South Dakota School of Mines & Technology
Department of Materials & Metallurgy

Met 426/526 HQ2 open book April 15, 2011

1. For the topochemical reduction of FeO by the reaction

   $FeO + CO = Fe + CO_2$ K_{EQ}

   a) Which is the correct mathematical relationship between F, the molar fraction of a spherical pellet with an oxide core of r in a partially-reduced pellet of radius r_o. You may assume the molar density ρ remains constant.

$$F = \left(\frac{r}{r_0}\right)^3 \qquad F = \left(\frac{r}{r_0}\right)^{1/3} \qquad F = 1 - \left(\frac{r}{r_0}\right)^3 \qquad F = 1 - \left(\frac{r}{r_0}\right)^{1/3}$$

   b. It is said that the molar rate of FeO reduction, dn_{Fe}, can be described for a spherical pellet by the equation

$$dn_{Fe} = -4\pi r^2 \rho dr$$

   Describe the rationale for the equation and the meaning of r and ρ.

   c. What is the overall driving force for the reduction process?
   Use the following position notation:
   B – Bulk Gas;
   S – Outer pellet surface;
   Rx – Reacting surface

   d. Describe the five kinetic resistances encountered in a reduction model of FeO with a porous Fe product layer?

   e. Which is the correct relationship between effective diffusivity (De), diffusivity (D), tortuosity (τ), and porosity (ε).

$$D_e = D\left(\frac{\tau}{e}\right) \qquad D_e = De\tau \qquad D = D_e e\tau \qquad D_e = D\left(\frac{e}{\tau}\right)$$

   f. Write the value of resistance R_1 for a particle of radius r_o.

2. To remove 99% of the oxygen from a 100-Ton 1050 steel melt covered by a slag (with a_{CaO}=0.7),
   a) requires what volume of argon (@STP)?
   b) requires what level of vacuum in atm?
   c) requires what mass of FeSi (50%)?

3. Layout as in MathCad the solution for the shaft reactor length. Assume the slopes of each of the dependent variables are as follows and already are placed on the MathCad solution sheet. The reactor is 160 long and 1000 increments are to be used to integrate the "--dot" equations. Use the terms and function names provided below.

TSO: = *given*	Tgdot(TS,TG,X,Y): = *given*
TGO: = *given*	Tsdot(TS,TG,X,Y); = *given*
XO: = *given*	Xdot(TS,TG,X,Y): = *given*
YO: = *given*	Ydot(TS,TG,X,Y): = *given*