JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCES)

1ST YEAR 1ST SEMESTER 2021/2022 ACADEMIC YEAR

MAIN REGULAR

COURSE CODE: SPB 9104

COURSE TITLE: BASIC CHEMISTRY II

EXAM VENUE: **STREAM: (BEd. Science and Eng)**

DATE:

TIME: **EXAM SESSION:**

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.**
4. **Some important information/formulas are found on the last page of this question paper**

SECTION A

Question 1

a) Write the electronic arrangements for Calcium, Cerium and Magnesium. (use the periodic table attached to this question paper for atomic numbers) (6 marks)

b) Describe the electron box notations of the following atoms.

  i. Vanadium (III) ion (V^{3+}) (2 mark)

  ii. Chlorine atom (Cl) (2 mark)

c) Describe the energy level diagram for the zinc atom (Zn). (4 marks)

d) Arrange the periodic table according to *spdf* electronic arrangement of atoms. (3 marks)

e) Promotion of an electron from principal quantum number $n = 1$ to $n = \infty$ corresponds to ionization of an atom. Deduce an equation that can be used to determine the energy required to for such a promotion. Given that one mole of a substance contains 6.022×10^{23} mol^{-1} particles, use the deduced equation to determine the first ionization energy for H. (4 marks)

f) Briefly explain why the 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) Use Bohr's equation to determine the Bohr radius of H atom at $n = 1$. (2 marks)

h) Define the following terms: (4 marks)

  i. Aufbau principal

  ii. Pauli's exclusion principal

  iii. Heisenberg's uncertainity principal

iv. Hund’s rule

SECTION B

Question 2

a) One of the most important applications of early quantum theory was the interpretation of the atomic spectrum of hydrogen on the basis of the Rutherford–Bohr model of the atom. Using a diagram, illustrate spectral lines in the emission spectrum of hydrogen. (5 marks)

b) Calculate the energy released by an electron as it returns to its ground state of 2p from a 3p orbital and characterize the resultant spectral line as either lyaman, balmer, paschen or pfund. (7 marks)

c) Provide a brief discussion on the four quantum numbers that fully describe the position of an electron in an atom. (8 marks)

Question 3

a) What is the potential of a fuel cell (a galvanic H_2/O_2 cell) operating at pH 5?

Overall reaction: $2\ H_2(g) + O_2(g) = 2H_2O(l)$ (10 marks)

b) Given that the principal quantum number, n, is 3, 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 = 4.

(5 marks)

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

(5 marks)

Question 4

a) By use of diagrams, illustrate the shape of atomic orbitals in an *s, p, d ,f* atomic orbitals. (10 marks)

b) Given that I^- can be oxidized to IO_3^- by MnO_4^-, which is further reduced to Mn^{2+}. Deduce a balanced inorganic reaction equation. (10 marks)

Question 5

a) Given the following half reaction: $2H^+ + 2e^- = H_2$, (E°1/2 = 0.000 V); determine $E_{1/2}$ at pH 5 and P_{H2} = 1 atm. (10 marks)

b) Briefly describe the Latimer diagram for Mn in acid. (10 marks)

Periodic table

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

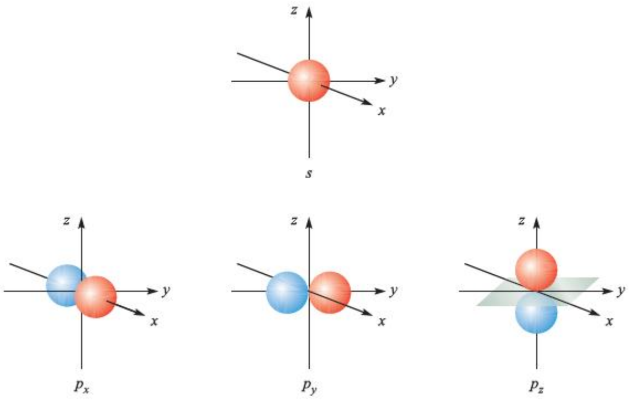


Fig. 1.9 Boundary surfaces for the angular parts of the 1*s* and 2*p* atomic orbitals of the hydrogen atom. The nodal plane shown in grey for the $2p_z$ atomic orbital lies in the *xy* plane.

