Copper Odyssey Conversion I

Conversion I - Changing elemental copper to copper (II) nitrate.
Pre-lab: Balance the following reaction.

$$\_\_\_\_ \ \mathbf{Cu_{(s)} + 4\ HNO_{3(aq)} \rightarrow \_\_\_\_\ Cu(NO_3)_{2(aq)} + 2\ NO_{2(g)} + 2\ H_2O_{(l)}}$$

In a complete sentence describe and name the above compounds.

In this reaction, solid copper reacts with nitric acid to form copper (II) nitrate, nitrogen dioxide, and water.

Data and Observations:

Original mass of copper _________g

Original observations:

Reaction observations:

Conversion I Questions
Directions: Answer the following questions in complete sentences.
1. What type of chemical reaction is Conversion I?

Copper loses electrons and is oxidized to blue copper (II) ion. Nitrogen gains the electrons copper loses, and is reduced to reddish brown nitrogen dioxide gas. Nitric acid is an oxidizing agent. This type of reaction, in which electrons are lost and gained, is called an oxidation reduction reaction or redox reaction.

2. Identify each reactant and product as having metallic, ionic, or covalent bonds.

Cu – metallic	***$Cu(NO_3)_2$ – ionic***	***H_2O – covalent***
HNO_3 – ionic	***NO_2 – covalent***	

3. Draw the Lewis Dot structures for each of the above compounds (not the Cu).
Example: HNO_3

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O= N- O
    I
    O
    I
    H
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4. Why does HNO_3 contain one nitrate and $Cu(NO_3)_2$ contain two nitrates? **Think charges**

To balance out, or make a neutral compound, there needs to be to two nitrate for every one copper (II) atom.

5. What does the 6M signify in the expression 6M HNO_3?

M is the label for molarity – meaning 6 moles of solute/Liter of solvent

6. Calculate the molar mass of each reactant and product. Be sure your work in clearly labeled!
Example: HNO_3 = 1 + 14 + (16 x 3) = 63 g/mol
Cu = 63.55 g/mol
$Cu(NO_3)_2$ = 63.55 + (2 x 14) + (6 x 16) = 187.55 g/mol
NO_2 = 14 + (2x 16) = 46 g/mol
H_2O = (2 x 1) + 16 = 18 g/mol

7. Using the initial mass of copper you obtained determine the number of moles of copper in your sample. (**Hint**: use the molar mass from #6)

$$.5 \text{ grams x } \frac{(1\ mole)}{(63.55\ g)} = 7.86 \text{ x } 10^{-3} \text{ moles}$$

This answer should be slightly different for each group because your original mass should be slightly different!

8. Calculate the number of atoms of copper in your sample. (**Hint**: use your answer from #7 and 6.02 x 10^{23} atoms/ mol)

$$\mathbf{7.86 \text{ x } 10^{-3} \text{ moles x } \frac{6.02\ x\ 10^{23}\ atoms}{1\ mole} = 4.73 \text{ x } 10^{23} \text{ atoms}}$$

This answer should be slightly different for each group because your original mass should be slightly different!

9. Using the initial mass of copper you obtained determine the mass of NO_2 you expected to be produced. (**Hint**: use a mole ratio from your balanced equation in the pre-lab section)

$$\mathbf{.5 \text{ grams x } \frac{(1\ mole\ Cu)}{(63.55\ grams\ Cu)} \text{ x } \frac{(2\ moles\ NO_2)}{(1\ mole\ Cu)} \text{ x } \frac{(46.01\ grams\ NO_2)}{(1\ mole\ NO_2)} = 0.724 \text{ grams } NO_2}$$

This answer should be slightly different for each group because your original mass should be slightly different!

10. Calculate the volume of NO_2 you expect to be produced at 27°C and 1.0 atm. (**Hint**: set up your solution using your answer from # 9, the molar mass of NO_2, (PV=nRT (R=0.08206 L atm/mol K)

(1 atm)(V) = (0.0157 moles)(0.08206)(300)
V = 0.387L or 387 mL

$$0.724 \text{ grams } NO_2 \text{ x } \frac{(1\ mole\ NO_2)}{(46\ grams\ NO_2)} = 0.0157 \text{ moles } NO_2$$

This answer should be slightly different for each group because your original mass should be slightly different!

11. Calculate the number of moles of nitric acid used. (**Hint**: use balanced equation, a mole ratio & start with grams Cu)

$$\mathbf{.5 \text{ grams Cu x } \frac{(1\ mole\ Cu)}{(63.55\ grams\ Cu)} \text{ x } \frac{(4\ moles\ HNO_3)}{(1\ mole\ Cu)} = 0.032 \text{ moles of } HNO_3}$$

This answer should be slightly different for each group because your original mass should be slightly different!

12. Calculate the mass of NO_2 produced from the amount of nitric acid used. (start with moles of nitric acid-from #11)

$$\mathbf{0.032 \text{ moles } HNO_3 \text{ x } \frac{(2\ mole\ NO_2)}{(4\ mole\ HNO_3)} \text{ x } \frac{(46.01\ grams\ NO_2)}{(1\ mole\ NO_2)} = 0.736 \text{ grams } NO_2}$$

This answer should be slightly different for each group because your original mass should be slightly different!

13. Which reactant would you expect to be limiting? Why? (nitric acid or Cu- compare answer in # 11 to moles of Cu used)

Copper is the limiting reactant – it will "run out" before the nitric acid will; thus, producing the smaller amount of the reactants due to the limitations on copper.

14. Write the compound formula of the brown gas formed. ***NO_2***

15. Write the compound formula of the blue product. ***$Cu(NO_3)_2$***

16. Why did the bottle have to be put in the fume hood?

The flask needed to be placed in the fume hood due to the toxic gas, NO_2, being produced during the reaction.

17. The copper metal disappeared during this reaction. What became of the copper atoms?

The metal dissolved into the nitric acid. The acid broke down the bonds between the copper and formed new bond with the nitric acid to produce copper (II) nitrate.

18. Make a list of everything in the liquid in the bottle at the end of reaction one.

Copper (II) nitrate, liquid water, and nitrogen dioxide gas

19. Why did we bother to mass the copper wire?

We found the mass of the copper wire so that we could do various theoretical calculations. We will use these calculations and this matter later in the lab!

20. What would happen to the NO_2 as it moves higher in the atmosphere where the pressure drops to 0.07 atm and the temperature drops to 15°C? (Calculate the volume of NO_2) (use the data from #10)

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \qquad \frac{(1\ \text{atm})(0.387\text{L})}{300\text{K}} = \frac{(0.07\ \text{atm})(V_2)}{288\text{K}}$$

V_2 = 5.3 Liters

This answer should be slightly different for each group because your original mass should be slightly different!

21. Why did we use nitric acid rather than some other acid, say hydrochloric acid?

If we would have used hydrochloric acid the reaction wouldn't have been as strong and we would have produced copper (II) chloride which is a solid powder that absorbs moisture from the air and turns to a turquoise blue like color.