

The Open University of Sri Lanka

Faculty of Natural Sciences

B.Sc/ B. Ed Degree Programme



Department	: Chemistry
Level	: 4
Name of the Examination	: Final Examination
Course Code and Title	: CYU4300; Inorganic Chemistry
Academic Year	: 2025/2026
Date	: 06-December-2025
Time	: 1.30 – 3.30 p.m.
Duration	: 2 hours
Index number	:

General Instructions

1. Read all the instructions **carefully** before answering the questions.
2. This question paper consists of 04 questions in 07 pages.
3. Answer all questions. Each question carries equal marks.
4. The answer to each question should commence from a new page.
5. Draw fully labeled diagrams where necessary.
6. Any unauthorized documents/mobile phones in your possession are a punishable offense.
7. Use blue or black ink to answer the questions.
8. Circle the number of questions you answered on the front cover of your answer script.
9. Clearly state your **index number in your answer script**.

Avogadro constant, $L = 6.023 \times 10^{23} \text{ mol}^{-1}$	Mass of a proton = 1.0073 a.m.u.
Gas constant, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$	Mass of a neutron = 1.0087 a.m.u.
Planck's constant, $h = 6.63 \times 10^{-34} \text{ J s}$	1 a.m.u. = $1.661 \times 10^{-27} \text{ kg}$
Velocity of light, $c = 3 \times 10^8 \text{ m s}^{-1}$	1 MeV = $1.6022 \times 10^{-13} \text{ J}$
Mass of an electron = 0.0005 a.m.u	$\ln x = 2.303 \log_{10} x$

Periodic Table of Elements

1																	18				
1 H 1.008	2	<div>atomic number</div> <div>Symbol</div> <div>atomic weight</div>														13	14	15	16	17	2 He 4.003
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18				
11 Na 22.99	12 Mg 24.31	3	4	5	6	7	8	9	10	11	12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95				
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80				
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc -	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3				
55 Cs 132.9	56 Ba 137.3	57-71	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po -	85 At -	86 Rn -				
87 Fr -	88 Ra -	89-103	104 Rf -	105 Db -	106 Sg -	107 Bh -	108 Hs -	109 Mt -	110 Ds -	111 Rg -	112 Cn -	113 Nh -	114 Fl -	115 Mc -	116 Lv -	117 Ts -	118 Og -				

01. Answer all parts (a) – (g).

(a) $\text{CoSO}_4\text{Cl}\cdot 5\text{NH}_3$ exists in two isomeric forms 'A' and 'B'. Isomer 'A' reacts with AgNO_3 to give a white precipitate but does not react with BaCl_2 . Isomer 'B' gives a white precipitate with BaCl_2 but does not react with AgNO_3 . Answer the following questions using the given information.

- Identify **A** and **B** and write their structural formulas.
- Name the type of isomerism involved.
- Write the ionic forms of complexes **A** and **B** in aqueous solution.
- Give the IUPAC name of **A** and **B**.

(25 marks)

(b) State the radioactive decay series for each of the following isotopes.

- ^{238}U
- ^{232}Th

(06 marks)

(c) Write balanced equations for the following nuclear processes.

- Protactinium-234 decays to form Uranium-234
- Uranium-235 is bombarded with a neutron and undergoes nuclear fission to produce Barium-141 and Krypton-92.

(09 marks)

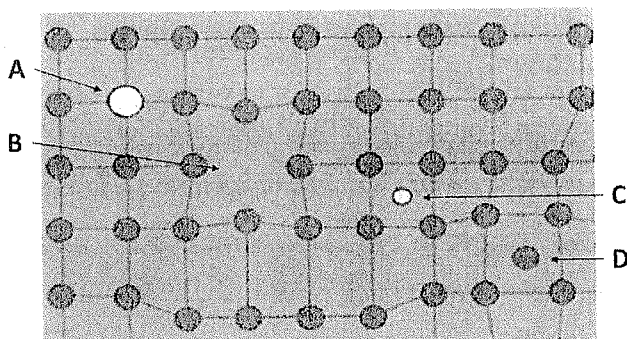
(d) Predict the most probable mode of radioactive decay for each of the following nuclides and write the corresponding balanced nuclear equation.

- $^{226}_{88}\text{Ra}$
- $^{11}_6\text{C}$

(10 marks)

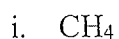
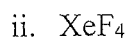
(e) Formation of point defects in crystal solids is a spontaneous process.

- What is a point defect in a crystal lattice?
- Identify the different types of point defects (A - D) shown in the metallic solid below.



