00368

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/CMU2122 Inorganic Chemistry**
Academic Year	: 2019/2020
Date	: 03-01-2020
Time	: 2.00-4.00 p.m.
Duration	: 2 hours
Index number	:

General Instructions

1. **Read all instructions carefully** before answering the questions.
2. This question paper consists of 06 questions in 07 pages.
3. Answer 04 questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Draw fully labelled diagrams where necessary
6. Having any unauthorized documents/mobile phones in your possession is a punishable offense
7. Use blue or black ink to answer the questions.
8. Circle the number of the questions you answered in the front cover of your answer script.
9. Clearly state your **index number** in your answer script.

Avogadro constant, L	$= 6.023 \times 10^{23}\ mol^{-1}$
Gas constant, R	$= 8.314\ J\ K^{-1} mol^{-1}$
Planck's constant, h	$= 6.63 \times 10^{-34}\ J\ s$
Velocity of light, c	$= 3 \times 10^{8}\ m\ s^{-1}$
Mass of an electron	= 0.0005 a.m.u
Mass of a proton	= 1.0073 a.m.u.
Mass of a neutron	= 1.0089 a.m.u.
1 a.m.u.	$= 1.661 \times 10^{-27}\ kg$
1 MeV	$= 1.6021 \times 10^{-13}\ J$

$$\ln x = 2.303 \log_{10} x$$

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Answer only FOUR (04) questions.

Questions 1, 2, 3 and 4 are COMPULSORY for students registered for CYU4300.
Questions 1 is COMPULSORY for students registered for CMU2122.
Questions 5 and 6 are ONLY for students registered for CMU2122.

1. (a) (i) What is the **oxidation number** of Fe in $[Fe(C_2O_4)(gly)(en)]$ (**A**)?
($gly^- = H_2NCH_2COO^-$ and en = $H_2NCH_2CH_2NH_2$)
(ii) Give the IUPAC name of (**A**).
(iii) What is the **coordination number** of Fe in (**A**)?
(iv) Determine the Effective Atomic Number (EAN) of Fe in (**A**).
(Atomic number of Fe is 26)
(v) Write the chemical formula of diaquatetrachlorochromate(III) ion? (25 marks)

(b) Write complete nuclear equation for each of the following notations:
(i) ${}^{32}_{16}S(n,p)$? (ii) ${}^{96}_{42}Mo\ (?, n)^{97}_{43}Tc$ (04 marks)

(c) Defining the term 'activity' of a radionuclide, calculate the activity of 1 mg of *fluorine- 18* ($t_{1/2}$ = 110 min) in Becquerel (Bq). (12 marks)

(d) Giving reasons, identify the nuclide from the pair given below that will be expected to be unstable and predict the mode(s) of decay that the radionuclide may undergo. Write nuclear equation(s) for the decay process(es).

${}^{11}_{5}B$, ${}^{8}_{5}B$ (09 marks)

(e) How does the melting point of a crystalline substance differ from that of an amorphous substance? Explain. (06 marks)

(f) Consider the equation, $n\lambda = 2d \sin\theta$.

(i) For what specific purpose does this equation used for?

(ii) Identify the parameters in the equation and the values/limitations each parameter can take. (08 marks)

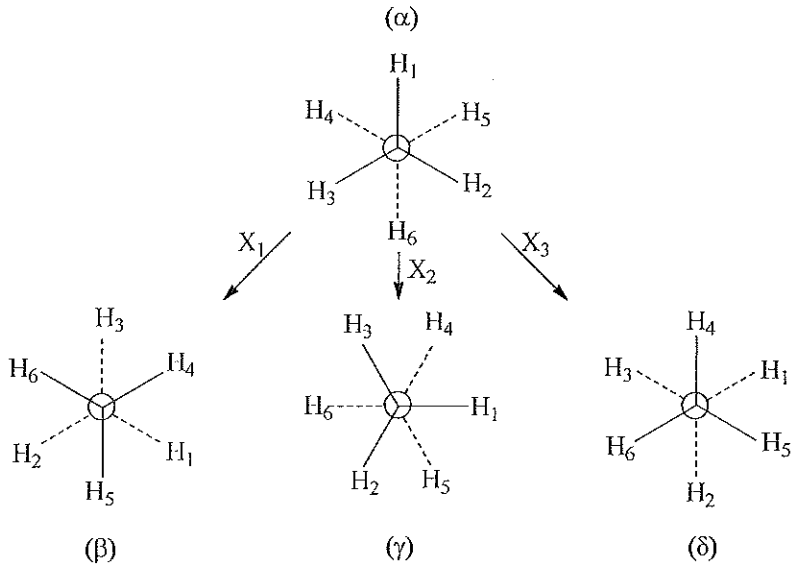
(g) Potassium crystallizes in a body centred cubic (bcc) lattice.

(i) Draw the bcc unit cell.

