Chemistry II

014

29/07/2022   8:30 AM-11:30AM

NESA NATIONAL EXAMINATION AND
SCHOOL INSPECTION
AUTHORITY
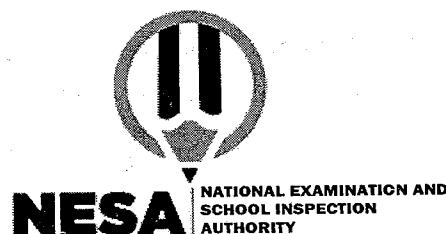
ADVANCED LEVEL NATIONAL EXAMINATIONS, 2021-2022

SUBJECT: CHEMISTRY II

PAPER II: THEORY

COMBINATIONS:

-   BIOLOGY-CHEMISTRY-GEOGRAPHY **(BCG)**
-   MATHEMATICS-CHEMISTRY-BIOLOGY **(MCB)**
-   PHYSICS-CHEMISTRY-BIOLOGY **(PCB)**
-   PHYSICS-CHEMISTRY-MATHEMATICS **(PCM)**

DURATION: 3 HOURS

INSTRUCTIONS:

1) Write your name and index number on the answer booklet as written on your registration form and **DO NOT** write your names and index number on additional answer sheets if provided

2) Do not open this question paper until you are told to do so.

3) This paper consists of two sections: **A** and **B**.
    -   **Section A**: Attempt **ALL** questions.   **(70 marks)**
    -   **Section B**: Attempt any **THREE** questions.   **(30 marks)**

4) You do not need the periodic table.

5) Silent non-programmable calculators may be used.

6) Use a **blue** or **black** pen for answering and a **pencil** for drawing.

SECTION A: ATTEMPT ALL QUESTIONS (70 marks)

1) a) What is an amphoteric compound? **(1 mark)**

   b) Which one of the following chemical species H_2S, HS^- and S^{2-} has an amphoteric character? **(1 mark)**

   c) Write a balanced chemical equation of a reaction between that amphoteric compound and water to explain your answer in (b) above. **(2 marks)**

2) Read the text and use the list of words given below to fill in the blank spaces. Each word should be used once:

   Vaporization chamber, mass spectrum, velocity, ionization, deflection, detector, acceleration.

   A sample of the element is placed in the _____ where it is converted into gaseous atoms. The gaseous atoms are ionized by bombardment of high energy electrons emitted by a hot cathode to become positive ions (in practice, the voltage in the _____chamber is set in such a way that only one electron is removed from each atom). The positive ions (with different masses) are then given a high and constant _____by two negatively charged plates: the process is called_____. The positive ions are then deflected by the magnetic field. This process is called _____ (ions with smaller mass will be deflected more than the heavier ones). These ions are then detected by the ion _____. The information is fed into a computer which prints out the_____ of the element.

   (3.5 marks)

3) The sketch graph below shows 13 successive ionization energies of Aluminium.
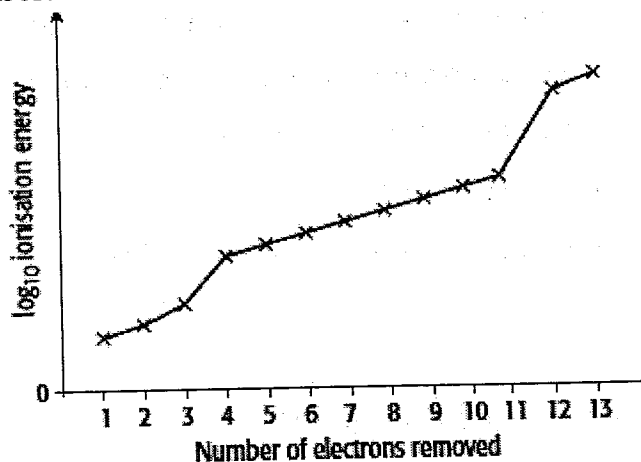
a) Define the term 1ˢᵗ ionisation energy of an element. **(2 marks)**

b) How does the graph provide evidence for the existence of three electron shells in an Aluminium atom? **(4 marks)**

c) Write an equation, including state symbols, to represent the 2ⁿᵈ ionization energy of Aluminium. **(1 mark)**

d) Write the electronic configuration of an Aluminium ion. **(1 mark)**

4) Chromium belongs to the transition metal elements in the periodic table. State five properties of the transition metal elements. **(5 marks)**

