MET4208 — Automne 2016 — Contrôle I

Solutionnaire

Question 1

$$h = -2309371 + 243.6602\,T - 15379068\,T^{-2} - 4068.8\,T^{0.5}$$

$$c_p = dh/dT = 243.6602 + 2(15379068)\,T^{-3} - 0.5(4068.8)\,T^{-0.5}$$

$$S = S_{298.15} + \int_{298.15}^{T} \frac{c_p}{T}\,dT$$

$$S = 119.660 + 243.6602 \ln\frac{T}{298.15} - \frac{2(15379068)}{(-3)}\left(\frac{1}{T^3} - \frac{1}{298.15^3}\right)$$

$$-\frac{0.5(4068.8)}{(-0.5)}\left(\frac{1}{T^{1/2}} - \frac{1}{298.15^{1/2}}\right)$$

$$S_{600\,K} = 220.19 \text{ J/mol K}$$

Question 2

Let $A = NaNO_3$
$B = KNO_3$

Phases are at equilibrium. Hence $a_A^\alpha = a_A^\beta$
$a_B^\alpha = a_B^\beta$

Raoult's Law for A in α and for B in β
Henry's Law for B in α and for A in β

$$X_A^\alpha = \gamma_A^\circ \cdot X_A^\beta$$

$$(1-0.16) = \gamma_A^\circ (1-0.90)$$

$$\underline{\gamma_A^\circ = 8.4 \text{ in } \beta}$$

$$X_B^\beta = \gamma_B^\circ X_B^\alpha$$

$$0.90 = 0.16\, \gamma_B^\circ$$

$$\underline{\gamma_B^\circ = 5.625 \text{ in } \alpha}$$

Question 3

$$H_2O(liq.) \rightarrow H_2O(gas)$$

$$\Delta G^{\circ}_{373.15} = 0 = \Delta H^{\circ} - (373.15)\Delta S^{\circ} = \Delta H^{\circ} - (373.15)(109.39)$$

$$\Delta H^{\circ} = 40818.9$$

$$\Delta G^{\circ} = 40818.9 - 109.39T = -RT\ln K$$

$$= -RT\ln\left(P_{H_2O}/a_{H_2O}\right) = -RT\ln\left(1.0/0.9418\right) = -0.4986T$$

$$T = \frac{40818.9}{(109.39 - 0.4986)} = 374.86\ K = \underline{\underline{101.71\ ^{\circ}C}}$$

Question 4

[redacted]

$$N_2 = 2N$$

$$K = \frac{a_N^2}{P_{N_2}} = \frac{(X_N \gamma_N)^2}{P_{N_2}}$$

Dilute Solution – Therefore $\gamma_N = \gamma_N^0 \approx cst.$

$$(\text{weight }\%)_N = C \cdot X_N \quad (C = cst.)$$

Hence: $$\frac{(\text{wt. }\%)_N^2}{P_{N_2}} \approx \text{constant}$$

$$\frac{(0.045)^2}{1} = \frac{(\text{wt }\%)_N^2}{10}$$

$$(\text{wt }\%)_N = 0.142 \text{ when } P_{N_2} = 10 \text{ atm.}$$

Question 5

$$h^E = \omega X_A X_B$$
$$s^E = \eta X_A X_B$$

$$h_A^E = \omega X_B^2 \qquad s_A^E = \eta X_B^2$$

$$g_A^E = h_A^E - T s_A^E = (\omega - \eta T) X_B^2$$
$$= RT \ln \gamma_A$$

$$\gamma_A = \exp\left(\frac{(\omega - \eta T) X_B^2}{RT}\right)$$
$$= a_A / X_A$$

$$a_A = X_A \exp\left(\frac{(\omega - \eta T) X_B^2}{RT}\right)$$

Question 6

$$FeS + SO_2 = FeS_2 + O_2$$

$$\Delta G^\circ = -RT\ln K = -RT\ln(p_{O_2}/p_{SO_2})$$

$$p_{SO_2} = 1.0$$

$$\Delta G^\circ = -RT\ln p_{O_2}$$

(i) At 900 K $\Delta G^\circ \approx 290$ kJ
At 1100 K $\Delta G^\circ \approx 315$ kJ

