Name_____ Bell_____

You are a chemistry teacher who has to grade a free response question. Below is the rubric that you must use. For each category, grade the response on the following scale.
4 - Exceeds expectations. 3 - Meets expectations 2 - Approaching 1 - Developing 0- No evidence.
Be sure to put comments for anything that does not receive “Exceeds” (4 points).

Score	Topic	Comments
	Balanced equation?	
	Total ionic?	
	Net ionic?	
	Limiting reagent and excess?	
	Subtract for water vapor?	
	Correct amount of product?	
	Percent yield?	
	Correct sig figs and labels?	
	Total score and final comments	

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Question -

22.30 grams of cobalt reacts with 21.00 mL of a .2550 M solution of hydrochloric acid. Please assume that the cobalt goes to cobalt +3 and write the balanced equation, total ionic equation and net ionic equation. Provide the volume of gas that is collected over water from the reaction. Indicate the limiting and excess reagent. The pressure during the experiment was .9732 atm and 294.3 K. The final experimental amount of gas was 68.40 mL. Make sure to calculate the percent yield.

Answer-

To answer this question, we need to use stoichiometry and chemical equations to determine the limiting and excess reagents, the amount of gas produced, and the percent yield of the reaction.

First, we need to write the balanced equation for the reaction between cobalt and hydrochloric acid. Since it is mentioned in the question that cobalt goes to cobalt +3, we need to balance the equation accordingly. The balanced equation is:

$2Co(s) + 6HCl(aq) \rightarrow 2CoCl_3(aq) + 3H_2(g)$

Next, we need to write the total ionic equation for the reaction, which shows all the ions that are involved in the reaction. The total ionic equation is:

$2Co(s) + 6H^+(aq) + 6Cl^-(aq) \rightarrow 2Co^{3+}(aq) + 6Cl^-(aq) + 3H_2(g)$

Since the Cl- ions appear on both sides of the equation, they can be canceled out to give the net ionic equation:

$2Co(s) + 6H^{+(}aq) \rightarrow 2Co^{3+}(aq) + 3H_2(g)$

Now, we can use stoichiometry to determine the amount of gas that is produced by the reaction. We know that 22.30 grams of cobalt reacts with 21.00 mL of a 0.2550 M solution of HCl, which is equivalent to 21.00/1000 * 0.2550 = 0.005355 moles of HCl. Using the balanced equation, we can see that 2 moles of Co react with 6 moles of HCl to produce 3 moles of H2 gas. Therefore, the amount of H_2 gas produced is 0.005355/6 * 3 = 0.002015 moles.

To determine the volume of gas collected over water, we need to use the ideal gas law:

$PV = nRT$

where P is the pressure, V is the volume, n is the number of moles, R is the gas constant, and T is the temperature. We know that the pressure is 0.9732 atm and the temperature is 294.3 K. We can rearrange the equation to solve for the volume of gas:

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V = nRT/P

V = 0.002015 * 0.08206 * 294.3 / 0.9732

V = 0.06258 L = 62.58 mL

Therefore, the volume of gas collected over water is 62.58 mL.

To determine the limiting reagent, we need to calculate the number of moles of Co that reacts with the HCl. The molar mass of Co is 58.93 g/mol, so 22.30 grams of Co is equivalent to 0.3782 moles of Co. Since 2 moles of Co react with 6 moles of HCl, the number of moles of HCl needed to react with 0.3782 moles of Co is 0.3782/2 * 6 = 1.1346 moles. However, we only have 0.005355 moles of HCl, which is less than the required amount. Therefore, HCl is the limiting reagent and Co is the excess reagent.

To calculate the percent yield, we need to compare the actual yield (68.40 mL of gas) to the theoretical yield (calculated to be 62.58 mL of gas). The percent yield is:

percent yield = actual yield / theoretical yield * 100%

percent yield = 62.58/68.40 = 91.5%