JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THEDEGREE OF BACHELOR OF EDUCATION (SCIENCE)

2^{ND} YEAR 2^{ND} SEMESTER 2016/17

MAIN REGULAR

COURSE CODE: SCH 202

COURSE TITLE: INORGANIC CHEMISTRY

EXAM VENUE: **STREAM: (BED SCI)**

DATE: **EXAM SESSION: 2.00 – 4.00 PM**

TIME: 2:00HRS

Instructions:

1. **Answer question 1 (Compulsory) in Section A and ANY other 2 questions in Section B.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room**

Section A, Answer <u>all</u> the questions (30 marks)

Question 1

a) Given the equation below, determine the Bohr radius of H atom at n = 1. (2 marks)

Bohr radius (r_n), $r_n = \frac{\varepsilon_0 h^2 n^2}{\pi m_e e^2}$

ε_0 = permittivity of vacuum = 8.854 x 10^{-12} Fm^{-1}

h=Planks constant = 6.626 x 10^{-34} Js

n = 1, 2, 3, ….describing a given orbit

m_e = electron rest mass = 9.109 x 10^{-31} kg

e = charge on an electron (elementary charge) = 1.602 x 10^{-19}C

b) An increase in the principal quantum number from n = 1 to n = ∞ corresponds to the ionization of the atom and the ionization energy can be determined from the equation below. Given that one mole of a substance contains 6.022 x 10^{23} mol^{-1} particles, determine the first ionization energy for H. (3 marks)

$IE = E_\infty - E_1 = \frac{hc}{\lambda} = hcR(\frac{1}{1^2} - \frac{1}{\infty^2})$ Where h = planks constant; R = Rydberg constant for hydrogen = 1.097 x 10^7 m^{-1} or 1.097 x 10^5 cm^{-1}; c = 2.998 x 10^8 ms^{-1}

c) The Schrodinger wave equation appropriate for motion in the x direction is given by the equation below. But in reality, electrons move in three dimensional space. Write the appropriate form of the Schrodinger wave equation satisfying this condition. (2 marks)

$$\frac{d^2\Psi}{dx^2} + \frac{8\pi^2 m}{h^2}(E - V)\Psi = 0$$

d) Given that the principal quantum number, n, is 2, and using the rules that govern quantum numbers *n* and *l*, write down the allowed values of *l* and m_l, and determine the number of atomic orbitals possible for n = 3. (3 marks)

e) Discuss the possible sets of quantum numbers that describe an electron in a 2*s* atomic orbital. What is the significance of the physical significance of these unique sets? (3 marks)

f) Confirm that the experimentally observed electronic configuration of K, $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^1$, is energetically more stable than the configuration $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^1$. (3 marks)

g) Determine (with reasoning) the ground state electronic configuration of P (Z = 15). (3 marks)

h) Briefly discuss the following principles: The aufbau principle, The Pauli exclusion principle, and The hands rule. (3 marks)

i) Briefly discuss the difference between the Valency Bond Theory and Molecular Orbital Theory. (3 marks)

j) Using a diagram explain the Lewis structure of Water. (2 marks)

k) The bond dissociation enthalpies for nitrogen-nitrogen bond N_2 and $[N_2]^-$ are 945 and 765 $kJmol^{-1}$ respectively. Account for this difference in terms of MO theory, and state whether $[N_2]^-$ is expected to be diamagnetic or paramagnetic. (3 marks)

Section B. Answer any <u>TWO</u> questions

Question 2

a) Consider a particle that is undergoing a simple-harmonic wave-like motion in dimension with the wave propagation along the *x* axis. The wave equation is given by: $\Psi = A\sin\frac{n\pi x}{a}$ And the quantized energy levels can be calculated using the equation $E = \frac{k^2h^2}{8\pi^2 m} = \frac{n^2h^2}{8ma^2}$. The resultant motion of such a particle is described by a series of standing sine waves. Describe using a diagram the sine waves when n = 1, n = 2, n = 3 and n = 4. Give the wavelength of the wave functions and on the same diagrams indicate the position of the wave when $\Psi = 0$

(15 marks)

b) The atomic numbers of He, Ne, Ar and Kr are 2, 10, 18 and 36 respectively. Briefly describe their ground state electronic configurations and comment upon their similarities or differences.

