UNIVERSITY OF RUHUNA

BACHELOR OF SCIENCE GENERAL DEGREE LEVEL-I (SEMESTER-I) EXAMINATIONS - NOVEMBER/DECEMBER 2020

SUBJECT: Chemistry **TIME**: Two (**02**) hours

COURSE UNIT: CHE1112 (General Chemistry and Basic Concepts in Analytical Chemistry)

Instructions:

- *A Periodic Table is provided on the last page.*
- *Use of calculators* ***is allowed****.*
- *Answer* ***FOUR*** *questions only by selecting* ***two*** *questions from the Sections* ***A*** *and* ***B****.*

Physical constants

Atomic mass unit, *amu*	=	1.661×10^{-27} kg
Avogadro number, N_A	=	6.022×10^{23} mol^{-1}
Boltzmann constant, k	=	1.381×10^{-23} J K^{-1}
Electron charge, e	=	1.602×10^{-19} C
Electron mass, m_e	=	9.10×10^{-31} kg
Faraday constant, F	=	9.6485×10^{4} C mol^{-1}
Planck's constant, h	=	6.626×10^{-34} J s
Proton mass, m_p	=	1.673×10^{-27} kg
Universal gas constant, R	=	8.314 J K^{-1} mol^{-1}
	=	0.0802 dm^3 atm K^{-1} mol^{-1}
Vacuum permittivity, ε_0	=	8.854×10^{-12} J^{-1} C^2 m^{-1}
Velocity of light, c	=	2.997×10^{8} m s^{-1}

Important conversion factors

1 atm = 760 mmHg = 1.01325 bar = 101325 Pa

2.303 (RT/F) = 59.15 mV at 298.15 K

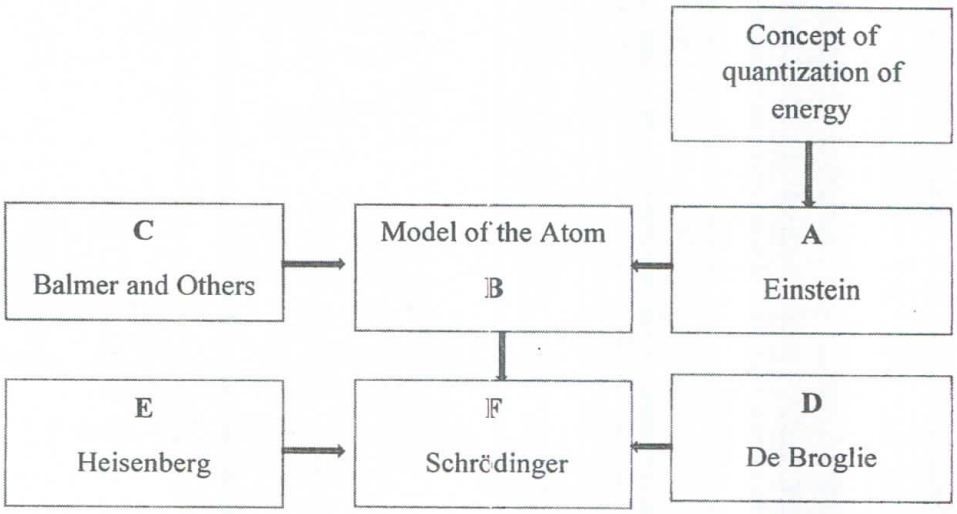
1 eV = 1.6022×10^{-19} J

Section A

01. Answer **all** parts.

(a) Since Dalton developed his ideas, scientists have made significant progress in furthering our understanding of atomic structure. The present atomic structure model is not developed by a single person. Following diagram shows historical persons/ideas responsible for the development of the modern atomic model. Complete either the missing name or theory labelled as **A**, **B**, **C**, **D**, **E** and **F**.

(05 x 6 marks)



(b) Sodium atomic spectrum has a yellow emission line at 590 nm. What is the energy and frequency of a photon of this emitting light?