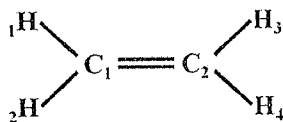
- Using the Gibbs free energy equation, $\Delta G = \Delta H - T\Delta S$, justify that defect formation is a spontaneous process.
- Crystals of NaCl grown from a melt containing a small amount of CaCl_2 exhibit higher electrical conductivity compared to pure NaCl crystals. Identify the defect that occurred and briefly explain how this defect leads to increased conductivity in the crystal. (25 marks)

(f) Using your knowledge of molecular symmetry, predict the polarity of each of the following molecules. If a molecule is nonpolar, identify the symmetry element(s) that are responsible for its nonpolar nature.



(10 marks)

(g) Consider the following molecule



Draw the resultant structure of the molecule after performing each of the following symmetry operations. (Ensure that the atom numbers are clearly shown in your answer.)

- Rotation through the principal axis (C_n)
- Inversion (i)
- Vertical mirror plane (σ_v)

(15 marks)

02. Answer all parts (a) – (d).

(a) When ambidentate ligands coordinate to a central metal ion, they can attach through different donor atoms.

- Name the type of isomerism exhibited by such compounds.
- Give two examples of ambidentate ligands.
- Illustrate your answer with an example of a complex that shows this isomerism and give the IUPAC names.
- Draw the structural formula of the complex $[(\text{H}_3\text{N})\text{ClPd}(\mu\text{-Cl})_2\text{PdCl}(\text{NH}_3)]$ showing the arrangement of ligands around both palladium centers and calculate the coordination number (C.N.) of the central metal atom **Pd** in the compound.

(25 marks)

(b) An octahedral complex (**F**) is formed when one mole of NiCl_2 reacts with one mole of ethylenediamine (en) and two moles of ammonia (NH_3) in aqueous solution. The resulting compound behaves as a non-electrolyte and exhibits paramagnetism.

- Write the possible molecular formula and draw the structure of complex (**F**).
- Determine the oxidation number of nickel in **F** and the type of hybridization involved.

(20 marks)

(c) The octahedral complexes $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Co}(\text{NH}_3)_6]^{2+}$, both contain the same central metal ion, but they exhibit different colors in aqueous solution.

- Write the electronic configuration of Co^{2+} .
- Explain the reason for the difference in their colors in terms of ligand field strength and crystal field splitting energy (Δ_o).

(15 marks)

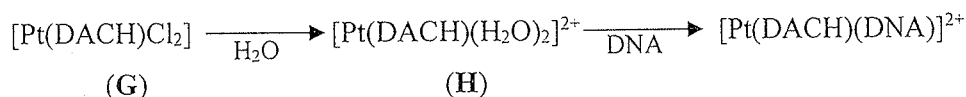
(d)

- List three factors that influence the magnitude of crystal field splitting energy (Δ_o) in octahedral complexes.
- According to Crystal Field Theory, determine the d-electron configuration (number of t_{2g} and e_g electrons) of **Co** in $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$. (*Assume H_2O is a weak field ligand.*)
- Calculate the Crystal Field Stabilization Energy (**CFSE**) in kJ mol^{-1} if $\Delta_o = 12,000 \text{ cm}^{-1}$. ($1 \text{ cm}^{-1} = 0.012 \text{ kJmol}^{-1}$)
- If the pairing energy (**P**) = $20,000 \text{ cm}^{-1}$, calculate the total Stabilization Energy (**TSE**) of the complex.
- Calculate the spin-only magnetic moment (μ_s) of this complex.

(40 marks)

03. Answer all parts (a) – (d).

- (a) Oxaliplatin (**G**) is a platinum (II) coordination complex used as an anticancer drug. It shows activity similar to cisplatin $[\text{PtCl}_2(\text{NH}_3)_2]$, but contains a chelating ligand, 1,2-diaminocyclohexane (DACH), instead of ammonia. Upon entering the cell, the chloride ligands are replaced by water molecules, forming the diaqua complex (**H**), which then binds to the nitrogen atoms of DNA bases and disrupts cell replication. (*DACH = 1,2-diaminocyclohexane*)



- What are the three main mechanisms involved in ligand substitution reactions of coordination compounds?
 - Out of these mechanisms, which one is most likely for the aquation of oxaliplatin ($\text{G} \rightarrow \text{H}$)? Explain your answer with reference to the metal center, geometry, and leaving group properties.
 - Define the term “trans effect.”
 - If you are asked to synthesize complex (**G**), which starting material would you choose $[\text{PtCl}_4]^{2-}$ or $[\text{Pt}(\text{NH}_3)_4]^{2+}$? Briefly explain your answer. (50 marks)
- (b) Technetium-99m ($^{99\text{m}}_{43}\text{Tc}$) is a radioactive isotope commonly used in medical imaging because it emits gamma radiation and decays to the stable isotope technetium-99 ($^{99}_{43}\text{Tc}$). A hospital receives a 200.0 MBq sample of $^{99\text{m}}_{43}\text{Tc}$ for diagnostic purposes. The isotope has a half-life of 6.0 hours.
- Define the following terms.