5) Nitrogen and phosphorous are the first two elements in group 15 of the periodic table. Their hydrides are ammonia (NH_3) and phosphine (PH_3).

a) Draw a diagram of an ammonia molecule showing its shape. Show the bond angles. *(Atomic Number: N =7), H=1)* **(1 mark)**

b) The boiling point of NH_3 and PH_3 are -33⁰C and -88⁰C respectively. Suggest the reasons for this difference in boiling points. **(2 marks)**

c) Explain why ammonia is a polar molecule. **(2 marks)**

6) An isotope of an element Uranium $^{235}_{92}U$, emits successively seven alpha particles and four beta particles to form a stable isotope of another element **X**.

Deduce:
a) The mass number of **X** **(2 marks)**

b) The atomic number of **X** **(2 marks)**

c) Identify **X** (Chose among $^{207}_{82}Pb$, $^{209}_{84}Po$, $^{204}_{81}Tl$) **(1 mark)**

7) The burning of fossil fuels can produce atmospheric pollutants.
   a) The combustion of petrol in an internal combustion engine can lead to the formation of carbon monoxide, CO, and nitrogen monoxide, NO.
      i) Write a chemical equation for the incomplete combustion of octane, C_8H_{18}, to produce CO and water only. **(2 marks)**
      ii) Write a chemical equation for the formation of Nitrogen Oxide (NO) in an engine. **(2 marks)**

   b) Some new petrol-engined cars are fitted with a catalytic converter.
      i) Name one of the metals used as a catalyst in a catalytic converter. **(1 mark)**
      ii) Write a chemical equation to show how CO and NO react with each other in a catalytic converter (the way to eliminate the two pollutants). **(2 marks)**
   c) State why sulphur dioxide gas is sometimes found in the exhaust gases of petrol-engined cars. **(1 mark)**
   d) Give one adverse effect of sulphur dioxide on the environment. **(1 mark)**

8) A complex is made of Co(III) and consists of four NH_3 molecules and two chloride ions as ligands.
   a) Calculate the charge number of the whole complex ion. **(1 mark)**
   b) Write the formula of the complex ion. **(2 marks)**
   c) Name the above complex ion using IUPAC. **(1 mark)**
   d) What is the coordination number of the metal ion in such a complex ion? **(1 mark)**

9) a) Give the electron structure of Copper (Z=29) using s,p,d,f,... notations. **(1 mark)**

   b) Explain why Cu^{2+} is coloured and Cu^+ is not coloured. **(2 marks)**

10) Explain the following statements:
   a) Sodium Chloride in solid state does not conduct electricity. **(2 marks)**

   b) Ionic compounds have high boiling and melting points. **(2 marks)**

11) Agricultural lime is manufactured from limestone (calcium carbonate) in two stages. Limestone is heated strongly in a limekiln (in which limestone is burnt). The product (quicklime or burnt lime) is cooled and a calculated amount of water is added. The highly exothermic reaction yields a white powder called slaked lime.

a) Write balanced chemical equations for the two stages (production of quicklime and slaked lime) showing state symbols. **(2 marks)**

b) Give one reason why slaked lime is used by farmers in agriculture. **(1 mark)**

c) How may the manufacture of burnt lime have an effect on the environment? Give 2 reasons. **(2 marks)**

d) What is the mass of limestone required to produce 280g of quicklime? (Ca=40,H=1,O=16,C=12) **(2 marks)**

12) The resistance of a 0.01M NH_4OH solution was found to be 3000 ohms in a conductivity cell of cell constant of 0.345 cm^{-1}. Given that the ionic conductance of ammonium ions (NH_4^+) and hydroxide ions (OH^-) are $73.4 \, S \, cm^2 mol^{-1}$ and $197.6 \, S \, cm^2 mol^{-1}$ respectively. Calculate:

a) The conductivity of NH_4OH. **(2 marks)**

b) The degree of dissociation NH_4OH. **(2 marks)**

13) a) Arrange the following carboxylic acids in order of increasing acid strength.

