

Chemistry II

014

01 Nov. 2013 08.30am - 11.30am

REPUBLIC OF RWANDA



RWANDA EDUCATION BOARD

ADVANCED LEVEL NATIONAL EXAMINATIONS 2013

SUBJECT: CHEMISTRY

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) Don't open this question paper until you are told so.
- 2) This paper consists of **two** sections: **A** and **B**.
 - **Section A:** Attempt **all** questions. (70 marks)
 - **Section B:** Attempt any **three** questions. (30 marks)
- 3) **You do not need the Periodic Table.**
- 4) Silent non-programmable calculators may be used.

SECTION A: ATTEMPT ALL QUESTIONS.**(70 marks)**

1. Explain the following observations:
- a) Atomic radius of fluorine is smaller than that of Lithium.
(Atomic number: F=9, Li=3) (2 marks)
 - b) Solubility of sulphates of group II (a) elements (MgSO_4 , CaSO_4 , SrSO_4 , BaSO_4) decreases as you move down the group. (2 marks)
 - c) Lead chloride (IV), PbCl_4 , is a covalent compound whereas lead chloride (II), PbCl_2 , is ionic. (2 marks)
2. a) Atomic number of magnesium is 12, atomic number of chlorine is 17:
- i. Write the electronic configuration of magnesium and that of chlorine (in terms of s, p, d...). (2 marks)
 - ii. Write a balanced chemical equation of the reaction between magnesium and chlorine. (1 mark)
- b) In terms of advantages and disadvantages; give four (4) differences between soap and detergents. (2 marks)
3. Write a balanced chemical equation for the reaction between:
- a) Cold dilute nitric acid (HNO_3) and Iron metal (Fe). (2 marks)
 - b) Copper metal (Cu) and concentrated nitric acid (HNO_3). (2 marks)
4. a) Define "enthalpy of solution". (2 marks)
- b) Calculate the enthalpy change (in joules) when 400g of water at 25°C is heated up to 100°C . (Specific heat capacity of water is $4.2 \text{ J/g}^\circ\text{C}$). (2 marks)
5. An electric current of 3.0 amperes is passed through a solution of Copper sulphate (CuSO_4) for 280 minutes.
- Equations:
- Anode : $4 \text{ OH}^-_{(\text{aq})} \longrightarrow 2 \text{ H}_2\text{O}_{(\text{l})} + \text{O}_{2(\text{g})} + 4\text{e}$
- Cathode: $\text{Cu}^{2+}_{(\text{aq})} + 2\text{e} \longrightarrow \text{Cu}_{(\text{s})}$ (2 marks)
- a) Calculate the mass (in g) of copper that is deposited.
 - b) Calculate the volume of $\text{O}_{2(\text{g})}$ liberated at the anode (at room temperature and pressure). (1 mole of a gas occupies 24 dm^3 at room temperature and pressure, 1 Faraday = 96500 C/mol, Atomic mass of Cu = 63.5) (2 marks)
6. This question deals with colligative properties of solutions **(a)** and **(b)**:
- a) An aqueous solution of 1.10 g of a protein in 100 ml of a solution has an osmotic pressure of 3.93×10^{-3} atmosphere at 25°C (298K).
Calculate the molar mass of the protein. ($R = 0.08203 \text{ L. atm.mol}^{-1} .\text{K}^{-1}$) (3 marks)
 - b) A solution of 2.95 g of sulphur (molecules) in 100 g cyclohexane has a freezing point of 4.18°C . Pure cyclohexane has a freezing point of 6.5°C .
 - i. Calculate the molecular mass of sulphur. (3 mark)
 - ii. Calculate the molecular formula of sulphur. (2 marks)(Atomic mass of sulphur=32, $K_f = 20.2^\circ\text{C Kg mol}^{-1}$).
7. a) Draw 4 different structural isomers (that are non cyclic) of a compound that is represented by the molecular formula of $\text{C}_4\text{H}_8\text{O}_2$. (4 marks)
- b) Complete and balance the following chemical equation: (2 marks)
- $\text{Cl}_2 + \text{NaOH}_{(\text{hot, concentrated})} \longrightarrow$

