RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General Degree) in Applied Sciences
Second Year - Semester I Examination – September / October 2019

CHE 2205 – INORGANIC CHEMISTRY

Time: Two (02) hours

Answer question No. 1(compulsory) and any other three questions.

Electronic rest mass	$m_e = 9.11\times10^{-31}$ kg
Proton rest mass	$m_p = 1.672\times10^{-27}$ kg
Neutron rest mass	$m_n = 1.675\times10^{-27}$ kg
Avogadro number	$N_A = 6.022\times10^{23}$ mol^{-1}
Universal gas constant	$R = 8.314$ J mol^{-1} K^{-1}
Planck constant	$h = 6.63\times10^{-34}$ J s
Speed of light in a vacuum	$c = 3.00\times10^{8}$ m s^{-1}
1 atomic mass unit (amu)	1 amu $= 1.66\times10^{-27}$ kg
	1eV $= 1.602\times10^{-19}$ J

The use of a non-programmable calculator is permitted.

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1. a) i. Give the systematic name for the coordination compound $[Cr(NH_3)_3(H_2O)_3]Cl_3$.

ii. Write down the formula of dicarbonylhydridobis(triphenylphosphane)iridium (I)

b) Give one example of each of the following ligand:

i. Ambidentate ligands.
ii. Bidentate ligands.
iii. Hexadentate ligands.

c) Identify whether the following ligands are strong field or weak field ligands.

i. $C_2O_4^{2-}$
ii. SCN^-
iii. $H_2N\text{-}CH_2\text{-}COO^-$
iv. NH_3

d) List two differences between crystalline and amorphous solids and give two examples of each solid.

e) If $[Co(NH_3)_6]^{3+}$ ion is diamagnetic, find whether NH_3 a weak field ligand or a strong field ligand toward the Co^{3+} transition metal ion?

f) How many unpaired electrons are present in the high spin crystal field splitting diagram (CFSD) of the $[CoCl_4]^{2-}$ tetrahedral complex ion? Write the electron configuration and calculate the crystal field stabilization energy (CFSE).

g) If the decrease between 18 and 24 years in mass of radioactive isotope is 4 g, find its initial mass. The half-life of this isotope is 6 years.

h) The mass defect for an isotope was found to be 0.410 amu / atom. Calculate the binding energy in kJ mol^{-1} of atoms.

(130 marks)

2. a) i. Draw labeled d orbital splitting diagrams for tetrahedral, square planar complexes.
Find the spin only magnetic momentum for tetrahedral and square planar structures formed by the $[ZnCl_4]^{2+}$ ions.

ii. Explain the Jahn-Teller distortion in $[Cu(H_2O)_6]^{2+}$.

(40 marks)

b) i. The $[PdCl_4]^{2-}$ ion is diamagnetic. What type of geometry does it have? Explain your answer.

ii. The $[Co(NH_3)_6]^{3+}$ complex ion has a crystal field splitting energy of 272 kJ mol^{-1}. Calculate the wavelength of light in nm that this ion will absorb.

(30 marks)

c) Draw the structures of geometrical isomerism for an octahedral complex of $[Co(NH_3)_4Cl_2]^+$

(20 marks)

3. a) Define the following:

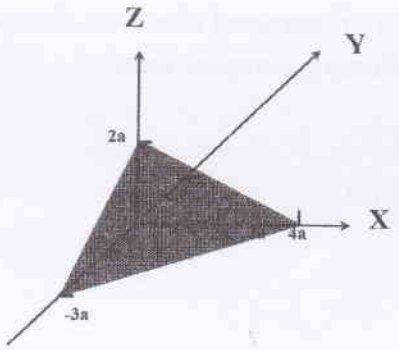
i. Unit cell.

ii. Crystal lattice.

iii. Atomic packing factor.

(15 marks)

b) Determine the Miller indices (hkl) of the shaded planes below:



(15 marks)

(c) (i) Determine the density of BCC iron, which has a cell edge of 0.2866 nm.

(Relative atomic mass of iron = 55.847 g mol^{-1})

(18 marks)

(ii) A metal of atomic mass of 75 g mol^{-1} form a cubic lattice of edge length 5Å and density 2 g cm^{-3}. Find the structure of the metal and calculate the radius in pm of the atom.

(18 marks)

d) One form of silicon has density of 2.33 g cm^{-3} and crystallizes in a cubic lattice with a unit cell edge of 543 pm. Calculate;

i. the mass of each unit cell,

ii. the number of silicon atoms contain in one unit cell.

(Relative atomic weight of Si = 28.09 g mol-1)

(24 marks)

4. a) i. Find the coordination numbers of the Fe atom in $K_3[Fe(C_2O_4)_3$ and the Au atom in $K[Au(CN)_2(SCN)_2]$.

ii. Calculate the oxidation state of the metal atom and the number of d electrons in the following coordination complexes:

a) $[CoCl_4]^{2-}$.

b) $[Fe(bpy)_3]^{3+}$.

(30 marks)

b) Predict the number of unpaired electrons, the spin-only magnetic moments at 25°C for each of the following complex ions.

i. $[Fe(CN)_6]^{4-}$

ii. $[Ru(NH_3)_6]^{3+}$

iii. $[Cr(NH_3)_6]^{2+}$

(30 marks)

c) Determine the configuration (in the form $t_{2g}^{m} e_g^{n}$ or $e^{m} t_2^{n}$, as appropriate), the number of unpaired electrons, and the ligand field stabilization energy as a multiple of Δo or Δ_T for each of the following complexes :

i. $[Co(NH_3)_6]^{3+}$.

ii. $[Fe(OH_2)_6]^{2+}$.

iii. $[Cr(NH_3)_6]^{3+}$.

(30 marks)

5. a) Identify the parent isotope and write a balanced nuclear reaction for each process.

i. Iodine-130 is formed by ejecting an electron and gamma ray from a nucleus.

ii. Uranium-240 is formed by an alpha decay.

iii. Curium-247 is formed by releasing an alpha particle and gamma ray.

(30 marks)

b) i. Explain the term binding energy. The mass of isotope of fluorine -19 is 18.9984 amu, calculate the binding energy of one mole of fluorine -19 in kJ/mol.

ii. Calculate the amount of energy produced when 1.00 g of plutonium-238 undergoes an alpha decay.
The masses of plutonium-238 , uranium-238 and alpha particle are 3.953×10^{-22} g , 3.886×10^{-22} g and 6.64×10^{-24} respectively.

(30 marks)

c) i. Drive a mathematical expression for radioactivity decay and show that the half-life ($t_{½}$) is independent of the initial concentration of the radioactive isotope. State any assumptions you have made in obtaining the expressions.

ii) phosphorus-32 is a radioactive isotope used as a tracer in the liver. Estimate the amount of phosphorus-32 was originally used, if there is only 3.50 mg left in a sample after 288 hours.
($t_{½}$ of phosphorus-32 -32 is 14.3 days)

(30 marks)

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The Periodic Table of the Elements

1 H Hydrogen 1.00794																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
11 Na Sodium 22.989770	12 Mg Magnesium 24.3050											13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938049	26 Fe Iron 55.845	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.29
55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 La Lanthanum 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.0289	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)