DEPARTMENT OF CHEMISTRY

UNIVERSITY OF SWAZILAND

NOVEMBER 2017 RE-SIT 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 <u>**ALL**</u> 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) With an aid of a diagram, describe Newtonian flow. [5]

b) An enzyme catalysed reaction conversion of a substance at 25°C has Michaelis constant of 0.042 mol L^{-1}. The rate of reaction is 2.45 x 10-4 mol L^{-1} s^{-1} when the substrate concentration is 0.89 mol L^{-1}. What is the maximum velocity of this enzmolysis [5]

c) Discuss the features, advantages and limitations of the Michaelis – Menten mechanism of enzyme action [5]

d) Compute the root mean square speed, the mean speed and the relative mean speed for CO_2 at 300K. [10]

Question 2 [25 Marks]

a) Derive the pressure of the perfect gas according to the kinetic model. [10]

b) Discuss the physical interpretations of the diffusion coefficient (D), coefficient of viscosity (η) and coefficient of thermal conductivity (κ). [10]

c) What is the difference between a strong electrolyte and a weak electrolyte? Give examples of each. [5]

Question 3 [25 Marks]

a) Calculate the mean free path of argon at 0.5 atm [5]

b) List the three assumptions of the Kinetic model [3]

c) Calculate the diffusion constant of Nitrogen at 25°C and

   i. 10.0 kPa, [4]

   ii. 100 kPa [2]

d) Given the following; $\lambda_m^0\ (KCl)$ = 0.0149 Sm2mol-1, $\lambda_m^0\ (NaCl)$ = 0.0127 and $\lambda_m^0\ (KNO_3)$ = 0.0145, determine the conductivity of $NaNO_3$ at infinite dilution. [5]

e) Derive the Ostwald dilution law for a weak electrolyte [6]

Question 4 [25 Marks]

a) For the perchlorate ion ClO_4^- , in water at 25°C, λ_m^0 = 67.2 Scm^2mol^{-1}

   i. Calculate the mobility, u, of ClO_4^- in water [2]

   ii. Calculate the drift speed , s, of ClO_4^- in water in a field of 24V/cm [2]

   iii. Calculate the diffusion coefficient of ClO_4^- in water [2]

b) 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]

c) Write short notes on the following;

(i) Limiting molar conductivity. [2]

(ii) Collision frequency. [2]

(iii)Half-life. [2]

d) Discuss one of the 3 ways of measuring transport numbers. [7]

Question 5 [25 Marks]

a) A container is filled with gas x;

(i) Identify gas **x**, by calculating it's molar mass, given that it's mean speed, $\hat{c}$, 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]

c) Why is a proton less mobile in liquid ammonia than in water. [4]

Question 6 [25 Marks]

a) Define the collision density for two different molecules A and B .
[6]

b) List the properties of enzymes.
[5]

c) Write short notes on the two major classes of polymerization kinetics.
[8]

d) The conductivity of KCl at 25°C is 14.668 mS/m when c=1.0000 mmol/dm^3 and 71.740 mS/m when c=5.0000 mmol/dm^3. Determine the limiting molar conductivity and the Kohlrausch constant K.
[6]