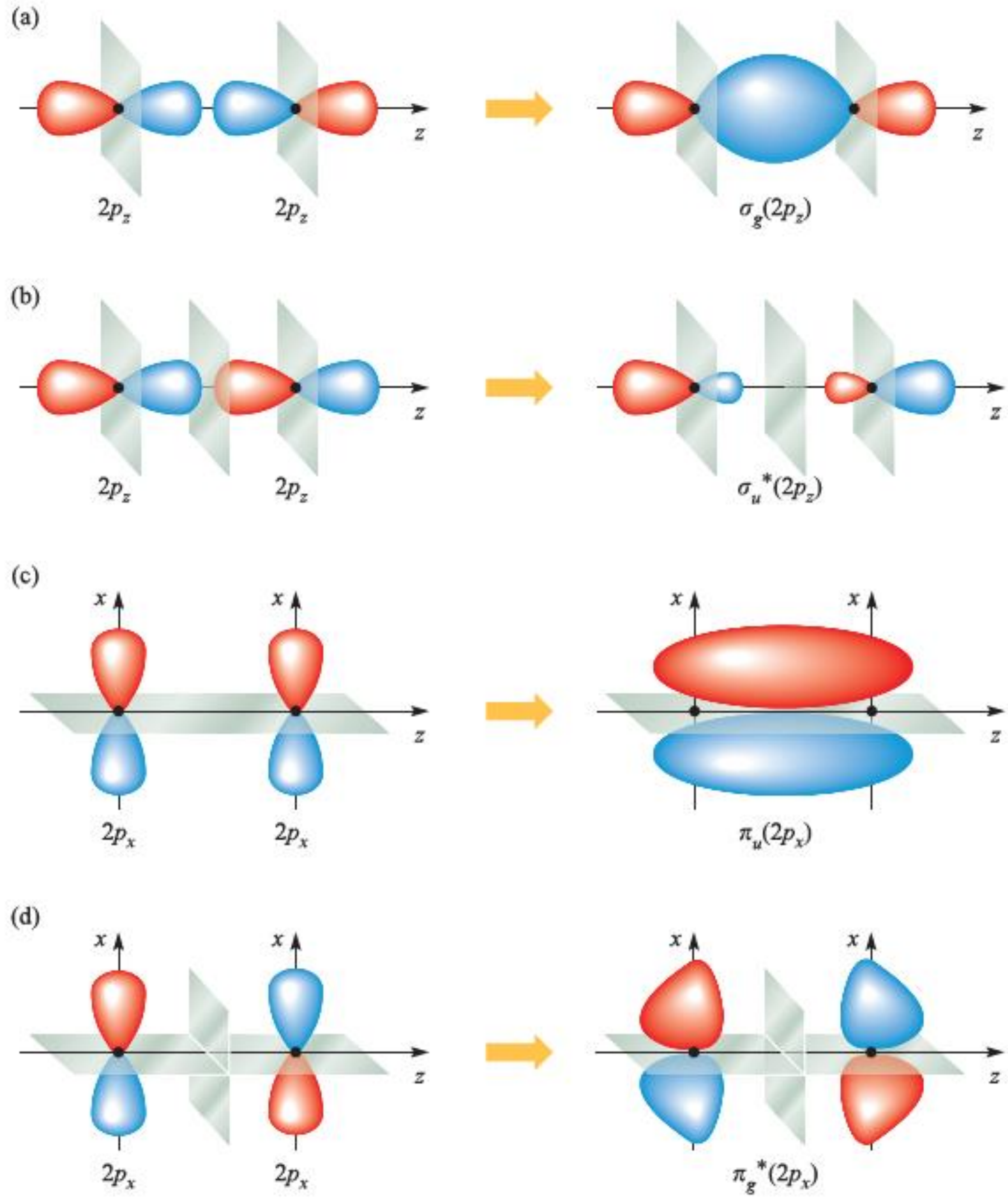
(5 marks)

Question 3

a) Consider the formation of F_2 molecule where the ground state electronic configuration of F is $[He]2s^2 2p^5$, and the presence of the single unpaired electron indicates the formation of an F – F single bond. Discuss the resonance structures of this bond.

(4 marks)

