Problem 3.95 from the textbook:

79.87 12.01 70.90 189.67] FORMULA WEIGHTS (g/mol)

$$3\,TiO_2 + 4\,C + 6\,Cl_2 \longrightarrow 3\,TiCl_4 + 2\,CO_2 + 2\,CO$$

A vessel contains 4.15 g of titanium(IV) oxide, 5.67 g of carbon, and 6.78 g of chlorine gas. If the reaction goes to completion as written, how many grams of titanium(IV) chloride can be produced?

TiO_2: $79.87\ g\ TiO_2 = 1\ mol\ TiO_2$ $3\ mol\ TiO_2 = 3\ mol\ TiCl_4$ $189.67\ g\ TiCl_4 = 1\ mol\ TiCl_4$

$$4.15\ g\ TiO_2 \times \frac{1\ mol\ TiO_2}{79.87\ g\ TiO_2} \times \frac{3\ mol\ TiCl_4}{3\ mol\ TiO_2} \times \frac{189.67\ g\ TiCl_4}{1\ mol\ TiCl_4} = 9.86\ g\ TiCl_4$$

C: $12.01\ g\ C = 1\ mol\ C$ $4\ mol\ C = 3\ mol\ TiCl_4$ $189.67\ g\ TiCl_4 = 1\ mol\ TiCl_4$

$$5.67\ g\ C \times \frac{1\ mol\ C}{12.01\ g\ C} \times \frac{3\ mol\ TiCl_4}{4\ mol\ C} \times \frac{189.67\ g\ TiCl_4}{1\ mol\ TiCl_4} = 67.2\ g\ TiCl_4$$

Cl_2: $12.01\ g\ C = 1\ mol\ C$ $6\ mol\ Cl_2 = 3\ mol\ TiCl_4$ $189.67\ g\ TiCl_4 = 1\ mol\ TiCl_4$

$$6.78\ g\ Cl_2 \times \frac{1\ mol\ Cl_2}{70.90\ g\ Cl_2} \times \frac{3\ mol\ TiCl_4}{6\ mol\ Cl_2} \times \frac{189.67\ g\ TiCl_4}{1\ mol\ TiCl_4} = 9.07\ g\ TiCl_4$$

Since all of these reactants are being consumed at once, the reaction will stop when any one reactant runs out. Chlorine gas runs out first, and 9.07 grams of product has been produced at that point. The final answer to the problem is:

9.07 g $TiCl_4$

(This is a limiting reactant problem!)