solve your question.

Standard electrode potentials at 25°C

Reaction	E^0, volts
$Cl_{2(g)} + 2e^- \rightarrow 2Cl^-$	+1.36
$HOCl + H^+ + 2e^- \rightarrow Cl^- + H_2O$	+1.49
$ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$	+0.90
$NH_2Cl + H_2O + 2e^- \rightarrow Cl^- + NH_3 + OH^-$	+0.75
$NHCl_2 + 2H_2O + 4e^- \rightarrow 2Cl^- + NH_3 + 2OH^-$	+0.79
$NH_3Cl^+ + H^+ + 2e^- \rightarrow Cl^- + NH_4^+$	+1.40
$NHCl_2 + 3H^+ + 4e^- \rightarrow 2Cl^- + NH_4^+$	+1.34
$O_3 + 2H^+ + 2e^- \rightarrow O_2 + H_2O$	+2.07
$O_3 + H_2O + 2e^- \rightarrow O_2 + 2OH^-$	+1.24
$H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$	+1.78
$HO_2^- + 2e + H_2O \rightarrow 3OH^-$	+0.85
$HO_2^- + 2e + H_2O \rightarrow 3OH^-$	+0.85
$ClO_2 + 2H_2O + 5e^- \rightarrow Cl^- + 4OH^-$	+1.71
$MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$	+1.68
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$	+1.49
$MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$	+0.58
$O_{2(g)} + 4H^+ + 4e^- \rightarrow 2H_2O$	+1.23
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$	+0.40
$HBrO + H^+ + 2e^- \rightarrow Br^- + H_2O$	+1.33
$MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$	+1.23
$ClO_2 + e^- \rightarrow ClO_2^-$	+1.15
$Fe(OH)_3 + e^- + 3H^+ \rightarrow Fe^{2+} + 3H_2O$	+1.06
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+0.77
$ClO_2 + 2H_2O + 5e^- \rightarrow Cl^- + 4OH^-$	+0.76
$ClO_3 + H_2O + 2e^- \rightarrow ClO_2 + 2OH^-$	+0.35
$S_{(s)} + 2H^+ + 2e^- \rightarrow H_2S_{(g)}$	+0.17
$NO_3^- + H_2O + e^- \rightarrow NO_2^- + 2OH^-$	+0.01
$\frac{1}{4}CO_{2(g)} + H^+ + e^- \rightarrow \frac{1}{24}(\text{glucose}) + \frac{1}{4}H_2O$	−0.20

Q.7. (10 points)

Determine the amount of carbon required to treat 10,000 gal/day of water contaminated with 600 mg/L xylenes. Assume a required effluent of 10 mg/L and the Freundlich isotherm is $q = 51.3C_f^{0.187}$.

Q. 8. (10 points)

Determine the amount of air required for the complete combustion of one tonne of organic solid waste (C_5H_{12}).

Q.9. (15 points)

A 5000-gal bioreactor operates at a biomass concentration of 2000 mg/L, measured as mixed liquor volatile suspended solids (MLVSS) and treats 10,000 gallons per day of liquid waste containing 1000 mg/L of total organic carbon (TOC). The suspended solids are separated in a clarifier following the bioreactor with recycle of separated sludge. The recycle flow rate is 5000 gals/day. Each day, 300 gal of recycle are wasted. The effluent from the clarifier contains 40 mg/L MLVSS. What is the solids retention time? If too short, how can the SRT be increased?

Q.10. (10 points)

Sketch two cross sections in a hazardous waste landfill showing the bottom liner and the final cover.