

SECTION A: Attempt ALL questions[70marks]

Q1. Choose the **letter** corresponding to **correct answer**. (1 mark for each)

(a) An electron receives enough energy to remove it from the attraction of the nucleus. The atom is:

- (i) Quantized
- (ii) Ionized
- (iii) Emitted
- (iv) Absorbed

(b) Which of the following is only acidic in nature?

- (i) $\text{Be}(\text{OH})_2$
- (ii) $\text{Mg}(\text{OH})_2$
- (iii) $\text{B}(\text{OH})_3$
- (iv) $\text{Al}(\text{OH})_3$

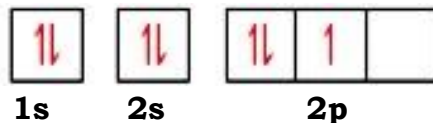
(c) Which of the following is most acidic?

- (i) Na_2O
- (ii) MgO
- (iii) Al_2O_3
- (iv) CaO

(d) Aluminium is a self-preserving metal, because

- (i) It is not tarnished by air
- (ii) A thin film of basic carbonate on its surface
- (iii) A non-porous layer of oxide is formed on its surface
- (iv) It is not affected by salt water

(e) A student attempted to draw the electron configuration of a nitrogen atom in its ground state and it was found that what the student did was incorrect as shown below.



The given configuration violates the

- (i) Pauli Exclusion Principle
- (ii) Hund's Rule
- (iii) Aufbau Rule
- (iv) Klechkowski's Rule

(f) The property of hydrogen which distinguishes it from other alkali metals is:

- (i) Its electropositive character
- (ii) Its affinity for non-metals

(iii) (iii) It's reducing character

(iv) Its non-metallic character

(g) Factors governing the formation of an ionic bond are:

(i) Low ionization energy of metal and high electron affinity of non-metal atom

(ii) High ionization energy of metal and high electron affinity of non-metal atom

(iii) Low ionization energy of metal atom and low electron affinity of nonmetal atom

(iv) High ionization energy of metal and low electron affinity of non-metal atom

(h) Aluminium vessels should not be washed with materials containing washing soda (NaOH) since

(i) Washing soda is expensive

(ii) Washing soda is easily decomposed

(iii) Washing soda reacts with aluminium to form soluble aluminate

(iv) Washing soda reacts with aluminium to form insoluble aluminium oxide

(I) The octet rule is _____

(i) The tendency of atoms to have eight pairs of electrons in the valency shell

(ii) The tendency of the molecule to have a total of eight electrons

(iii) The tendency of atoms to have eight non-bonding electrons

(iv) The tendency of atoms to have eight electrons in the outermost shell

(j) Four numbers, called quantum numbers, were introduced to describe the characteristics of electrons and their orbitals. Which of those quantum numbers describes the various orientations of the orbitals?

(i) Azimuthal

(ii) Magnetic

(iii) Principal

(iv) Spin

Q2. For each of the following descriptions, write the **suitable term** commonly used. **(1 mark for each)**

(a) Net positive charge from the nucleus that an electron can feel attractions from.

(b) A shared pair of electrons in which both electrons come from same atom.

(c) Type of spectrum formed by electromagnetic radiation that has passed through a medium, in which radiation of some frequencies is absorbed.

(d) The energy released or absorbed during the formation of a solid ionic compound from its constituent gaseous ions.

(e) Type of chemical bonding that arises from the electrostatic attractive force between delocalized electrons and positively charged metal ions.

Q3. The electronic structure of an atom of element **X** is: **(2marks)**



From the given structure, deduce, with a reason, each of the following.

- (a) Atomic number of **X**
- (b) The period in which it is found
- (c) The group in which it is found
- (d) The block in which it is found.

Q4. The mass spectrum of the sample of magnesium contains three peaks with the mass-to-charge ratios and relative intensities shown below.

m/z	24	25	26
Relative intensities	1	0.127	0.139

- (a) Explain why magnesium gives three peaks in mass spectrum. **(1 mark)**
- (b) Calculate the relative atomic mass of magnesium. **(2 marks)**

Q5. There are many uses for Group 2 elements and their compounds.

- (a) Magnesium hydroxide is used in antacid preparations to neutralise excess stomach acid. Write an equation for the reaction of magnesium hydroxide with hydrochloric acid. **(1 mark)**
- (b) A solution of magnesium sulphate is sometimes given as first aid to someone who has swallowed barium chloride. Explain why drinking magnesium sulphate solution is effective in the treatment of barium poisoning.
(2 marks)
- (c) Limestone is a naturally occurring material used to produce quicklime and slaked lime (ishwagara).

