In General,

Π_{O_2} **= constant (with radius)**

$$\overline{\Delta G_{O_2}} = RT \ln \Pi_{O_2} = \overline{\Delta H_{O_2}} - T\overline{\Delta S_{O_2}}$$

= -65 + 120 RTx kcal/mole

(T in units of 1000 °K)

$$\text{or, } x = \frac{1}{120}\left\{\ln \Pi_{O_2} + \frac{65}{RT}\right\} \qquad \text{1.)}$$

and

$$\left(\frac{T - T_s}{T_o - T_s}\right) = 1 - \left(\frac{r}{R}\right)^2$$

a.)

$$\bar{x} = \frac{1}{\pi R^2}\int_0^R 2\pi r \bullet x(r) \bullet dr$$

$$\eta = \left(\frac{r}{R}\right)^2, d\eta = \frac{2r}{R^2}dr$$

Then, $T = T_s - (T_o - T_s)(1 - \eta)$

$$\bar{x} = \int_0^1 x(\eta)\,d\eta$$

$$\bar{x} = \frac{1}{120}\int_0^1 \left[\ln \Pi_{O_2} + \frac{65}{RT_s\left[1 + \frac{T_0 - T_s}{T_s}(1-\eta)\right]} \right] d\eta$$

Solving;

$$\ln \Pi_{O_2} = 120\bar{x} - \frac{65}{R(T_O - T_s)} \ln\left(\frac{T_O}{T_s}\right)$$

or since $\bar{x} = 0.05$

$$\ln \Pi_{O_2} = 120 \cdot 0.05 - \frac{65}{1.98(1.5)} \ln(2.5)$$

$$= -14.1$$

$$\therefore \Pi_{O_2} = 7.5 \times 10^{-7}\ \text{atm} \quad (6 \times 10^{-4}\ \text{torr})$$

b.) to plot x(r), use eq. 1

$$x = \frac{1}{120}\left\{ \ln \Pi_{O_2} + \frac{65 \cdot 1}{RT} \right\}$$

$$= -\frac{14.1}{120} + \frac{65}{1.98 \cdot 120 \cdot T}$$

$$= -0.1175 + 0.274\left(\frac{1}{T}\right)$$

Use x from above with parabolic temperature Profile to get x(R)

c.) @ r=R

$$\overline{\Delta G_{O_2}} = RT_s \ln \Pi_{O_2}$$

=1.98•1.00 • (-14.1)

= -28 kcal

in chapter 12 we will see that

$Zr + O_2$ (g)--> ZrO_2

1000°K≈ -220 kcal/mole

$\overline{\Delta G^{\circ}_{O_2}} > \overline{\Delta G^{\circ}_{Zr}}$ **cladding oxidized. We shall see later that oxide layer prevents oxidation from occurring too fast.**