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FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI
SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY
DEPARTMENT OF MATERIALS AND METALLURGICAL ENGINEERING

2019/2020 HARMATTAN SEMESTER EXAMINATIONS

COURSE CODE: MME 409
COURSE TITLE: METALLURGICAL THERMODYNAMICS AND KINETICS

INSTRUCTION: ATTEMPT ANY FIVE QUESTIONS TIME ALLOWED: 3 HOURS

(1)(a)(i) State Kirchoff's law. Write the formula. [2 Marks]
(ii) State Hess' law. Write the illustration.[2 Marks]

(b) Calculate the heat of the reaction $ZrO_2 + 2Cl_2 + C \rightarrow ZrCl_4 + CO_2$ at 25^0C and 777^0C given:

	ΔH^0_{298}	C_p
$Zrcl_4$	-234.7Kcal/mole	$31.92\text{-}2.91X\ 10^5T^{-2}$Cal/deg/mole
CO_2	-94.05 Kcal/mole	$10.55 + 2.16\ X\ 10^{-3}T - 2.05\ X\ 10^5T^{-2}$Cal/deg/mole
ZrO_2	-259.5 Kcal/mole	$16.64 + 1.80\ X\ 10^{-3}T - 3.36\ X\ 105T^{-2}$ Cal/deg/mole
Cl_2		$8.82 - 0.06\ X\ 10^{-3}T - 0.68\ X\ 105T^{-2}$ Cal/deg/mole
C		$4.10 + 1.02\ X\ 10^{-3}T - 2.10\ X\ 10^5T^{-2}$

[10 Marks]

(2) (a) Calculate the standard entropy of Zinc at 750^0C given Tm = 420^0C, Heat of fusion = 1.74Kcal/mole, S^0_{298} = 9.95Cal/deg/mole,
$C_{p<Zn>} = 5.35 + 2.40 \times 10^{-3}T$ Cal/deg/mol, $C_{p\{Zn\}}$= 7.50Cal/deg/mole. [8 Marks]

(b) Show that $\left(\frac{d\Delta G^0}{dT}\right)_p = -\Delta S^0$ [6 Marks]

(3)(a) Chromium and Carbon present in stainless steel form Chromium carbide at 600°C. Show by calculation which of the metals among Si, Ti and V should be alloyed to stainless steel to avoid Chromium carbide formation. Given:
(i) $3Cr + 2C = Cr_3C_2; \Delta G^0 = -20\,800 - 4.0T\ Cal$
(ii) $Si + C = SiC; \Delta G^0 = -12\,770 + 1.66T\ Cal$
(iii) $V + C = VC; \Delta G^0 = -20\,000 + 1.6T\ Cal$
(iv) $Ti + C = TiC; \Delta G^0 = -45\,000 + 2.8T\ Cal$ [8 Marks]

(b) Between Ni and Cr, which has greater probability of oxidation in steam at 827°C and 1atm pressure? Given:
$<NiO> + (H_2) = <Ni> + (H_2O); \Delta G^0 = -2\,301 - 42.59T\ J$
$\frac{1}{3}<Cr_2O_3> + (H_2) = \frac{2}{3} < Cr > + (H_2O); \Delta G^0 = 126\,566 - 30.67T\ J$ [6 Marks]

(4) (a) The isothermal and reversible expansion of 1 mole of an ideal gas at 25°C caused a change of pressure from 6.5N/m² to 4.2N/m². What work was done in the process? (Take R = 8.314J/mole) [6 Marks]

(b)(i) State Clausius-Clapeyron equation, define the terms and highlight the applications. [4 Marks]

(ii) Given the vapour pressure of liquid Titanium at 2220°C as 1.5mm Hg, the heat of vapourization at its normal boiling point as 138.8Kcal, Calculate its normal boiling point. [4 Marks]

(5) (a) The reaction between FeO in slag with Carbon in pig iron may be regarded as first order, and at a certain temperature, the reaction is 50% complete at the end of 90 minutes.

(i) In how many minutes will the reaction be 80% complete at that temperature? [5 Marks]

(ii) Calculate the rate constant. [5 Marks]

(b) The radioactive decay of uranium 238 is first-order and the half-life is 4.51×10^9 years. Calculate the specific reaction rate. [4 Marks]

(6) (a) A second-order reaction has an initial concentration of the reactants of 0.5moles/litre (0.5mol/dm³). The reaction is 25% complete in 70 minutes. Calculate the rate constant and the time it would take for the reaction to be 90% complete. [8 Marks]

(b) For the reaction A + B = C, the following data were determined:

Experiment No.	Initial Concentration				Half-life period
	A		B		
	moles/litre	mol/dm³	moles/litre	mol/dm³	hour
1	2.0	2.0	2.0	2.0	3.0
2	6.0	6.0	6.0	6.0	1.0

Calculate the order of the reaction and the specific reaction rate.[6 Marks]

(7) The rate constants (k) for the leaching of galena in an aqueous medium containing ammonium acetate under oxygen pressure at different temperatures are listed below where k and T are expressed in mole²/cm⁴/min and K respectively.

log k	-11.0	-11.2	-11.3	-11.6	-12.2	-12.7
$\frac{1}{T} X 10^3$	2.40	2.45	2.48	2.55	2.71	2.85

Calculate the activation energy of the leaching process. [14 Marks]