The end

Data Sheet

$pV = \frac{1}{3} nMc^2$

$z = \sigma \hat{c}_{rel} ℵ$

$s = uE$

$z = \frac{\sigma c_{rel} P}{kT}$

$\lambda = \frac{kT}{\sigma P}$

$Z_w = \frac{P}{(2\pi mkT)^{\frac{1}{2}}}$

$\Lambda_m = K/c$

$\Lambda_m = \Lambda_m^0 - K\sqrt{c}$

$\lambda = zuF$

R = 8.314 J K^{-1} mol^{-1}

h = 6.626 x 10^{-34} J s

c = 2.9979 x 10^8 ms^{-1}

NA= 6.022x10^{23}

F=96485.34 C mol^{-1}

k=1.38065x10^{-23} JK-1

electronic charge (e) = 1.602177x10^{-19}

General data and fundamental constants

Quantity	Symbol	Value
Speed of light	c	$2.997\ 924\ 58 \times 10^{8}\ \mathrm{m\ s^{-1}}$
Elementary charge	e	$1.602\ 177 \times 10^{-19}\ \mathrm{C}$
Faraday constant	$F = N_A e$	$9.6485 \times 10^{4}\ \mathrm{C\ mol^{-1}}$
Boltzmann constant	k	$1.380\ 66 \times 10^{-23}\ \mathrm{J\ K^{-1}}$
Gas constant	$R = N_A k$	$8.314\ 51\ \mathrm{J\ K^{-1}\ mol^{-1}}$
		$8.205\ 78 \times 10^{-2}\ \mathrm{dm^3\ atm\ K^{-1}\ mol^{-1}}$
		$6.2364 \times 10\ \mathrm{L\ Torr\ K^{-1}\ mol^{-1}}$
Planck constant	h	$6.626\ 08 \times 10^{-34}\ \mathrm{J\ s}$
	$\hbar = h/2\pi$	$1.054\ 57 \times 10^{-34}\ \mathrm{J\ s}$
Avogadro constant	N_A	$6.022\ 14 \times 10^{23}\ \mathrm{mol^{-1}}$
Atomic mass unit	u	$1.660\ 54 \times 10^{-27}\ \mathrm{Kg}$
Mass		
electron	m_e	$9.109\ 39 \times 10^{-31}\ \mathrm{Kg}$
proton	m_p	$1.672\ 62 \times 10^{-27}\ \mathrm{Kg}$
neutron	m_n	$1.674\ 93 \times 10^{-27}\ \mathrm{Kg}$
Vacuum permittivity	$\varepsilon_0 = 1/c^2\mu_0$	$8.854\ 19 \times 10^{-12}\ \mathrm{J^{-1}\ C^2\ m^{-1}}$
	$4\pi\varepsilon_0$	$1.112\ 65 \times 10^{-10}\ \mathrm{J^{-1}\ C^2\ m^{-1}}$
Vacuum permeability	μ_0	$4\pi \times 10^{-7}\ \mathrm{J\ s^2\ C^{-2}\ m^{-1}}$
		$4\pi \times 10^{-7}\ \mathrm{T^2\ J^{-1}\ m^3}$
Magneton		
Bohr	$\mu_B = e\hbar/2m_e$	$9.274\ 02 \times 10^{-24}\ \mathrm{J\ T^{-1}}$
nuclear	$\mu_N = e\hbar/2m_p$	$5.050\ 79 \times 10^{-27}\ \mathrm{J\ T^{-1}}$
g value	g_e	$2.002\ 32$
Bohr radius	$a_0 = 4\pi\varepsilon_0\hbar/m_e e^2$	$5.291\ 77 \times 10^{-11}\ \mathrm{m}$
Fine-structure constant	$\alpha = \mu_0 e^2 c/2h$	$7.297\ 35 \times 10^{-3}$
Rydberg constant	$R_\infty = m_e e^4/8h^3 c\varepsilon_0^2$	$1.097\ 37 \times 10^{7}\ \mathrm{m^{-1}}$
Standard acceleration of free fall	g	$9.806\ 65\ \mathrm{m\ s^{-2}}$
Gravitational constant	G	$6.672\ 59 \times 10^{-11}\ \mathrm{N\ m^2\ Kg^{-2}}$

Conversion factors

1 cal	=	4.184 joules (J)	1 erg	=	1×10^{-7} J
1 eV	=	$1.602\ 2 \times 10^{-19}$ J	1 eV/molecule	=	96 485 kJ $\mathrm{mol^{-1}}$

Prefixes

f	p	n	μ	m	c	d	k	M	G
femto	pico	nano	micro	milli	centi	deci	kilo	mega	giga
10^{-15}	10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^{-1}	10^{3}	10^{6}	10^{9}

PERIODIC TABLE OF ELEMENTS

GROUPS

PERIODS	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
1	1.008 H 1																	4.003 He 2
2	6.941 Li 3	9.012 Be 4										Atomic mass → Symbol → Atomic No. →	10.811 B 5	12.011 C 6	14.007 N 7	15.999 O 8	18.998 F 9	20.180 Ne 10
3	22.990 Na 11	24.305 Mg 12					TRANSITION ELEMENTS						26.982 Al 13	28.086 Si 14	30.974 P 15	32.06 S 16	35.453 Cl 17	39.948 Ar 18
4	39.098 K 19	40.078 Ca 20	44.956 Sc 21	47.88 Ti 22	50.942 V 23	51.996 Cr 24	54.938 Mn 25	55.847 Fe 26	58.933 Co 27	58.69 Ni 28	63.546 Cu 29	65.39 Zn 30	69.723 Ga 31	72.61 Ge 32	74.922 As 33	78.96 Se 34	79.904 Br 35	83.80 Kr 36
5	85.468 Rb 37	87.62 Sr 38	88.906 Y 39	91.224 Zr 40	92.906 Nb 41	95.94 Mo 42	98.907 Tc 43	101.07 Ru 44	102.91 Rh 45	106.42 Pd 46	107.87 Ag 47	112.41 Cd 48	114.82 In 49	118.71 Sn 50	121.75 Sb 51	127.60 Te 52	126.90 I 53	131.29 Xe 54
6	132.91 Cs 55	137.33 Ba 56	138.91 *La 57	178.49 Hf 72	180.95 Ta 73	183.85 W 74	186.21 Re 75	190.2 Os 76	192.22 Ir 77	195.08 Pt 78	196.97 Au 79	200.59 Hg 80	204.38 Tl 81	207.2 Pb 82	208.98 Bi 83	(209) Po 84	(210) At 85	(222) Rn 86
7	223 Fr 87	226.03 Ra 88	(227) **Ac 89	(261) Rf 104	(262) Ha 105	(263) Unh 106	(262) Uns 107	(265) Uno 108	(266) Une 109	(267) Uun 110								

*Lanthanide Series	140.12 Ce 58	140.91 Pr 59	144.24 Nd 60	(145) Pm 61	150.36 Sm 62	151.96 Eu 63	157.25 Gd 64	158.93 Tb 65	162.50 Dy 66	164.93 Ho 67	167.26 Er 68	168.93 Tm 69	173.04 Yb 70	174.97 Lu 71
**Actinide Series	232.04 Th 90	231.04 Pa 91	238.03 U 92	237.05 Np 93	(244) Pu 94	(243) Am 95	(247) Cm 96	(247) Bk 97	(251) Cf 98	(252) Es 99	(257) Fm 100	(258) Md 101	(259) No 102	(260) Lr 103

( ) indicates the mass number of the isotope with the longest half-life.