Questions for Class 13
Char Oxidation 1
Chemical Engineering 733

1. Please explain (a) film diffusion, (b) surface reaction, (c) pore diffusion.
2. Show the reaction rate expression in terms of g-C/s for (a) pure film diffusion control, and (b) pure surface reaction control.
3. Derive Eq. 6.19.
4. Show the procedure for determining the reaction rate if no one process is controlling and the surface reaction rate expression is $\dot{r}'' = k''P^{n}_{O_2,surface}$ and 0.5 < n < 1.0.
5. Explain <u>all</u> of the effects of having some CO_2 as a product of char oxidation at the surface of the particle (instead of just CO).
6. The χ factor (pronounced kai) is the ratio of the actual burning rate to the film-diffusion limited burning rate (i.e, the maximum burning rate), as shown on p. 333. Derive an expression for χ from the actual and maximum film diffusion rates in terms of the partial pressure of oxidizer.
7. Please explain figures 133 and 134, including an explanation for the rank dependence of reactivity (including Figures 113 and 114).
8. If T_g=T_p = 1800 K, the initial coal has a daf carbon content of 80%, use the correlations for rate coefficients (Eqs. 6.27-30) to determine the diameter dependence of χ over the range 20μm < d_p < 500μm. You may assume 100% conversion to CO at the surface, and that the velocity lag is low enough to ignore the Reynolds number. Assume that the ambient gas consists of 10 mole% O_2, 90 mole% N_2 at a total pressure of 1 atm.
9. Repeat problem 8 as follows (for the same range of diameters):
   (a) change the temperature to 1400 K, and comment on how temperature affects the χ factor (10 mol% O_2);
   (b) change the concentration of O_2 to 21 mole% and comment on the effect of O_2 on the χ factor (T = 1800 K);
   (c) change the total pressure to 10 atm and comment on the effect of pressure on the χ factor (10 mol% O_2, 1800 K).
10. Repeat problem 8 for the same range of diameters assuming that T_g = 1800 K, but calculate the particle temperature. Assume a Nusselt number of 2.0, that the particles radiate to a surface that is 1000 K with a particle emissivity of 0.8, and that the heat of reaction is approximated by the reaction of carbon going to CO.