(ii) Calculate the approximate number of unit cells in 4.0 g of potassium.
Molar mass of potassium = 39 g mol^{-1} (11 marks)

(h) Define *equivalent configurations* of a molecule.

(i) In the following figure, (α), (β), (γ) and (δ) represent four staggered configurations of ethane in Newman projection formulae. Configurations (β), (γ) and (δ) are obtained when operations X_1, X_2 and X_3 are performed on (α).



(i) Identify the symmetry operation/s out of X_1, X_2 and X_3. Briefly explain your answer.

(ii) Describe operation X_2. (25 marks)

2. (a) (i) According to the Crystal Field Theory, what is the *d*-electron configuration (number of t_{2g} and e_g electrons) of iron in $[Fe(CN)_6]^{3-}$?
CN^- is a strong field ligand and the Group number of Fe is 8.

(ii) Calculate the Crystal Field Stabilization Energy (**CFSE**) in kJ mol^{-1} if $\Delta_o = 300$ kJ mol^{-1}.

(iii) Calculate the Total Stabilization Energy (**TSE**) in kJ mol^{-1}

if Pairing Energy = 120 kJ mol^{-1}.

(iv) Calculate the spin only magnetic moment (μ_s) of $[Fe(CN)_6]^{3-}$.

(v) Determine the Valence Electron Count (VEC) of Fe in $[Fe(CN)_6]^{3-}$. (44 marks)

(b) (i) State **three** assumptions made in Valence Bond Theory.

(ii) Using Valence Bond Theory, predict the hybridization of Fe in the **diamagnetic** complex ion $[Fe(CN)_6]^{4-}$. (18 marks)

(c) (i) What is meant by "trans effect"?

(ii) How would you prepare *trans*-$[PtCl_2(NH_3)(CO)]$ from $[PtCl_4]^{2-}$ if the *trans*-effect order is $CO > Cl^- > NH_3$. (20 marks)

(d) An octahedral complex (**B**) with the empirical formula $CoCl_3 \cdot 4NH_3$ shows a molar conductivity typical for a 1:1 electrolyte (100 $m^2\Omega^{-1}mol^{-1}$). What is the molecular formula of (**B**)? Draw the structures of the two isomers of (**B**) and identify the type of isomerism involved. (18 marks)

3. (a) Draw the structures of the **four** geometrical isomers of $[RhBr(en)(NH_3)_2]$ (**C**) if the geometry of (**C**) is **square pyramidal**. (en = $H_2NCH_2CH_2NH_2$) (20 marks)

(b) The **tetradentate** ligand, $H_2NCH_2CH_2NHCH_2CH_2NHCH_2CH_2NH_2$, (trien) reacts with $PtCl_2$ to give the square planar complex (**D**). With an excess of $AgNO_3$, a mole of (**D**) gives two moles of AgCl. Draw the **structure** of (**D**). (15 marks)

(c) Predict the product(s) of the following reactions using the hint given in the brackets.

(i) $[PtCl_4]^{2-} + CH_2 = CH_2 \rightarrow ? + ?$ (substitution)

(ii) $[Mn(CH_3)(CO)_5] + CO \rightarrow ?$ (insertion) (15 marks)

(d) (i) Define the term 'binding energy' of a radionuclide.

(ii) Given the mass of hydrogen atom = 1.007825 u, mass of *lithium-7* = 7.016003 u, calculate the average binding energy of *lithium-7*. (12 marks)

(e) (i) Define the term 'nuclear fusion'.

(ii) Giving the complete nuclear equation, calculate the Q - value for the D-T fusion reaction: ${}_1^3H(d,n){}_2^4He$

Given that the mass of ${}_1^3H = 3.0160492$ u; ${}_1^2H = 2.0141017$ u; ${}_2^4He = 4.0026033$ u. (18 marks)

(f) *Potassium- 40* decays to *argon- 40* with a half- life of 1.27×10^9 y. Write nuclear equation(s) for the radioactive decay of *potassium-40* to *argon-40*. If a rock is composed of these elements in which the mass ratio of ^{40}Ar to ^{40}K is 3.6, what is the age of the rock? (20 marks)

4.(a) Iron metal has a body-centered cubic (bcc) unit cell with an edge length of 286.65 pm. Molar mass of Fe = 55.8 g mol^{-1}. Use the given data to calculate the density of iron. (25 marks)

(b) The atomic packing factor (APF) is defined as the ratio of sphere volume to the total unit cell volume.

(i) Write an expression for the atomic packing factor for a simple cubic unit cell if the unit cell parameter is "a" and atomic radius is " r".

(ii) Calculate the APF for a simple cubic structure as a percentage. What percentage of the unit cell is vacant?

(iii) Can the above structure be considered as a "close packed structure"? Explain. (assume atoms touch along the atomic parameter) (25 marks)

(c) Define the following terms as applied in studying symmetry of molecules.

