



UNIVERSITY
OF
JOHANNESBURG

<u>PROGRAM</u>	:	BACCALAUREUS TECHNOLOGIAE ENGINEERING: METALLURGY_ METALLURGICAL THERMDYNAMICS III
<u>CODE</u> :		THM32-1
<u>DATE</u>	:	SUMMER EXAMINATION 2017 16 NOVEMBER 2017
<u>DURATION</u>	:	(SESSION 2) 12:30 - 15:30
<u>WEIGHT</u>	:	40:60
<u>FULL MARKS</u>	:	100
<u>TOTAL MARKS</u>	:	100
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<u>EXAMINER</u>	:	Mr. C BANGANAYI 082016003
<u>MODERATOR</u>	:	MR M KALEMBA 5112
<u>NUMBER OF PAGES</u>	:	3 PAGES + ONE ANNEXURE
<u>INSTRUCTIONS</u>	:	CALCULATORS ARE PERMITTED (ONLY ONE PER STUDENT)
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<u>REQUIREMENTS</u>	:	EXAM PAPER TO BE HANDED IN AFTER THE EXAM

2/...

INSTRUCTIONS TO STUDENTS:

ANSWER ALL QUESTIONS.

QUESTION 1:

Calcium carbide is considered to be a potential fuel in a basic oxygen converter and would be expected to burn into CaO and CO or CO₂, depending upon the conditions. If the heat required to raise steel scrap to 1600 °C (1873 K) is 1393.27 kJ/kg of scrap, calculate how many kg of steel scrap can be charged per 1000 kg of CaC₂ when:

- a) All CaC₂ is consumed to form CO. (10)
- b) All CaC₂ is consumed to form CO₂. (10)
- c) 60 % of CaC₂ is utilized to produce CO₂ and the rest for CO. (5)

Assume the reaction takes place at 298 K

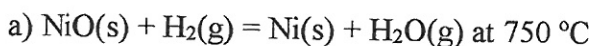
Given:

- (i) $\Delta H_{298}^{\circ}, \text{CaC}_2 = -58.99 \text{ kJ/mol}$
- (ii) $\Delta H_{298}^{\circ}, \text{CaO} = -635.13 \text{ kJ/mol}$
- (iii) $\Delta H_{298}^{\circ}, \text{CO} = -110.54 \text{ kJ/mol}$
- (iv) $\Delta H_{298}^{\circ} \text{CO}_2 = -393.50 \text{ kJ/mol}$

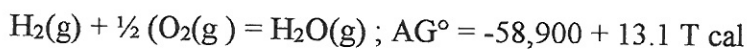
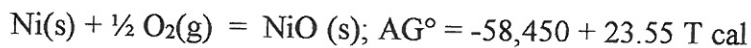
Atomic weights for Ca and C are: 40 g.mol⁻¹ and 12 g.mol⁻¹ respectively.

QUESTION 2:(20 marks)

Calculate the equilibrium constant for the following reaction



Given:

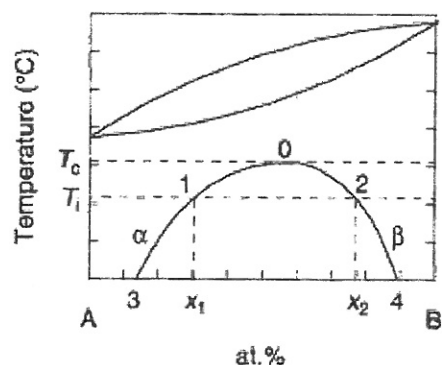


- b) Could pure nickel sheet be annealed at 750°C in an atmosphere containing 95% H₂O and 5% H₂ by volume without oxidation?

QUESTION 3:

The effect of pressure P on the equilibrium transformation of phases can be expressed through Clausius Clayperon equation i.e. $dG=VdP-SdT$. Knowing that at equilibrium $G^L=G^S$ for a liquid to solid transformation.