8. Ammonia is produced by Haber-Bosch process according to the following equation: $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$, $\Delta H = -92 \text{ kJ mol}^{-1}$
Indicate and explain what will happen to the position of equilibrium if:
a) Pressure is decreased. b) Temperature is decreased. (4 marks)
9. Write the mechanism of reaction of each chemical equation:
a) $\text{CH}_2 = \text{CH}_2 + \text{Br}_2 \longrightarrow \text{CH}_2\text{Br} - \text{CH}_2\text{Br}$ (2 marks)
b) $\text{CH}_3\text{CH}_2\text{Cl} + \text{OH}^- \longrightarrow \text{CH}_2 = \text{CH}_2 + \text{H}_2\text{O} + \text{Cl}^-$ (2 marks)
10. An organic compound A is constituted of C, H and O.
Its percentage composition by mass is as follows:
C=66.7%; H=11.1%; and O=22.2% (Atomic mass: C=12, H=1, O=16)
a) Find the empirical formula of compound A. (2 marks)
b) Find the molecular formula of compound A if its molecular mass is 72. (2 marks)
11. By using appropriate equations, illustrate how propan-1-ol can be converted (by using one step reaction equation or more than one step) into the following compounds indicating reactants and conditions required.
a) 2-Chloro propane. b) Amino butane (butyl amine). (4 marks)
12. a) Write 2 characteristics of transition metals. (1 mark)
b) Explain the reason why Zinc is not generally considered to be a transition metal. (Atomic number of Zinc=30) (1 mark)
c) Explain the reason why transition metals are coloured. (2 marks)
13. a) Write a chemical equation (or equations) to describe how zinc ions (Zn^{2+}) act as: i. An acid; ii. A base. (2 marks)
b) Write a balanced chemical equation for the reaction between:
i. Hot Concentrated sulphuric acid (H_2SO_4) and Carbon (C). (2 marks)
ii. Hot Concentrated nitric acid (HNO_3) and Sulphur (S). (2 marks)
14. Aluminium is obtained on a large scale by electrolysis.
a) Draw a labelled diagram for industrial production of Aluminium. (2 marks)
b) Write chemical equations that represent the reactions which take place on the cathode and on the anode during this electrolysis. (2 marks)
15. Draw the shapes of the following molecules and give the name of each shape. a) NH_3 b) IF_5 c) H_2O (3 marks)

SECTION B: Attempt any three questions. (30 marks)

16. Using appropriate equations of reaction by showing clearly the reagents, conditions and using structural formulae of the organic compounds, describe how the following compounds can be synthesized:
a) Phenol to 4-Nitrobenzoic acid. b) Nitro Benzene to 2-Bromo Phenol. (10 marks)
17. a) The pK_a of phosphoric acid (H_3PO_4) is 2.1. Given a 0.1M solution of H_3PO_4 and you are required to obtain a buffer solution of $\text{pH}=2$ by adding solution of NaH_2PO_4 . What should be the concentration of the salt (NaH_2PO_4)? (Atomic mass: H=1, O=16, Na=23, P=31). (3 marks)
b) The table below shows the rates of reaction between substance A and B at different concentrations.

| Experiment | [A] mol dm^{-3} | [B] mol dm^{-3} | Initial rate of reaction in $\text{mol dm}^{-3} \text{s}^{-1}$ |
|------------|-----------------------------|-----------------------------|---|
| 1. | 0.50 | 0.50 | 2.0×10^{-2} |
| 2. | 1.00 | 0.50 | 8.0×10^{-2} |
| 3. | 1.00 | 1.00 | 16.0×10^{-2} |

