



# MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATIONS AND INFORMATION  
TECHNOLOGY)

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

BACHELOR OF EDUCATION (SPECIAL NEEDS)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF EDUCATION (SCIENCE)

BACHELOR OF SCIENCE (BIOLOGY)

SCH 100: FUNDAMENTALS OF INORGANIC CHEMISTRY

DATE:16/03/2022

TIME: 8:30-10:30 AM

## INSTRUCTIONS

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks)
- Answer any **two** questions from section **B** (each 20 marks)

### A table of useful constants

$R_H = 1.09737 \times 10^7 \text{ m}^{-1}$	$h = 6.626 \times 10^{-34} \text{ Js}$	$r_n = \frac{\epsilon_0 n^2 h^2}{\pi m_e e^2}$
$\epsilon_0 = 8.85418 \times 10^{-12} \text{ C}^2 \text{ J}^{-1} \text{ m}^{-1}$	$m_e = 9.11 \times 10^{-31} \text{ kg}$	
$c = 3.0 \times 10^8 \text{ m/s}$	$1 \text{ eV} = 1.602 \times 10^{-19}$	

## SECTION A

### QUESTION ONE (30 MARKS)

- (a) Write the electronic configuration of the following in spdf notation to the nearest noble gas: **(3 marks)**
- (i) Sn
  - (ii)  $\text{Sn}^{2+}$
  - (iii)  $\text{Pb}^{2+}$
- (b) State limitations of Bohr's Atomic Theory **(3 marks)**
- (c)(i) Calculate the shortest wavelength in Balmer series **(3 marks)**
- (ii) Calculate the wavelength associated with an electron that travels at 40 % of the speed of light. **(3 marks)**
- (d) Account for the trend in first ionization energies of elements across the second period of the periodic and explain the anomalies why Be has higher first ionization energy than B, and N having a higher first ionization energy than O. **(5 marks)**
- (e) Balance the following redox reactions using the half-reaction method **(4 marks)**
- (i)  $\text{ClO}_3^-(aq) + \text{I}^-(aq) \rightarrow \text{I}_2(s) + \text{Cl}^-(aq)$  [acidic medium]
  - (ii)  $\text{Fe}(\text{OH})_2(s) + \text{Pb}(\text{OH})_3^-(aq) \rightarrow \text{Fe}(\text{OH})_3(s) + \text{Pb}(s)$  [basic medium]
- (f) The work function for cesium is 1.35 eV.
- (i) What is the longest wavelength that can cause photo-emission from cesium surface? **(2 marks)**
  - (ii) What is the maximum velocity with which photoelectrons will be emitted from the cesium surface illuminated with light of wavelength 400 nm? **(3 marks)**
- (g) Calculate the pH of a 0.020 M solution of benzoic acid ( $\text{C}_6\text{H}_5\text{CO}_2\text{H}$ ) if it's  $K_a = 6.3 \times 10^{-5}$ . **(4 marks)**

## SECTION B

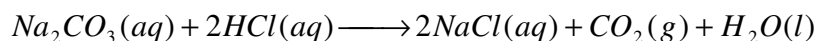
### QUESTION TWO (20 MARKS)

- (a) Explain two reasons of Neil Bohr's objection to Rutherford's atomic model. **(4 marks)**
- (b) Sodium lamp emits light of 589.0 nm. Calculate :
- (i) The frequency of the light **(2 marks)**

- (ii) The wavenumber of the light **(2 marks)**
- (iii) The energy of the photons in J and eV **(2 marks)**
- (iv) The momentum of the photons **(2 marks)**
- (c) The molecules BF<sub>3</sub> and NF<sub>3</sub> have similar formulae, but completely different shapes. Draw diagrams to show the shapes of the two molecules, and explain why they are different. **(4 marks)**
- (d) (i) Define isotopes? **(1 mark)**
- (ii) Copper (Cu = 63.546) is made up of two isotopes, Cu (62.9296 amu) and Cu (64.9278 amu). Determine the percentage abundance of each isotope? **(3 marks)**

