Department of Materials and Metallurgical Engineering
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Met 426/526 Homework

1. Construct an Ellingham Diagram of the relative chemical potential of P_2 showing
   - One of the P reduction reactions on the accompanying sheet (1 – 12)
   - The 1 wt% P in liquid Fe consumption reaction with a wt% $\underline{P}$ nomograph (13), and
   - Two of the iron phosphide formation reactions (14-17).

Possible Blast Furnace Phosphorous Reactions												$\Delta G^o = A + BT$		
												A (Kcal)	- B (cal/K)	Temperature Range, °C
1.		$Ca_3(P0_4)_{2\,(S)}$				=	3.0	$CaO_{\,(S)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	553.4	140.0	25 –
2.		$Ca_3(P0_4)_{2\,(5)}$	+	3.0	$SiO_{2\,(s)}$	=	3.0	$CaSiO_{3\,(S,\,L)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	489.5 493.7	139.6 142.5	25 – 1210 1210 – 1543
3.		$Ca_4P_2O_{9\,(S)}$				=	4.0	$CaO_{\,(S)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	563.6	144.0	25 –
4.		$Ca_4P_2O_{9\,(S)}$	+	4.0	$SiO_{2\,(s)}$	=	4.0	$CaSiO_{3\,(S,\,L)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	478.4 484.0	143.5 147.3	25 – 1210 1210 – 1543
5.		$Fe_3(PO_4)_{2\,(S)}$				=	3.0	$FeO_{\,(S)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	480.5	155.8	25 – 1238
6.		$Fe_3(PO_4)_{2\,(S,\,L)}$	+	1.5	SiO_2	=	1.5	$Fe_2SiO_{4\,(S)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	468.6 502.8	150.3 173.0	25 – 1217 1217 – 1238
7.		$Mg_3(PO_4)_{2\,(S)}$				=	3.0	$MgO_{\,(S)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	501.6	144.0	25 –
8.		$Mg_3(PO_4)_{2\,(S)}$	+	3.0	$SiO_{2\,(S)}$	=	3.0	$MgSiO_{3\,(S)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	474.9	140.7	25 – 1300
9.		$Mn_3(PO_4)_{2\,(S)}$				=	3.0	$MnO_{\,(S)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	495.9	156.0	25 – 1119
10.		$Mn_3(PO_4)_{2\,(S)}$	+	3.0	$SiO_{2\,(S)}$	=	3.0	$MnSiO_{3\,(S)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	478.1	147.0	25 – 1119
11.	2	$Na_3PO_{4\,(S)}$				=	6.0	$Na_{\,(g)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	1106.2	366.3	925
12.	2	$Na_3PO_{4\,(S)}$	+	6.0	$SiO_{2(S)}$	=	3.0	$Na_2Si_2O_{5\,(L)}$	+	$P_{2\,(g)}$	+ 2.5 $O_{2\,(g)}$	1779.0	1434.0	925
13.	2	$[\,\underline{P}\,]_{(1\text{ wt\% in Fe (L)})}$				=				$P_{2\,(g)}$		101.6	6.6	
14.	2	$Fe_3P_{\,(S)}$				=	6.0	$Fe_{\,(S)}$	+	$P_{2\,(g)}$		102.0	22.6	
15.	2	$Fe_2P_{\,(S)}$				=	4.0	$Fe_{\,(S)}$	+	$P_{2\,(g)}$		100.0	22.6	
16.	4	$FeP_{\,(S)}$				=	2.0	$Fe_2P_{\,(S)}$	+	$P_{2\,(g)}$		37.8	22.0	
17.	2	$FeP_{2\,(S)}$				=	2.0	$FeP_{\,(S)}$	+	$P_{2\,(g)}$		58.7	43.0	

References

- K. L. Komarek, Trans TMS-AIME, 1963, vol. 227, pp. 136-145.
- U.S. Dept. of Commerce, MBS: JANAF Thermochemical Tables, 2 ed., U.S. Govt Printinq Office, Washington, D.C., 1971