Problem of the Day
2014.Nov.11

Discussion
The Water Environment Federation is the trade organization for water professionals, including wastewater treatment operations professionals (http://wefcom.wef.org/home). Individual states, or groups of states, sponsor local chapters. On October 29, 2014, I gave a 6-hour Math for Operators Workshop at the annual conference of the Pacific Northwest Clean Water Association (PNCWA). PNCWA represents Idaho, Oregon and Washington (http://www.pncwa.org/). All operators should seriously consider joining their local association. In California it is the California Water Environment Association (http://www.cwea.org/).

Long story short: I randomly covered a series of math problems in the PNCWA workshop, and I have been requested by several attendees to send them the problems. Instead, I am going to post them here (starting with the 2014.Nov.04 Problem of the Day). They are good practice for all visitors to WWTT's Problem of the Day.

For those of you who may be new to WWTT's Problem of the Day, we insert a page break after the problem statement so you can print it without looking at the solution. **See what you can do to solve the problem before looking at the solution**.

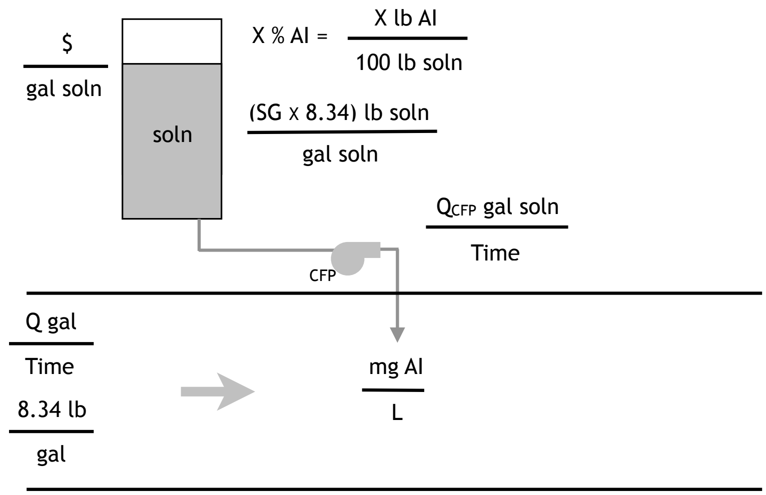
Problem
As demonstrated in yesterday's Problem of the Day, sometimes it takes a couple of steps to express the "active ingredient" in chemical solutions. Today's problem is about **aqueous ammonia (AqA)**. **Nitrogen (N) is the active ingredient in AqA**. Many industrial wastewater treatment plants use AqA as a source of N when the wastewater is deficient in this macro nutrient (life cannot exist without nitrogen). Aqueous ammonia contains **ammonia**, ammonia contains nitrogen, as demonstrated in today's problem.

Problem of the Day: Given the following information, calculate the daily aqueous ammonia feed rate.

- Effluent flow = 7.8 Mgal/d
- Aqueous ammonia (AqA) is 80% ammonia (NH3) = 80 lb NH3/100 lb AqA
- Ammonia is 82% nitrogen (N) = 82 lb N/100 lb NH3
- Specific gravity of AqA = 0.745
- Influent BOD = 550 mg BOD/L
- Influent N is essentially non detect
- Need 1 part N for every 20 parts BOD for desirable biological growth (1 mg N/20 mg BOD)
- **Calculate: AqA feed rate in gal AqA/d**.

Solution

This is a chemical dosing problem where nitrogen (N) is the active ingredient. WWTT puts all chemical dosing problems in terms of the following graphic:



Generic graphic for setting up chemical dosing problems (AI = active ingredient, SG = specific gravity, CFP = chemical feed pump, Q_{CFP} = flow rate of chemical feed pump, and Q = process flow).

The six elements (sometimes more) that are important in doing these calculations were discussed in the 2014.Oct.18, 20 and 26 Problems of the Day (http://wastewatertechnologytrainers.com/wp-content/uploads/2014/10/2014.Oct_.18.pdf, http://wastewatertechnologytrainers.com/wp-content/uploads/2014/10/2014.Oct_.20.pdf, http://wastewatertechnologytrainers.com/wp-content/uploads/2014/11/2014.Oct_.26.pdf).

The first thing that must be done in this problem is to calculate what the N dose (mg N/L) should be for the given influent BOD concentration in order to support good biological growth. This is a simple railroad track.

$$\frac{\textbf{mg N}}{\textbf{L}} = \frac{550\ \cancel{\text{mg BOD}}}{\text{L}} \cdot \frac{1\ \text{mg N}}{20\ \cancel{\text{mg BOD}}} = \frac{27.5\ \text{mg N}}{\text{L}}$$

Interesting to note in this problem, too, that specific gravity can be less than one. This is why oil floats on water! **The density of the AqA solution is calculated in the usual way (by multiplying the specific gravity times the density of water), then labeling it very specifically**.

$$0.745 \cdot \frac{8.34\ \text{lb}}{\text{gal}} = \frac{6.21\ \text{lb AqA}}{\text{gal AqA}}$$

The problem can now be solved.

Problem of the Day: Given the following information, calculate the daily aqueous ammonia feed rate.

1A. Percent ammonia (NH_3) in aqueous ammonia (AqA) = 80% NH_3 = 80 lb NH_3/100 lb AqA
1B. Percent nitrogen (N) in NH_3 = 82% N = 82 lb N/100 lb NH_3
2. Density of AqA = 6.21 lb AqA/gal AqA (calculated above from SG)
3. **Calculate AqA feed rate in gal AqA/d**
4. Flow rate of water to which AqA is being dosed, Q = 7.8 Mgal/d
5. Density of water = 8.34 lb/gal
6. N dose = 27.5 mg N/L (calculated above).

gal AqA	=	gal AqA	100 ~~lb AqA~~	100 ~~lb NH3~~	27.5 ~~mg N~~	~~L~~	7.8 ~~Mgal~~	8.34 ~~lb~~
d		6.21 ~~lb AqA~~	80 ~~lb NH3~~	82 ~~lb N~~	~~L~~	~~M·mg~~	d	~~gal~~

All the units have canceled except those needed in the answer, **gal AqA/d**. The arithmetic gives the answer:

100 x 100 x 27.5 x 7.8 x 8.34 ÷ 6.21 ÷ 80 ÷ 82 = **439 gal AqA/d**.

Happy calculating!

Let us know if you see any mistakes or want us to do a specific problem.

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