University of Ruhuna - Faculty of Technology

BACHELOR OF ENGINEERING TECHNOLOGY

Level 1 (Semester 1) Examination, October 2018

Course Unit : TMS 1122 Chemistry of Materials

Time Allowed: 2 hours

*** Answer all four (04) questions** **All symbols have their usual meanings**

Related physical constants

Planck's constant	$h = 6.6262 \times 10^{-34}$ Js
mass of electron	$m_e = 9.1091 \times 10^{-31}$ kg
charge on electron	$e = 1.60210 \times 10^{-19}$ C
Permittivity of vacuum	$\varepsilon_o = 8.854185 \times 10^{-12}$ kg^{-1} m^{-3} A^2 s^4
velocity of light	$c = 3 \times 10^8$ m s^{-1}

01. Answer **both** parts.

(a) Answer following questions regarding **He^+ ion** using your knowledge of Bohr's planetary model.

i. Derive an equation to calculate the radius of n^{th} orbit of He^+ ion.

(06 marks)

ii. Derive an equation to calculate the kinetic energy of electron in n^{th} orbit of He^+ ion.

(06 marks)

iii. Derive an equation to calculate the total energy of electron in n^{th} orbit of He^+ ion.

(02 marks)

iv. Calculate the wave number (cm^{-1}) of radiation emitted by electron transition from n = 2 energy level to n = 1 energy level of He^+ ion.

(03 marks)

Related equations

Coulomb's law: $F_{attraction} = \frac{1}{4\pi\varepsilon_o} \frac{q_1 \times q_2}{r^2}$

Centripetal acceleration $a = \frac{v^2}{r}$

De-Broglie Equation (for angular momentum) $mvr = \frac{nh}{2\pi}$

Potential energy of electron P. E. = $\frac{-Ze^2}{4\pi\varepsilon_o r}$

Kinetic energy K. E. = $\frac{1}{2}mv^2$

(b) Draw the Lewis structures of following molecules and determine their shapes according to Valence Shell Electron Pair Repulsion (VSEPR) theory.

(i) NCl_3

(ii) CH_4

(iii) H_2S

(iv) $BeCl_2$

(02 × 4 marks)

02. Answer **both** parts.

(a) Answer following questions regarding atomic structure.

i. Write down the Pauli's exclusion principle. (02 marks)

ii. Write down the Hund's rule. (02 marks)

iii. Draw a sketch to illustrate Aufbau principle. (02 marks)

iv. Write down the names of four (04) quantum numbers of an electron in an atom. (02 marks)

v. Name the quantum number which indicates the average distance between the nucleus and electron. (02 marks)

vi. Write down the electronic configurations of following atoms.

(I) O
(II) Cl
(III) Mg
(IV) Cu (04 marks)

Vii. Write down the sets of four (04) quantum numbers corresponding to valence electrons in Mg atom. (02 marks)

(V) Answer following questions using your knowledge of molecular orbital theory.

i. Sketch the molecular orbital diagram and electrons in bonding and antibonding orbitals of a N_2 molecule. (03 marks)

ii. Calculate the bond order of N_2 molecule. (02 marks)

iii. Using your molecular orbital diagram, determine whether N_2 is paramagnetic or diamagnetic. (01 marks)

iv. Calculate the bond order of N_2^+ ion. (01 marks)

v. Using your molecular orbital diagram, determine whether N_2^+ is paramagnetic or diamagnetic. (02 marks)

03. Answer **all** parts.

(a) Answer following questions regarding thermal decomposition of $KMnO_4$.

$$KMnO_{4\,(s)} \xrightarrow{\Delta} K_2MnO_{4\,(s)} + MnO_{2\,(s)} + O_{2\,(g)}$$

i. Rewrite the balanced chemical reaction of the thermal decomposition of $KMnO_{4\,(s)}$.

(04 marks)

ii. An amount of **3.160** g of $KMnO_{4\,(s)}$ was thermally decomposed, completely. The released $O_{2\,(g)}$ was collected under standard temperature and pressure.

(I) Calculate the number of moles of $O_{2\,(g)}$ released.

(01 mark)

(II) Calculate the volume of $O_{2\,(g)}$ collected.

(01 mark)

(III) Calculate the weight of remaining solid residues after the thermal decomposition reaction. (assume that all $KMnO_4$ has been decomposed.) (02 marks)

(Relative atomic masses O = 16, K = 39, Mn = 55)
(Molar volume of gas under standard temperature and pressure = 22.4 $dm^3\ mol^{-1}$)

(b) Answer following questions regarding the preparation and identification of chemical solutions.

i. A mass of 0.0140 g of $KOH_{(s)}$ was dissolved in 250 mL of pure water.

(I) Calculate the concentration of the solution.

(03 marks)

(II) Calculate the pH of the above solution.

(02 marks)

ii. A solution of 0.1 mol dm^{-3} $HCl_{(aq)}$ is available in the laboratory. A portion of 25.00 mL was transferred to beaker and 225.00 mL of pure water was added to the beaker. The prepared solution was thoroughly mixed.

(I) Calculate the concentration of the prepared solution.

(03 marks)

(II) Calculate the pH of the solution.

(02 marks)

iii. A student forgot to label both of his $KOH_{(aq)}$ solution and $HCl_{(aq)}$ solutions. Propose a simple method to identify these solutions using usual chemicals available in the laboratory.

