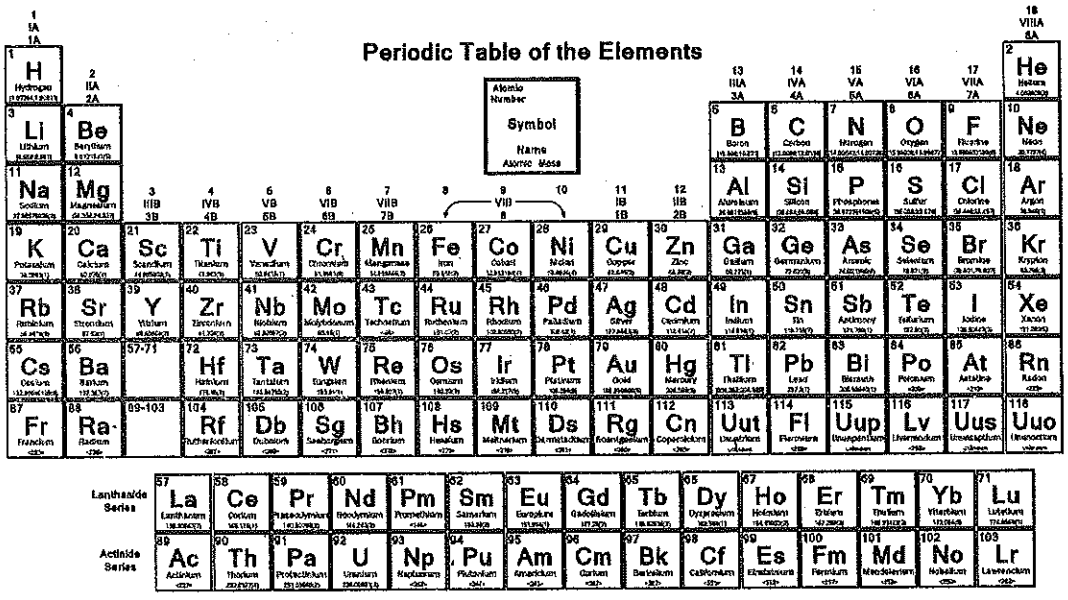
The Open University of Sri Lanka
Faculty of Natural Sciences
B.Sc/ B. Ed Degree Programme

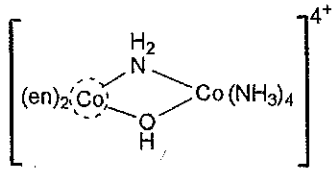
Department	: Chemistry
Level	: 4
Name of the Examination	: Final Examination
Course Code and Title	: **CYU4300 - Inorganic Chemistry**
Academic Year	: 2021/2022
Date	: 20-10-2022
Time	: 1.30 – 3.30 p.m.
Duration	: 2 hours
Index number	:

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



Answer all questions 1, 2, 3, and 4.

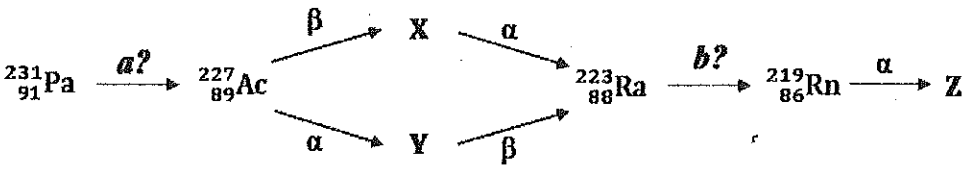
1. Answer all parts (a) – (f).
   (a) Answer the following questions based on the dicobalt complex (**A**) given below.



Complex **A**

(i) What is the **oxidation number** of the circled Co atom?
Assume that the oxidation number of each Co is the same. (en = $H_2NCH_2CH_2NH_2$)
(ii) What is the **coordination number** of the circled Co atom?
(iii) Determine the Effective Atomic Number (EAN) of the circled Co atom.
Give the IUPAC name of **A**. (25 marks)

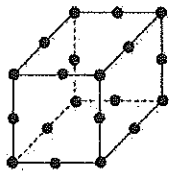
(b) Given below is a part of the actinium decay (4n+3) series.



(i) Identify the elements **X**, **Y** and **Z**. Write their **mass** and **atomic** numbers.
(ii) Identify the missing particles, ***a*** and ***b***. (15 marks)

(c) Write **balanced equations** for the nuclear reactions described below.
(i) carbon-11 undergoes positron emission.
(ii) The emission of an α particle followed by gamma emission from $^{185}_{74}W$ (10 marks)

(d) The diagram below shows the structure of an oxide of rhenium. The unit cell is cubic, with rhenium at each corner and oxygen at each edge's center. What is the chemical formula of this oxide? (10 marks)

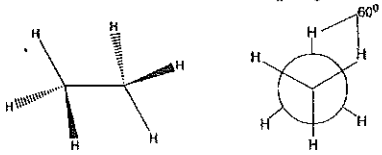


● = Re ● = O

(e) Chromium forms a cubic unit cell with a cell edge of 3.015Å. If the density of chromium is 6.9 g cm^{-3} and the relative atomic mass is 51.9 g mol^{-1}, calculate the number of chromium atoms in the unit cell. Identify the type of cubic cell in chromium. (15 marks)

(f) (i) Define the term "improper rotation axis" with a suitable example. (10 marks)
(ii) Using the Newmann projection formula of the staggered conformation of ethane draws the outcomes of all improper rotation operations about the C-C axis. Hence show what operation has the same effect as each of the following actions.
A) S_6^2 B) S_6^3 (15 marks)

Hint: Staggered conformation and Newmann projection formula of ethane:



Staggered conformation Newmann projection

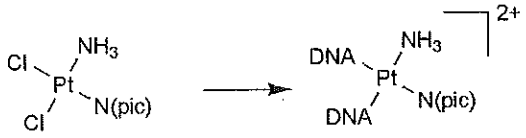
2. Answer all parts (a) – (c).

