Construct a reaction table for a mixture of 1.9 grams of $CaCl_2$ with 1.9 grams of Na_3PO_4. Assuming that the equilibrium constant is extremely large for this reaction determine the limiting reagent and then determine the mass of each reactant remaining and each product produced after the reaction has taken place. The unbalanced chemical reaction is:

$$\_CaCl_2 + \_Na_3PO_4 \rightleftarrows \_Ca_3(PO_4)_2 + \_NaCl$$

Solution: Step 1. Balance the chemical reaction

$$3\ CaCl_2 + 2\ Na_3PO_4 \rightleftarrows Ca_3(PO_4)_2 + 6\ NaCl$$

Step 2. Determine the number of moles of each reactant.

$$n_{CaCl_2} = \frac{m_{CaCl_2}}{M_{m,CaCl_2}} = \frac{1.9\ gm}{111\ gm/mol} = 0.0171\ moles$$

$$n_{Na_3PO_4} = \frac{m_{Na_3PO_4}}{M_{m,Na_3PO_4}} = \frac{1.9\ gm}{164\ gm/mol} = 0.0115\ moles$$

Step 3: Determine the stoichiometry ratio (theoretical)

$$\frac{v_{CaCl_2}}{v_{Na_3PO_4}} = \frac{3}{2}$$

Step 4: Determine the actual ratio based on the calculation of number of moles

$$\frac{n_{CaCl_2}}{n_{Na_3PO_4}} = \frac{0.0169}{0.0115} = 1.486$$

The actual ratio is very close to the stoichiometric ratio. However, the $CaCl_2$ is limiting by a small amount. So we will assume that the number of moles of $CaCl_2$ determines the numbers of moles of the final products.

Step 5: In order to construct the table we need to use the stoichiometric ratio for each reactant or product relative to $CaCl_2$ (since we are starting with it as the limiting reagent).

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	$CaCl_2$	Na_3PO_4	$Ca_3(PO_4)$	$NaCl$
Stoichiometric Ratio	1	2/3	1/3	6/3 = 2

Step 6: Then we use those stoichiometric ratios to calculate the change and final amounts. Keep in mind that we will have a minus sign on the reactant side (since the reactants are decreasing in concentration) and a plus sign on the product side.

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	$CaCl_2$	Na_3PO_4	$Ca_3(PO_4)$	$NaCl$
Initial	0.0171	0.0115	0.0	0.0
Change	-0.0171	-0.0114	+0.0057	+0.0342
Final	0.0	0.0001	0.0057	0.0342

Finally, we note that the question asked for the mass of each species.

Step 7: Calculate the masses of the species at the end of the process.

$$m_{Na_3PO_4} = n_{Na_3PO_4} M_{m,Na_3PO_4} = (1\ x\ 10^{-4})\left(164\,\frac{gm}{mol}\right)$$

$$m_{Na_3PO_4} = 0.0164\ gm$$

$$m_{Ca_3(PO_4)_2} = n_{Ca_3(PO_4)_2} M_{m,Ca_3(PO_4)_2} = (0.0057)\left(310\,\frac{gm}{mol}\right)$$

$$m_{Ca_3(PO_4)_2} = 1.77\ gm$$

$$m_{NaCl} = n_{NaCl} M_{m,NaCl} = (0.0342)\left(58.5\ \frac{gm}{mol}\right)$$

$$m_{NaCl} = 2.00\ gm$$