- i. Determine the overall order of reaction. (3 marks)
 ii. Calculate the rate constant indicating clearly its units. (2 marks)
 c) Suggest 2 processes used to obtain hydrogen gas on a large scale from water. (2 marks)
18. a) The molecular formula of alanine amino acid is $\text{CH}_3\text{CHNH}_2\text{COOH}$.
 i. Why does alanine amino acid present optical stereoisomerism? (1 mark)
 ii. Draw the 2 structures of alanine that represent its optical stereoisomers. (2 marks)
 b) i. Draw the 2 structures of 1, 2-dichloroethene that represent its geometrical stereoisomerism. (2 marks)
 ii. Write the structural formula of the monomer which is used to synthesize natural rubber (Isoprene) (1 mark)
 iii. State 2 requirements for improving the physical properties of rubber when tyres are manufactured. (2 marks)
 iv. State 2 monomers (or draw the structural formulae of the monomers) that are used to make polyester (terylene). (2 marks)
19. a) i. Define HESS' law. (2 marks)
 ii. Calculate the enthalpy of reaction (X) (3 marks)
- $$\text{CO}_{(\text{g})} + 2\text{H}_{2(\text{g})} + \frac{3}{2}\text{O}_{2(\text{g})} \longrightarrow \text{CO}_{2(\text{g})} + 2\text{H}_2\text{O}_{(\text{l})}; \Delta H_1^\circ = -204.2\text{Kcal}$$
- $$\text{CH}_3\text{OH}_{(\text{l})} + \frac{3}{2}\text{O}_{2(\text{g})} \longrightarrow \text{CO}_{2(\text{g})} + 2\text{H}_2\text{O}_{(\text{l})}; \Delta H_2^\circ = -182.5\text{Kcal}$$
- $$\text{CO}_{(\text{g})} + 2\text{H}_{2(\text{g})} \longrightarrow \text{CH}_3\text{OH}_{(\text{l})}; \Delta H_3^\circ = \text{X Kcal}$$
- b) According to the data given below in relation to the reaction:
- | [I ⁻]
(mol/dm ³) | [BrO ₃ ⁻]
(mol/dm ³) | [H ⁺]
(mol/dm ³) | Rate (mol dm ⁻³ s ⁻¹) |
|---|--|---|--|
| 0.10 | 0.10 | 0.10 | 3.0×10^{-4} |
| 0.14 | 0.18 | 0.10 | 7.56×10^{-4} |
| 0.10 | 0.18 | 0.10 | 5040×10^{-4} |
| 0.31 | 0.18 | 0.20 | 1.67×10^{-3} |
- Equation
 $\text{BrO}_3^- (\text{aq}) + 9\text{I}^- (\text{aq}) + 6\text{H}^+ \longrightarrow 3\text{I}_3^- (\text{aq}) + \text{Br}^- (\text{aq}) + 3\text{H}_2\text{O}_{(\text{l})}$
- i. Find the order of reaction with respect to:
 I⁻, BrO₃⁻ and H⁺ (3 marks)
 ii. Find the overall order of reaction. (1 mark)
 iii. Find the rate constant K for the reaction. (1 mark)
20. a) Write the structural formula of the following molecules:
 i. 3-Ethyl 2, 4-dimethyl pentane. (2 marks)
 ii. 3, 4-Dimethyl pentan-2-ol. (2 marks)
 b) Write a chemical equation for the cracking n-octane
 ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$). (2 marks)
 c) Explain the following observations (use chemical equations to clarify your answer):
 i. Zinc hydroxide precipitate, $\text{Zn}(\text{OH})_2$, disappears (becomes soluble) when a solution of ammonia, NH_3 , is added to it. (2 marks)
 ii. Calcium phosphate, $\text{Ca}_3(\text{PO}_4)_2$ is sparingly soluble in water but it dissolves in a solution of Nitric acid (HNO_3). (2 marks)