Questions for Class 9
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

   \( r'' = k'' P_{O_2, surface}^n \), and \( 0.5 < n < 1.0 \).

5. Explain all 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 \( \chi \) 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 \( \chi \) 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 \( \chi \) over the range \( 20 \mu m < d_p < 500 \mu m \). 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:
   (a) change the temperature to 1400 K, and comment on how temperature affects the \( \chi \) factor;
   (b) change the concentration of O\(_2\) to 21 mole% and comment on the effect of O\(_2\) on the \( \chi \) factor;
   (c) change the total pressure to 100 atm and comment on the effect of pressure on the \( \chi \) factor.

10. Repeat problem 8 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.