00653

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	: 2020/2021
Date	: 15-12-2021
Time	: 1.30 - 3.30 p.m.
Duration	: 2 hours

General Instructions

1. **Read all instructions carefully** before answering the questions.
2. This question paper consists of 04 questions in 05 pages.
3. Answer all questions. 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 All FOUR (04) questions.

1. (a) (i) What is the **oxidation number** of Co in $[Co(acac)(CN)_2(NH_3)_2]$ (**A**)?
(acac = Me(C=O)CH=C(Me)O); Z of Co is 27.
(ii) Give the IUPAC name of (**A**).
(iii) What is the **coordination number** of Co in (**A**)?
(iv) Determine the Effective Atomic Number (EAN) of Co in (**A**).
(v) Write the chemical formula of (ethylenediamine)difluoroglycinatoiron(III)?
(25 marks)

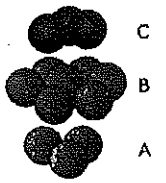
(b) Given below is a part of the (4n+2) decay series.

$$^{238}_{92}U \xrightarrow{-\alpha} X \xrightarrow{?} {}^{234}_{91}Pa \xrightarrow{-\beta} Y \xrightarrow{?} {}^{230}_{90}Th \xrightarrow{-\alpha} Z$$

(i) Write the **mass** and **atomic** numbers of X, Y and Z,
(ii) Identify the missing particles. (10 marks)

(c) Write **balanced equations** for the nuclear reactions described below:
(i) Positron emission by $^{15}_{8}O$
(ii) Electron capture by $^{82}_{38}Sr$
(iii) Boron-10 is used as control rods in nuclear reactors.
It can absorb a neutron and emit an α-particle. (15 marks)

(d) The ABC ABC type of packing of spheres is shown below. What is the coordination number of the central atom of the B layers?
Explain your answer. (05 marks)



(e) Consider the equation, $n\lambda = 2d \sin\theta$. This is known as Bragg equation. Identify each term. A crystalline solid sample scatters a beam of X-rays of wavelength 70.93 pm at an angle of 7.33°. If this is a second order reflection, calculate the distance between the 2 parallel planes of atoms responsible for this effect. (07 marks)

(f) An element crystallizes in a face centered cubic lattice. If the relative atomic mass of this element is 60 and the length of the unit cell is 400 pm, calculate the density of this element. (13 marks)

(g) The symmetry operators for NH_3 are E, C_3, and $3\sigma_v$.
(i) Draw the structure of NH_3.
(ii) What is the meaning of the E operator?
(iii) Draw a diagram to show the rotation and reflection symmetry operations. (25 marks)

2. (a) Draw the structures of the **four** isomers with the **square pyramidal** geometry for $[RuBr(I)(PPh_3)_3]$ (**B**). (20 marks)

(b) (i) Calculate the Crystal Field Stabilization Energy (CFSE) for the aqua-cations $[Cr(H_2O)_6]^{2+}$ (**C**) and $[Cr(H_2O)_4]^{2+}$ (**D**). On the basis of CFSE, which of the above two species is expected to be more stable in aqueous solutions?
(ii) Calculate the 'spin only' magnetic moment (μ_s) of (**D**).
(Atomic number of Cr = 24) (20 marks)

(c) (i) An **octahedral** complex (**E**) is formed by the reaction of one mole of $Co(CN)_3$ with one mole of KCN and one mole of ethylenediamine. (**E**) is an 1:1 electrolyte and its molar conductivity is 110 $m^2ohm^{-1}mol^{-1}$.
Draw the structure of (**E**).
(ii) $[Mn(H_2O)_6]^{2+}$ is off-white but $[V(H_2O)_6]^{2+}$ is purple. Explain. (20 marks)

(d) A mole of $PtCl_2$ reacts with two moles of glycine (H_2NCH_2COOH) in the presences of a base to give a neutral square-planar complex (**F**).
(i) Write the molecular formula of (**F**).
(ii) Draw the structures of the two isomers of (**F**) and **identify** them.
(Hint: COOH group generates COO^- ion when deprotonated.) (16 marks)

(e) State a chemical test to distinguish $[CrCl(NH_3)_3]SO_4$ from $[CrSO_4(NH_3)_5]Cl$. (10 marks)

