Problem of the Day

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Introduction

This is the same problem as yesterday's Problem of the Day except instead of water, the tank has ferric chloride solution in it. Do we need to add the weight of the tank into our calculation? No, because the question specifically asks for how many pounds of solution are in the tank.

Solution

The question asks to calculate pounds of solution, which I will abbreviate lb soln. These units, as always, are entered between heavy vertical lines followed by an equals sign and the blank solution bridge.

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$$\left| \text{lb soln} \right| = \_\_\_\_\_$$

I have recently been working with an operator who struggles terribly with "word problems." A lot of people do. He was telling me it's hard for him to even extract the "givens" out of the problem statement. I suggest that you underline each **number**, with units, given in the problem statement and any "descriptors" that go with each number. So today's problem might look like this with underlines:

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Since these are math problems, the numbers in the problem statement are what are important to us; that's why we underline them. We all know problems sometimes give us numbers we don't need, but don't worry about picking up what you need and don't need as you list the information given in the problem statement. Each of the numbers has to be described in our list of givens. Here I say describe them anyway you want to but take as much out of the problem statement descriptors that you've underlined as you can. This is what I see:

1. Tank height (i.e., "tall") = 25 ft
2. Tank diameter = 15 ft
3. Depth of solution = 15.5 ft
4. Specific gravity of solution = 1.45
5. Density of solution = 1.45 × 8.34 lb/gal = 12.1 lb soln/gal soln

Again, what I see in this list is a lot of 5s and ft. One of the strategies used by exam question authors is to include numbers that are easily confused, like using numbers with a lot of 5s. Be diligent and keep the numbers straight in your head and on your paper.

Unlike yesterday's problem, today we're asked to calculate weight (pounds) of solution in the tank. When doing water and wastewater math problems, we are constantly switching back and forth between gallons and pounds. When it comes to liquids, the physical characteristic that allows us to calculate pounds from gallons and vice versa is the density.

Instead of giving us the density of the ferric chloride solution, the problem gives us the specific gravity (abbreviated SG). If a problem gives the SG, you are almost guaranteed to use it, which is exactly what we did in No. 5 or the list. In order to calculate the density of a liquid, the density of water (8.34 lb/gal) is multiplied by SG. Notice in No. 5 that it isn't until multiplying 1.45 times 8.34 that the density of the solution is labelled, lb soln/gal soln. Perhaps not so much in this problem, but in a lot of problems labelling the density of anything except water as shown here really helps setting up the solution bridge.

As we have done many times before, we start the solution bridge with the units needed in the numerator of the answer, lb. The only place the units lb soln shows up is in the numerator of the density (No. 5), so that's what we use to start the solution bridge giving us the units we need in the answer as shown in bold.

$$\left| \textbf{lb soln} \right| = \left| \frac{12.1\ \textbf{lb soln}}{\text{gal soln}} \right|$$

By simply entering the density of the solution, we now have the units in the solution bridge needed in the answer. Proceeding, we cancel unwanted units until only lb soln remain. We have to cancel gal soln but there is nothing in our list that has gal soln. All those ft in our list should give us a hint that we can calculate volume in ft^3 . We all know the conversion factor that allows us to go between gal and ft^3 and vice versa (truly a conversion factor):

$$\frac{7.48\ \text{gal}}{ft^3} \quad \text{or} \quad \frac{ft^3}{7.48\ \text{gal}}$$

But, you ask, does this conversion factor apply to our ferric chloride solution?

Here I get pretty annoyed, again, at what various certification entities do to operators. Here is a link to the Equivalents and Formulae sheet that accompanies wastewater operator certification exams in California: http://www.waterboards.ca.gov/water_issues/programs/operator_certification/docs/opcert_formulasheet.pdf. It gives this equivalent:

1 ft^3 of water = 7.48 gallons

Noooooooooooooooooo!

1 ft^3 of **anything** = 7.48 gallons.

Here is a link to the Formula/Conversion Table used by ABC, which oversees certification in more than 25 states: http://www.abccert.org/pdf_docs/abcwwtfctable.pdf. I copy below three entries from that table with commentary:

1 cubic foot = 7.48 gallons (Correct, but WWTT never uses "cubic foot.")

1 cubic foot = 62.4 pounds (No, only if it's **water**.)

1 gallon = 8.34 pounds (No, only if it's **water**.)

I know I am ranting here, but this really perturbs me: If the entities who are writing certification exam questions, administering certification exams, correcting certification exams, and certifying operators can't get these things right, how do they expect operators to? The wastewater treatment plant operators profession needs a complete overhaul of the certification process starting with the Sacramento Manuals because so much is based on them! Write a comment if you agree, or if you don't.

Proceeding: since the volume we're interested in in the tank is occupied by the solution, we can modify the conversion factor above as shown here to cancel gal soln.

$$\left| \textbf{lb soln} \right| = \left| \frac{12.1\ \textbf{lb soln}}{\cancel{\text{gal soln}}} \right| \left| \frac{7.48\ \cancel{\text{gal soln}}}{ft^3} \right|$$

Remember: 1 ft^3 of anything = 7.48 gallons or 7.48 gallons of anything = 1 ft^3.

To cancel ft^3, does it make sense to simply multiply the three ft we have in our list? No. We have to do some thinking here. What ft^3 of volume are we interested in? The volume of the tank? No. The volume of the liquid (solution) is what we have to calculate and to calculate the volume of a cylinder we multiply the cross sectional area, which is a circle, by the depth of the solution (No. 3), not the depth of the tank. The area of a circle is calculated by multiplying 0.785 times $diameter^2$ (i.e., "diameter squared") or 0.785 times

the diameter (No. 2) times the diameter (No. 2) again. In one step we enter the volume of the solution. Remember to include the units associated with each number so you can see how ft^3 cancels with ft × ft × ft.

$$\left| \textbf{lb soln} \right| = \frac{12.1\ \textbf{lb soln} \quad 7.48\ \cancel{\text{gal soln}} \quad 0.785 \quad 15\ \cancel{\text{ft}} \quad 15\ \cancel{\text{ft}} \quad 15.5\ \cancel{\text{ft}}}{\cancel{\text{gal soln}} \quad \cancel{\text{ft}^3}}$$

We didn't use the height of the tank (No.1) in the solution bridge. Students ask all the time, "How do I know when I'm not going to use something given in the problem?"

My answer to this is simple: "If you don't use it in the solution bridge, you didn't need it."

I know that sounds a little bit flippant, but I don't know how else to say it. If you read a problem and start fretting over whether or not you're going to use all the information given, you're not thinking about how you're going to solve the problem! Just . . . don't . . . worry . . . about it. Test anxiety happens to all of us. Get rid of some of your anxiety by not worrying about whether you're going to use all the information given in the problem.

Because all the units have canceled except those needed in the answer, **lb soln**,we know the solution bridge is complete and the arithmetic gives the **answer**.

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12.1 × 7.48 × 0.785 × 15 × 15 × 15.5 = **247,783 lb soln**.

Discussion

This volume of solution is nearly 77,000 lb heavier than an equal volume of water (calculated in yesterday's Problem of the Day). Being able to calculate these kinds of things is pretty cool, don't you think?

As I wrote yesterday, I just want to make sure, since I'm always ranting about using units, that readers understand that when I write "the arithmetic gives the answer" and then show the numbers in the solution bridge without units, I'm showing what I am entering into my calculator. Just making sure.

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.