Reverse Boudouard Reaction:

$$C + CO_2 \underset{k_b}{\overset{k_f \rightarrow}{\leftrightarrow}} 2\,CO\ , \qquad \Delta_r H^0_{298} = 172.4 \text{ kJ/mol, Keq} \qquad \text{[Eqn 1]}$$

for $\gamma = +1$: $\chi_{(C)} \uparrow$ as $T \uparrow$, $p \downarrow$, $[CO_2] \uparrow$

Where C, carbon, is the limiting reactant, species A.

Le Chatelier's Principle indicates an increase in the conversion of carbon as the concentration of carbon dioxide increases, as temperature increases, and as pressure decreases.

The Gibbs Phase Rule as applied to this system yields two (2) degrees of freedom so a temperature, T of 900 C, and a pressure, p of 1 atm, are chosen.

Given Equilibrium Expression:

$\log_{10}(Keq_{for}) = 9141/T + 2.24E\text{-}04T - 9.595$[1] (500–2200 K)[1]

Converting $\log_{10}(Keq_{for})$ to natural logarithm notation:

$\ln(Keq_{for}) = 21042/T + 5.16E\text{-}04{*}T - 22.088$

Note: Keq for the reverse reaction is $1/Keq_{for} = k'_b/k'_f = k_f/k_b$,

then $k_b = k_f\ Keq_{for}$

Using the suggestion from Jasper's Posting, one of the two equations needed to solve the problem is:

$$F(f, k_f)\big|_{eq} = \Phi_f - \Phi_b = 0 \qquad \text{[Eqn 2]}$$

$F(f, k_f)$ an expression of Power Law Kinetics for a reversible reaction

f fractional conversion

r reaction rate

k_f forward reaction rate constant

Subscript

eq equilibrium, when $\Delta_{rxn}G^0 = 0$, at equilibrium, $r = 0 \Rightarrow r_f = r_b$

The second equation is:

$$r = (-n^0_A/\nu_A\ W)\ df/dt = k_f\ \theta_f(f) - k_f\ Keq_{for}\theta_b(f) \qquad \text{[Eqn 3]}$$

[1] Boudouard reaction, Wiki, retrieved 17Nov 15