

2915/305
PHYSICAL CHEMISTRY III
Oct./Nov. 2022
Time: 3 hours



THE KENYA NATIONAL EXAMINATIONS COUNCIL
DIPLOMA IN ANALYTICAL CHEMISTRY

MODULE III

PHYSICAL CHEMISTRY III

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:

Answer booklet;

Scientific calculator.

This paper consists of TWO sections; A and B.

Answer ALL the questions in section A and any THREE questions from section B.

Each question in section A carries 4 marks while each question in section B carries 20 marks.

Maximum marks for each part of a question are indicated.

Candidates should answer the questions in English.

This paper consists of 5 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

SECTION A (40 marks)

Answer ALL the questions in this section.

1. For an ideal gas, show that $R = C_p - C_v$. (4 marks)
2. (a) State Faraday's 1st law of electrolysis. (2 marks)
(b) State two applications of electrolysis (2 marks)
3. The equivalent conductances of sodium chloride, hydrochloric acid and sodium acetate at infinite dilutions are 126.45 and 91.0 Ohms/cm²/eq respectively. Calculate the conductance of acetic acid at infinite dilutions. (4 marks)
4. Calculate the change in entropy when 500 cm³ of water at 0 °C is heated to 80 °C. ($C_p = 75.6 \text{ J/mol/K}$). (4 marks)
5. Draw an energy level diagram, that relates the heats of formation of CO₂, H₂O, C₂H₂ and the heat of combustion of C₂H₆. (4 marks)
6. (a) State Hess's laws. (2 marks)
(b) Explain why AgCl is insoluble in water and NaCl is soluble in water. (2 marks)
7. For each of the following reactions, state with reasons whether the entropy increases, decreases or stays the same:
 - (i) $2 \text{CO}_{(g)} + \text{O}_{(g)} \rightarrow 2 \text{CO}_{2(g)}$; (2 marks)
 - (ii) $\text{C}_{(s)} + \text{CO}_{2(g)} \rightarrow 2 \text{CO}_{(g)}$. (2 marks)
8. Given the following reaction $2 \text{NOCl}_{(g)} \rightleftharpoons 2 \text{NO}_{(g)} + \text{Cl}_{2(g)}$. Calculate the equilibrium constant given $T = 400 \text{ K}$, $\Delta H^\circ = 77.2 \text{ KJ}$ and $\Delta S = 122 \text{ J/K}$. (4 marks)
9. (a) Define the following terms:
 - (i) entropy; (1 mark)
 - (ii) adiabatic change. (1 mark)
(b) Write the Nersts equation. (2 marks)
10. (a) State **two** advantages of potentiometric titrations. (2 marks)
(b) State **two** conditions necessary for alloying of metals. (2 marks)

SECTION B (60 marks)

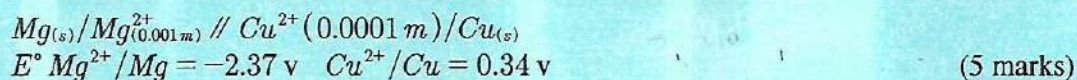
Answer any **THREE** questions from this section.

11. (a) Define the following terms as used in thermodynamics:
- (i) isochoric change; (2 marks)
 - (ii) isobaric change. (2 marks)
- (b) An ideal gas of 5.2 moles, undergoes a reversible isothermal compression from 3 litres to 1litre at 260 K. Calculate :
- (i) work done (w); (3 marks)
 - (ii) heat flow (q); (2 marks)
 - (ii) du; (3 marks)
 - (iv) ΔH . (3 marks)
- (c) 3 moles of an ideal gas was heated at constant pressure in the process absorbing 299 J of heat energy with the temperature increasing by 2.55 K. Calculate:
- (i) C_p ; (2 marks)
 - (ii) C_v . (2 marks)
- (d) State an example of an isolated system. (1 mark)
12. (a) On the same axes, sketch a graph of the molar conductivity Vs $\sqrt{\text{concentration}}$ for a strong electrolyte and a weak electrolyte. (4 marks)
- (b) (i) Describe how the graph above, can be used to determine molar conductivity value at infinite dilution for a strong electrolyte. (3 marks)
- (ii) State why it is impossible to use the graph above to determine the molar conductivity value at infinite dilution for a weak electrolyte. (2 marks)
- (c) Consider the following cell:
- $$2 Ag_{(s)} + Zn^{2+}_{(aq)} \rightarrow 2Ag^+ + Zn_{(s)} \text{ given that } E_{zn}^{\circ} = -0.76 \quad E_{Ag}^{\circ} = +0.80 .$$
- (i) Write the half cell equations for:
 - (I) anode; (2 marks)
 - (II) cathode. (2 marks)
 - (ii) Predict wether or not the cell is feasible (4 marks)
- (d) State **three** advantages of glass electrodes. (3 marks)

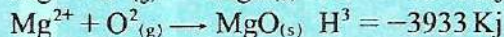
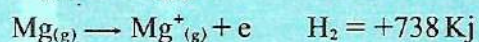
13. (a) State **three** types of potentiometric titrations. (3 marks)
- (b) Describe how qualitative analysis is done in polarography. (7 marks)
- (c) State **three** applications of Kohlrausch's law of independent migration. (3 marks)
- (d) (i) State Ostwald's dilution law. (2 marks)
(ii) Using appropriate equations, explain why rust is considered an electrochemical process. (5 marks)

14. (a) Differentiate the following terms as used in solid state chemistry:
- (i) crystal lattice and unit cell; (3 marks)
(ii) hexagonal close packing and cubic-close packing. (3 marks)
- (b) With examples, differentiate crystalline solids from amorphous solids. (4 marks)
- (c) Aluminium crystallizes in a cubic close packed structure. Its metallic radius is 125×10^{-10} cm.
- (i) calculate the length of the side of the unit cell;
(ii) calculate the volume of the unit cell. (5 marks)

- (d) Calculate the E_{cell} of the cell below:

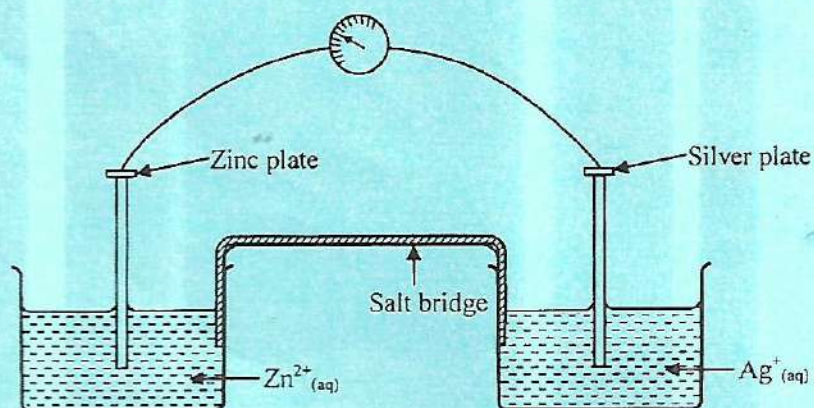


15. (a) Analyse the data given below and use it to answer the questions below:



- (i) Construct a Born-Haber energy level diagram for the data above. (12 marks)
(ii) Calculate the heat of formation of MgO. (3 marks)

(b)



- (i) Explain what would happen if the salt bridge is removed. (2 marks)
- (ii) State the anode and cathode in this cell. (2 marks)
- (iii) Predict the direction of electron flow in the cell above if $E_{\text{Zn}}^{\circ} = -0.62$ $E_{\text{Ag}}^{\circ} = -0.32$. (1 mark)

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