THE UNITED REPUBLIC OF TANZANIA
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA
ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/1

CHEMISTRY 1
(For Both School and Private Candidates)

Year: 2023

Time: 3 Hours

Instructions

1. This paper consists of sections A and B with a total of **ten (10)** questions.

2. Answer **all** questions in section A and **two (2)** questions from section B.

3. Each question carries **ten (10)** marks in section A and **fifteen (15)** marks in section B.

4. Mathematical tables and non-programmable calculators may be used.

5. All writing must be in **blue** or **black** ink **except** drawing which must be in pencil.

6. Cellular phones and any unauthorised materials are **not** allowed in the examination room.

7. Write your **Examination Number** on every page of your answer booklet(s).

8. For calculations you may use the following:
   - Gas constant, $R = 8.31$ J mol^{-1} K^{-1} or 0.0821 atm mol^{-1} K^{-1} dm^3
   - GMV = 22.4 dm^3
   - Standard temperature = 273 K
   - Standard pressure = 760 mm Hg = 1.0×10^5 N m^{-2} = 1 atm
   - Planck's constant, $h = 6.63 \times 10^{-34}$ J s
   - Velocity of light, $c = 3.0 \times 10^8$ m/s
   - Mass of an electron = 9.11×10^{-31} kg
   - Atomic masses: H = 1, C = 12, N = 14, O = 16, Cl = 35.5, Ca = 40

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Answer **all** the questions in this section.

1. (a) A person swallowed a drop of liquid oxygen, O_2 (l), which has a density of 1.149 g/cm^3. Assuming the drop has a volume of 0.050 cm^3, calculate the volume of a gas that will be produced in the person's stomach at body temperature (37°C) and a pressure of one (1) atmosphere. **(03 marks)**

    (b) A compound contains only nitrogen and hydrogen and is 87.4% nitrogen by mass. A gaseous sample of the compound has a density of 0.977 g/L at 710 mmHg and 100 °C. Determine the molecular formula of the compound. **(04 marks)**

    (c) A total volume of 2.50×10^2 cm^3 chlorine gas was collected over water at 20 °C and a total pressure of 1 atm. Calculate the mass of chlorine collected at this temperature if the vapour pressure of water was 17.5 mm Hg. **(03 marks)**

2. (a) Comment briefly on the following observations:
    (i)   Sodium chloride solution freezes at a lower temperature than that of pure water but boils at higher temperature than pure water.
    (ii) A driver adds ethylene glycol to water in a car radiator during winter season.
    (iii) The blood cells which are isotonic with 0.9% sodium chloride solution are placed in 1.2% sodium chloride solution.
    (iv) When dehydrated fruits and vegetables are placed in water, they slowly swell and return to the original forms. **(04 marks)**

    (b) (i)   Eighteen grams (18 g) of glucose, $C_6H_{12}O_6$ (molar mass = 180 g/mol) are dissolved in 1 kg of water in a sauce pan. At what temperature will this solution boil? Given the K_b for water = 0.52 kg/mol. **(03 marks)**

        (ii) Calculate the elevation in boiling point that is expected for an alcohol when 5 g of urea (molar mass 60 g/mol) are dissolved in 75 g of it. Given the molal elevation constant for the alcohol = 1.15 K/m. **(03 marks)**

3. (a) What are the two conditions necessary for the formation of hydrogen bonding? Briefly explain. **(02 marks)**

    (b) Study the chemical structures of compounds **I** and **II** and answer the questions that follow while giving one reason in each case:

        I   **II**
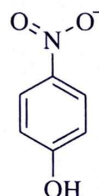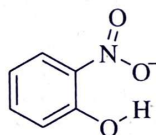
    (i)   What type of hydrogen bonding is exhibited in each compound?

Page 2 of 6

(ii) Which of the two compounds is expected to have higher melting point than the other?

