

**Department of Materials and Metallurgical Engineering**  
**South Dakota School of Mines and Technology**

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% P nomograph (13), and
  - Two of the iron phosphide formation reactions (14-17).

Possible Blast Furnace Phosphorous Reactions						$\Delta G^\circ = A + BT$				
						A (Kcal)	- B (cal/K)	Temperature Range, °C		
1.	$Ca_3(PO_4)_2 (s)$	= 3.0	$CaO (s)$	+ $P_2 (g)$	+ 2.5 $O_2 (g)$	553.4	140.0	25 –		
2.	$Ca_3(PO_4)_2 (s)$	+ 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 $[P]$ (1 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 Printing Office, Washington, D.C., 1971