

- An engineer proposes that metal-plating sludges be disposed of in a municipal waste landfill. To demonstrate the safety of the proposal, the engineer predicted leachate concentrations based on a laboratory test. The test involved drying and pulverizing the sludge, adding distilled water (proportional to the ratio between the mass of sludge to be landfilled and the total pore volume of the landfill), and stirring the mixture for 90 days. Would this test be expected to yield conclusive predictions of worst case leachate concentrations? [15%] Also briefly describe the sources of volatile emissions from the landfill. [10%]
- An off gas of the following composition: 30.0% CO, 30.0% H₂, 10% CH₄, 10% O₂ and 30% N₂ is burned with 20% excess air. The barometer reads 760 mmHg. Calculate the dewpoint of the stack gas. ($\ln P_{\text{water}}^* (\text{mmHg}) = 18 - (3820/(-46 + T(K)))$) [25%]
- Chlorinated organics, when burned in air, will produce HCl gas and some chlorine gas in the combustion products. The amount of chlorine in the flue gas is proportional to the incineration temperature and the amount of excess air in the combustion process. It is desirable to maximize the HCl and minimize the Cl₂ in the flue gas because HCl is very soluble in water. If much chlorine is formed it will have to be removed with a caustic solution. The reason the excess air affects the chlorine content is due to the reaction ($2\text{HCl} + 1/2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{Cl}_2$). The equilibrium constant (K_p) for this reaction can be expressed as follows:

$$K_p = \frac{(P_{\text{HCl}})^2 (P_{\text{O}_2})^{1/2}}{(P_{\text{H}_2\text{O}})(P_{\text{Cl}_2})}$$

where P is the partial pressure of the gas in the mixture. At 1200°C the K_p for the reaction is 30 while at 1000°C it is 20. When burning 200 lb/hr of monochlorobenzene in a liquid injection incinerator with 10 percent excess air, how much more chlorine will be in the flue gas at the lower temperature? [25%]

- The total mass of contaminants leached in a column leaching test from the unstabilized and pozzolanic reagent stabilized Imhoff sludge is as follows:

Parameter	Untreated sludge	Treated sludge
Arsenic	0.724	0.049
Cadmium	3.3	0.126
Chromium	0.566	1.16
Copper	3.86	3.2
Iron	48.4	1.57
Lead	0.238	0.019
Zinc	120	3.02

- Calculate the percent reduction in the mass of the leached constituents. [5%]
- What do you consider the average reduction in leached constituent concentrations? [10%]
- Which chemical parameter requires further consideration in evaluating the effectiveness of stabilization and why? [10%]