(ii) $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$
Assume ΔH° and ΔS° are independent of T

$$290 = \Delta H^\circ - 900\,\Delta S^\circ$$
$$315 = \Delta H^\circ - 1100\,\Delta S^\circ$$

$$-200\,\Delta S^\circ = 25$$
$$\Delta S^\circ = -0.125 \text{ kJ/K}$$
$$\Delta H^\circ = 177.5 \text{ kJ}$$

(Question 6)

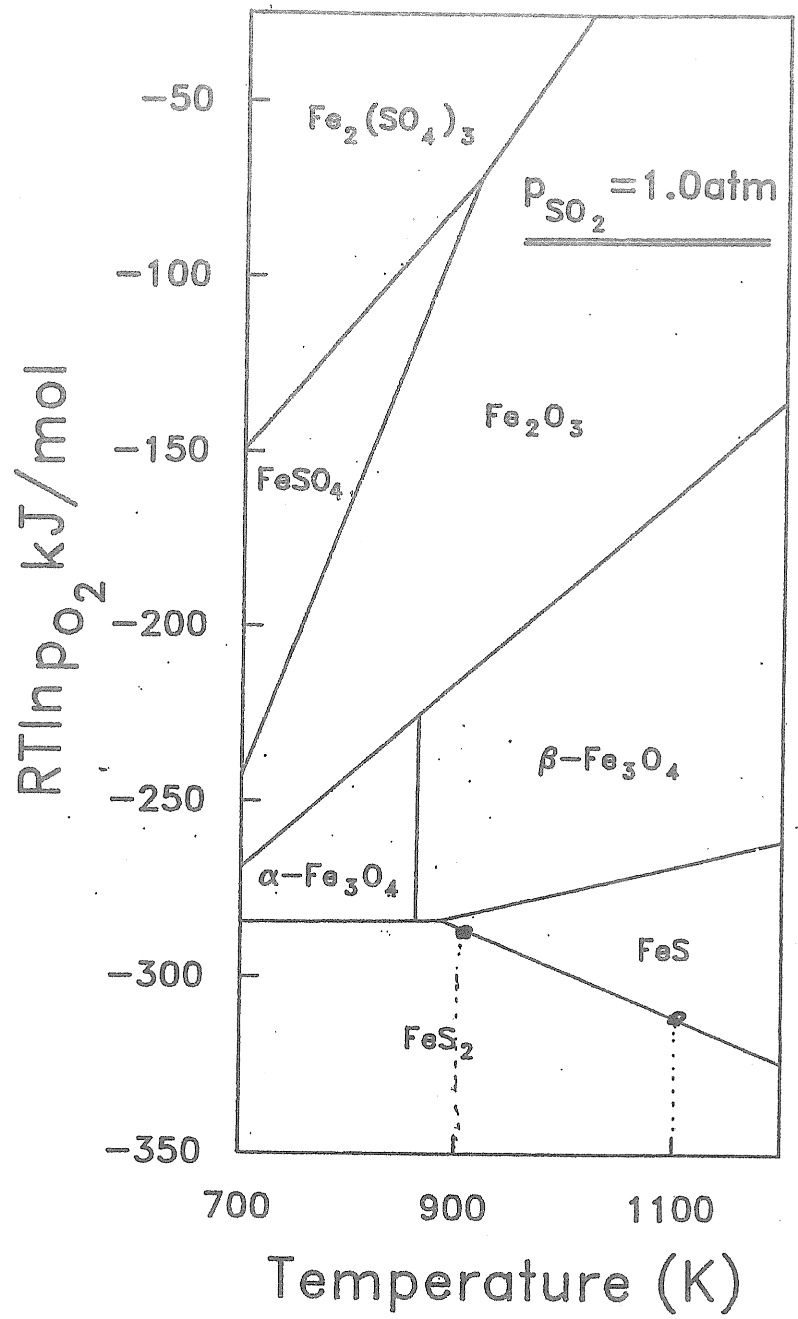

Figure 2

Question 7.