(i) Chemically, describe how “ishwagara” may be obtained from limestone through quicklime. **(2marks)**

(ii) Explain the importance of “ishwagara” for Rwandan agriculture. **(1mark)**

Q6. This question refers to group 1 and 2 compounds.

- a) Write an equation for the reaction between chlorine and cold, dilute aqueous sodium hydroxide. **(1 mark)**
- b) Sodium chloride and magnesium oxide both are ionic compounds found in nature and in our everyday life.
 - i. Using arrows show the formation of ionic bond in magnesium oxide.
(1marks)
 - ii. Sodium chloride (NaCl) melts at 801°C; magnesium oxide (MgO) melts at 2,852 °C. Both have identical structures.

Why is there such a difference in their melting points? **(2 marks)**

Q7. The electronic configuration describes the arrangements of electrons in an atom.

(a) Show the electronic structure of the following elements and ions using s, p, d, f configuration:

(i) Cu^{2+} **(1 mark)**

(ii) Fe **(1 mark)**

[Atomic numbers: Cu = 29, Fe = 26]

- b. The compounds made by Fe^{3+} ions show greater stability over those made by Fe^{2+} ions. In terms of their electronic structures, explain why

Fe^{3+} is more stable than Fe^{2+} . (2 marks)

Q8. Consider the first ionization energy of neon and the electron affinity of fluorine.

(a) Write equation for the electron affinity of fluorine. **(1 mark)**

(b) These two quantities will have opposite signs. Which of them will be positive? **(1 mark)**

(c) How does the effective nuclear charge experienced by the valence electrons of an atom vary going from left to right across a period of the periodic table?

(1marks)

(d) Why are monoatomic anions larger than their corresponding neutral atoms? **(2 marks)**

Q9. The Group 2 element radium, Ra, is used in medicine for the treatment of cancer. Radium was discovered in 1898 by Pierre and Marie Curie by extracting radium chloride from its main ore pitchblende.

(a) Predict the formula of radium chloride. **(1 mark)**

(b) Pierre and Marie Curie extracted radium from radium chloride by reduction. Radium reacts vigorously when added to water.



i. Use the above equation to predict two observations that you would see during this reaction. **(2 marks)**

ii. Predict a pH value for this solution. **(1 mark)**

Q10. This question refers to group 14 elements and their compounds.

(a) CO_2 and SiO_2 are oxides of Group 14 elements. Account for the fact that CO_2 is a gas while SiO_2 is a high melting solid under room temperature and atmospheric pressure. **(1 mark)**

(b) Give a reason why hydrofluoric acid is stored in plastic containers and not in glasses. **(1 mark)**

(c) Lead was very efficient to use in plumbing but today copper pipes and plastic pipes are used instead. Why? **(1 mark)**

Q11. Copper is made up of two isotopes, Cu-63 and Cu-65. Given copper's relative atomic weight of 63.546, what is the percent abundance of each isotope? **(2 marks)**

Q12. This question refers to the intermolecular forces.

(a) Give the name of the type of intermolecular bonding present in hydrogen sulphide, H_2S . **(1 mark)**

(b) Account for the much lower boiling point of H_2S (-61°C) compared with that of water (100°C). **(1 mark)**

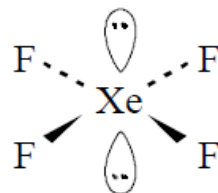
(c) Show, by means of a diagram, how two molecules of **hydrogen fluoride** are attracted to each other by hydrogen bonding. Include all partial

charges in your diagram. **(1 mark)**

Q13. Fluorine is a very reactive halogen. It forms compounds like NF_3 and XeF_4 .

(a) Draw a Lewis structure for NF_3 molecule. **(2 marks)**

(b) The shape of the XeF_4 molecule is shown below.



(i) State the bond angle in XeF_4 **(0.5 mark)**

(ii) Name the shape of this molecule. **(0.5 mark)**

Q14. This question refers to the ionisation of atoms.

(a) Explain the meaning of the term first ionisation of an atom. **(1 mark)**

(b) The table below shows the first 6 successive ionization energies (in kJ mol^{-1}) of an element **X** that is in period 3 of the Periodic Table.

