(6)

Name of the Program: B.Sc. in MPE/IPE
Semester: 1st

Date: 23 December 2023 (Group A)
Time: 01:30 am–04:30 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course No.: Chem 4115
Course Title: Physical and Inorganic Chemistry

Winter Semester, A. Y. 2022-2023
Time: 3 hours
Full Marks: 150

There are **6 (three)** questions. Answer all **6 (three)** questions. The symbols have their usual meanings. Programmable calculators are not allowed. Marks of each question and corresponding COs and POs are written in the brackets.

1. a) Explain the orbital overlap diagram associated with formation of C_2H_2 molecule. 7 CO1 PO1

   b) Describe peptization method for the preparation of $Fe(OH)_3$ sol. 7 CO1 PO1

   c) Discuss Kohlrausch's law of independent migration of ions. 7 CO1 PO2

2. a) How does the molecular orbital theory (MOT) describe the less stability of the He_2^+ ion than the H_2^+ ion? 8 CO2 PO2

   b) For the following reaction identified the conjugated acid-base pairs and decide which species (reactant or product) is favored at the completion of the reaction? 8 CO2 PO2
   SO_4^{2-} (aq) + HCN (aq) ⇌ HSO_4^- (aq) + CN^- (aq); here HCN is considered as the weakest acid.

   c) Establish a relationship between an ion's migration speed and its transport number. 8 CO2 PO2

3. a) Calculate the bond order of O_2 molecule displaying the electronic states in various bonding and anti-bonding molecular orbitals? 10 CO3 PO2

   b) Determine whether an aqueous solution of NH_4CN is acidic, basic or neutral at 25 °C. (Here, the dissociation constant of HCN and NH_3 are 6.2×10^{-10} and 1.76×10^{-5} respectively) 10 CO3 PO2

   c) What is the cell potential of the following voltaic cell at 25 °C? 10 CO3 PO2
   $Zn(s)|Zn^{2+}(1.000\times10^{-5}\ M)\ ||\ Cu^{2+}(0.100\ M)|Cu(s)$;
   the cell potential of this cell is 1.10 Volt.

4.	a)	Discuss the Raoult's law for elevation of boiling point.	7	CO1 PO1
	b)	Explain how rates of zero-, first- and second order reactions change with increasing concentrations.	7	CO1 PO1
	c)	Deduce the relationship between K_c and K_p.	7	CO1 PO2
5.	a)	Derive thermodynamically an expression for ebullioscopic constant, K_b, from boiling point elevation.	8	CO2 PO2
	b)	"First-order reaction never complete." Justify this statement by considering the first-order reaction, $A \rightarrow P$.	8	CO2 PO2
	c)	Discuss the effect of temperature on equilibrium and equilibrium constant.	8	CO2 PO2
6.	a)	100 mL 0.01 mol L^{-1} solutions of KCl, ethanol and ethanoic acid are taken separately into three beakers. Arrange them in order of increasing boiling point with proper explanation.	10	CO3 PO2
	b)	Calculate the rate constant of an exothermic reaction at 600 °C. (Here, the activation energy is 182 kJ mol^{-1} and the rate constant is 1.57×10^{-3} s^{-1}at 700 °C). Hence, discuss the effect of temperature on the rate of exothermic reaction.	10	CO3 PO2
	c)	Calculate the pH of a mixture containing 60 mL 0.02 mol L^{-1} CH_3COOH and 40 mL 0.025 mol L^{-1} CH_3COONa after establishing Henderson–Hasselbalch equation for this system. [Given that $K_a = 1.7 \times 10^{-5}$]	10	CO3 PO2