A. Activity of a radioactive sample	B. Half-life
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 - Calculate the decay constant (λ) of $^{99\text{m}}_{43}\text{Tc}$ in s^{-1} .
 - Calculate the radioactive activity (in MBq) of $^{99\text{m}}_{43}\text{Tc}$ after 18 hours.
 - A patient scan requires a minimum activity of 6.25 MBq. Calculate the maximum storage time (in hours) of the $^{99\text{m}}_{43}\text{Tc}$ sample before its activity falls below this value. (32 Marks)
- (c) A 2.00 kg batch of pharmaceutical powder contains an unknown amount of the compound Medorin. To determine its content, 2.00 mg of ^{14}C -labelled Medorin (radioactive tracer) is added and thoroughly mixed. The tracer's specific activity

before mixing is 180 counts/min/mg, and after mixing, it decreases to 30 counts/min/mg. Calculate the mass percentage of Medorin in the sample.

(18 Marks)

04. Answer all parts (a) – (e).

(a) Potassium crystallizes in a body-centered cubic (BCC) lattice. The molar mass of potassium is 39.0 g mol^{-1} .

- Draw the unit cell of a body-centered cubic (BCC) lattice.
- Calculate the number of atoms per BCC unit cell.
- Calculate the approximate number of unit cells present in 4.0 g of potassium. Avogadro's number is $6.023 \times 10^{23} \text{ mol}^{-1}$.

(20 marks)

(b) The interplanar spacing d for a cubic lattice is given by, $d = \frac{a}{\sqrt{h^2+k^2+l^2}}$, where a is the lattice parameter and d is the perpendicular distance between two adjacent (hkl) planes.

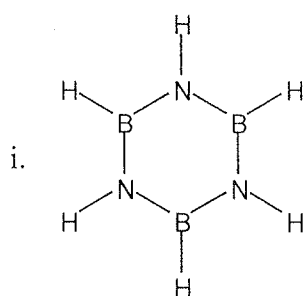
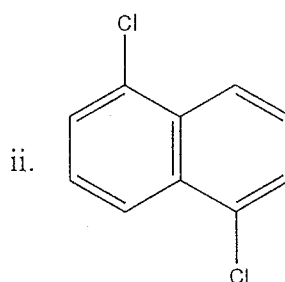
- Draw a cubic unit cell and indicate the (122) plane on it.
- For a crystal with atoms arranged in the (122) planes, the lattice parameter is $4.056 \text{ \AA}$. Calculate the perpendicular interplanar spacing d between adjacent (122) planes.
- When this crystal is exposed to a Cu $K\alpha$ X-ray beam of wavelength $1.54 \text{ \AA}$ in an X-ray diffractometer, determine the Bragg angle at which first-order diffraction ($n = 1$) occurs.

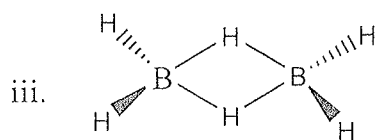
(30 marks)

(c) Using the principal rotational axis of the H_2O molecule as a reference, define the identical and equivalent structures. Illustrate the answer with clearly labeled diagrams.

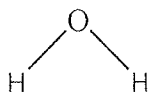
(10 marks)

(d) Indicate all the symmetry elements **other than E** present in the following molecules. One mark will be deducted for each incorrect answer.

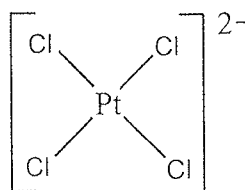




iv.



v.



(25 Marks)

(e) Which single symmetry operation is equivalent to each of the following products for the XeF₄ molecule?

i. $C_2(x) \times C_2(y)$ [Perform C_2 operation about the y-axis, then C_2 operation about the x-axis]

ii. $\sigma_{d1} \times \sigma_{d2}$ [Reflect across any diagonal plane, then reflect across the remaining diagonal plane.]

iii. $C_4 \times C_4$

(15 marks)