(a) (i) State the **four** assumptions made in Crystal Field Theory.
(ii) According to the Crystal Field Theory, what is the *d*-electron configuration (number of t_{2g} and e_g electrons) of iron in $[FeF_6]^{4-}$ (**B**)?
Hint: $[FeF_6]^{4-}$ is a **high spin** complex.
(iii) Calculate the Crystal Field Stabilization Energy (**CFSE**) in kJ mol^{-1}, if Δ_o = 300 kJ mol^{-1}.
(iv) Calculate the Total Stabilization Energy (**TSE**) in kJ mol^{-1} if Pairing Energy = 120 kJ mol^{-1}.
(v) Calculate the spin-only magnetic moment (μ_s) of **B**. (50 marks)

(b) Unlike $[FeF_6]^{4-}$, $[Fe(CN)_6]^{4-}$(**C**) is a **low spin** complex.
(i) What can you say about the nature of CN^- ligand relative to F^- ligand?
(ii) What is Fe's d-electron configuration (number of t_{2g} and e_g electrons) in complex **C**?
(iii) Comment on the magnetism of complex **C**.
(iv) Using Valence Bond Theory and your answer for (b) (iii), predict the hybridization of Fe in complex **C**. (25 marks)

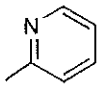
(c) The empirical formula of an octahedral complex (**D**) is $KNiCl_3 \cdot 3NH_3$. The solution does not show any significant change when mixed with an excess amount of $AgNO_3$. What is the molecular formula of **D**? Draw the structures of all the isomers and identify the type of isomerism/s involved. (25 marks)

3. Answer both parts (a) and (b).
(a) *Picoplatin* (**E**) was extensively studied in the late nineties for its therapeutic activity in treating solid tumors. Upon entering a tumor cell, chloride ligands of E are expected to be replaced by nitrogen bases of DNA, and producing **F**. The **F** adducts interrupt cell activities and eventually lead to cell death.



Complex **E** Complex **F**

N(pic) = picoline = 2-methylpyridine =



(i) What are the **three** distinct types of mechanisms employed in inorganic substitution reactions?
(ii) Out of the three types, what type of mechanism could be employed in the above substitution reaction? Give reason/s.
(iii) What is meant by "trans effect"?
(iv) If you are given the option to choose between $[PtCl_4]^{2-}$ and $[Pt(NH_3)_4]^{2+}$ as the starting material to prepare **E**, which one will you pick? Give your reason/s. The trans-effect order is Cl^- > picoline, NH_3. (50 marks)

(b) The age of an ancient wooden tool may be determined by comparing the radioactive isotope ^{14}C decay of it with living wood. In wood samples, for each 10^{12} carbon atoms, one atom is of the radioactive isotope, ^{14}C.

(i) Define the terms *activity* and *half-life* of a radionuclide.

(ii) If the half-life of ^{14}C is 5730 years, determine the decay constant in the unit of per second (s^{-1}).

(iii) A sample of 3.00×10^{23} atoms of carbon is removed from a block of living wood. Show that the rate of decay of the atoms in the living wood sample is 1.15 Bq.

(iv) A sample of 3.00×10^{23} atoms of carbon is removed from the ancient wooden tool. The rate of decay in this sample is 0.65 Bq. Calculate the age of the ancient tool in years.

(50 marks)

4. Answer all parts (a) – (d).

(a) (i) Describe Shottky and Frenkel defects using clear sketches of NaCl crystal.

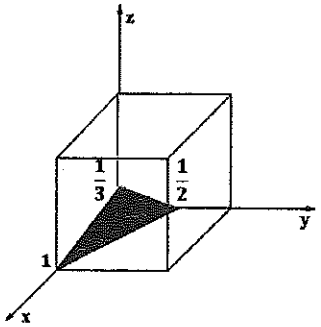
(ii) In each defect, by giving reasons, state whether the defect will lead to a stoichiometric or a non-stoichiometric compound.

(iii) Comment on the conduction of electricity of compounds with defects in each case.

(iv) Compare the density of crystalline NaCl with a Shottky defect with the perfect NaCl crystal.

(25 marks)

(b) Work out the Miller indices of the shaded plane.



(25 marks)

(c) Distinguish the symmetry operation and symmetry element using suitable examples.

(10 marks)

(d) Classify the symmetry elements **<u>other than E</u>** present in **<u>any four</u>** of the following species.

(i) BF_3 (ii) C_2H_2 (iii) PCl_3

(iv) *mer*-$Co(NH_3)_3Cl_3$ (v) *cis*-$Co(NH_3)_4Cl_2$ (vi) CO_3^{2-}

(40 marks)