University of Ruhuna - Faculty of Technology

BACHELOR OF ENGINEERING TECHNOLOGY

Level 1 (Semester 1) Examination, October 2019

Course Unit : TMS 1122 Chemistry of Materials

Time Allowed: 2 hours

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

1. Answer following questions on sub atomic particles, atomic structure and properties.

a) Sketch the experimental set up and briefly explain the evidences that revealed about existence of negatively charged and positively charged subatomic particles. (10 marks)

b) Draw rough sketches of following atomic models.

(i) Thompsons plum pudding model
(ii) Rutherford's model
(iii) Bohr's planetary model

(15 marks)

c) Write down the names of four (04) quantum numbers and their standard symbols. (10 marks)

d) Identify the quantum numbers which indicate following physical entities. (20 marks)

(i) The shape of an orbital
(ii) The orientation of an orbital in the space
(iii) The direction of spin of an electron
(iv) The average distance between the nucleus and electron

e) Write down the sets of four (04) quantum numbers for the electron(s) of incompletely filled orbitals in the valance shell of the following atoms.

(i) Be
(ii) C
(iii) K
(iv) N

(20 marks)

f) Identify the largest atom in the sets given below.

(i) H, Li, C, O
(ii) Na, Mg, K, Rb
(iii) F, Cl, Br, I
(iv) H, K, F, Cl

(10 marks)

g) X, Y, Z are consecutive elements in the Periodic table. (X, Y, Z are not real symbols). Y naturally exists as a diatomic gas. First ionization energy (I_1) of Y is lower than that of Z. Giving reasons identify and write down the standard symbol of element Y.

(15 marks)

2. Answer following questions about atomic structure and chemical bonding.

a) Draw a sketch to illustrate Aufbau principle. (10 marks)

b) Write down the electronic configurations of following atoms.
(i) P
(ii) Zn
(iii) I
(iv) S
(v) C (25 marks)

c) Sketch an orbital diagram to determine the number of unpaired electrons in Carbon atom. (10 marks)

d) The number of unpaired electrons in C atom is less than four (04). However, carbon atom makes four (04) chemical bonds with chlorine atoms to make a CCl_4 molecule.

(i) Using the concept of orbital hybridization, explain the ability of C atom to form four chemical bonds. (10 marks)

(ii) What is the orbital hybridization of C atom in CCl_4 molecule? (05 marks)

(iii) CCl_4 does not react with water while $SiCl_4$ easily hydrolyze by reacting with water. Briefly explain the reasons for this phenomenon using your knowledge of atomic structure and chemical bonding. (15 marks)

e) Sketch the orbital overlapping diagrams of following molecules. (15 marks)
(i) N_2
(ii) O_2
(iii) Cl_2

f) Draw the Lewis structures of following molecules and determine their shapes according to Valence Shell Electron Pair Repulsion (VSEPR) theory. (10 marks)
(i) $AlCl_3$
(ii) SF_6

03. Answer **all** parts.

(a) Answer following questions regarding thermal treatment of chemical compounds.

(i) A sample of 1.1575 g of $CuSO_4.4H_2O_{(s)}$ was heated until the sample becomes anhydrous $CuSO_{4\,(s)}$. Calculate the remaining weight of the sample after the heating process.

(15 marks)

(Relative atomic masses H = 1, O =16, S = 32, Cu = 63.5)

(ii) A sample of **5.0400** g of $NH_4Cr_2O_{7\,(s)}$ was thermally decomposed, completely. Answer following questions regarding the thermal decomposition reaction.

$$(NH_4)_2Cr_2O_{7\,(s)} \xrightarrow{\Delta} Cr_2O_{3(s)} + N_{2(g)} + H_2O_{(l)}$$

I. Rewrite the balanced chemical reaction of the thermal decomposition of $NH_4Cr_2O_{7\,(s)}$.

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

III. Calculate the weight of remaining solid residues after the thermal decomposition reaction.

(Relative atomic masses H = 1, N =14, O = 16, Cr = 52) (40 marks)

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

(i) A sample of 0.8550 g of $Ba(OH)_{2(s)}$ was completely dissolved in 1000 mL of distilled water.

I. Calculate the concentration of $OH^-_{(aq)}$ in the solution.

II. Calculate the pOH of the above solution.

III. Calculate the pH of the above solution. (20 marks)

(Relative atomic masses H = 1, O = 16, Ba = 137)

(ii) A solution of 0.05 mol dm^{-3} $H_2SO_{4\,(aq)}$ is available in the laboratory. A portion of 10.00 mL was transferred to beaker and 90.00 mL of pure water was added to the beaker. The prepared solution was thoroughly mixed.

I. Calculate the $H^+_{(aq)}$ concentration of the prepared solution.

II. Calculate the pH of the solution. (15 marks)

(c) Answer the following question regarding buffer solutions.

I. Give one example for the usage of buffer solutions. (10 marks)

04. Answer **both** parts.

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

(i) Answer questions regarding the kinetics of following reaction.

$$A \longrightarrow B$$

I. Write down the differential form of the rate law for the above reaction. (10 marks)

II. If the above reaction is 1st order with respect to [A], derive the integral form of the rate law. (5 marks)

III. If the rate constant of the reaction (k) is 0.1 s^{-1}, calculate the half-life of the reaction. (10 marks)

Consider that:

$$\int_0^x dx = [X]_0^x \ , \quad \int_0^x \frac{1}{x} dx = 2.303 log[X]_0^x \ , \quad \log(2) = 0.3$$

(ii) Sketch the concentration profiles of following reaction assuming it is:

$$A \longrightarrow B$$

I. 0th order

II. 1st order

III. 2nd order (15 marks)

(iii) A chemical reaction between reactants A with B results the product C.

$$A + B \longrightarrow C$$

I. Write down the differential form of the rate law for the above reaction. (10 marks)

II. Determine the order of the reaction with respect to A and B, using the experimental data of the above reaction given in the table below. (10 marks)

III. Calculate the rate constant of the reaction (10 marks)

** Information required for this question is given in the table in next page (page 5)**

Reaction Number	[A] (mol dm^{-3})	[B] (mol dm^{-3})	Rate (mol dm^{-3} s^{-1})
(1)	0.2	0.1	1.5×10^{-4}
(2)	0.3	0.1	5.1×10^{-4}
(3)	0.2	0.4	2.4×10^{-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) What is meant by "nuclear binding energy". (10 marks)

(ii) Give an example for the usage of nuclear radiation for material testing. (05 marks)

(iii) Name one suitable radioactive element for each of the following applications.

I. Nuclear medicine
II. Nuclear power generation
III. Food preservation (15 marks)

@@@@@@@@

EKCP

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	89-103 actinoids	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
89 Ac actinium	90 Th thorium 232.04	91 Pa protactinium 231.04	92 U uranium 238.03	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

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.