(30 marks)

(c) What is the maximum number of electrons allowed to have the following set of quantum numbers in an atom?

(i) n = 4 and m_l = +2

(ii) n = 3 and l = 1

(iii) n = 1 and m_s = +1/2

(05 x 3 marks)

(d) Sketch the radial distribution function P(r) for 2s, 2p and 3d orbitals

(15 marks)

(e) Sketch the shapes of d_{xy}, and d_{z^2} orbitals

(10 marks)

02. Answer **all** parts.

(a) What is **Aufbau Principle**? (10 marks)

(b) Write down complete electron configuration of following ion and element

(i) Fe^{3+}

(ii) Cu (10 marks)

(c) (i) Clearly defining all the terms, write down the Bohr equation in terms of **Effective Nuclear Charge, *Z**.

(10 marks)

(ii) Calculate effective nuclear charge for valence electron of oxygen atom.

(20 marks)

(d) Give the missing information **R - Z** of the following table relevant to sp^3d hybridization

hybridization	Number of orbitals combined	Resulting number of hybridized orbitals	Ideal bond angles	Geometry	Possible shapes	Number of lone pairs
sp^3d	**R**	**S**	**T**	**V**	**W**	0
					X	1
			U		**Y**	2
					Z	3

(30 marks)

(e) Predict the bond order and the magnetism of F_2^+ ion using its molecular orbital diagram

(20 marks)

03. Answer **all** parts.

(a) Deuterium (^2H) is a stable isotope of hydrogen, found in natural hydrogen compounds.

(i) Briefly explain what an isotope is. (10 marks)

(ii) List all the fundamental particles present in the deuterium atom by performing a systematic breakdown. Indicate relevant names for the parts you found in this breaking down process. (15 marks)

(iii) Calculate the charge of the deuterium nucleus by using the charge of fundamental particles. (10 marks)

(iv) What is the nuclear binding energy of ^2H in MeV, if the observed mass is 2.014103 amu?

Note: Mass of a proton and a neutron are 1.007277 amu and 1.008665 amu respectively. Assume that the mass of electrons can be neglected.

(20 marks)

(v) Briefly explain the fundamental force which keeps fundamental particles together in a nucleus. (10 marks)

(b) $^{24}_{11}Na$ is an unstable isotope of sodium with the half-life of 15 hours.

(i) Derive an equation to show the relationship between radioactive decay constant and the half life, if the rate of the decay is given by the equation $\ln\left(\frac{N_t}{N_0}\right) = -\lambda t$.

where N_o – Number of nuclei initially present, N_t – number of nuclei at time t and λ – decaying constant.

(20 marks)

(ii) Calculate the radioactive decay constant for $^{24}_{11}Na$. (15 marks)

Section B

04. Answer **all** parts.

(a) Briefly describe the following terms pertaining to analytical chemistry.

(i) Qualitative analysis

(ii) Quantitative analysis

(iii) Equivalence point

(iv) End point

(20 marks)

(b) Give <u>two</u> advantages and <u>two</u> disadvantages of titrimetric analysis compared to instrumental analysis.

(20 marks)

(c) A titration was carried out using 40.00 cm^3 of 0.1000 mol dm^{-3} NH_3 solution in a titration flask with 0.1000 mol dm^{-3} HCl solution.

(i) Sketch a suitable titration curve for this titration considering the pH for the y-axis and the volume of HCl for the x-axis.

(10 marks)

(ii) Indicate the buffering region of this titration (if any) in the same plot.

(10 marks)

(iii) Select the most suitable indicator to determine the end point of this titration among the three indicators phenolphthalein (8.1-10.2), methyl red (4.4-6.2), methyl orange (3.1-4.4). The indicator colour change intervals are given in the parentheses. Give reasons for your selection.