(b) ~ −770°

(c) 506°

(d) (i) primary = $\frac{ab}{ac}$ = 0.32 × 100 = 32 moles

(ii) ternary eutectic = be/de = 0.52 × 100 = 52 moles

(iii) binary eutectic = 100 − 32 − 52 = 16 moles

(a)

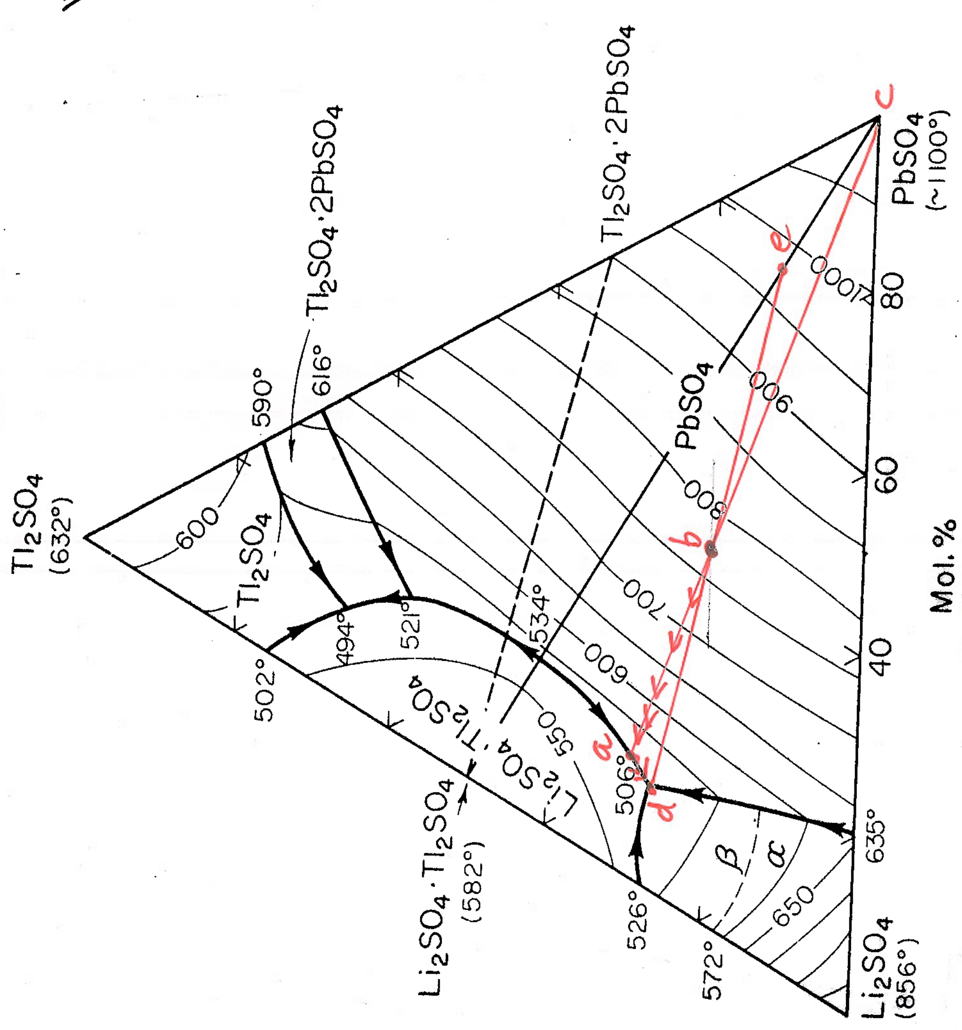

Figure 3