(iii) Which compound is likely to be more soluble in a polar solvent? **(04 marks)**

(c) Indicate the types of bonds present in NH_4NO_3 and state the mode of hybridization of the N atom in the NO_3^- ion. **(04 marks)**

4. (a) All radiations are associated with wave nature and differ from one another in terms of wavelength, frequency, velocity and energy. Give the relationship between the following:
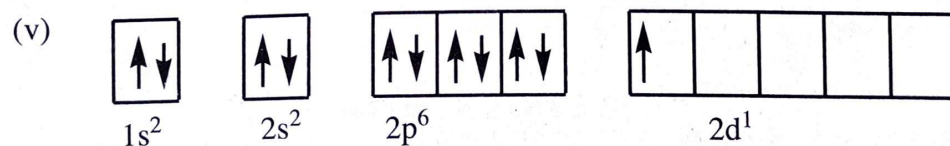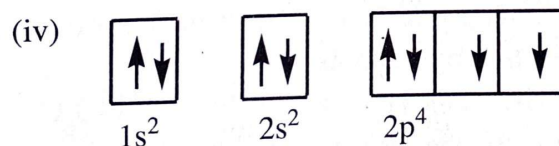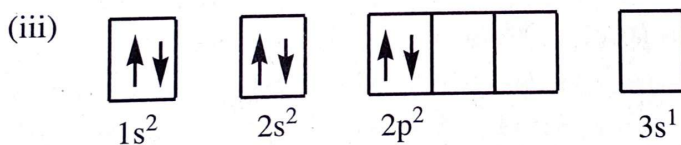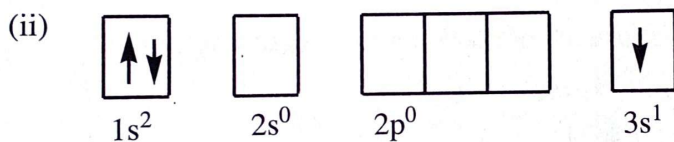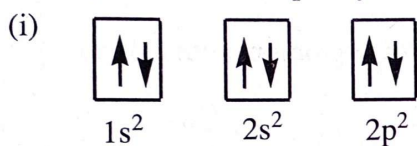
(i) Frequency and wavelength

(ii) Wavelength and wavenumber

(iii) Energy and frequency

(iv) Energy and wavelength **(04 marks)**

(b) Indicate whether the following electronic configurations are possible or impossible. For the impossible ones, specify the rules which have been violated.

(i)

$$1s^2 \quad 2s^2 \quad 2p^2$$

(ii)

$$1s^2 \quad 2s^0 \quad 2p^0 \quad 3s^1$$

(iii)

$$1s^2 \quad 2s^2 \quad 2p^2 \quad 3s^1$$

(iv)

$$1s^2 \quad 2s^2 \quad 2p^4$$

(v)

$$1s^2 \quad 2s^2 \quad 2p^6 \quad 2d^1$$

(05 marks)

(c) How many orbitals are there in each of the following sub-shells?

(i) $2p$

(ii) $3d$ **(01 mark)**

5. (a) In the process of manufacturing chemicals, in one of the emerging chemical industries in Tanzania, a Chemist performed the following activities:

(i) Exposed sodium metal to air followed by addition of water.

(ii) Burned sodium metal in air followed by addition of water.

Briefly, explain the chemical processes that took place while supporting your answer with balanced chemical equations in each case. **(04 marks)**
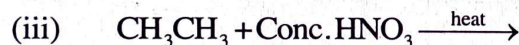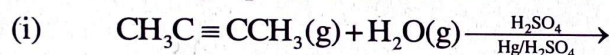
(b) Using balanced chemical equations, describe the reactions between the oxides of lead, aluminium and calcium with dilute;
    (i) Sulphuric acid
    (ii) Nitric acid **(06 marks)**

6. (a) Differentiate between the following terms:
    (i) Born-Haber cycle and enthalpy of formation.
    (ii) Heat of neutralization and heat of solution. **(03 marks)**

(b) You are given an equation representing the hydrogenation of ethene as $C_2H_4(g) + H_2(g) \rightarrow CH_3CH_3(g)$. What would be the value for standard enthalpy of hydrogenation of ethene (in kJ) if the bond enthalpies were: C–H = 416; C=C = 612; C–C = 348 and H–H = 436? **(07 marks)**
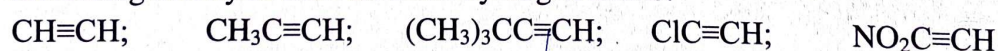
7. (a) Using one chemical test, distinguish the following organic compounds:
    (i) $CH_3CH=CH_2$ and $CH_3CH_2CH_3$
    (ii) $CH_3C\equiv CCH_3$ and $CH_3CH_2C\equiv CH$ **(04 marks)**

