MACHAKOS UNIVERSITY COLLEGE

(A Constituent College of Kenyatta University)
University Examinations for 2015/2016 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (MATHEMATICS)
BACHELOR OF EDUCATION

SCH 200: ATOMIC STRUCTURE AND CHEMICAL BONDING

DATE: 8/8/2016 **TIME: 2.00-4.00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory**.
- Answer any **two** questions from section **B**.

REQUIRED DATA/INFORMATION

- Mass of electron (m) = 9.1079×10^{-31} Kg, electronic charge (e-) = 1.602×10^{-19} C
- **Rydberg's constant (R) =** 10 973 731.6 m^{-1}, **Planck's constant (h)=**6.63×10^{-34}Js, **Speed of light (C)** = 3 $x10^{8}$m/s,**σ = Stefan's constant** = 5.670×10^{-8} $Wm^{-2}K^{-4}$, **c_2=2nd radiation constant** = 1.44 cmK
- 1 eV = 0.001 KeV = 1.6022 x 10^{-19} J
- 1 nm = 1×10^{-9}m = 1000 pm

This Paper Consists of 6 Printed Pages. Please Turn Over.

SECTION A (COMPULSORY)

QUESTION 1 (30 MARKS) COMPULSARY

a) Define the following

i. Heat Capacity (1 mark)

ii. Photoelectric effect (1 mark)

iii. Balmer series (1 mark)

iv. Metallic bonds (1 mark)

b) The Bohr atomic model treats the electron as a particle, a small sphere of negative charge that orbits around the nucleus. Explain why an electron remains within the orbit while rotating around the nucleus (2 marks)

c) Sketch and label

i. A typical graph that is obtained when a blackbody is heated at two different temperatures? (3 marks)

ii. Rayleigh-Jeans plot (3 marks)

i. Explain the limitation of this plot (2 marks)

ii. What term is normally used to explain this limitation (1 mark)

d) Show your work for the following questions on electromagnetic radiation

i. Calculate the frequency of electromagnetic radiation emitted by the hydrogen atom in the electron transition from n = 6 to n= 3. (4 marks)

ii. Calculate the energy in eV of a photon of wavelength 700 nm. (3 marks)

iii. A 0.110 nm photon collides with a stationary electron and scatters by 180°. After the collision, the electron moves forward and the photon recoils backward. Find the kinetic energy of the electron.(5marks)

iv. Suppose that by some means an electron in a hydrogen atom with a total energy of 3.40 eV is determined to be between 2.0 and 2.2 Å away from its proton. Estimate the resulting uncertainty in radial momentum of the electron (3 marks)

SECTION B:

ATTEMPT ANY TWO QUESTIONS

QUESTION TWO

a) Experimental evidence showed that several concepts of classical mechanics are untenable when applied to atomic and molecular systems.

i. List the four experimental evidence that explains the untenability of classical mechanic to microsystems (2 marks)

ii. Explain this statement that, 'the oscillators in a blackbody may oscillate with only certain energies for a certain frequency'. (2 marks)

iii. How much energy is radiated on a $1cm^2$ surface of a black body at 1000K (2 marks)

iv. Find the peak wavelength in μm of the blackbody radiation emitted by the tungsten of a light bulb at 3000 K (3 marks)

v. What part of the electromagnetic radiation does it belong to (1 mark)

b) Max Planck made many contributions to theoretical physics, but his fame as a physicist rests primarily on his role as an originator of quantum theory

i. State Max Planck's Law (2 marks)

ii. Sketch and label graph depicting Planck's model (3 marks)

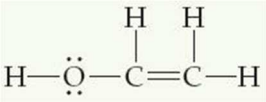
iii. Explain why Planck's law does not suffer from an ultraviolet catastrophe (2 marks)

iv. Assume that a certain 660-Hz tuning fork can be considered as a harmonic oscillator whose vibrational energy is 0.04 J. Calculate the energy quanta in electron volts (eV) of this tuning fork (3 marks)

QUESTION THREE

a) Define Covalent bond and give a relevant example; (2 marks)

b) Eye drops for dry eyes usually contain a water soluble polymer called poly(vinyl alcohol), which is based on the unstable organic molecule called *vinyl alcohol*:



Predict the approximate values for the H-O-C and O-C-C bond angles in vinyl alcohol. (2 marks)

c) Write Lewis structure of NH_3 compound (1 mark)

d) Valence Shell Electron Pair Repulsion (VSEPR) theory can help one to determine the shape of the molecule;

i. Predict the electron domain geometries and molecular geometries of SF_4 and $SnCl_3^-$ using VSEPR (4 marks)

ii. Give the geometry BeF_2 and explain why its bond lengths are identical. (4 marks)

iii. Predict whether SO_2 is polar or non-polar molecule. Explain your answer (3 marks)

e) From your knowledge of ionic radii and the charge on the cations and anions, answer the following questions:

i. Define lattice Energy (1 mark)

ii. Arrange the compounds in the order of increasing lattice energy. Explain your answer NaF, CsI and CaO (3 marks)

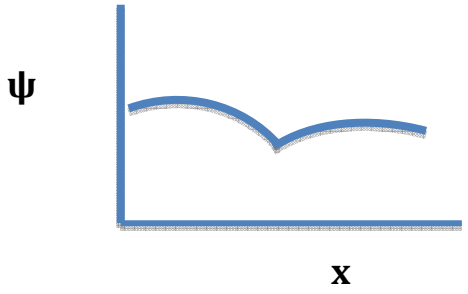
QUESTION FOUR

a) Quantum Mechanics is necessary for describing molecular properties of matter. Explain briefly

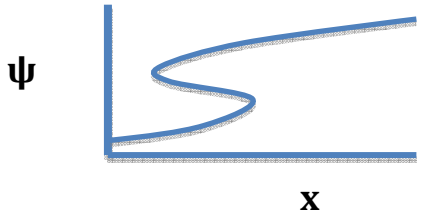
i. The significance of Schrödinger equation (2 marks)

ii. What requirements of the wave function Ψ must it satisfy in order to obtain important properties from the Schrödinger Equation? (4 marks)

iii. Why the following graphs are considered to be unacceptable plots of the wave function



(1 mark)



(1 mark)

b) Solution of the Schrodinger equation for hydrogen, while imposing boundary conditions, gives rise to three quantum numbers, *n, l and ml*.

i. If the value of n is 7, what are the permitted values of l? (1 mark)

ii. If the value of l = 2, what are the permitted values of ml? (1 mark)

iii. Which atomic orbitals are represented by the following quantum number values?
n = 4, l = 3, ml = -2 (1 mark)

iv. Calculate the permitted energies for an electron confined in a box 2.5 Å wide (3 marks)

c) Electron density normally changes with distance from the nucleus

i. How many radial nodes does a 6f orbital have? Show your working (2 marks)

ii. Sketch and label graphs of radial function against atomic radius (or ψ vs r) for the following selected orbitals;

I) 4d (2 marks)

II) 6s (2 marks)

QUESTION FIVE

a) Define the following:

i. Compton effect (1 mark)

ii. Threshold frequency (1 mark)

b) A light source of wavelength illuminates a metal and ejects photoelectrons with a maximum kinetic energy of 1.00 eV. A second light source with half the wavelength of the first ejects photoelectrons with a maximumkinetic energy of 4.00 eV. Determine the work function of the metal. (4 marks)

c) X-rays with energy of 300 keV undergo Compton scattering with a target. If the scattered X-rays are detected at 30° relative to the incident X-rays, determine

i. The Compton shift at this angle (2 marks)

ii. The energy of the scattered X-ray (4 marks)

iii. The energy of the recoiling electron (2 marks)

d) In a Compton collision with an electron, a photon of violet light (λ = 400 nm) is backward scattered through an angle 180°.

i. How much energy is transferred to the electron in this collision? (3 marks)

ii. Compare the result with the energy the electron would acquire in aphotoelectric process with the same photon (2 marks)

iii. Could violet light eject electrons from a metal by Compton collision? Explain (1 mark)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.0079																	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.065	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.409	31 **Ga** 69.723	32 **Ge** 72.64	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57-71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89-103 #	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (264)	108 **Hs** (270)	109 **Mt** (268)	110 **Ds** (281)	111 **Rg** (272)	112 **Uub** (285)	113 **Uut** (284)	114 **Uuq** (289)	115 **Uup** (288)	116 **Uuh** (291)		118 **Uuo** (294)

* Lanthanide series	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
# Actinide series	89 **Ac** (227)	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)