(f) Using Valence Bond Theory, predict the hybridization of Fe in the

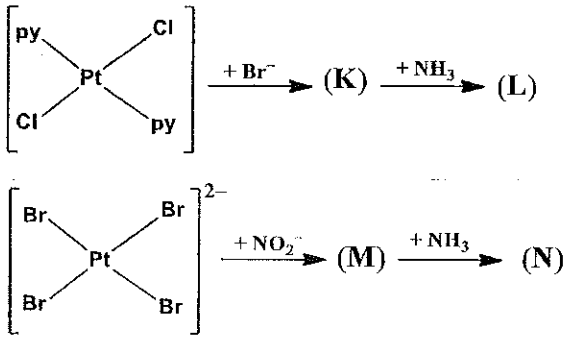
diamagnetic complex ion $[Fe(CN)_6]^{4-}$ (atomic number of Fe = 26) (14 marks)

3. (a) (i) What is meant by the term binding energy of a nucleus?
(ii) Calculate the binding energy per nucleon in MeV for the nucleus $^{58}_{28}Ni$ which has a mass of 57.9199 amu. (15 marks)

(b) Defining the term 'activity' of a radionuclide, calculate the activity of 1 mg of fluorine-18 ($t_{1/2}$ = 110 min) in Becquerel (Bq). (10 marks)

(c) Strontium-90 is a nuclear fission product that tends to concentrate in bones and milk. It undergoes β-decay with a half-life of 28.1 years.
(i) Calculate the decay constant
(ii) Write down the nuclear equation for the decay process.
(iii) If strontium-90 is accidentally released into the environment, what fraction will remain after 10 year?
(iv) What fraction of the strontium-90 released in the atomic bomb explosions of 1945 would still be remaining in the year 2000? (25 marks)

(d) Identify (**K**), (**L**), (**M**) and (**N**) if the *trans*-effect order is $NO_2^- > Br^- > Cl^- > NH_3$. py = pyridine. Indicate *cis-trans* isomerism and the **charge** of (**K**), (**L**), (**M**) and (**N**), if any. (20 marks)

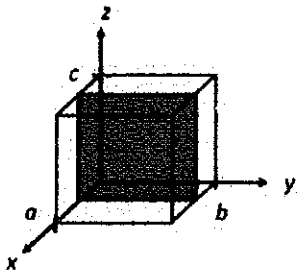


(e) (i) Show that $\beta_2 = K_1K_2$ for the equilibrium $M + 2L \rightleftharpoons ML_2$, β_2 is the overall formation constant; K_1 and K_2 are the stepwise formation constants for the intermediates ML and ML_2, respectively.
(ii) If β_2 is $10^{6.0}$ and $\log K_2$ is 2.4. calculate the stepwise formation constant K_1. (16 marks)

(f) (i) *cis*-$[PtMe_2(NMe_3)_2]$ undergoes an oxidative addition reaction with one mole of MeI to give a **neutral octahedral** complex (**X**). What is the molecular formula of (**X**)?
(ii) The 16e-complex $[MeCo(CO)_4]$ undergoes an **migratory insertion** reaction to give a 16e-Co(I) complex (**Y**). What is the molecular formula of (**Y**)? (14 marks)

4. (a) The following parts (i) to (iii) are based on defects found in ionic solids.
   (i) Defects can be categorized as stoichiometric and non-stoichiometric defects? What is the main difference of these two categories?
   (ii) Under which category does the Frenkel defect belong? Explain your answer. Sketch a diagram to show the Frenkel defect in a silver chloride lattice.
   (iii) How does the F-center form? What are the two properties associated with solids with F-centers? (25 marks)

(b) (i) What are the types of holes produced by stacking of two closed packed anion layers? Describe briefly by illustrating appropriate figures.
   (ii) Work out the Miller indices of the shaded square. (25 marks)



(c) (i) What is the difference between symmetry and symmetry operation?
   (ii) Define the term improper axis of rotation.
   (iii) Prove that when n is odd, $S_n^{2n} = E$.
   (iv) Find the improper axis of rotation in the following molecules.
      (a) CCl_4 (b) C_2H_4 (staggered)
   (v) Sketch and describe all the S_4 operations in *trans*-$[Co(NH_3)_4Cl_2]$.
(50 marks)
