# KENYATTA UNIVERSITY

## UNIVERSITY EXAMINATIONS 2019/2020

## FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

## SCH 100: FUNDAMENTALS OF INORGANIC CHEMISTRY

**DATE: Thursday, 5th December 2019** **TIME: 11.00 a.m. - 1.00 p.m.**

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**INSTRUCTIONS:**

1. **There are a total of 3 pages, please make sure this paper has them all**
2. **Answer all (four) questions in the exam notebook provided. Do not write in the margins**
3. **Questions worth one mark only require short answers.**
4. **Students are requested, in their own interests, to write legibly**
5. **A data sheet are attached at the end of this question paper**
6. **Show all your working**

***Question 1***

a) Give the meaning of the following terms usually encountered in chemistry:

i). Electromagnetic radiation (1 mark)

ii). Atomic orbitals (1 mark)

iii) Disproportionation reactions (1 mark)

b) Rutherford used *scientific method* in order to probe the structure of an atom.

Briefly describe:

i) What they did? (1 mark)

ii) What they observed? (1 mark)

iii) Their conclusion(s) (1 mark)

c) i) State the assumptions made by Bohr in order to explain hydrogen spectrum (3 mark)

ii) Determine the wavelength of the line in the Balmer series of hydrogen corresponding to the transition from n=5 to n=2. (2 marks)

Given $\Delta E = -2.179x10^{-18}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ J

d) An electron in an atom can be described by four quantum numbers. List the four quantum numbers and explain the information that each one gives (6 marks)

e) What type of orbitals (i.e. 3s, 4p,…) is designated by the following quantum numbers:

i). $(n = 5, l = 3, m_l = 0, m_s = {}^1/_2)$

ii). $(n = 4, l = 1, m_l = 0, m_s = {}^{-1}/_2)$

f) Draw the orbitals for which $l = 2$ (3 marks)

**Total** **(20 marks)**

**Question 2**

a) Explain the usefulness of each of the following in coming up with electron configurations of atoms:

i). Pauli exclusion principle (2 marks

ii). Hund's maximum multiplicity rule (2 marks)

b) i) Write the electron configuration of the following species (the atomic number z is given in bracket):

I) U (z=92) (1 marks)

II) $S^{2-}$ (z=16) (1 marks)

III) $Ru^{+3}$ (z=44) (1 marks)

IV Ag (z=47) (1 mark)

iii) Atom X (not its chemical symbol) has atomic number 83. Identify the Groups and Periods to which the elements represented belong. (2 marks)

b) Describe the trends of the following properties across the periods and down the groups:

i) Effective nuclear charges (2 marks)

ii) First ionization energies (2 marks)

d) Copper occurs in two isotopes in nature. Calculate the relative atomic mass for naturally occurring Cu if the distribution of isotopes is 69.2% $^{63}_{29}Cu$ and 30.8% $^{65}_{29}Cu$; accurate masses are 62.93 and 64.93. (3 marks)

**Total** **(17 marks)**

**Question 3**

a) Draw the Lewis structures of the following molecules

i) $H_2O$ ii) $AlCl_3$ iii) $PCl_5$ (3 marks)

b) From the Lewis structures in (b) above

i). Identify molecular geometry of each of the molecules (3 marks)

ii). Explain why $AlCl_3$ exist as a dimer (1 mark

iii). Explain why $PCl_5$ has expanded octet (1 mark)

c) i) Using suitable diagrams or otherwise, explain important distinctions between a sigma (σ) and a pi (π) bond (2 marks)

ii) Using suitable a diagram or otherwise demonstrate that the in ethane double bond, one bond is sigma (σ) while the other is pi (π) bond (3 marks)

d) Highlight the main differences between chemical and nuclear reactions. (4 marks)

e) Identify the missing particles X and Y in the following nuclear reaction equations

i) $^{24}_{12}Mg + ^{1}_{1}p \rightarrow He + X$

ii) $^{40}_{19}K \rightarrow {}^{0}_{-1}\beta + Y$

f) State two applications of radioisotopes (2 marks)

