Problem of the Day

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How many pounds of chlorine (Cl_2) are in one gallon of sodium hypochlorite if it has 12.5% available Cl_2? The specific gravity of sodium hypochlorite is 1.2.

Introduction

In the "real world," operators need to be aware that chemical companies sell sodium hypochlorite, or "hypo," based on what is called "trade strength." Trade strength is **not** the same as available chorine although they can be calculated from each other. What's important in determining how much hypo is needed to achieve a desired chlorine dose is available chlorine. Most certification exam question give available chlorine, not trade strength. It also is important to know that hypo degrades over time. The rate of degradation is primarily a function of the available chlorine concentration and temperature. For both of these factors, the higher they are the more quickly the hypo degrades. When we say "hypo degrades," we mean that the available chlorine decreases over time, storage time.

Solution

As with most problems, the solution bridge starts with identifying the units needed in the answer. Specifically, the problem states, "[h]ow many pounds of chlorine (Cl_2) are in one gallon of sodium hypochlorite," so that's how we start things off: The units needed in the answer, lb Cl_2/gal hypo, are entered between heavy vertical lines followed by an equals sign and the blank solution bridge.

Problem of the Day: How many pounds of chlorine (Cl_2) are in one gallon of sodium hypochlorite if it has 12.5% available Cl_2? The specific gravity of sodium hypochlorite is 1.2.

$$\left|\frac{\text{lb } Cl_2}{\text{gal hypo}}\right| = \left|\frac{\quad}{\quad}\right|$$

Again, the information from the problem statement is repeated here and expressed, with units, the way WWTT teaches:

1. 12.5% Cl_2 = 12.5 lb Cl_2/100 lb hypo
2. 1 gal hypo

Notice from this list the units gal hypo and lb hypo. Density is used in many, many wastewater math problems to convert between gal and lb and vice versa. The problem needs the density of hypo. The specific gravity of the hypo is given, 1.2, so it is multiplied by the density of water to calculate the density of hypo and, as before, **labeled very specifically**:

3. 1.2 x 8.34 lb/gal = 10.01 lb hypo/gal hypo

In most instances, the solution bridge is started on the righthand side of the equals sign with the units needed in the numerator of the answer, in this case lb Cl_2. In the list given, the only place the units lb Cl_2 appear is in No. 1 so this starts the solution bridge:

$$\left|\frac{\textbf{lb } \textbf{Cl}_2}{\text{gal hypo}}\right| = \left|\frac{12.5\ \textbf{lb } \textbf{Cl}_2}{100\text{ lb hypo}}\right|\quad\Bigg|$$

The units lb Cl_2 need to be preserved because they are needed in the answer. This is why they are shown in bold on both sides of the equals sign. From this point, the solution is found by canceling out unwanted units. In order to cancel units, they need to be in the numerator and the denominator. The units lb hypo need to be canceled. In the list given, the only other place the units lb hypo appear is in No. 3. This factor, then, is entered into the solution bridge so the units lb hypo cancel in the numerator and denominator as shown.

$$\left|\frac{\textbf{lb } \textbf{Cl}_2}{\textbf{gal hypo}}\right| = \left|\frac{12.5\ \textbf{lb } \textbf{Cl}_2}{100\ \cancel{\text{lb hypo}}}\right|\left|\frac{10.01\ \cancel{\text{lb hypo}}}{\textbf{gal hypo}}\right|$$

Since the only units remaining are the units needed in the answer, lb Cl_2/gal hypo, shown in bold on both sides of the equals sign, we know the solution bridge is complete. The arithmetic gives the answer:

12.5 x 10.01 ÷ 100 = **1.25 lb Cl_2/gal hypo**.

Discussion

A working operator told me in one of WWTT's classes that his boss had told him several years ago, "A gallon of hypo, a pound of chlorine."

As we just showed, this is not true. Well, it could be true given the percent available chlorine in the hypo. But it definitely is not true when the hypo is 12.5% available chlorine. I got to thinking where this incorrect "rule of thumb" might have come from. What if the "boss" had simply converted 12.5% Cl_2 to 125,000 mg Cl_2/L using the equivalent discussed in the last two Problems of the Day, 1% = 10,000 mg/L, and then just used the pounds equation with 1 gal = 0.000001 Mgal:

$$\text{lb } Cl_2 = \frac{125{,}000 \text{ mg } Cl_2}{\text{L}} \times \frac{\text{L}}{\text{M·mg}} \times \frac{0.000001 \text{ Mgal}}{} \times \frac{8.34 \text{ lb}}{\text{gal}}$$

The arithmetic gives how many lb Cl_2 are in 1 gal of hypo:

125,000 x 0.000001 x 8.34 = **1.04 lb Cl_2**.

Ahhhhhh almost 1 pound of chlorine! While this is **incorrect**, this explains where the "A gallon of hypo, a pound of chlorine" came from. As I said yesterday, I don't like using 1% = 10,000 mg/L because:

1. **You have to remember to use the appropriate density if it's not equal to 8.34 lb/gal**
2. You have to make the conversion from % to mg/L and there is the very real likelihood you will misplace the decimal point
3. If volume or flow is given in other units, you have to convert it to Mgal or Mgal/day (like 0.000001 Mgal).

Our boss friend, I bet you a million bucks, didn't use the density of the hypo in developing his shortcut and passed this wrong rule of thumb onto his operators. Sad, this kind of thing happens all the time.

Happy calculating! Let us know, by leaving a comment, if you want us to do a specific problem, if you see a mistake, or if you have a question on any of the Problems of the Day you are looking at.