   i) $CH_2Cl-COOH$,
   ii) CH_3COOH,
   iii) CH_2FCOOH **(1.5 marks)**

b) Name two compounds that are required to make soap. **(1 mark)**

14) Calculate the pH of a solution made by mixing 10 ml of 0.1M HCl and 10.1ml of 0.1M NaOH **(5 marks)**

SECTION B: ATTEMPT ANY THREE QUESTIONS. (30marks)

15) Benzoic acid, C_6H_5COOH, is a weak monoacid. ($Ka= 6.4 \times 10^{-5}$)

    a) Explain how a mixture of benzoic acid and sodium benzoate can act as a buffer solution on the addition of small amounts of either HCl (aq) or NaOH (aq).

                                              (3 marks)

    b) What is the $[H^+]$ in 0.02 mol.dm^{-3} benzoic acid?   **(2.5 marks)**

    c) What is the pH of 0.02 mol.dm^{-3} benzoic acid?   **(1 mark)**

    d) What is the pH of a solution containing 0.05 mol.dm^{-3} of sodium benzoate in 1 dm^3 of 0.02 mol.dm^{-3} benzoic acid?   **(3.5 marks)**

    (C: 12, H: 1, O: 16, Na: 23)

16) The two compounds **V** and **W** are isomers with the molecular formula C_4H_8O, and show the following properties and reactions:
Both compounds react with sodium metal, and both decolorize bromine water. Compound **V** forms a yellow precipitate with alkaline aqueous iodine, whereas compound **W** does not. When reacted with cold $KMnO_4$(aq), both **V** and **W** produce the same neutral compound **X**, $C_4H_{10}O_3$.
Both **V** and **W** exist as pairs of stereoisomers.

    a) Suggest which functional groups are responsible for the reactions with:
        i) Sodium.   **(1mark)**
        ii) Bromine water.   **(1mark)**
        iii) Alkaline aqueous iodine.   **(1mark)**

    b) Suggest structures for **V** and **W**.   **(2 marks)**

    c) State the type of stereoisomerism shown by compound **V** and draw the structures of the stereoisomers.   **(3 marks)**

    d) Suggest the structure of the neutral compound **X**.   **(2 marks)**

17) Consider the equilibrium: $N_2O_4(g) \rightleftharpoons 2 NO_2(g)$

    a) i) One mole of dinitrogen tetroxide, N_2O_4 was introduced into a vessel of volume 10.0 dm^3 at a temperature of 80°C. At equilibrium, 60% had dissociated. Calculate Kc.   **(3 marks)**
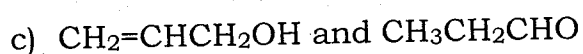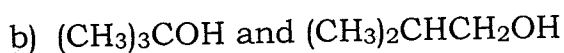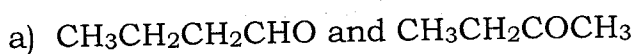
ii) Using the following data, calculate the enthalpy change for the forward reaction. **(2 marks)**

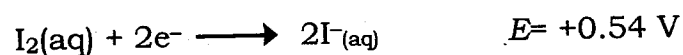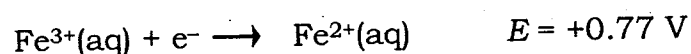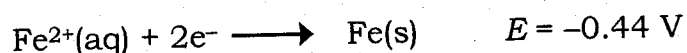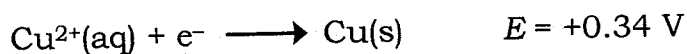|	H_f^0 (kJ. mol^{-1})
N_2O_4	+9.70
NO_2	+33.90

iii) If the same experiment is carried out at 100°C, state qualitatively, giving your reasons, how the equilibrium composition will change. **(2 marks)**

b) What is the effect of a catalyst on the following?
   i) The value of K_c. **(1 mark)**
   ii) The equilibrium position. **(1 mark)**
   iii) The rate of attainment of equilibrium. **(1 mark)**