### QUESTION THREE (20 MARKS)

- a) An experiment was carried out to determine the percentage of water of crystallization and the degree of water of crystallization  $x$ , in a sample of hydrated sodium carbonate crystals ( $Na_2CO_3 \cdot xH_2O$ ). An 8.20 g sample of the crystals was weighed accurately on a clock glass and then made up to 500 cm<sup>3</sup> of solution in a volumetric flask. A pipette was used to transfer 25.0 cm<sup>3</sup> portions of this solution to a conical flask. A previously standardised 0.11 M hydrochloric acid (HCl) solution was used in titration of each sample. The average volume of hydrochloric acid solution required in these titrations was 26.05 cm<sup>3</sup>. The titration was described by the equation:



- (i) Name the indicator suitable for this titration and explain why not more than 1-2 drops of indicator should be used. **(2 marks)**
- (ii) From the titration data, calculate the concentration of sodium carbonate in the solution in moles per litre and in grams per dm<sup>3</sup>. **(3 marks)**
- b) Calculate the percentage of water of crystallization and determine the value of  $x$  in  $Na_2CO_3 \cdot xH_2O$  **(6 marks)**
- c) State five demerits of Dalton's Atomic Theory **(5 marks)**
- d) Explain why NH<sub>3</sub> act as a Lewis base? **(2 marks)**
- e) Draw the Lewis structure of BeCl<sub>6</sub>. **(2 marks)**

#### QUESTION FOUR (20 MARKS)

- (a) (i) Define orbital degeneracy using a relevant example (2 marks)
- (ii) Using phosphorus as an example briefly explain the rules for filling electrons into orbitals of this atom clearly defining Aufbau Principle, Pauli Exclusion Principle and Hund's Rule of maximum multiplicity (7 marks)
- (b) Calculate the energy emitted when electrons of 1.0 g atom of hydrogen undergo transition giving the spectral lines of lowest energy in the visible region of its atomic spectra. (4 marks)
- (c) Give the number of orbitals in each of the  $s$ ,  $p$ ,  $d$ ,  $f$  and  $g$  subshells of the shell with  $n = 5$ . (3 marks)
- (d) Calculate the de Broglie wavelength of an electron in the first Bohr orbit in the hydrogen atom (4 marks)

#### QUESTION FIVE (20 MARKS)

- a) (i) Sodium chloride and magnesium oxide have exactly the same structure, their melting and boiling points are given in the table below: Explain why the values for MgO are much higher than those for NaCl. (2 marks)

	NaCl	MgO
Melting point (K)	1074	3125
Boiling point (K)	1686	3873

- (ii) Explain why copper is paramagnetic and zinc is diamagnetic. (2 marks)
- b) Draw the Lewis structures of the following and state the number of electrons at the central atom:
- (i)  $\text{PF}_5$
- (ii)  $\text{SF}_6$
- (iii)  $\text{H}_2\text{SO}_4$  (6 marks)
- c) Calculate the hydronium and hydroxide ion concentrations of a solution that has a pOH of 4.40. (3 marks)
- d) Define the term buffer (2 marks)

- e) Determine the concentration of  $[HA]$  and  $[A^-]$  given that total concentration of  $[HA]$  and  $[A^-]$  to be 1.0 M and  $pH = 5.0$ , using acetic acid with  $pK_a$  of 4.757. (5 marks)

**Periodic Table  
of the  
Elements 2006**

1 H 1.01																	18 Ar 39.95	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80												
3 Li 6.94	4 Be 9.01																	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	10 Ne 20.18	11 Na 22.99	12 Mg 24.31																	5 B 10.81	6 C 12.01	7 N 14.01	8 O 15.99	9 F 19.00	4 He 4.00
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)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29	55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	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 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)												
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (270)	109 Mt (268)	110 Ds (281)	111 Rg (272)																																					
																		58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97																
																		90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)																