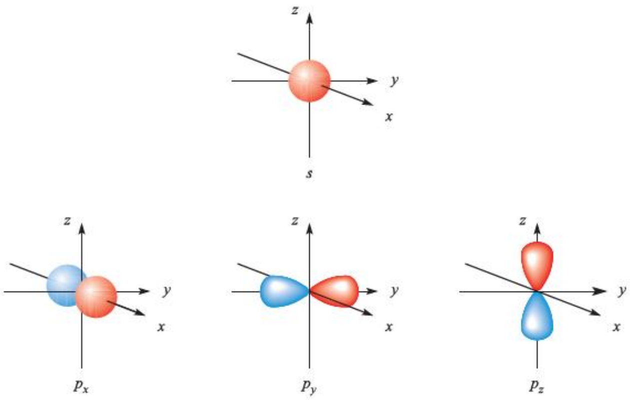


Fig. 1.10 Representations of an *s* and a set of three degenerate *p* atomic orbitals. The lobes of the p_x orbital are elongated like those of the p_y and p_z but are directed along the axis that passes through the plane of the paper.

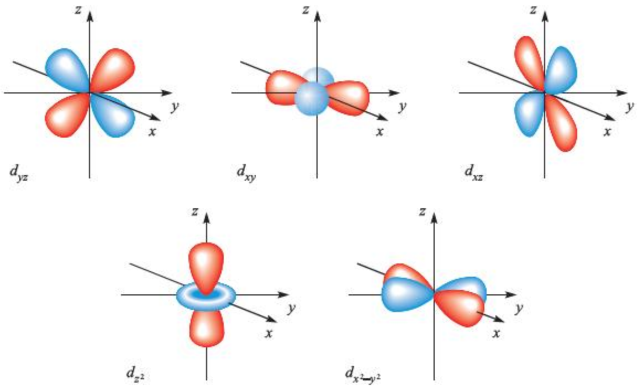


Fig. 1.11 Representations of a set of five degenerate *d* atomic orbitals.

a) R = Rydberg constant for hydrogen = 1.097×10^7 m^{-1} or 1.097×10^5 cm^{-1};

b) Speed of light C = 2.998×10^8 ms^{-1}

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

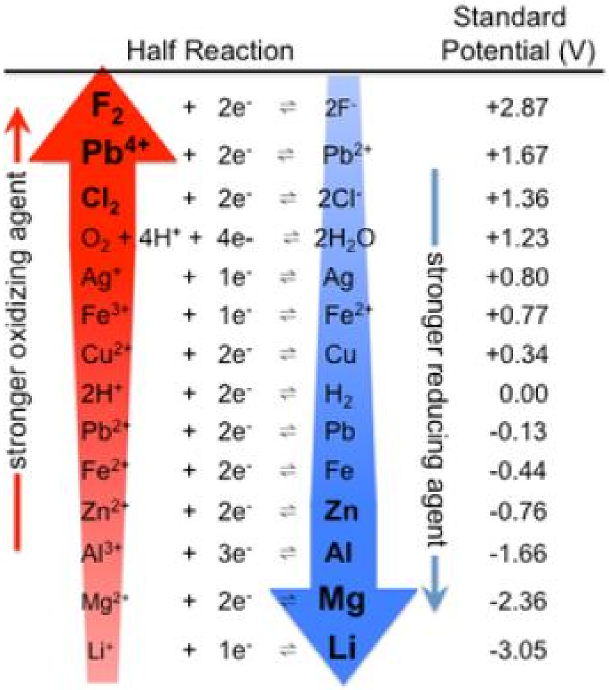
ε_0 = permittivity of vacuum = 8.854 x 10^{-12} Fm^{-1}

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



Half Reaction	Standard Potential (V)
$F_2 + 2e^- \rightleftharpoons 2F^-$	+2.87
$Pb^{4+} + 2e^- \rightleftharpoons Pb^{2+}$	+1.67
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
$O_2 + 4H^+ + 4e- \rightleftharpoons 2H_2O$	+1.23
$Ag^+ + 1e^- \rightleftharpoons Ag$	+0.80
$Fe^{3+} + 1e^- \rightleftharpoons Fe^{2+}$	+0.77
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$2H^+ + 2e^- \rightleftharpoons H_2$	0.00
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	-0.13
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	-0.44
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	-0.76
$Al^{3+} + 3e^- \rightleftharpoons Al$	-1.66
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	-2.36
$Li^+ + 1e^- \rightleftharpoons Li$	-3.05

Nernst equation

$$E = E^o - \frac{0.0592}{n} * logQ$$

where Q is the concentration ratio of products over reactants, raised to the powers of their coefficients in the reaction.