University of Eswatini

Department Of Chemistry

November 2018 Main Examination

TITLE OF PAPER : **Transport and Chemical Kinetics**

COURSE NUMBER : **CHE 341**

TIME : **3 Hours**

Important Information : Each question is worth **25 marks**.

: Answer **questions one (1)** and any other three **(3)** questions in this paper.

: Marks for **ALL** procedural calculations will be awarded.

: Start each question on a fresh page of the answer sheet.

: Diagrams must be large and clearly labelled accordingly.

: This paper contains an appendix of chemical constants.

: Additional material: data sheet and the periodic table.

You are not supposed to open this paper until permission has been granted by the chief invigilator

Question 1 [25 marks]

a) Write short notes on the following;

i. Define catalysis as modelled by enzyme action [2]

ii. Write short notes and compare the relaxation effect and the electrophoretic effect [8]

b) The following data was obtained for an enzyme in the absence of an inhibitor and in the presence of an inhibitor.

[S] (mM)	V (set 1, μmol s^{-1})	V (set 2, μmol s^{-1})
1	8.6	24
2	16	40
4	28	58
10	42	70

i. Define the process of inhibition during enzyme catalysis. [2]

ii. Given that the enzyme catalysis is by the Michaelis Menten mechanism, determine the Michaelis constant for both sets of data then identify which set is for inhibited catalysis. [10]

iii. What is the maximum velocity of this catalysis? [3]

Question 2 [25 Marks]

a) The diffusion coefficient (D) of H_2 is given by 9.0 x $10^{-5}m^2s^{-1}$ at 1 bar and 25°C. Determine; the relative mean speed, the collision flux of H_2 molecules and the cross-section of H_2. [15]

b) Given the mechanism below, extract the rate law for the resultant overall reaction. [5]

$$H_2 + ICl \rightarrow HI + HCl \quad (slow, k_1)$$

$$HI + ICl \rightarrow I_2 + 2HCl \quad (fast, k_2)$$

c) Write short notes on the following;

i. Maxwell-Boltzmans distribution of speeds [5]

Question 3 [25 Marks]

a) Consider the reaction of methane with molecular chlorine:

$$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$$

For which the following mechanism was proposed

$$Cl_2 \rightarrow 2Cl^{\cdot}$$

$$Cl^{\cdot} + CH_4 \rightarrow HCl + CH_3^{\cdot}$$

$$CH_3^{\cdot} + CH_3Cl + Cl^{\cdot}$$

$$Cl^{\cdot} + Cl^{\cdot} \rightarrow Cl_2$$

Show that the mechanism is consistent with the experimental rate law [10]

$$\frac{d[HCl]}{dt} = k[CH_4][Cl_2]^{1/2}$$

b) Discuss two methods with which transport number may be determined. [8]

c) Write short notes on the following

i. Mean free path, [3]

ii. Arrhenius Equation [4]

Question 4 [25 Marks]

a) A solution of LiCl was electrolyzed in a Hittorf cell. A current of 0.77 A had been passed for two hours, the mass of LiCl in the anode compartment had decreased by 0.793 g. Calculate the transport numbers of the Li^+ and Cl^- ions. [6]

b) Estimate the effective radius of glycerine molecule in water at 25°C given that its diffusion coefficient is $5.2 \times 10^{-10} m^2 s^{-1}$ and that the viscosity of water is 1.00 cP. [7]

c) The rate constant for the first order decomposition of a compound A in the reaction $A \rightarrow P$ is $k=2.78 \times 10^5 s^{-1}$ at 25°C. If the initial pressure is 32.1 kPa, calculate;

(i) The half-life of A

(ii) The pressure, 10 seconds after the initiation of the reaction. [6]

d) Using an equation of your choice, briefly explain the pre-equilibrium approach. [6

Question 5 [25 Marks]

a) Write short notes on the following;

i. Pseudo first order reaction [3]

ii. Collision flux [3]

b) Give an elaborate derivation of the Ostwalds dilution law and outline a procedure you may follow to utilise this law for an electrolyte of your choice to determine its limiting molar conductivity. [12]

c) What are the units of k_r for 2^{nd} and 3^{rd} order rate reactions if the rate laws are expressed with;

i. concentrations in molecules per metre cubed, [3]

ii. Pressures in kilopascals, what are the units of k_r for second order and third order rate constants. [4]

Question 6 [25 Marks]

a) Write short notes on the Kohlrausch's law [4]

b) A container is filled with gas x;

(i) Identify gas **x**, by calculating it's molar mass, given that it's mean speed, $\hat{\mathbf{c}}$, is 475 m/s at 25 °C. [5]

(ii) Calculate the relative mean speed, $\hat{c}_{rel}$, of gas **x** using two methods. [7]

(iii) Given that the gas x is enclosed in a container and a pressure of 65 Torr is maintained, what is the volume of the container? [5]

b) Account physically for the form of the diffusion equation. [4]

The end

THE PERIODIC TABLE OF ELEMENTS

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
Period 1	1 H 1.008																	2 He 4.003
2	3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.9	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.01	25 Mn 54.9	26 Fe 55.85	27 Co 58.71	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.7	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.91	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 91.22	42 Mo 95.94	43 Tc 98.9	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	71 Lu 174.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 196.9	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 208.9	84 Po 210	85 At 210	86 Rn 222
7	87 Fr 223	88 Ra 226.0	103 Lr 257	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une									

NON-METALS

METALLOIDS

METALS

Lanthanides	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm 146.9	62 Sm 150.9	63 Eu 151.3	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0
Actinides	89 Ac 227.0	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.1	94 Pu 239.1	95 Am 241.1	96 Cm 247.1	97 Bk 249.1	98 Cf 251.1	99 Es 254.1	100 Fm 257.1	101 Md 258.1	102 No 255

*Numbers **below** the symbol indicates the **atomic masses**; and the numbers above the symbol indicates the atomic numbers.*

SOURCE: International Union of Pure and Applied Chemistry, I mills, ed., Quantities, Units, and symbols in Physical Chemistry, Blackwell Scientific publications, Boston, 1988, pp 86-98.