(15 marks)

(iv) If the above titration was stopped after addition of 20.00 cm^3 of 0.1000 mol dm^{-3} HCl into the titration flask. Calculate the pH of the resultant solution in the flask. (consider that K_b of NH_3 as 1.75×10^{-5})

(25 marks)

05. Answer **all** parts.

(a) Define the following terms.

(i) Accuracy

(ii) Precision

(10 arks)

(b) The following results were obtained by measuring the weight of a coin four times using an analytical balance, which has a considerable uncertainty: 4.5241, 4.3456, 4.4783, and 4.5404 g. The coin itself indicated that its weight is 4.5000 g.

(i) Calculate the mean and the standard deviation for the above data set.

(ii) Comment on the accuracy and the precision of the data set.

(ii) What type of error (random/systematic) is associated with the analytical balance? Give reasons to your answer.

(30 marks)

(c) Calculate the following and give the answer with correct number of significant figures.

(i) the mass of a heterogeneous mixture containing 139.3 g sand, 34.99 g gravel, and 9.372 g salt.

(ii) the mass of a concrete slab, which has the dimensions of 51.0 cm long, 17.34 cm deep, and 6.2 cm tall, with a density of 5.3 g/cm^3.

(20 marks)

(d) The maximum contaminant level for arsenic is 0.010 ppm for drinking water per SLS regulations. The arsenic concentration for the drinking water sample of a municipality was measured to be 4.92×10^{-6} mol dm^{-3}. Atomic mass of arsenic is 74.9216 g/mol.

(i) What is the arsenic concentration of the water sample in ppm? Assume that the drinking water sample has a density of 1.0000 g/mL.

(ii) Does this water sample meet SLS guidelines?

(20 marks)

(e) The sulfur content of an ore was determined gravimetrically by reacting the ore with concentrated nitric acid and potassium chlorate, converting all sulfur to sulfate. The excess nitrate and chlorate were removed and the sulfate was precipitated as barium sulfate (233.43 g/mol) using excess $BaCl_2$ solution. Analysis of a 10.1830-g ore sample yielded the 13.0221 g of $BaSO_4$. Atomic mass of S is 32.065 g/mol

(i) Give the balanced chemical equations for the above precipitation reaction.

(ii) Determine the percent of sulfur by mass in the ore

(20 marks)

06. Answer **all** parts.

(a) Ethylenediamminetetraacetic acid (EDTA) and Eriochrome Black T (EBT) are widely used in complexometric determination of certain metal ions.

(i) What are the advantages of using EDTA as a complexing agent?

(10 marks)

(ii) Briefly explain the chemistry behind the detection of the end point of an EDTA titration with a metal ion using EBT as the indicator. Give the relevant chemical equations whenever necessary.

(You may use common abbreviations, M^{2+}, H_2Y^{2-} and HIn^{2-} for a divalent metal ion, EDTA and EBT indicator, respectively.)

(20 marks)

(iii) Write down **three (03)** significant factors influencing EDTA titrations.

(10 marks)

(iv) Propose a suitable complexometric method to determine concentration of SO_4^{2-} ions in an aqueous solution.

(15 marks)

(b) A student was given an impure zinc salt in order to determine the percentage of Zn. He dissolved 0.7100 g of the given salt in 25.00 mL distilled water and the pH of the solution was adjusted to 10. It was titrated with 0.0160 mol dm^{-3} EDTA solution using EBT as the indicator and obtained the average volume of 21.00 mL from triplicate readings for the end point. Determine the gram percentage of Zn in this sample. Assume that Zn is the only metal ion which reacts with EDTA in this sample.(atomic mass of Zn is 65.38g)

(20 marks)

(c) A solution prepared by mixing 0.10 mol dm^{-3} sodium chloride and 0.10 mol dm^{-3} sodium chromate was titrated with silver nitrate. Determine the first precipitating compound using a suitable calculation.

(K_{SP}, AgCl = 1.8×10^{-10}, Ag_2CrO_4 = 3.6×10^{-12})

(25 marks)

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Periodic Table of the Elements