



University of Ruhuna- Faculty of Technology
Bachelor of Engineering Technology Honours
Level 1 (Semester I) Examination, June/July 2023
Academic year 2021/2022

Course Unit: TMS 1122 Chemistry of Materials

Duration: 2 hours

Instruction to Candidates

- Answer all **Four (04)** questions.
- All symbols have their usual meaning.
- Calculators are allowed.

1. Answer all parts.

- (a) Briefly describe the following. (20 marks)
- (i) Electron filling sequence using Aufbau principle.
 - (ii) Four Quantum numbers.

- (b) Draw the Lewis structure for the following molecules. (18 marks)
- (i) N_2
 - (ii) C_2F_4
 - (iii) CO_2

- (c) Answer the following questions using your knowledge of electronic configurations.

- (i) Write down the electronic configurations for Chromium (Cr). (04 marks)
- (ii) Draw the orbital diagram for the above element. (14 marks)
- (iii) Briefly define the terms diamagnetic substance and paramagnetic substances. (08 marks)
- (iv) Determine whether the Chromium (Cr) is diamagnetic or paramagnetic. (06 marks)

- (d) The four successive ionization energies of an unknown element (A) are:

900, 1760, 14800, 21000 (kJ/mol)

- (i) Define the term ionization energy of an elements. (08 marks)
- (ii) Determine the corresponding group of the periodic table the unknown element (A) belongs to. (06 marks)
- (iii) What is the reason for the significant difference between the second and third ionization energies of the above-mentioned unknown element? (06 marks)
- (iv) Briefly describe the ionization energy trend of the periodic table across period and down a group by giving reasons. (10 marks)

2. Answer all parts.

(a)

- (i) Define the term **Molecular Orbital**. (10 marks)
- (ii) Briefly describe the two possibilities and their results when two wave functions of atomic orbitals are combined to form a molecular orbital. (10 marks)
- (iii) Sketch the molecular orbital diagram of a Li_2 molecule. Write the electron configuration for Li_2 molecule. (20 marks)
- (iv) Calculate the bond order of Li_2 molecule. (10 marks)

- (b) Determine the shapes of the following molecules using Valence Shell Electron Pair Repulsions (VSEPER) theory.

- (i) NH_3
- (ii) H_2O (16 marks)

(c) Titan submarine is powered by the electricity generated through the combustion of methane (CH_4) gas. O_2 gas is required for the underwater combustion of CH_4 while CO_2 and H_2O are the products of the reaction. (Molar mass of C is 12 g mol^{-1} , O is 16 g mol^{-1} and H is 1 g mol^{-1})

(i) Write the balanced equation for the above combustion reaction. (05 marks)

(ii) How many moles of O_2 are consumed when 12.5 mol of CO_2 are produced? (05 marks)

(iii) Calculate the mass of O_2 required for the full combustion of 1.6 kg of CH_4 . (14 marks)

(d) Describe how you would prepare 0.15 M of Isotonic saline (NaCl) of 2.0 L from a 6.0 M stock solution. Calculate the volume needed from the stock solution. (10 marks)

3. Answer all parts.

(a)

(i) Define melting point of a substance? (10 marks)

(ii) How does soluble impurity affect the melting point of a substance? (10 marks)

(iii) Briefly describe the following bonds. (20 marks)

(I) Hydrogen Bond.

(II) Covalent Bond.

(b) The reaction between reactants A and B results the products C and D.



The rates of the reaction measured at 25°C for the above reaction in different concentrations of hydrogen and iodine are given in the table below.

Experiment No.	$[\text{A}] \times 10^{-3} / (\text{mol L}^{-1})$	$[\text{B}] \times 10^{-3} / (\text{mol L}^{-1})$	Rate $\times 10^{-6} / (\text{mol L}^{-1} \text{ s}^{-1})$
1	5.0	2.0	1.2
2	10.0	2.0	5.0
3	10.0	4.0	10.0

(i) Calculate the orders for the above reaction. Consider the orders of the reaction with respect to A and B as x and y respectively. Calculate the overall order of the reaction using the data given in the table. (34 marks)

(ii) Calculate the rate constant for the above reaction. (16 marks)

(iii) The decomposition of ethane (C_2H_6) to methyl radicals is a first-order reaction with a rate constant of $5.36 \times 10^{-4} \text{ s}^{-1}$ at 700°C . Calculate the half-life of the reaction in minutes. (10 marks)

4. Answer all parts.

(a) Acid rain is a harmful effect of environmental pollution. It contains highly acidic water droplets due to the presence of Nitric (HNO_3) and Sulfuric (H_2SO_4) acids. Natural buffering agents in the soil can minimize the effects of acid rain on soil pH.

In an analysis to check the quality of rainwater, a 100 ml water sample was collected during a rainy day. This sample was labeled as "Y". A preliminary pH test on water sample Y indicated that it contains acidic water.

(i) Define an acid using the Brønsted-Lowry, Arrhenius, and Lewis theories on acids and bases. (09 marks)

(ii) Predict what would happen if the following actions were performed on the water sample Y. (06 marks)

- (I) Inserted a blue litmus paper.
- (II) Dropped a small piece of Magnesium metal.
- (III) Added a few drops of phenolphthalein.

(iii) Write the chemical formulas of conjugate bases of the acids present in water sample Y. (09 marks)

(iv) The pH of the water sample Y was found to be 4.82 at 25 °C.

- (I) Calculate the pOH of Y. (10 marks)
- (II) Calculate the H^+ ion concentration in Y. State what would happen to this value upon addition of Sodium Hydroxide (NaOH). Give reasons for your answer. (10 marks)

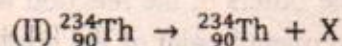
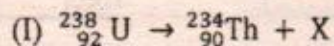
(III) Determine the volume of 0.001 M NaOH required to reach the endpoint in the titration of sample Y. Take the volume of the sample as 100.0 mL. (Hint: Burette contains NaOH). (10 marks)

(v) Briefly describe the buffering action of a buffer. (06 marks)

(b)

(i) State five (05) types of radioactive decay. (10 marks)

(ii) Complete the following nuclear equations and identify X. (12 marks)



(iii) Briefly Explain the following terms. (18 marks)

- (I) Isotopes.
- (II) Nuclear fission.
- (III) Nuclear fusion.

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The Periodic Table of the Elements

1 H Hydrogen 1.00794	2 He Helium 4.0026	3 Li Lithium 6.941	4 Be Beryllium 9.012182	5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.0074	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797	11 Na Sodium 22.989770	12 Mg Magnesium 24.304	13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.8	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.905848	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium 98	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.29	55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 La Lanthanum 138.90547	58 Ce Cerium 140.12	59 Pr Praseodymium 140.90766	60 Nd Neodymium 144.24	61 Pm Promethium 144.9126	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.59	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.9304	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.222	78 Pt Platinum 195.084	79 Au Gold 196.96657	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium 209	85 At Astatine 210	86 Rn Radon 222	87 Fr Francium 223	88 Ra Radium 226	89 Ac Actinium 227	90 Th Thorium 232.0377	91 Pa Protactinium 231.036888	92 U Uranium 238.02891	93 Np Neptunium 237	94 Pu Plutonium 244	95 Am Americium 243	96 Cm Curium 247	97 Bk Berkelium 247	98 Cf Californium 251	99 Es Einsteinium 252	100 Fm Fermium 257	101 Md Mendelevium 258	102 No Nobelium 259	103 Lr Lawrencium 262
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