Materials and Energy Balance

Exercise Problems

1. A natural gas contains 60.7% CH4, 29.03% H2, 7.92% C2H6, 0.98% C2H4, 0.78% O2, 0.58% CO

   Find the volume of air necessary to completely burn one mole of it at standard temperature

   Find the volume of products of combustion at 1000 K

2. An annealing furnace uses a fuel oil containing 16.4% H and 83.6% C. It is proposed to fire this furnace with 25% excess air. Calculate the flue gas produced by burning 100 m³ of fuel oil. Repeat the calculation assuming that 30% of carbon is burnt to CO.

3. A pyrite ore is reduced with hydrogen. The ore contains 10% gangue. Twenty percent excess H2 is used. On the basis of 100 kg of ore charged, calculate the volume of furnace gases at 400 C and 1 atm.   FeS + 2H2 = Fe + 2H2S

4. A zinc retort is charged with 700 kg of roasted zinc concentrates containing 45% Zn, present as ZnO. 20% of the ZnO remains unreduced. Calculate the volume of CO at 300 C.

   ZnO + C = Zn + CO

5. An anthracite coal contains 89% carbon, 3% hydrogen, 1% oxygen and 7% ash. It is burned with 15% excess air. Calculate the volume of air used at standard conditions to burn 1 kg of coal. Calculate the volume and composition of flue gases at 700 K.

6. A limestone is analyzed as 93% CaCO3, 5.5% MgCO3 and 1.5% H2O. How many kg of CaO can be obtained from 5 tons of limestone? What is the volume of CO2 given off at 500 K?

7. How many moles of Fe2O3 would be formed by oxidation of 100 kilograms of iron?

8. Iron pyrite is burned in air to obtain SO2. How many liters of SO2 is obtained at 300 C for 100 liters of oxygen at standard conditions?

   4FeS + 11O2 = 2Fe2O3 + 8SO2

9. Calculate the charge required to produce 1 ton of ferro-chromium using an ore with the analysis 54% Cr2O3, 15.5% FeO, 13.5% MgO, 10% Al2O3, 7% SiO2. Quartz (97% SiO2) is used as flux and 25% excess coke with the analysis 87% C. Assume all Cr2O3 and FeO are reduced by coke.

10. 1 ton of coke (90% C, 6% SiO2, 2% Al2O3, 2% CaO) is used per ton of pig iron (95% Fe, 4% C, 1% Si) produced. The slag has a ratio of CaO:MgO:Al2O3:SiO2=45:10:15:30. Determine the weight of each input to be charged for 2000 kg of pig iron: Ore 1 (78% Fe2O3, 11% SiO2, 5% CaO, 4% MgO, 2%Al2O3), Ore 2 (70% Fe2O3, 16% SiO2, 12% Al2O3, 2% CaO), Limestone (4% Fe2O3, 4% SiO2, 2% Al2O3, 46% CaO, 4% MgO, 40% CO2)

11. You are assigned to cool off a heat of steel which is liquid but too hot. It weighs 90 tons and is at 1700 C. You want to add cold (25 C) steel to it to lower its temperature to 1500 C. Assuming no heat loss from the furnace, how many kilograms would you add? Assume all thermal properties are those of iron.

12. Producer gas of the following composition is burned with 10% excess air. Both air and gas are preheated to 1000 C. Calculate the theoretical maximum temperature of the flame.
    28% CO, 4% CO2, 4% H2, 2%CH4, 1% H2O, 61% N2