1 st I.E.	2 nd I.E.	3 rd I.E.	4 th I.E.	5 th I.E.	6 th I.E.
578	1817	2745	11578	14831	18378

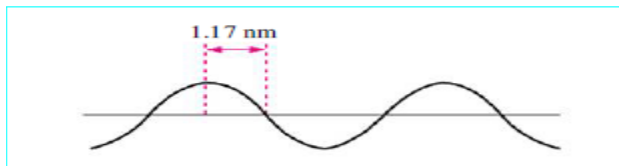
(i) By giving the reason of your answer, identify the group of the Periodic Table in which **X** must be found. **(3 marks)**

(ii) Write the chemical formula of the **X** oxide. **(1 mark)**

(c) Write an equation to illustrate the process occurring when the **third** ionisation energy of magnesium is measured. **(1 mark)**

(d) Explain why the value of the first ionisation energy of magnesium is higher than that of sodium. **(2 marks)**

Q15. a) A hypothetical electromagnetic wave is pictured here. What is the wavelength and energy of this radiation? **(3marks)**



b) what electron transition in a hydrogen atom, ending in the orbit $n=3$ will produce light of wavelength 1090 nm? ($R_H=1.097 \times 10^7 \text{ m}^{-1}$, Planck's constant, $h = 6.626 \times 10^{-34} \text{ Js}$). **(3marks)**

Q16. Li is in group I and Mg is in group II but the two elements show similar chemical properties.

a. State the name of the relationship. **(0.5marks)**

b. State 2 properties in which these two elements show similar properties. **(2marks)**

c. Give two other pairs of elements that show that same relationship. **(0.5marks)**

SECTION B: Answer any three (3) questions only [30 marks]

Q17.

- a) Using equations explain the process of manufacture of nitric acid in industry. **(3marks)**
- b) Using equations explain the manufacture of sulphuric acid by the contact process. **(4marks)**
- c) why SO_3 is not hydrolysed directly to sulphuric acid? **(2marks)**
- d) What is the use of sulphuric acid. **(1mark)**

Q18. use chemical test to differentiate the following pairs and state the observations: **(10marks)**

- a) $\text{SO}_{2(g)}/\text{CO}_{2(g)}$
- c) $\text{SO}_4^{2-(aq)}/\text{SO}_3^{2-(aq)}$
- b) $\text{Pb}^{2+(aq)}/\text{Sn}^{2+(aq)}$
- d) $\text{CO}_3^{2-(aq)}/\text{HCO}_3^{-(aq)}$

Q19. An s-block element **A** is a starting point of a series of reaction that are described in the following lines.

The element **A** reacts with water to produce a solution of substance **B** and a colorless gas **C**. When **A** is burnt in chlorine gas, the substance **D** is obtained.

The aqueous solution of the substance **D** conducts electricity and gives a yellow color on a Bunsen flame.

On the other side **A** burns in oxygen gas giving 2 types of oxides **E** and **F**.

The oxide **E** gives a solution of substance **B**, while the oxide **F** reacts with water producing a solution of substance **B** and the release of a gas a colorless gas **G**.

The substance **B** reacts with an acidic solution of nitric acid to give a salt solution **H** of nitrate of **A** which decomposes on heat to produce a salt I and the colorless gas **G**.

- a) Identify substance A to I (4.5marks)**
- b) Write the equations of reactions that lead to substance B in the description above. (1marks)**
- c) Explain what happens when A is burnt in oxygen to form E and F. (0.5marks)**
- d) Write the equation of reaction between F and water. (1marks)**
- e) Describe the chemical tests to differentiate the gases C and G. (1.5marks)**
- f) Write the equation of thermal decomposition of substance H. (1.5marks)**

Q20. **Q** is a compound which contains two ions.

Complete the table by adding the conclusion for **(a)**, the observations for **(b)(i)** and **(ii)** and **(c)(i)** and **(ii)**, both the test and observation for **(d)**, and after conclude giving the formula of **Q**. **(8marks)**

Test	Observation	Conclusion
(a) Q is dissolved in water and the solution divided into three parts for use in (b), (c) and (d).	A colorless solution is formed
(b)(i) To the first part, aqueous sodium hydroxide is added until a change is seen. (ii) An excess of aqueous sodium hydroxide is added to the mixture from (i).	Q may contain Al³⁺ , Ca²⁺ or Zn²⁺ ions. Q may contain Al³⁺ or Zn²⁺ ions.
(c)(i) To the second part, aqueous ammonia is added until a change is seen. (ii) An excess of aqueous ammonia is added to the mixture from (i).	Q may contain Al³⁺ or Zn²⁺ ions. Q contains Al³⁺ ions.
(d)	Q contains SO₄²⁻ ions

Conclusion: The formula of compound **Q** is:(2marks)