(i) Order of a rotational axis

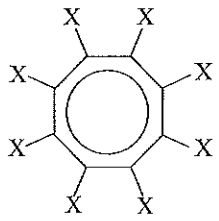
(ii) Principal axis of a molecule.

(iii) Vertical plane.

(iv) Dihedral plane.

(v) Horizontal plane. (20 marks)

(d) A student prepared an unstable molecule, C_8X_8, by replacing all eight hydrogen atoms in C_8H_8 with X atoms. The configuration of this planar molecule, C_8X_8, is shown in the figure.



(i) Locate all the rotational axis of symmetry in the molecule and indicate their orders.

(ii) Giving reasons identify the principal axis of the molecule.

(iii) Locate all the symmetry planes of the molecule.

(iv) Giving reasons, classify them as vertical, dihedral or horizontal planes.

(30 marks)

Questions 5 and 6 are ONLY for students registered for CMU2122

5. (a) (i) What is the **molecular formula** of the **binuclear** compound diamminedichloro-μ-dichlorodiplatinum(II) (**E**).

(ii) (**E**) is a symmetrical 16e complex without a metal-metal bond. Draw the **structures** of the two isomers (*cis*- and *trans*-forms) of (**E**).

(iii) What is the **coordination number** of each Pt in (**E**). (30 marks)

(b) The substance with the composition $CrCl_3 \cdot 5H_2O \cdot NH_3$ shows hydrate **isomerism**.

(i) Give the chemical formulae of **three** salts if they form octahedral geometry.

(ii) State a **chemical test** to distinguish these isomers. (20 marks)

(c) Radiotracers have found wide use as diagnostic tools in medicine.

The diagnostic use of these isotopes is based upon the ability of their compounds to localize and concentrate in the organ or tissue under investigation.

(i) Relate the use of *iodine-131* and *phosphorus-32* to the area of the body studied.

(ii) Giving **one** example of a radionuclide used, briefly describe the method, Positron Emission Tomography (PET). (30 marks)

(d) Draw a labelled diagram of Geiger- Muller counter and briefly describe the method of detection of radiation. (20 marks)

6. (a) Titanium monoxide, TiO has a rock-salt structure. X-ray diffraction data show that the length of one edge of the cubic unit cell for TiO is 4.18Å, and the density as determined by volume and mass measurements is 4.92 g cm^{-3}. (Molar masses, Ti = 47.88 g mol^{-1}, O = 16 g mol^{-1}).

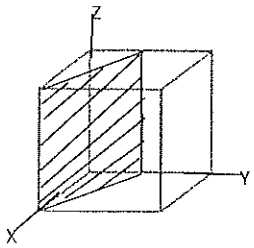
(i) How many **formula units** are there in a unit cell?

(ii) Calculate the density and compare with the given value to judge whether any defects are present in the crystal.

(iii) If defects are there, are they vacancy or interstitial defects?

(iv) Comment on the stoichiometry of the defected crystal based on your answer for (iii). (25 marks)

(b) (i) Determine the Miller indices of the plane shown below.



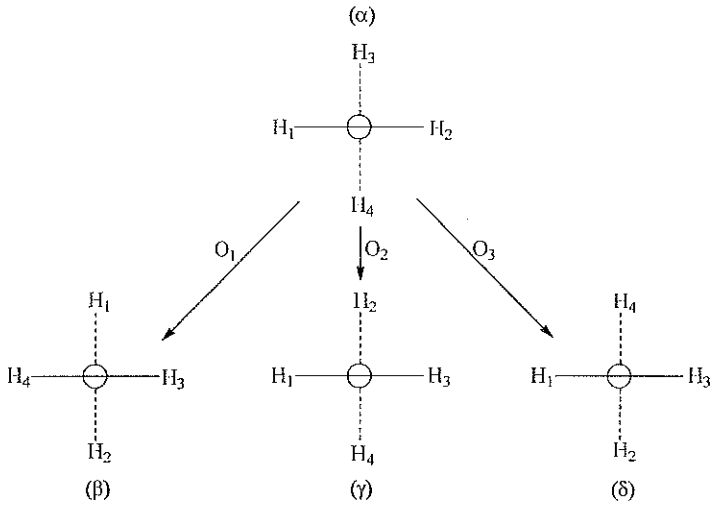
(ii) Indicate the (011) plane on a cube. (25 marks)

(c) Define the following as applied in studying symmetry of molecules.

(i) Improper rotational operation.

(ii) Improper (symmetry) axis of rotation. (14 marks)

(d) In the following figure, (α), (β), (γ) and (δ) represent four configurations of a CH_4 molecule (tetrahedral), in Newman projection formulae. Configurations (β), (γ) and (δ) can be obtained by performing the symmetry operations O_1, O_2 and O_3, respectively, on configuration (α).



Identify (fully) the operations O_1, O_2 and O_3, and locate the symmetry element associated with each of them.

(36 marks)