(b) Predict the major product in each of the following organic reactions:
    (i) $CH_3C \equiv CCH_3(g) + H_2O(g) \xrightarrow[Hg/H_2SO_4]{H_2SO_4}$
    (ii) $CH_3CH_2Br + Na \xrightarrow{dry\ ether}$
    (iii) $CH_3CH_3 + Conc.HNO_3 \xrightarrow{heat}$
    (iv) $CH_3CH=CH_2 + Br_2 \xrightarrow{U.V.\ light}$ **(04 marks)**

(c) A form six student wanted to arrange the following organic compounds in order of increasing acidity of their terminal hydrogen atoms.
    $CH\equiv CH$; $CH_3C\equiv CH$; $(CH_3)_3CC\equiv CH$; $ClC\equiv CH$; $NO_2C\equiv CH$
    Suggest a correct sequence required by the student and give two reasons for your choice of arrangement. **(02 marks)**

SECTION B (30 Marks)

Answer **two** (2) questions from this section.

8. (a) (i) "A chemical system at equilibrium is dynamic." Explain briefly the meaning of this statement. **(01 mark)**
    (ii) The equilibrium constant, K_p for the reaction $CCl_4(g) \rightarrow C(s) + 2Cl_2(g)$ is 0.76 atm at 978 K. Calculate the initial pressure of carbon tetrachloride that will

produce a total equilibrium pressure of 1.2 atm at 978 K. **(04 marks)**

(b) (i) Why the solubility of CO_2 in soft drinks like Coca-cola decreases with rise in temperature? Briefly, explain.

(ii) What happens to equilibrium in a reversible reaction if a catalyst is added to it? Explain briefly.

(iii) What happens to equilibrium constant of an exothermic reaction if temperature is raised? Explain briefly. **(03 marks)**

(c) When a yellow solution of iron(III) chloride and a colourless solution of potassium thiocyanate (KSCN) are mixed in a test tube, a red colour appears according to the following equilibrium:

$$Fe^{3+}(aq) + SCN^-(aq) \rightleftharpoons [Fe(SCN)]^{2+}(aq)$$

red solution
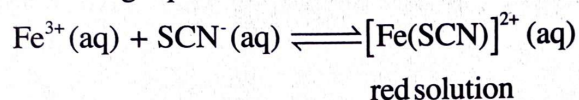
(i) What would be the effect on Fe^{3+} ions upon addition of KSCN to the equilibrium?

(ii) What would happen to the equilibrium position when the pressure of the system was to be doubled? Briefly, explain.

(iii) The red colour faded when the test tube containing the equilibrium mixture was placed in an ice-water bath. Briefly explain whether the value of K_c for this reaction is high or low and whether the reaction is exothermic or endothermic. **(07 marks)**

9. (a) After a successful completion of your Secondary Education, some farmers in your area of residence invite you to give a talk as far as the concept of Soil Chemistry is concerned. Briefly, explain each of the following terms while citing one example in each case:
   (i) Soil reaction
   (ii) Soil colloids
   (iii) Liming
   (iv) Organic fertilizers
   (v) Artificial fertilizers **(05 marks)**

(b) Why is it necessary to measure soil pH? Briefly, explain by giving two reasons. **(04 marks)**

(c) A farmer was advised to supply 200 kg of nitrogen on the paddy farm. What would be the mass of a fertilizer with 60% by mass $Ca(NO_3)_2$ which the farmer has to buy in order to meet the nitrogen requirements for the farm? **(06 marks)**

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10. (a) (i) What are the two effects of substituent groups on the reactivity of benzene ring? Briefly, explain.

(08 marks)

(ii) By giving one example in each case, briefly justify the statement "Despite the fact that both benzene and alkenes are unsaturated hydrocarbons, benzene undergoes electrophilic substitution reactions whereas alkenes undergo electrophilic addition reactions."

(03 marks)

(b) Why do activators when attached to benzene ring direct the incoming electrophile to *ortho* and *para* positions? Briefly, explain.

(02 marks)

(c) Why are the products of nitration of methylbenzene obtained at a shorter time than those of sulphonation of benzene? Explain briefly supporting your answer with a chemical equation in each case.

(02 marks)