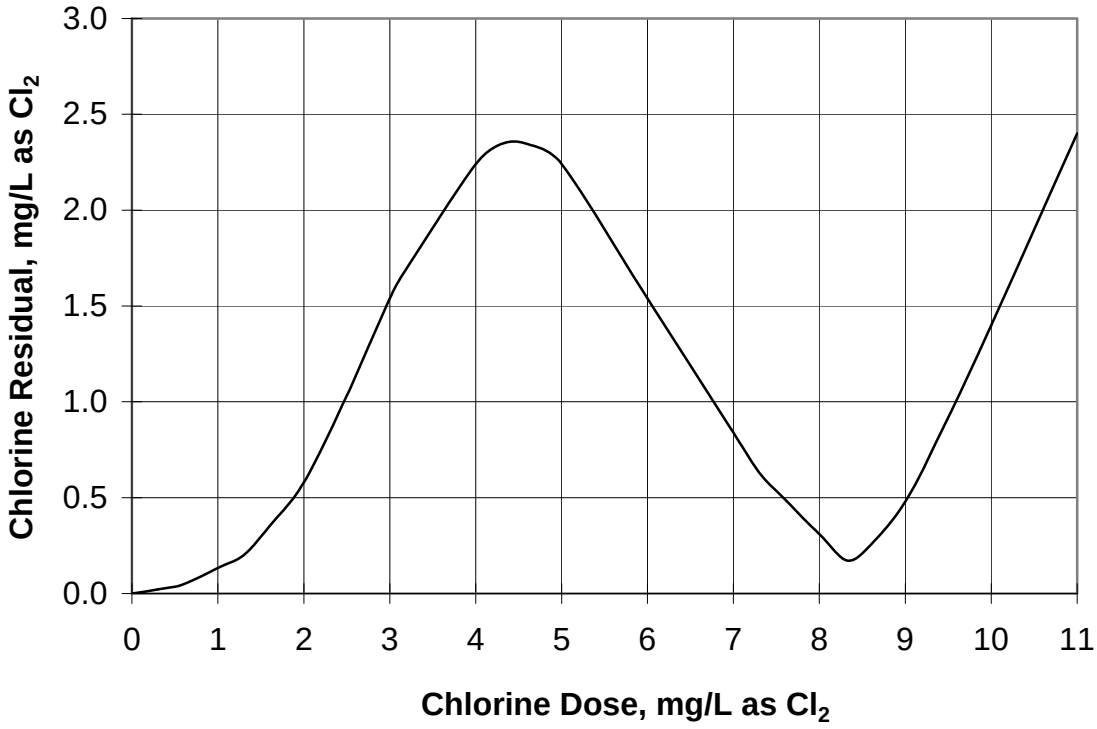
CEE 483, Winter 2009, HW#6

1. Below is a curve showing the chlorine residual as a function of chlorine dose for a water system.

   (a) At what chlorine dosage or dosages do the following statements apply:
   - (i) the combined chlorine residual is 3 mg/L.
   - (ii) the chlorine demand is 6 mg/L.
   - (iii) the free residual is greater than the combined residual.
   - (iv) at least 80% of the chlorine dose is converted to Cl^-.
   - (v) the free residual is increasing as chlorine is added.

   (b) What is the chlorine demand when the chlorine dose is 7 mg/L?



2. When natural organic matter (NOM) is exposed to ozone (O_3), one of the major final products is oxalate ion, $C_2HO_4^-$. A reasonable, average chemical formula for the molecules that make up NOM is $C_{24}H_{24}O_{12}$. A solution containing NOM is dosed with 25 mg/L ozone and allowed to react for 30 minutes. An analyst determines that the ozone demand has been 15 mg/L. Assuming that the NOM that reacts all forms oxalate, determine the concentration of NOM (mg/L) that has reacted.

