B.Sc. Eng.IPE/1st Sem.

Date: 12 January 2026
Afternoon

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF NATURAL SCIENCES

Mid Examination
Course Number: Chem 4115
Course Title: Physical and Inorganic Chemistry

Winter Semester: 2024-2025
Full Marks: 120
Time: 2 Hours

Please answer according to the order of the questions. Answer all the **4 (FOUR)** questions. The symbols have their usual meanings. Marks of each question and the corresponding CO and PO are written in the brackets.

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1. a)	Describe the Bohr's postulates of atomic structure and how it can be used to calculate the radius of orbit of a hydrogen like atom.	(12)	(CO2, PO1)
b)	"Within any period, values of first ionization energy tend to increase with atomic number, except for small drops at the group IIIA and VIA elements." Justify the statement with appropriate examples.	(10)	(CO2, PO1)
c)	Calculate the longest wavelength of the electromagnetic radiation emitted by the hydrogen atom during a transition from n = 7 level to n=1 level.	(8)	(CO2, PO1)
2. a)	Define colligative properties. If 1 mol samples of urea, sodium chloride, and calcium chloride are each dissolved in equal volumes of water in separate containers, explain the following with appropriate equations: i) Which solution has the highest boiling point? ii) Which solution has the highest freezing point?	(12)	(CO2, PO1)
b)	Automotive antifreeze consists of ethylene glycol, $CH_2(OH)CH_2(OH)$, a nonvolatile nonelectrolyte. Calculate the boiling point and freezing point of a 25.0 % solution of ethylene glycol in water. K_b and K_f for water are 0.512°C/m and 1.86°C/m, respectively.	(8)	(CO2, PO1)
c)	Draw the phase diagram for water system and explain each part in it. Show triple point for one component system is an invariant point.	(10)	(CO2, PO1)
3. a)	Explain Raoult's law for lowering of vapor pressure for a dilute solution. Derive an equation for determining molecular mass of a solute using lowering of vapor pressure.	(7)	(CO1, PO1)
b)	Estimate the maximum number of electrons that can occupy each of the following sublevel in an atom. Explain your answer with the help of the four quantum numbers. (i) $4p$ (ii) $n = 3, l = 1, m = +1$ (iii) $n = 5, l = 3, m = 2, s = -1/2$	(8)	(CO1, PO1)

c) Deduce a relationship between K_p and K_c, and find this relationship for the following reactions: (15) (CO1, PO1)

i) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

ii) $2NH_3(g) + 3CuO(s) \rightleftharpoons 3H_2O(g)\ N_2(g) + 3Cu(s)$

iii) $H_2O(g) \rightleftharpoons H_2O(l)$

iv) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

v) $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$

4. a) Explain Nernst's distribution law and describe how it is altered when the solute associates in one of the solvents. (8) (CO1, PO1)

b) How is the reaction quotient useful for predicting the direction of reaction? Given that at 700K, K_p=54.0 for the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ and $K_p = 1.04 \times 10^{-4}$ for the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, determine the value of K_p for the reaction $2NH_3(g) + 3I_2(g) \rightleftharpoons 6HI(g) + N_2(g)$ at 700K. (10) (CO1, PO1)

c) Explain Le Chatelier's principle? (12) (CO1, PO1)

Consider the equilibrium

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \quad \Delta H^0 = 58.0\ kJ$$

In which direction will the equilibrium shift when (a) N_2O_4 is added, (b) NO_2 is removed, (c) the pressure is increased by addition of $N_2(g)$, (d) the volume is increased, (e) the temperature is decreased? Explain briefly