Ugwuru Emmanuel C. 2013187363

FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI
SCHOOL OF ENGINEERING & ENGINEERING TECHNOLOGY
DEPARTMENT OF MATERIALS & METALLURGICAL ENGINEERING
2018/2019 HARMATTAN SEMESTER EXAMINATIONS.
COURSE: MAE/MTE 521 –KINETIC PROCESSES IN MATERIALS.
DATE: 25/06/2019 **TIME: 3 HOURS.**
ANSWER FIVE QUESTIONS.

1. (a). Derive an expression similar to Jander's equation for the fraction, α that has reacted in a disc-shaped particle of $Mg(OH)_2$, radius r, and height h, reacting radially inwards. Relate the layer y, formed after time t, to the rate of decomposition dy/dt during a constant-temperature experiment, given that there was no catalytic nor retarding effect of the product layer, y.

(b). One-micron discs of $Mg(OH)_2$ particles are subjected to a decomposition reaction and 60% of the $Mg(OH)_2$ decomposed to form MgO during the first hour of a constant-temperature experiment. How long will it take for all the $Mg(OH)_2$ to decompose?

2 (a). Write an equation for the number of vacancies contained in a metal at equilibrium at a particular temperature, and also that for the Arrhenius rate equation in the common logarithmic form.

(b.i) Calculate the equilibrium concentration of vacancies per cubic meter in pure silver at 850°C

(ii) What is the vacancy fraction at 800°C? Assume the energy of formation of a vacancy in pure silver is 1.10 eV. Assume C=1, Boltzmann's constant = 8.62×10^{-5} eV/K, density of silver=10.5 g/cm^3, atomic mass of silver=107.868 g/at.mass.

3 (a) A gear made of 1018 steel (0.18 wt% C) is to be gas-carburized at 927°C. If the carburizing time is 7.5 h, at what depth in millimeters will the carbon content be 0.40 wt% ? Assume the carbon content at the surface of the gear is 1.20 wt%. D (C in □ iron at 927°C) = 1.28×10^{-11} m^2/s.

(b)The diffusion coefficient for Ni in MgO is 1.23×10^{-12} cm^2/s at 1200°C and is 1.45×10^{-10} cm^2/s at 1800°C.Calculate the activation energy and the diffusion constant D_o.

4. Derive an expression similar to Jander's equation for the fraction, α that has reacted in a cylindrical particle, radius r, height h, reacting from one end face relating the layer y, formed after time t, to the rate of decomposition dy/dt, if this rate is inversely proportional to the layer, y that has formed.

5. Derive the expression for the rate constant, k for a decomposition reaction of a substance A which is a first order reaction.

6. In an experiment, the following data were generated:

Time (s)	Concentation (mol m^{-3})
0	0.00735
105	0.00584
242	0.00463
840	0.00241

Confirm if this is a first or second order reaction and hence determine the rate constant.

TABLE OF THE ERROR FUNCTION	
z	erf z
0	0
0.025	0.0282
0.05	0.0564
0.10	0.1125
0.15	0.1680
0.20	0.2227
0.25	0.2763
0.30	0.3286
0.35	0.3794
0.40	0.4284
0.45	0.4755
0.50	0.5205
0.55	0.5633
0.60	0.6039
0.65	0.6420
0.70	0.6778
0.75	0.7112
0.80	0.7421
0.85	0.7707
0.90	0.7970
0.95	0.8209
1.00	0.8427
1.10	0.8802
1.20	0.9103
1.30	0.9340
1.40	0.9523
1.50	0.9661
1.60	0.9763
1.70	0.9838
1.80	0.9891
1.90	0.9928
2.00	0.9953