Part I. Problem (10 points)  (Show all work for credit!)
Methanol, a clean-burning, easily handled fuel, can be made by the direct reaction shown below:

\[ \text{CO} (g) + 2 \text{H}_2 (g) \rightarrow \text{CH}_3\text{OH} (l) \]

If the initial reactant mixture is comprised of 120.0 g H\(_2\) and 745.0 g of CO,

(a) what is the limiting reactant? 

\[
\text{mol CH}_3\text{OH (from CO)} = \frac{745.0 \text{ g CO}}{28.01 \text{ g CO}} \times \frac{1 \text{ mol CH}_3\text{OH}}{1 \text{ mol CO}} = 26.60 \text{ mol CH}_3\text{OH}
\]

\[
\text{mol CH}_3\text{OH (from H}_2) = \frac{120.0 \text{ g H}_2}{2.016 \text{ g H}_2} \times \frac{1 \text{ mol CH}_3\text{OH}}{2 \text{ mol H}_2} = 29.76 \text{ mol CH}_3\text{OH}
\]

26.60 mol CH\(_3\)OH < 29.76 mol CH\(_3\)OH, so CO is limiting reactant and H\(_2\) is reactant in excess

(b) how many grams of methanol, CH\(_3\)OH (32.04 g/mol) can theoretically be produced?

\[
g \text{CH}_3\text{OH} = 26.60 \text{ mol CH}_3\text{OH} \times \frac{32.04 \text{ g CH}_3\text{OH}}{1 \text{ mol CH}_3\text{OH}} = 852.3 \text{ g CH}_3\text{OH}
\]

(c) what mass (grams) of the excess reactant is left after the reaction is complete?

Excess reactant is H\(_2\) and

\[\text{mol xs H}_2 = \text{initial mol H}_2 - \text{mol H}_2 \text{ used in reaction}\]

\[\text{mol xs H}_2 = (120.0 \text{ g H}_2 \times \frac{1 \text{ mol H}_2}{2.016 \text{ g H}_2}) - (26.60 \text{ mol CH}_3\text{OH} \times \frac{2 \text{ mol H}_2}{1 \text{ mol CH}_3\text{OH}})\]

\[\text{mol xs H}_2 = 59.52 - 53.20 = 6.32 \text{ mol H}_2\]

\[g \text{H}_2 = 6.32 \text{ mol H}_2 \times \frac{2.016 \text{ g H}_2}{1 \text{ mol H}_2} = 12.7 \text{ g H}_2\]

Part II. Multiple Choice (2 points each)

1. What coefficient is required for HNO\(_3\) to correctly balance the following equation?
   \[3 \text{ Cu} + ____ \text{HNO}_3 \rightarrow 3 \text{ Cu(NO}_3)_2 + 2 \text{ NO} + 4 \text{ H}_2\text{O}\]
   5. 8

2. When 0.340 mol C\(_4\)H\(_{10}\) burns in excess oxygen, how many moles of O\(_2\) are also used?
   \[2 \text{C}_4\text{H}_{10} (g) + 13 \text{O}_2 (g) \rightarrow 8 \text{CO}_2 (g) + 10 \text{H}_2\text{O} (l)\]
   4. 2.21 mol (= 0.340 mol C\(_4\)H\(_{10}\))(13 mol O\(_2\)/2 mol C\(_4\)H\(_{10}\))

3. What mass of Al\(_2\)O\(_3\) (101.96 g/mol) in grams, can be made when 4.6 g Al (26.98 g/mol) reacts with excess oxygen?
   \[4 \text{ Al} (s) + 3 \text{O}_2 (g) \rightarrow 2 \text{Al}_2\text{O}_3 (s)\]
   2. 8.7 g (= (4.6 g Al)(1 mol Al/26.98 g Al)(2 mol Al\(_2\)O\(_3\)/4 mol Al)(101.96 g Al\(_2\)O\(_3\)/mol)

4. How many mol NH\(_3\) are formed for every mol H\(_2\) used if \[3 \text{H}_2 + \text{N}_2 \rightarrow 2 \text{NH}_3\]?
   4. 0.7 mol NH\(_3\) (= 1 mol H\(_2\) (2 mol NH\(_3\)/3 mol H\(_2\))

5. The limiting reactant is 5. the reactant that is completely used up. (definition)