18) For each of the following pairs of isomers, suggest a test that will distinguish between the two compounds. **(10 marks)**
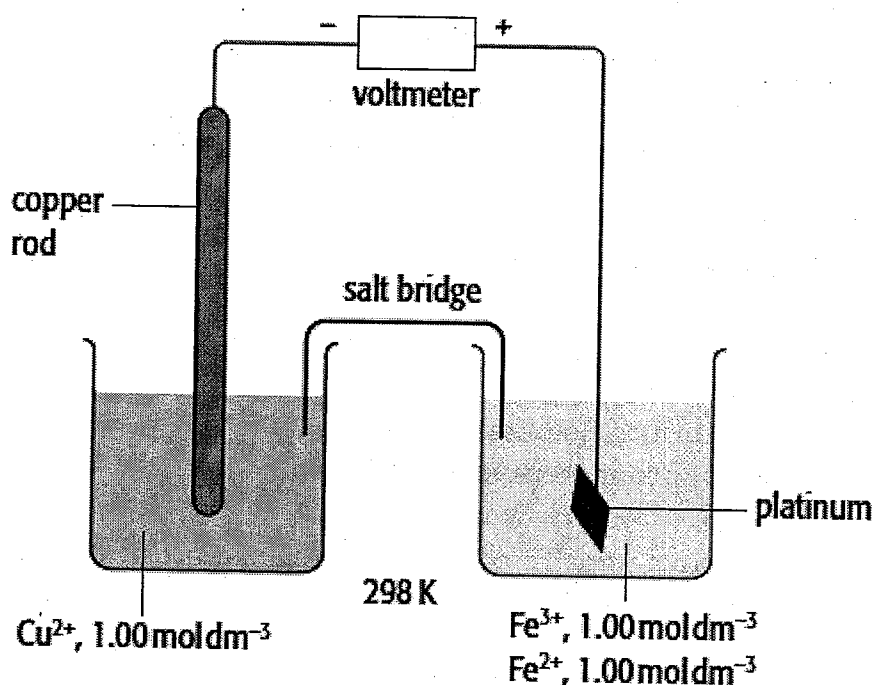
   a) $CH_3CH_2CH_2CHO$ and $CH_3CH_2COCH_3$

   b) $(CH_3)_3COH$ and $(CH_3)_2CHCH_2OH$

   c) $CH_2=CHCH_2OH$ and CH_3CH_2CHO

19) The list below gives the standard electrode potentials for five half-reactions.

   $Cu^{2+}(aq) + e^- \longrightarrow Cu(s)$ $E = +0.34$ V

   $Fe^{2+}(aq) + 2e^- \longrightarrow Fe(s)$ $E = -0.44$ V

   $Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$ $E = +0.77$ V

   $I_2(aq) + 2e^- \longrightarrow 2I^-(aq)$ $E = +0.54$ V

   $Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s)$ $E = -0.76$ V
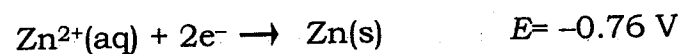
   a) What is the meaning of standard electrode potential? **(3 marks)**

   b) Which species in the list is:
      i) The strongest oxidizing agent? **(1 mark)**
      ii) The strongest reducing agent? **(1 mark)**

c) A cell was set up as shown below.

voltmeter

copper rod

salt bridge

platinum

298 K

Cu^{2+}, $1.00\,mol\,dm^{-3}$

Fe^{3+}, $1.00\,mol\,dm^{-3}$
Fe^{2+}, $1.00\,mol\,dm^{-3}$

   i)   Calculate the standard cell potential of this cell. **(1 mark)**

  ii)   In which direction do the electrons flow in the external circuit? Explain your answer. **(2 marks)**

 iii)   Write a chemical equation for the complete cell reaction. **(2 marks)**

20) $50\,cm^3$ of 0.1M aqueous ammonia solution was shaken to equilibrium with $50\,cm^3$ of trichloromethane in a stoppered bottle, at 25°C. The two solvent layers were allowed to separate. 25 cm^3 of the aqueous layer reacted completely with $24\,cm^3$ of 0.1M HCl solution.

a) What is the concentration of ammonia in the aqueous layer at equilibrium? **(4 marks)**

b) What is the concentration of ammonia in the trichloromethane layer at equilibrium? **(3 marks)**

c) Calculate the distribution coefficient K_D for ammonia between water and trichloromethane at 25°C. **(3 marks)**

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