

For each problem, show the details of your calculations (equations, units etc.).

### **Problem 1**

Estimate the daily carbon utilization to remove chlorobenzene from 1 million gal/day of groundwater saturated with chlorobenzene. Assume a chlorobenzene concentration of 5 mg/L is acceptable for discharge to a POTW.

### **Problem 2**

Provide a preliminary design of a carbon adsorption system (i.e. the height of the adsorption zone, the number and size of column units, and the daily carbon usage rate) for the removal of 2,4,6-trichlorophenol from 250,000 gal/day of water. The following data are provided: Bohart-Adams model:  $a = 2.3$  days/ft;  $b = -10$  days (for the 90% removal line) in laboratory tests where trichlorophenol concentration was reduced from 395 mg/L to 10 mg/L at a loading of 4 gal/(ft<sup>2</sup>·min) using laboratory columns with the following specifications: 2.3 m column length, 0.051 m column diameter, and 0.5 L/min flow rate. The adsorption zone was 19 ft. Assume that the unit weight of carbon is 481 kg/m<sup>3</sup>.

### **Problem 3**

A plating waste with a flow of 40,000 gal/day contains 274 mg/L of NaCN. Determine the amounts of chlorine as Cl<sub>2</sub> and NaOH required to oxidize the cyanide to CO<sub>2</sub> and N<sub>2</sub>.

### **Problem 4**

A waste contains 150 mg/L of copper at a flow rate of 75 L/min. Determine the amount of sodium borohydride required to treat this waste.