THE UNIVERSITY OF ZAMBIA TG----

SCHOOL OF NATURAL SCIENCES

2020/2021 ACADEMIC YEAR FIRST TERM
TEST 1

CHE1000: Introductory Chemistry
TIME: Two hours March 2021

STUDENT ID NUMBER_____

INSTRUCTIONS TO THE CANDIDATES

1. Indicate your **student ID number** and **TG number** in space provided.
2. The test consists of two (2) sections: **A** and **B**
3. Section **A** has eight **(8)** short answer questions. Questions carry equal marks. (Total marks = 40).
4. Section **B** has four **(4)** long answer questions. Questions carry equal marks. (Total marks = 60).
5. **ATTEMPT ALL QUESTIONS IN SECTION A AND B1 IN SECTION B**
6. **ATTEMPT ANY OTHER TWO QUESTIONS IN SECTION B.**
6. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**

INFORMATION TO THE CANDIDATES:

1. **Useful data is printed on page 14.**
2. **Periodic table is printed on the last page.**

For official use

QUESTION	A1	A2	A3	A4	A5	A6	A7	A8	B1	B2	B3	B4
MARKS												

TOTAL %

Checked by_____

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SECTION A **ANSWER ALL QUESTIONS**

QUESTION A1.

(a) Distinguish precision from accuracy [2 Marks]

(b) Find the answer for $\frac{3.478\ g + 1.164\ g}{2.00\ ml}$ [3 Marks]

QUESTION A2.

2 moles of hydrochloric acid was reacted with 4 moles of sodium carbonate. Which reagent is a limiting reagent? Justify your answer with calculations. [5 Marks]

QUESTION A3.

You are supplied with 16.00 M sulfuric acid that must be used to prepare 1.5 L of a 0.10 M H_2SO_4 solution. What volume of the 16.00 M sulphuric acid will you need? [5 Marks]

QUESTION A4.

State Boyle's law in less than 50 words and express it mathematically. [5 Marks]

QUESTION A5.

A sample of hydrogen gas (H_2) has a volume of 8.56 L at a temperature of 0 °C and a pressure of 1.5 atm. Calculate the number of moles of H_2 molecules present in this gas sample. [5 Marks]

QUESTION A6.

(a) Write the electron configuration for Beryllium. (Use a noble gas abbreviation) [1 Mark]

(b) Give one possible complete set of quantum numbers for an electron in the highest energy occupied orbital of beryllium. [2 Marks]

(c) The lowest energy transition in the emission spectrum of a beryllium atom has a wavelength of 455 nm. Calculate the energy of this transition. [2 Marks]

QUESTION A7.

Copper metal has a threshold energy of 7.5×10^{-19} J. A sample of copper is struck with a photon and an electron is ejected with a kinetic energy of 1.30×10^{-18} J.

(a) Calculate the maximum possible wavelength of the photon. [4 Marks]

(b) What phenomenon is described in A7 part (a)? [1 Mark]

QUESTION A8.

(c) Differentiate between an orbit and an orbital. [2 Marks]

(d) Draw the structures of the P_x and d_{xy} Orbital. [3 Marks]

SECTION B

ANSWER B1 AND ANY TWO QUESTIONS

QUESTION B1

(a) According to Laboratory safety and rules, why should you never add water to a concentrated acid? [2 Marks]

(b) During a Laboratory experiment, a student weighed out 1.9253g of a given reagent needed for an experiment.

(i) Indicate the level of uncertainty in the measurement of the analytical balance? [2 Marks]

(ii) Give a reason for your answer above. [2 Marks]

(c) As you conducted your measurements to determine density of water, two types of errors were possible, random and systemic. What is a random error and what is a systemic error? [2 Marks]

(d) In volumetric analysis, briefly explain how you would determine the titration endpoint accurately. [2 Marks]

(e) You used sodium hydroxide, ammonia and hydrochloric acid reagents to conduct the back titration experiment. In the table below state hazards and risks posed by these reagents and how you mitigated your risk of exposure to these hazards. [6 Marks]

Reagent	Hazard/Risk	Mitigation
NaOH		
NH_3		
HCl		

(f) Briefly describe the procedure you employed in carrying out the back titration experiment in (e) above. [4 Marks]

[TOTAL = 20 Marks]

QUESTION B2.