(03 marks)

(c) Answer following questions regarding buffer solutions.

i. Explain the concept of a buffer solution.

(02 marks)

ii. Provide two (02) examples for buffer solutions and name their chemical special involved.

(01× 2 marks)

04. Answer both parts.

(a) Answer following questions using your knowledge of kinetics.

i. Explain the concept of rate of a reaction and its importance in the chemical industry (02 marks)

ii. Explain the difference between elementary reaction and complex reaction. (02 marks)

iii. Sketch the graphical plots which can be used to calculate the rate constant of following reactions. (Titles of X and Y axis must be written in your sketches.)

$$A \longrightarrow B$$

(I) 0^{th} order

(II) 1^{st} order

(III) 2^{nd} order

(02 × 3 marks)

iv. A chemical reaction between reactants A with B results the product C.

$$A + B \longrightarrow C$$

(I) Write down the differential form rate law for the above reaction. (01 mark)

(II) Calculate the order of the reaction with respect to A and B, using the experimental data of the above reaction given in the table below. (05 marks)

Reaction Number	[A] ($mol\ dm^{-3}$)	[B] ($mol\ dm^{-3}$)	Rate ($mol\ dm^{-3}\ s^{-1}$)
(1)	0.1	0.1	2.0×10^{-3}
(2)	0.1	0.3	5.4×10^{-2}
(3)	0.15	0.1	4.5×10^{-3}

*All of the reactions were carried out at the same temperature.

(b) Answer following questions using your knowledge on nuclear structure and nuclear processes.

i. Explain the reasons for positively charged nucleus containing multiple protons to remain stable while positive charged protons repel each other. (02 marks)

ii. Explain the difference between nuclear fission and nuclear fusion. (02 marks)

Provide an example for each type of following nuclear processes.

(a) Alpha (α) emission

(b) Beta (β) emission

(02 marks)

iii. Write down three (03) applications of nuclear reactions. (01 × 3 marks)

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IUPAC Periodic Table of the Elements

1																	18
1 H hydrogen 1.008 [1.0078, 1.0082]	2											13	14	15	16	17	2 He helium 4.0026
3 Li lithium 6.94 [6.938, 6.997]	4 Be beryllium 9.0122		Key: atomic number Symbol name conventional atomic weight standard atomic weight									5 B boron 10.81 [10.806, 10.821]	6 C carbon 12.011 [12.009, 12.012]	7 N nitrogen 14.007 [14.006, 14.008]	8 O oxygen 15.999 [15.999, 16.000]	9 F fluorine 18.998	10 Ne neon 20.180
11 Na sodium 22.990	12 Mg magnesium 24.305 [24.304, 24.307]	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 26.982	14 Si silicon 28.085 [28.084, 28.086]	15 P phosphorus 30.974	16 S sulfur 32.06 [32.059, 32.076]	17 Cl chlorine 35.45 [35.446, 35.457]	18 Ar argon 39.948
19 K potassium 39.098	20 Ca calcium 40.078(4)	21 Sc scandium 44.956	22 Ti titanium 47.867	23 V vanadium 50.942	24 Cr chromium 51.996	25 Mn manganese 54.938	26 Fe iron 55.845(2)	27 Co cobalt 58.933	28 Ni nickel 58.693	29 Cu copper 63.546(3)	30 Zn zinc 65.38(2)	31 Ga gallium 69.723	32 Ge germanium 72.630(8)	33 As arsenic 74.922	34 Se selenium 78.971(8)	35 Br bromine 79.904 [79.901, 79.907]	36 Kr krypton 83.798(2)
37 Rb rubidium 85.468	38 Sr strontium 87.62	39 Y yttrium 88.906	40 Zr zirconium 91.224(2)	41 Nb niobium 92.906	42 Mo molybdenum 95.95	43 Tc technetium	44 Ru ruthenium 101.07(2)	45 Rh rhodium 102.91	46 Pd palladium 106.42	47 Ag silver 107.87	48 Cd cadmium 112.41	49 In indium 114.82	50 Sn tin 118.71	51 Sb antimony 121.76	52 Te tellurium 127.60(3)	53 I iodine 126.90	54 Xe xenon 131.29
55 Cs caesium 132.91	56 Ba barium 137.33	57–71 lanthanoids	72 Hf hafnium 178.49(2)	73 Ta tantalum 180.95	74 W tungsten 183.84	75 Re rhenium 186.21	76 Os osmium 190.23(3)	77 Ir iridium 192.22	78 Pt platinum 195.08	79 Au gold 196.97	80 Hg mercury 200.59	81 Tl thallium 204.38 [204.38, 204.39]	82 Pb lead 207.2	83 Bi bismuth 208.98	84 Po polonium	85 At astatine	86 Rn radon
87 Fr francium	88 Ra radium		104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium	113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganesson

57 La lanthanum 138.91	58 Ce cerium 140.12	59 Pr praseodymium 140.91	60 Nd neodymium 144.24	61 Pm promethium	62 Sm samarium 150.36(2)	63 Eu europium 151.96	64 Gd gadolinium 157.25(3)	65 Tb terbium 158.93	66 Dy dysprosium 162.50	67 Ho holmium 164.93	68 Er erbium 167.26	69 Tm thulium 168.93	70 Yb ytterbium 173.05	71 Lu lutetium 174.97

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

For notes and updates to this table, see www.iupac.org. This version is dated 28 November 2016.