

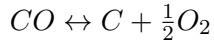
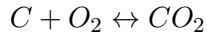
Question 2

ΔG° of relevant reactions:

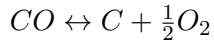
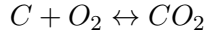
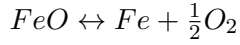
$C + O_2 \leftrightarrow CO_2$	$-394(10)^3 - 0.836T$
$CO \leftrightarrow C + \frac{1}{2}O_2$	$-112.9(10)^3 - 86.5T$
$Fe_3O_{4,(s)} \leftrightarrow 3Fe_{(s)} + 2O_{(g)}$	$-(-1103.1(10)^3 + 307.4T)$
$FeO \leftrightarrow Fe + \frac{1}{2}O_2$	$-(264(10)^3 + 64.6T)$
$3Fe_2O_3 \leftrightarrow Fe + 3O_2$	$-(-815(10)^3 + 251.1T)$

1. $\frac{1}{4}\mathbf{Fe_3O_4} + \mathbf{CO} \leftrightarrow \frac{3}{4}\mathbf{Fe} + \mathbf{CO_2}$; $\Delta G_{rxn}^\circ = -231.125(10)^3 - 164.186T$ J

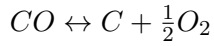
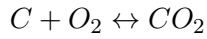
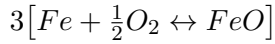
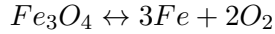
$$\frac{1}{4}[Fe_3O_{4,(s)} \leftrightarrow 3Fe_{(s)} + 2O_{(g)}]$$



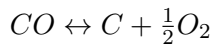
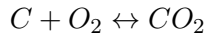
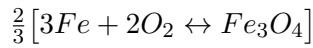
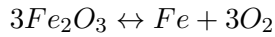
2. $\mathbf{FeO} + \mathbf{CO} \leftrightarrow \mathbf{Fe} + \mathbf{CO_2}$; $\Delta G_{rxn}^\circ = -545.1(10)^3 + 150.264T$ J



3. $\mathbf{Fe_3O_4} + \mathbf{CO} \leftrightarrow \mathbf{FeO} + \mathbf{CO_2}$; $\Delta G_{rxn}^\circ = -592.2(10)^3 + 199.264T$ J



4. $\mathbf{3Fe_2O_3} + \mathbf{CO} \leftrightarrow \mathbf{2Fe_3O_4} + \mathbf{CO_2}$; $\Delta G_{rxn}^\circ = -360.7(10)^3 + 131.831T$ J



Plotting

$$\Delta G = -RT \ln k$$

$$k = \exp \frac{-\Delta G^\circ}{RT} = \frac{P_{CO_2}}{P_{CO}}$$

Let the vertical axis be: $\frac{P_{CO}}{P_{CO}+P_{CO_2}}$

vertical axis in terms of k: $\frac{P_{CO}}{P_{CO}+kP_{CO}} = \frac{1}{1+k}$

equations for phase boundary curves

For each reaction $i = 1 \dots 4$:

$$\Delta G_i^\circ(T) = a_i + b_i T \quad \Rightarrow \quad K_i(T) = \exp\left(\frac{-\Delta G_i^\circ(T)}{RT}\right)$$

and the plotted ordinate is

$$\%CO_i(T) = 100 \cdot \frac{1}{1 + K_i(T)}.$$

Use $R = 8.314462618 \text{ J mol}^{-1} \text{ K}^{-1}$ and the coefficients (in J/mol, T in K):

$$\Delta G_1^\circ = -231.125 \times 10^3 - 164.186 T,$$

$$\Delta G_2^\circ = -545.1 \times 10^3 + 150.264 T,$$

$$\Delta G_3^\circ = -592.2 \times 10^3 + 199.264 T,$$

$$\Delta G_4^\circ = -360.7 \times 10^3 + 131.831 T.$$

