Copper (II) Sulfate Pentahydrate Lab - Composition of a Hydrate Lab ANSWERS

The labs I read so far were a bit disappointing. I don't understand why when someone does not "get" something that they copy, or leave blank, or worse, leave me a big "?" but does not think to ASK ME for help. That is the definition of my job: Help the Kids Learn. So, I graded the lab reports, but only marked them Pass/Fail. Fail is bad, and they need fixing. Pass means good enough but maybe not.
Read through this and see if YOU need help. Use this to help you do the MgSO4 Lab, due Monday. That one will be right, or marked off for points. Think, use this, and get it right. Or at least, no complaints.

The first thing is this: the stuff we used, the blue stuff, is called Copper (II) Sulfate Pentahydrate and has a formula of $CuSO_4 \cdot 5H_2O$. That means that there is a copper cation with a +2 charge, bonded to a sulfate (table E) anion. Also, this is important now: five molecules of water are "loosely" bonded to that ionic compound.

When you heat it up (the 3.00 grams, not the 3 grams) the water evaporates away as steam. This is the equation for your brain to hold onto: $CuSO_4 \cdot 5H_2O$ makes $CuSO_4 + 5H_2O$
The "hydrate" or the $CuSO_4 \cdot 5H_2O$, when heated turns into an anhydrous salt with this formula: $CuSO_4$ when the water is given off as an invisible gas to the air. Anhydrous means "not with water". "The hydrate" refers to the whole compound, the copper (II) sulfate pentahydrate - not just to the water. Pentahydrate does mean has 5 molecules of water attached.

As to the data table: the mass of the dish empty, then dish plus the 3.00 g of the $CuSO_4 \cdot 5H_2O$ are obvious. The "final" mass it the mass of the dish plus the anhydrous salt. That means everything you started with minus the water that steamed away. If you looked at the right column, you'd see to get the mass of just the salt, subtract the "A" box from the "C" box. That would allow you to measure the salt and the dish, take away the dish, equals the salt alone. We don't really care about that number, the mass of the salt, but we NEED it. The last row is where you subtract the salt mass from the original 3.00 grams of stuff you started with. That difference is the mass of the missing water! That's the whole point of this lab. Use THAT number in question 2, where you do the math to MEASURE the % composition by mass of water in your 3.00 g of hydrate, to COMPARE your measuring to the AV of 36% water!

You did the math, the molar mass and the percent comp by mass on the 2nd page of the lab. The molar mass is the mass of ONE MOLE of this stuff. This stuff is 250 grams per mole, written as 250 g/mole. The parts of this stuff are copper, sulfur, oxygen, and water. One could break up the water into hydrogen and oxygen as well, but since the point of this lab is to measure the "percent composition by mass of water in $CuSO_4 \cdot 5H_2O$, we keep the water as a whole unit". We found that this stuff is 36% water by mass. (90 grams of the 250 are made up of water).

You did that part of the % comp math by using the FORMULA on the back page of the reference table called percent composition by mass. LOOK at that formula now. The formula is the mass of the part you are looking at in this moment, divided by the whole mass of the stuff it's part of, then multiplied by 100%.

For the water in $CuSO_4 \cdot 5H_2O$, that was 90 grams water / 250 grams total hydrate mass X 100% = 36% water by mass.

Question 1 asks you to JUST STATE that fact. Your answer should be $CuSO_4 \cdot 5H_2O$ is 36% water by mass. You already did the math before. For the second question, here you are actually going to be measuring, in the lab, how many grams of water steam off from the TOTAL mass of 3.00 grams of this hydrate (the $CuSO_4 \cdot 5H_2O$) you started with. It's not 3 grams.
We're being scientific, we spent hundreds of dollars for those extra sig figs in the scale. $3\ g \neq 3.00\ g$

This will be your MEASURED value. The 36% water number is your ACTUAL value.

The third question is about your percent error. Few of you wrote the percent error formula. If you are super-duper-smart, you will always know this formula and never make a boo boo. Most of you need to write the formula so that you put the numbers in the right place. The formula TELLS YOU what to do. If you rely on your memory, in the midst of your crazy teenage life, you will put the MV in the AV place and not notice. You would then deserve to lose a point. I don't know why I worry so much about your feelings. DO THE MATH. It's easy if you do it, it's confusing when you try to remember. It's a pain to grade wrong, it's important but should be a "free point" for you.

Question 4 is the chart. Yes I suppose I did "forget" to include the oxygen, but it's less work. The Molar Mass is the mass per mole. The units are ALWAYS g/mole. The answers, in order are 250 g/mole, 64 g/mole, 32 g/mole, and 18 g/mole. It's only going to be 90 g/mole for "D" if you write in a FIVE in front of the H_2O.
The atomic mass is the mass of the atoms, or particles. One copper mole is 64 grams. One copper atom is 64 AMU. For sulfur

it's 32 AMU which stands for atomic mass units. Sulfur has 16 protons and 16 neutrons. Each neutron and each proton has about a 1 amu mass each. Water would be 18 AMU (each hydrogen has mass of 1 AMU, and oxygen atoms are 16 amu, so, 1+1+16 = 18 AMU).