**Total** (2 marks)

**(21 marks)**

**Question 4**

a) i) State de Broglie theory. (1 mark)

ii) Calculate the wavelength associated with an electron traveling with a speed $3.0\text{x}10^7$ m/s (Given mass of electron me=$9.109\text{x}10^{-31}$ kg) (2 marks)

b) Hypchlorous acid, *HOCl*, is used water treatment and as disinfectant in swiming pools. A 0.150 M solution of *HOCl* has a pH 0f 4.18. Determine $K_a$ for Hypchlorous acid. (3 marks)

c) Assume you are provided with a solution of potassium permanganate of approximately 0.020 M and are required to **standardize** it using sodium oxalate in a solution (in acidic media). If 0.2482 g $Na_2C_2O_4$ is dissolved in water and titrated with 23.36 $cm^3$ of $KMnO_4$. The redox reaction is:

$$2MnO^-_{4(aq)} + 5C_2O^{2-}_{4(aq)} + 16H^+_{(ag)} \rightarrow 2Mn^{2+}_{(aq)} + +CO_{2(g)} + 8H_2O_{(i)}$$

i) Explain the meaning of the term "**standardization**" (1 marks)

ii) State two properties a primary standard should have (2 mark)

iii) Calculate the number of moles in 0.2482 g $Na_2C_2O_4$ (1 mark)

iv) Determine the molarity of $KMnO_4$ (2 marks)

(Given K=39.0983, Mn=54.9381,Na=22.9898, O=15.9994)

**Total** C=12.61 **(13 marks)**

## DATA SHEET

**Physical Constants**

| | | |
|---|---|---|
| Boltzmann constant | $k$ | $= 1.381 \times 10^{-23}$ J K$^{-1}$ |
| Planck constant | $h$ | $= 6.626 \times 10^{-34}$ J s |
| Elementary charge | $e$ | $= 1.602 \times 10^{-19}$ C |
| Speed of light in vacuum | $c$ | $= 2.998 \times 10^{8}$ m s$^{-1}$ |
| | | $= 2.998 \times 10^{10}$ cm s$^{-1}$ |
| Avogadro constant | $L$ or $N_A$ | $= 6.022 \times 10^{23}$ mol$^{-1}$ |
| Gas constant | $R = kL$ | $= 8.315$ J K$^{-1}$ mol$^{-1}$ |
| | | $= 8.315$ L kPa K$^{-1}$ mol$^{-1}$ |
| | | $= 0.08206$ L atm K$^{-1}$ mol$^{-1}$ |
| Molar volume of an ideal gas | $V_m^\circ$ | $= 22.414$ L mol$^{-1}$ |
| | | (at 1.000 atm and 273.2 K) |
| | $V_m$ | $= 24.789$ L mol$^{-1}$ |
| | | (at 100.0 kPa and 298.2 K) |
| Faraday constant | $F = eL$ | $= 9.6485 \times 10^{4}$ C mol$^{-1}$ |
| Atomic mass unit (amu) | $u$ | $= 1.661 \times 10^{-27}$ kg |
| Rest mass of electron | $m_e$ | $= 9.109 \times 10^{-31}$ kg |
| Rest mass of proton | $m_p$ | $= 1.673 \times 10^{-27}$ kg |
| Rest mass of neutron | $m_n$ | $= 1.675 \times 10^{-27}$ kg |
| Vacuum permittivity | $\varepsilon_o$ | $= 8.854 \times 10^{-12}$ J$^{-1}$ C$^2$ m$^{-1}$ |
| Standard acceleration of free fall | $g$ | $= 9.807$ m s$^{-2}$ |
| Rydberg constant for the H atom | $R_H$ | $= 109677$ cm$^{-1}$ |

**Conversion Factors**

| | |
|---|---|
| 1micron ($\mu$) | $= 10^{-6}$ m = 1 $\mu$m |
| 1 Ångström (Å) | $= 1 \times 10^{-10}$ m = 0.1 nm = 100 pm |
| 1 L | $= 10^{-3}$ m$^3$ = 1 dm$^3$ |
| 1 atm | $= 1.013 \times 10^{5}$ N m$^{-2}$ = $1.013 \times 10^{5}$ Pa |
| | = 760 mmHg = 760 torr |
| 1 bar | $= 1.000 \times 10^{5}$ Pa |
| 1J | = 0.2390 cal |
| | = 1 Pa m$^3$ = 1 m$^2$ kg s$^{-2}$ |
| 1 cal | = 4.184 J |
| 1 eV | $= 1.602 \times 10^{-19}$ J |
| 1 L atm | = 101.3 J |
| 1 W | = 1 J s$^{-1}$ |
| 1 ppm | = 1 $\mu$g g$^{-1}$ = mg kg$^{-1}$ |
| | = 1 mg L$^{-1}$ (dilute aqueous solutions only) |
| 1 tonne | = 1000 kg |

**Prefixes to Units**

| P | T | G | M | k | d | c | m | μ | n | p | f |
|---|---|---|---|---|---|---|---|---|---|---|---|
| peta | tera | giga | mega | kilo | deci | centi | milli | micro | nano | pico | femto |
| $10^{15}$ | $10^{12}$ | $10^{9}$ | $10^{6}$ | $10^{3}$ | $10^{-1}$ | $10^{-2}$ | $10^{-3}$ | $10^{-6}$ | $10^{-9}$ | $10^{-12}$ | $10^{-15}$ |