Show that $dT/dP= \Delta V/ \Delta S$. Say whether this is positive or negative and what does this mean if it's positive or negative, give example. (15)

QUESTION 4:

The diagram shown here represent a binary solution that exhibits a miscibility gap at low temperatures. The interaction parameter Ω can be used to predict the type of phase diagram if its sign in the liquid phase and solid phase is known.

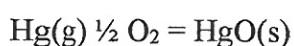
(i) What sign will Ω have in the liquid and solid phase of the isomorphous region and in miscibility gap region. (5)

ii) Show using sketches what type of phase diagrams will come out of the following: s=solid l=liquid a) $\Omega^l = -ve$, $\Omega^s = 0$ b) $\Omega^l = 0$, $\Omega^s = -ve$ (12)

iii) State using an expression a condition that should be met for a complete isomorphous binary solution. (3)

QUESTION 5

a) Calculate the equilibrium constant K at 600 K for the reaction:



Given that $K_{298} = 1.72 \times 10^{10}$ and the standard enthalpy change for the reaction

$$\Delta H_{600}^\circ = 48,6 \text{ kJ} \quad (10)$$

b) The boiling point of manganese under normal conditions is 2097 °C. Calculate the vapour pressure of manganese at 1600 °C given that its heat of vaporization is 225 kJ/mol (10)

Total

100

FORMULAE-LIST

1. $\frac{dP}{dT} = \frac{\Delta H}{T\Delta V}$
2. $\ln \frac{P_2}{P_1} = \frac{\Delta H}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$
3. $\Delta G^\circ = -RT \ln k$
4. $\Delta G_A = RT \ln \gamma_A + RT \ln \left(\frac{M_B}{100M_A} \right)$
5. $\Delta G^M = RT (X_A \ln a_A + X_B \ln a_B)$
6. $\Delta S^M = -R (X_A \ln X_A + X_B \ln X_B)$
7. $\Delta H^M = RT (X_A \ln \gamma_A + X_B \ln \gamma_B)$
8. $G_A^{XS} = RT \ln \gamma_A$
9. $N = \frac{L}{T} \times \frac{273}{0.022414}$
10. $m = \frac{M}{L}$
11. $\square c = \sqrt{\frac{8RT}{\pi M}}$
12. $d = \sqrt{\frac{cm}{2\sqrt{2}\pi\mu}}$
13. $U = \frac{m_A m_B}{m_A + m_B}$
14. $Z_{AB} = N_A N_B d_{AB}^2 \sqrt{8\pi k T u^{-1}}$
15. $\Delta G^{XS} = X_A \Delta G_A^{XS} + X_B \Delta G_B^{XS}$
16. $V = Z A e^{\frac{-E}{RT}}$
17. $\log f_A = \text{wt \% A } e_A^A + \text{wt \% B } e_A^B + \text{wt \% C } e_A^C$ (e = interaction-parameter)
18. $S_A = k \sqrt{P_A}$
19. $\ln f_B = X_B e_B^B + X_C e_B^C + X_D e_B^D$
20. $\frac{-d[C]}{dT} = D \frac{[O]_{sat} - [O]}{l\Delta l} \times \frac{12}{16}$
21. $\Delta T_A = \frac{X_A R T_{(f)B}^2}{H_{(f)B}}$
22. $\Delta G = -ZFE$
23. $\Delta S = ZF \left[\frac{\partial E}{\partial T} \right]_P = S^M \text{ (molar)}$
24. $\Delta H_A = -ZF \left[E - T \left(\frac{\partial E}{\partial T} \right) \right] = H_A^M \text{ (molar)}$
25. $\Delta G_A = RT \ln a_A + \Delta G^\circ$
26. $\Delta G = \Delta H - T \Delta S$
27. $t_x = \frac{1}{k} \ln \left(\frac{c_o}{c_o - x} \right)$
28. $k = A e^{\left(\frac{-E}{RT} \right)}$
29. $t_{0.5} = \frac{1}{kC} \text{ or } \frac{\ln 2}{k}$
30. $k = \frac{1}{t} \times \frac{x}{c_o(c_o - x)}$