(a) Student A collected a sample which contained the following isotopes; ^{10}B (molar mass 10.013g/mol) and ^{11}B (molar mass 11.093g/mol).

(i) What is an isotope? [1 Marks]

(ii) Given that Molar mass of boron atoms in a natural sample is 10.91g/mol, calculate the percentage abundances of the two Boron isotopes. [6 Marks]

(b) Student B collected 5.4kg of aluminum from a recycling bin.

(i) Calculate the number of moles of aluminum. [2 Marks]

(ii) How many Aluminium atoms were collected? [2 Marks]

(c) Student C carried out the combustion analysis of adipic acid which contains C, H and O only. The mass percentages of C and H are 49.3% and 6.9% in adipic acid respectively.

(i) Distinguish between empirical and molecular formula. [2 Marks]

(ii) What is the empirical formula of adipic acid ? [5 Marks]

(iii) The molecular formula mass of adipic acid is about 146 g/mol. What is its molecular formula? [2 Marks]

[TOTAL = 20 Marks]

QUESTION B3.

The vanadium in a sample of ore is converted to VO^{2+}. The VO^{2+} ion is subsequently titrated with MnO_4^- in acidic solution to form $V(OH)_4^+$ and manganese(II) ion. The unbalanced titration reaction is

$$MnO_4^-(aq) + VO^{2+}(aq) + H_2O(l) \rightarrow V(OH)_4^+(aq) + Mn^{2+}(aq) + H^+(aq)$$

To titrate the solution, 26.45 mL of 0.02250 M MnO_4^- was required.

(a) What is the oxidation state of V in $V(OH)_4^+$? [2 Marks]

(b) Balance the equation using the appropriate method. [8 Marks]

(c) Calculate the number of moles of vanadium in the sample. [3 Marks]

(d) If the mass percent of vanadium in the ore was 58.1%, what was the mass of the ore sample?
[6 Marks]

[TOTAL = 20 Marks]

QUESTION B4.

(a) State any **three** drawbacks (limitations) of the Neils Bohr model of an atom. [3 Marks]

(b) Calculate the wavelength of light emitted when $n=3 \rightarrow n=2$ transitions occur in the hydrogen atom. Use the Rydberg equation. [3 Marks]

(c) The Pauli Exclusion Principle guides the filling of electrons in orbitals.

(i) State the Pauli Exclusion Principle. [2 Marks]

(ii) Using the **short notation**, write the electronic configuration of K and Br atoms. [2 Marks]

(iii) Hence using the valence electrons of K and Br atoms, draw the **orbital diagram** (box notation) for each of these atoms [2 Marks]

(d) In 1924, Louis de Broglie argued that radiation could exhibit the properties of both particles and waves.

(i) Write the De Broglie equation. [1 Mark]

(ii) What is the wavelength of an electron moving at 5.31×10^6 m/sec? [2 Marks]

(e) The threshold frequency ν_0 for a metal is $6.0 \times 10^{13}\ s^{-1}$. Calculate the kinetic energy of an electron when radiation having a frequency of $\nu = 1.0 \times 10^{14}\ s^{-1}$ hits the metal. [3 Marks]

[TOTAL = 20 Marks]

USEFUL DATA

Avogadro's constant, N_A	6.022×10^{23} mol^{-1}
Molar volume of gas at S.T.P	22.4 dm^3 mol^{-1}
Planck Constant, h	6.626×10^{-34} Js
Rydberg constant,R_H	1.097×10^7 m^{-1}
Speed of light in vacuum, c	3.00×10^8 ms^{-1}
Mass of an electron	9.11×10^{-31} kg
1 electron volt (1 eV)	1.602×10^{-19} J