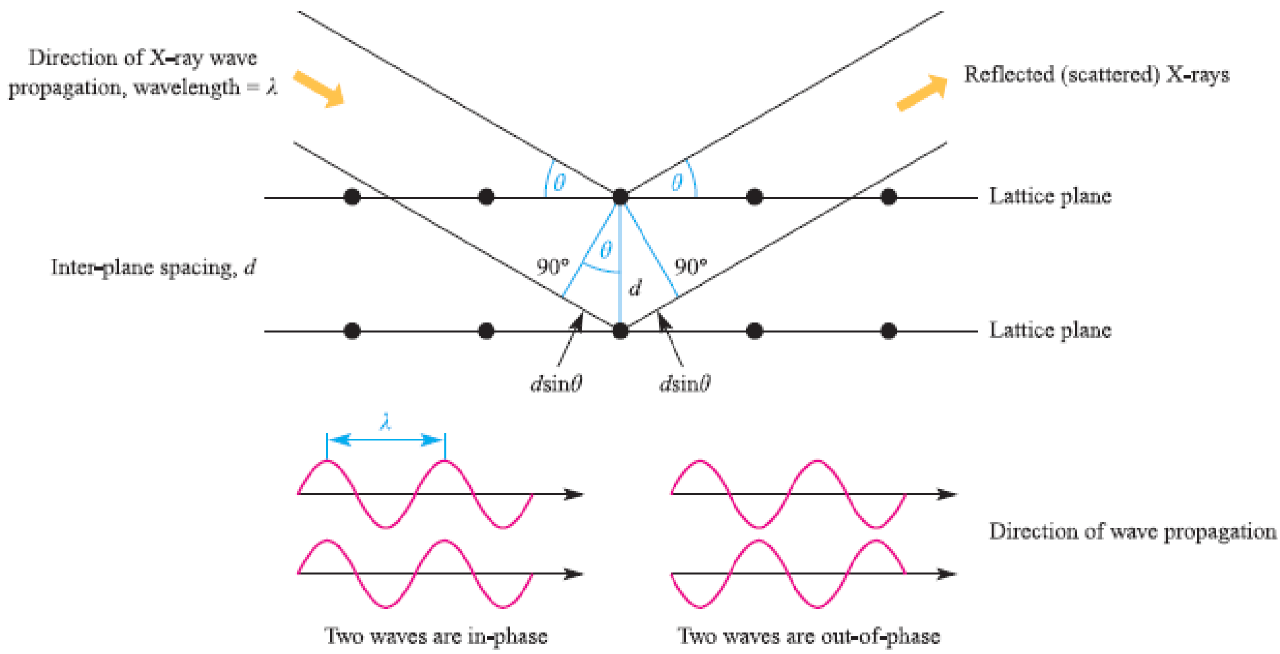
c) Given the diagram below, briefly discuss bonding and anti-bonding using the molecular orbital theory. (10 marks)



d) Briefly discuss the orbital interaction diagrams for the formation of He_2 and Li_2 molecules from their atoms (6 marks)

Question 4

a) Use an example to describe how the distance between atoms can be determined in a molecule using X ray diffraction patterns. (Use the diagram below as a guide). (14 marks)



a) The Born–Lande´ expression, $\Delta U(0K) = -\frac{LA|z_+||z_-|e^2}{4\pi\varepsilon_0 r_0}(1-\frac{1}{n})$, is the one that chemists tend to use in many chemical problems that involve the use of estimated lattice energies, for example in hypothetical compounds. Often lattice energies are incorporated into thermochemical cycles, and so an associated enthalpy change can be calculated. Sodium fluoride adopts the NaCl type lattice. Estimate the lattice energy of NaF using an Born–Lande´ expression.

Data required: L = 6:022 x 10^{23} mol^{-1}; A= 1:7476; e = 1:602 x 10^{-19}C; ε_0 = 8:854 x 10^{-12} Fm;$^{-1}$ Born exponent for NaF = 7; Internuclear Na-F distance = 231 pm (6 marks)

Question 5

a) The dipole moment of a gas phase HBr molecule is 0.827 D. Determine the charge distribution in this diatomic molecule if the bond distance is 141.5 pm. (1 D = 3.336 x 10^{-30} Cm). (5 marks)

b) Using the following data, estimate a value for *D*(Br-F): *D*(F-F) = 158 kJ $mole^{-1}$, *D*(Br-Br) = 224 kJ $mole^{-1}$, X^p(F) = 4.0, X^p(Br) = 3.0

(10 marks)

c) Predict the structure of XeF_2 (5 marks)

Periodic table

1
1 H 1.008

← Atomic number, Z
← Element symbol
← Relative atomic mass, A_r

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.008																	2 He 4.00
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
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
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 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.54	30 Zn 65.41	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.91	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98.91	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.40	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30
55 Cs 132.91	56 Ba 137.34	La–Lu	72 Hf 178.49	73 Ta 180.95	74 W 183.85	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 204.37	82 Pb 207.19	83 Bi 208.98	84 Po 210	85 At 210	86 Rn 222
87 Fr 223	88 Ra 226.03	Ac–Lr	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [277]	109 Mt [268]	110 Ds [271]	111 Rg [272]	112 Uub [285]						

Lanthanoids	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 146.92	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
Actinoids	89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu 239.05	95 Am 241.06	96 Cm 244.07	97 Bk 249.08	98 Cf 252.08	99 Es 252.09	100 Fm 257.10	101 Md 258.10	102 No 259	103 Lr 262