For questions 5 and 6, one mole of $CuSO_4 \cdot 5H_2O$ is 250 grams (see your math above your data table).
One mole is 250 grams. 5 moles X 250 grams per mole = 1250 grams in total.

One FORMULA UNIT is just 250 AMU. Particles are different mass than one mole of particles. Same number but grams are huge compared to AMU.
So, one FU is 250 AMU. 5 FU X 250 AMU per particle = 1250 AMU. Units matter, not everything is grams. Not every flavor is your favorite. Things can be cherry or chocolate or mint. Sometimes grams are great, but not all of the time. Pay attention. It's not a lack of understanding, it's disinterest and it shows sometimes.

7. Where did the water in your $CuSO_4 \cdot 5H_2O$ go? It evaporated. (that's enough)

8. All you need to say here is that the $CuSO_4$ anhydrous salt (which is white) turns blue again because you rehydrated it. Don't use funky vocabulary words, which don't really fit. You PUT THE WATER back into it, rehydrated. (ask if you are unsure)

In here I had some numbering problems, which I am sorry about, but you are big. Deal with it please.

9. Calculate the % comp by mass for water in magnesium nitrate hexahydrate.
The formula for this stuff is $Mg(NO_3)_2 \cdot 6H_2O$ hexa = 6 Mg is a +2 cation, nitrate is a -1 anion from table E. Writing formulas will be very important for the rest of the year, you must learn this, the sooner the better. This stuff is 256 g/mole, and water makes up 42% of it by mass (unlimited SF, so 42.2% is good as well.)

10. Calculate the % comp by mass for water in barium hydroxide octahydrate. Formula is $Ba(OH)_2 \cdot 8H_2O$ molar mass is 315 g/mole, water is just 6.4% by mass.

11. Calculate the % comp by mass for water in mercury (I) nitrate monohydrate. This means mercury with a +1 cation, nitrate is still a -1 anion, with ONE water. So, $HgNO_3 \cdot H_2O$ with molar mass of 281 g/mole and 6.4% water.

10. (again, sorry) Calculate the % Comp by mass of water in vanadium (V) bromide dihydrdrate with vanadium having a +5 cation, bromine is the -1 anion here. So, $VBr_5 \cdot 2H_2O$ with molar mass of 487 g/mole and 7.4% water

11. Define anhydrous salt: ionic compounds can be hydrated with water molecules, but when the water is heated off, the remaining salt WITHOUT water is called anhydrous salt. Ex: $HgNO_3 \cdot H_2O$ is a hydrate while the $HgNO_3$ is an anhydrous salt.

12. How many formula units of copper (II) sulfate pentahydrate are in just 3.00 grams. This is a 2 step mole math island problem. 3.00 grams (mass island) convert to moles, then convert to FU's which are particles of ionic compounds.

13. skip this one
14. Of the 3.00 grams of $CuSO_4 \cdot 5H_2O$ you used in this experiment, what mass is copper. Using your math from above your data table, copper is 26% of the mass of this $CuSO_4 \cdot 5H_2O$. So multiply the 3.00 g X 0.26 = 0.78 grams (or 0.78 grams)

15. Of the 3.00 grams of $CuSO_4 \cdot 5H_2O$ you used in this experiment, what mass is sulfur? Same as the problem above almost: 3.00 g x 0.128 = the answer (if you used 12.8%) or else it's 3.00 g x 0.13 = the answer (if you rounded to 13%)

16. If you used 3.00 grams of a different hydrate, say $Co(NO_3)_2 \cdot 4H_2O$ (which is cobalt (II) nitrate tetrahydrate, what is the mass of cobalt? Here you need to do the molar mass and the percent comp by mass AND then multiply 3.00 g X the percent that is cobalt. This stuff is 255 g/mole and water is 23% so: 3.00 g X 0.23 = 0.69 grams (unlimited SF)

As to a conclusion: say: I measured out 3.00 g of $CuSO_4 \cdot 5H_2O$ and heated away the water. My measure of 1.89 g salt meant that the mass of the missing water was 1.11 grams (3.00 - 1.89 = 1.11) My measured percent comp by mass was 37.0 % (3 SF) and my percent error was +2.87%, possibly caused by scale error or not getting all of the water out of the hydrate with my hearing. I learned the formula and how to use it for % comp by mass, and I can now figure out the molar mass and the percent comp by mass of each part of each compound in the Universe. I feel more god-like each day. I love chem the end.