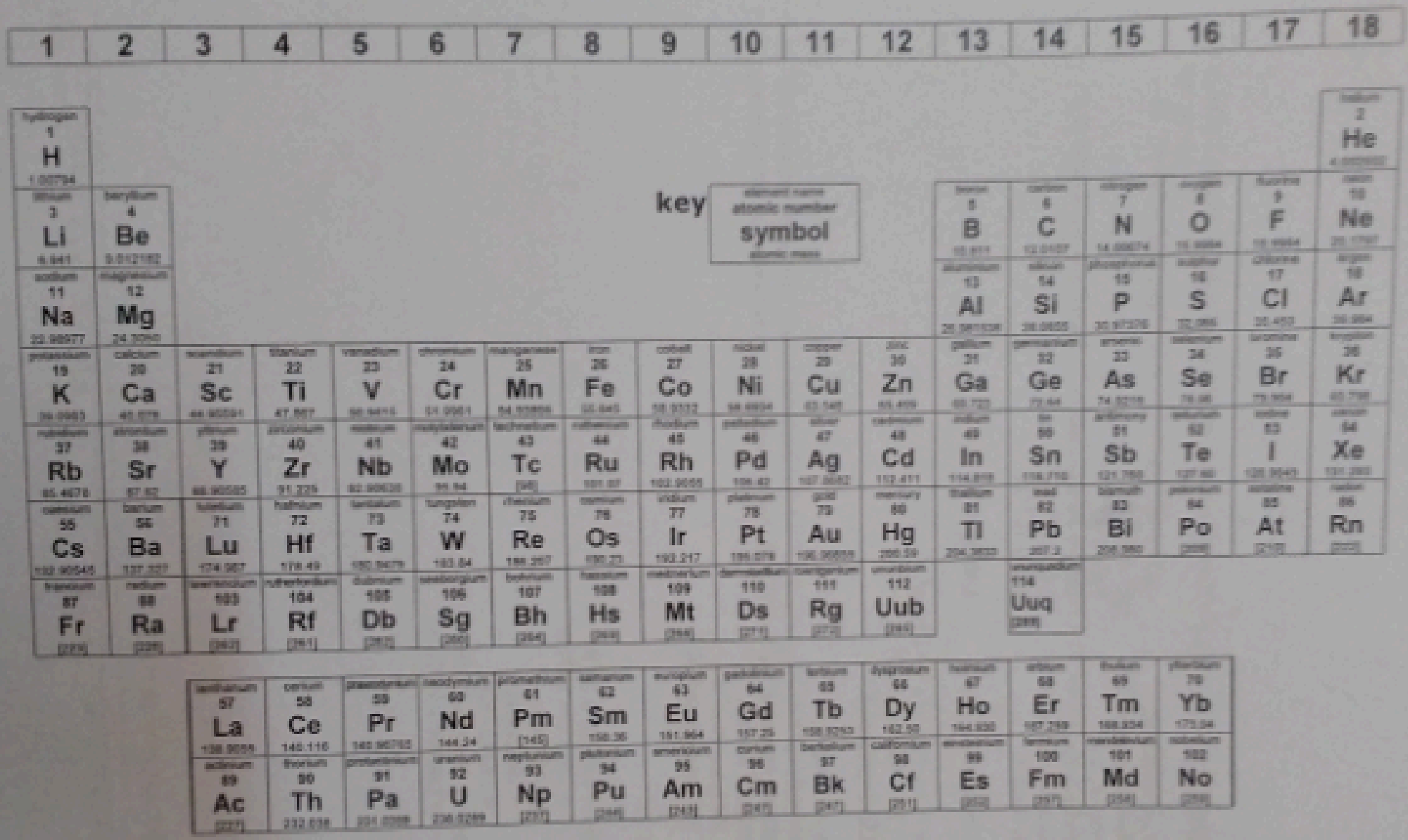
1 Joule = 1 J = 1 kg m^2 s^{-2} = 1 Pa m^3
1 Faraday (F) = 96485 C mol^{-1}

Universal Gas constant R

8.3145 J mol^{-1}K^{-1}
8.314 k Pa L K^{-1} mol^{-1}
0.083145 L bar mol^{-1} K^{-1}
0.08206 L atm mol^{-1} K^{-1}
62.364 L torr mol^{-1} K^{-1}
62.364 L mmHg mol^{-1} K^{-1}

Pressure

1 atm = 1.01325×10^5 Pa
= 1.01325×10^5N m^{-2}
= 760 torr
= 760 mmHg
= 1.01325 bar
1 bar = 1.00000×10^5 Pa
= 1.00000×10^5 N m^{-2}



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