1. A coal burning burner is fed with powdered coal (assume pure carbon) preheated to 1800K and dry air (N2:O2=79:21, by volume) preheated to 1200K. The coal to air ratio is such that the product is only a gas containing CO and N2. Perform a material balance and a heat balance and calculate the adiabatic flame temperature (of the product gas).

Take only 1 kg carbon as the mass basis. You need to present data as **mass and heat balance tables, fully filled**.

Sensible heats are enthalpy above 298K :( HT-H298)=

Data:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Answer:**

1 kg C = 1000/12 = 83.333mol; C(s) + ½ O2(g) = CO(g); Δ298f = -111000 J/mol

|  |  |  |  |
| --- | --- | --- | --- |
| **Mass balance** : Basis 1 kg of carbon | | | |
| input | kg | Output | kg |
| Carbon : 83.333 mol  Oxygen: 41.667 mol  Nitrogen: 156.747 mol | 1.0000  1.3333  4.3889 | CO: 83.333 mol  Nitrogen: 156.747 mol | 2.3333  4.3889 |
| Total | 6.7222 | Total | 6.7222 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Heat Balance** | | | |
| Input | kJ | Output | kJ |
| Sensible heats  Carbon : 83.333x23.5(1800-298)/1000  Oxygen: 41.667x36.2(1200-298)/1000  Nitrogen:156.747x34.4(1200-298)/1000  Reaction heat: Σ n(-Δ298f) =  83.333x111000/1000 | 2941.40  1360.53  4863.67  9249.96 | Sensible heats  CO : 83.333x35.3(Tf -298)/1000  Nitrogen:156.747x34.4(1200-298)/1000  Losses | **6500.27**  **11914.92**  **0** |
| Total | 18415.56 | Total | **18415.19** |

Calculation : Tf ( 2.9417+5.3921) = 18415.56 + 876.63 + 1606.85 = 20899.04

Tf = 20899.04/8.3333 = 2507.7K Accept ±10K

Always verify by substituting in the table and checking balance

1. Natural gas (86 vol% CH4, rest N2) is burnt with stoichiometric amount of air (79% N2, rest O2, just sufficient for complete combustion) in a gas burner in a furnace. What is the theoretical maximum temperature of the flame, if the natural gas and air enter the burner at 25°C? Present answer in mass and heat balance tables.