Gas Stoichiometry : Answer Key.

1. Cracking. At T > 1600 K two methane (CH_4) molecules rearrange to give three molecules of hydrogen and one molecule of acetylene (C_2H_2). A 50.0 L steel vessel was filled with methane to a P of 10.0 atm at 298 K. The gas was heated to 1600. K to crack methane and produce C_2H_2. If this process went to 100% yield, what mass of C_2H_2 would be produced? What P would the reactor reach at 1600 K?

Need a balanced chemical equation:

$$2\ CH_{4(g)} \xrightarrow{1600K} 3\ H_{2(g)} + C_2H_{2(g)}$$

a) Write plan: P CH_4 -------→ mol CH_4 --------→ mol C_2H_2 ------→ mass C_2H_2

Ideal gas law (P CH_4 → mol CH_4); SR (mol CH_4 → mol C_2H_2); MM (mol C_2H_2 → mass C_2H_2)

$$n = \frac{(10.0\ \text{atm})\ (50.0\text{L})\ \text{mol K}}{(0.0286\ \text{L atm})\ (298\ \text{K})} = 20.\underline{4}5\ \text{mol } CH_4$$

$$(20.\underline{4}5\ \text{mol } CH_4)\ \frac{(\text{mol } C_2H_2)}{(2\ \text{mol } CH_4)}\ \frac{(26.04\ C_2H_2)}{(1\ \text{mol } C_2H_2)} = 266\ \text{g acetylene}$$

b) Write a data table

T = 1600 K

R from table

V = 50.0 L

n = moles in the reactor at the end of reaction = mol H_2 + mol C_2H_2

P = ? use ideal gas law.

To get the moles of product there are several possibilities (as in most problems). Some of them:

a) P CH_4 -------m ol CH_4----mol H_2
   mol CH_4 ---- mol C_2H_2 add the results
b) mol CH_4 ---mol C_2H_2
   mol C_2H_2 ---mol H_2 add the results.

c) Here, we will try mol of CH_4 to mol of product using the stoichiometric ratio for both gases present:

$$(20.\underline{4}5\ \text{mol } CH_4)\ \frac{(4\ \text{mol gases})}{(\text{mol } CH_4)} = 40.\ 9\ \text{mol in reactor}$$

P = 107 atm. (Substitute all values in ideal gas law)