RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General Degree) in Applied Sciences
Second year Semester I Examination – June 2022

CHE 2205 – Inorganic Chemistry

Answer all four questions. Time: Two (02) hours.

Mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
Mass of proton	$m_p = 1.672 \times 10^{-27}$ kg
Mass of neutron	$m_n = 1.675 \times 10^{-27}$ kg
Avogadro number	$N_A = 6.022 \times 10^{23}$ mol^{-1}
Universal gas constant	$R = 8.314$ J mol^{-1} K^{-1}
Planck constant	$h = 6.63 \times 10^{-34}$ J s
Speed of light	$c = 3.00 \times 10^{8}$ m s^{-1}
1 atomic mass unit (amu)	1 amu $= 1.66 \times 10^{-27}$ kg
	1 eV $= 1.602 \times 10^{-19}$ J

The use of a non-programmable calculator is permitted.

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1. a) Give the IUPAC name of the following complexes

(i) $[CrCl_4(OH_2)_2]^-$

(ii). $[Mn(CO)_3(C_6H_6)]^+$

b) Give the formula of the following:

(i) ammonium tetrachloroaurate (I)

(ii). chloridobis(ethylenediaminehydroxido cobalt (III) ion.

c) Draw the structure for each of the following complex compounds or ions.

(i). trans-dichloridobis(ethylenediamine)cobalt (III) chlorate

(ii). *cis*-diammine-*trans*-dibromo-*cis*-dichloroplatinum (VI) bromate

d) Determine the oxidation number for each of the transition metal atoms or ions.

(i) $[V(OH_2)_6](NO_3)_3$

(ii) $(NH_4)_2[CoCl_4]$

(iii). $[Co(py)_4]Br_2$

(iv) $[Co(P(CH_3)_3)_4]_2(SO_4)_3$

(e) At -173 °C, Xe has a face centered cubic structure with a unit cell side of 618 pm. Compute the density and the radius of the Xe atom. (Xe = 131.29 g mol^{-1}).

(f) X-ray diffraction studies of NaCl crystals, give the cubic unit cell dimensions as 564 pm. The density of NaCl is 2.165 g mol^{-1}. Calculate the number of NaCl units in a unit cell. Predict giving reasons structure of the unit cell.

(g) Tungsten has a density of 19.2×10^3 kg m^{-3}. Its structure is body-centered cubic. Calculate the length of the edge of the unit cell and the metallic radius of the tungsten atom. (atomic mass of tungsten is 183.85 g mol^{-1}).

(h) Bragg's diffraction law is given by the equation $n\lambda = 2d \sin\theta$, define the terms in the equation. An X-ray diffraction study of a metal gave a first order reflection for one set of planes at an angle 21.82° and for another set at 25.42°. The x-radiation has a wavelength of 154.1 pm . What is the separation for each of the two sets of planes?

(i) Write a balanced equation for each of the following nuclear reactions:

(i). ^{212}Bi decays into ^{212}Po .

(ii). $^{8}_{4}Be$ and a positron are produced by the decay of an unstable nucleus.

(iii). ^{239}Np forms from the reaction of ^{238}U with a neutron and then spontaneously converts into ^{239}Pu .

(iii) $^{232}_{90}Th$ decays and produces an alpha particle and $^{228}_{88}Ra$ nucleus, which decays into $^{228}_{89}Ac$ by beta decay

(j) The mass of the atom ^{23}Na is 22.9898 amu.

(i) Calculate its binding energy per atom.

(ii) Calculate its binding energy per nucleon in MeV.

(16x 10 = 160 marks)

2. a). (i) Draw all possible isomers of the complex ion $[Co(en)_2Cl_2]^{2+}$ and identify the active isomer.

(ii). Match the column I with column II and write down the correct options from the code for the type of the complex species.

type	Column I Complex species	code	Column II Isomerism
i.	$[Co(NH_3)_4Cl_2]^+$	p	optical
Ii	cis-$[Co(en)_2Cl_2]^+$	q	ionization
iii	$[Co(NH_3)_5(NO_2)]Cl_2$	r	coordination
Iv	$[Co(NH_3)_6][Cr(CN)_6]$	s	Geometrical
		t	linkage

(30 marks)

b). (i). What are the limitations of VB theory?

(ii). Based on VB theory explain why $[Cr\ (NH_3)_6]^{3+}$ is paramagnetic, while $[Ni\ (CN)_4]^{2-}$ diamagnetic. Predict the types of hybridization, coordination number, number of unpaired electrons and the value of the magnetic moment for each compound.

(30 marks)

(c) (i). A solution of $[Ni\ (H_2O)_6]^{2+}$ is green, whereas a solution of $[Ni\ (CN)_4\ ]^{2+}$ is colorless. Explain.

(ii) Give one test to differentiate $[\ Co\ (NH_3)_5Cl]\ SO_4$ and $[\ Co(\ NH_3)_5\ SO_4\ ]\ Cl$.

(20 marks)

3. a). (i). Distinguish between crystalline solid and amorphous solid. Name two solids in each type.

(ii). Find the number of atoms in fcc and bcc unit cell structures. Calculate the packing efficiency and the void percentage for bcc lattice.

(30 marks)

b). An element has bcc structure, with a cell edge of 288 pm. The density of the element is 7.2 g cm^{-3}. Calculate the number of atoms are present in 208 g of the element.

(20 marks)

C) (i) Calculate the Miller indices of crystal planes which cut through the crystal axes at
(1) (2a, 3b, c)
(2) (6a, 3b, 3c) and
(3) (2a, -3b, -3c).

(ii) Draw the plane and determine the axis intersects of a surface with the Miller indices (111), (100) and (123) in a simple cubic lattice.

(30 marks)

4. a) i. Give one example of fusion and fission reactions. What are the advantages of fusion over fission for energy production?

ii. How much energy released in kJ mol^{-1} of ${}_2^4He$ produced is the following fusion reaction.

$$ {}_1^1H + {}_1^3H \longrightarrow {}_2^4He $$

The masses of ${}_1^1H$ atom, ${}_1^3H$ atom and ${}_2^4He$ are 1.007825 amu , 3.01605 amu and 4.00150 amu respectively.

(20 marks)

b) ^{32}P is a radioactive isotope used as a tracer in the liver. How much ^{32}P was originally used if there is only 3.50 mg left in a sample after 288 h? (The half-life ($t_{1/2}$ of ^{32}P is 14.3 days.)

(20 marks)

c) What quantity of energy would be produced as 1.00 g of ^{238}Pu undergoes alpha decay? The nuclide mass of ^{238}Pu is 238.0495 amu, and the nuclide mass of ^{234}U is 234.0409 amu. (alpha particle mass is 6.64465×10^{-24} g).

(20 marks)

(d) Discuss, briefly the uses of radioactive isotopes.

(20 marks)

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hydrogen 1 H 1.0079																	helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122											boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305											aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078		scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62		yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 * *	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	ununnilium 110 Uun [271]	unununium 111 Uuu [272]	ununbium 112 Uub [277]	nihonium 113 Nh [284]	flerovium 114 Fl [289]	moscovium 115 Mc [288]	livermorium 116 Lv [293]	tennessine 117 Ts [294]	oganesson 118 Og [294]

*Lanthanide series	lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
**Actinide series	actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]