UNIVERSITY OF ESWATINI

Re-Sit EXAMINATION 2018/2019

TITLE OF PAPER: INTRODUCTION TO QUANTUM MECHANICS

COURSE NUMBER: CHE343

TIME: TWO (2) HOURS

INSTRUCTIONS:

Answer all questions

NB: Each question should start on a new page.

A data sheet and a periodic table are attached

A non-programmable electronic calculator may be used

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Useful Integrals

1. $\int x^2 e^{-x^2} dx = \frac{\sqrt{\pi}}{2}$
2. $\int x^3 e^{-x^2} dx = 0$
3. $\int_0 x^n e^{-ax} dx = \frac{n!}{a^{n+1}}$
4. $\int sin\theta d\theta = -cos\theta + constant$
5. $d\tau = r^2 sin\theta dr d\theta d\phi$
6. $\int x^n dx = \frac{1}{a^{n+1}} \qquad n \neq -1$
7. $\int_0^{2\pi} cos^2\theta sin\theta d\theta = \frac{2}{3}$

i). The Planck constant [4]

ii). The threshold frequency [2]

iii). The work function for lithium [2]

c) For the following functions and operators, show that f(x) is an eigen-function of the operator $\widehat{\Omega}$ and determine the eigen-value

i). $\widehat{\Omega} = \frac{\partial}{\partial y}$ $f(x) = x^2 e^{6y}$ [2]

ii). $\widehat{\Omega} = \frac{d^2}{dx^2} + 4\frac{d}{dx} + 3$ $f(x) = e^{3x}$ [3

d) There is an uncertainty principle for energy and time; $\Delta E \Delta t \geq h$. One application of this relationship has to do with the excited state energies and lifetimes of atoms and molecules. If we know that the lifetime of an excited state is 10^{-9} s, then what is the uncertainty in the energy of this state? [3]

e) Calculate the de Broglie wavelength of a neutron moving at 6.0 x10^6 cm/s [4]

QUESTION 3 [25 MARKS)]

a) Given that one solution for the Schrödinger equation for a simple harmonic oscillator is $\psi = e^{-\frac{\omega x^2}{2}}$, show that the ground state eigen value is $\frac{\hbar\omega}{2}$ [7]

b) Consider a harmonic oscillator consisting of a particle of mass 2.33 x 10-26 kg and force constant 155N/m. calculate

i). The zero point energy of the oscillator [3]

ii). The difference in energy between the adjacent levels [2]

iii). The wavelength of a photon needed to excite a transition between adjacent levels. [2]

c) The rotation of $H^{127}I$ molecule can be pictured as the orbital motion of an H atom at a distance 160 pm from a stationary **iodine** atom. Suppose the molecule rotates only in one plane. ^{127}I =126.9045u, H = 1.0078u

i). Calculate the energy needed to excite the molecule into rotation [4] ii). What is the minimum non-zero angular momentum of the molecule?

[3]

d) What does a wave node mean in quantum mechanics? With the aid of sketches, compare the wave nodes for a harmonic oscillator and that for translational motion. [4]

Total Marks ***/75/***

General data and fundamental constants

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

TRANSITION ELEMENTS

Atomic mass →
Symbol →
Atomic No. →

*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.

UNIVERSITY OF ESWATINI

SUPPLEMENTARY EXAM – 2019

TITLE OF PAPER : Advanced Organic Chemistry

COURSE NUMBER : C 403

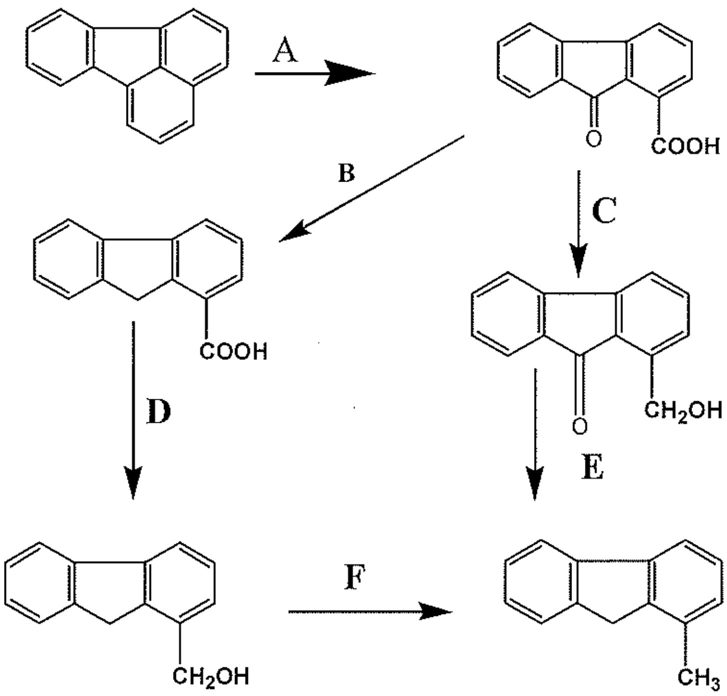
TIME : Three Hours

INSTRUCTIONS:

Answer any four (4) questions of the six (6) questions and every question holds 25 marks.

NB: all questions are to be answered in a separate answer sheet.

Reaction Scheme.



Question 3

A) 5- and 6-membered organic ring compounds are the easiest to make, stable and quite common in nature. Why? (5)

B) Prepare methyl substituted payroll and pyridine using a diketone starting material and "4+1" and "5+1" strategies, respectively. (5)

C) Discuss the reactivity of Pyridine in comparison with Benzene. (5)

D) Electrophilic Substitution of Pyridines favors the β position as compared to α/γ. What is the underlying cause for this preference? (5)

E) What is the identity of the intermediate A? Explain why? (5)