3. . A water supply contains 4.0 mg/L Fe^{2+} and 8.5 mg/L NH_3. Chlorine gas is bubbled into the water and reacts with these two constituents according to the reactions shown below. The reaction with Fe^{2+} is much faster than that with NH_3. The reaction shown for ammonia is the

overall reaction in which the ammonia is oxidized. That is, it is the overall reaction between ammonia and chlorine which must occur for the system to reach the breakpoint. Reactions of N-containing species prior to the oxidation of the N are not shown, but they do occur and should be taken into account, if you think they are significant. A negligible amount of chlorine is used to oxidize other substances in the water (e.g., NOM).

$$2\ Fe^{2+} + Cl_2 \leftrightarrow 2\ Fe^{3+} + 2\ Cl^-$$

$$2\ NH_3 + 3\ Cl_2 \leftrightarrow N_2(g) + 6\ H^+ + 6\ Cl^-$$

(a) What chlorine dose (mg Cl_2/L) is required to provide a combined chlorine residual of 4.0 mg/L as Cl_2?

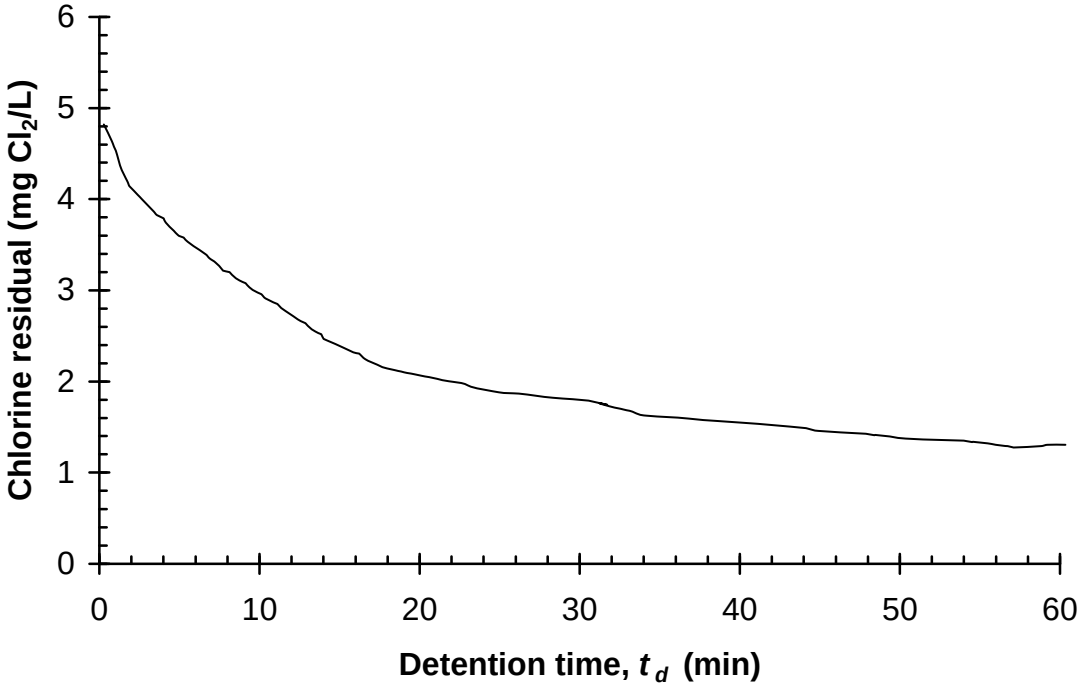
(b) What chlorine dose (mg Cl_2/L) is required to provide a free chlorine residual of 4.0 mg/L as Cl_2?

(c) If the chlorine in part *a* were added as NaOCl instead of bubbling with Cl_2 gas, what would the required dose be, in mg NaOCl per liter of water. (Note: if you were unable to do part *a*, just assume a value for the required dose of Cl_2, and answer this part of the question based on that assumption.)

4. Shown below are the results of experiments in which the chlorine residual in a reactor was measured when the reactor was operated as a CMR with various hydraulic detention times. The disinfectant that was added in the tests was NaOCl, although the residual is expressed in terms of Cl_2. The initial dose was 5.8 mg/L as Cl_2.

   (a) What is the chlorine demand exerted by the water if the residence time is 20 min?

   (b) What *CT* credit would the plant receive if it operated the CMR with a t_d of 45 min? Note: the fraction of a spike input tracer that remains in a CMR after time t is $\exp(-t/t_d)$.


Chlorine residual (mg Cl2/L)
0
1
2
3
4
5
6
0
10
20
30
40
50
60
Detention time, td (min)