# THE OPEN UNIVERSITY OF SRI LANKA

## B.Sc./B.Ed. DEGREE/STAND ALONE COURSES IN SCIENCE – LEVEL 4

### FINAL EXAMINATION – 2007/2008

### CHU2123/CHE4123 – INORGANIC CHEMISTRY

---

Date: 28$^{th}$ June 2008 (Saturday)　　　　　10.00 a.m. – 12.30 p.m.

---

| | | |
|---|---|---|
| Gas constant, R | = | 8.314 J K$^{-1}$ mol$^{-1}$ |
| Planck's constant, h | = | $6.63 \times 10^{-34}$ J s |
| Avogadro constant, L | = | $6.023 \times 10^{23}$ mol$^{-1}$ |
| Velocity of light, c | = | $3 \times 10^{8}$ m s$^{-1}$ |
| Charge on electron | = | $1.602 \times 10^{-19}$ C |
| 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 |

**Answer any FOUR (04) questions.**

If more than four questions are answered, **only the first four answers will be marked.**

1. (a) ( i ) Give the IUPAC name of [FeBr$_2$(acac)(H$_2$O)$_2$]. (acac = acetylacetonate ion)

      (ii) What is the coordination number of Fe in (i)?

      (iii) Calculate the Effective Atomic Number (EAN) of Fe in ( i ).

        (Atomic number of Fe is 26)

      (iv) Does it obey the EAN rule?

                                                          (20 marks)

(b) Draw the **structures** of all five **geometrical** isomers of [FeBr$_2$(NH$_3$)$_2$(CO)$_2$]˙ (20 marks)

(c) (i) According to the Crystal Field Theory, what is the d-electron configuration

      of cobalt in [CoBr$_4$]$^{2-}$ ? (Atomic number of Co is 27).

    (ii) Calculate the Crystal Field Stabilisation Energy in kJ mol$^{-1}$

      of [CoBr$_4$]$^{2-}$ if $\Delta_t = 150$ kJ mol$^{-1}$.

    (iii) Calculate the spin only magnetic moment ($\mu_s$) of [CoBr$_4$]$^{2-}$.

                                                          (25 marks)

(d) Using Valence Bond Theory predict the hybridization of cobalt in

    [Co(NH$_3$)$_6$]$^{3+}$ if the magnetic moment of the complex is zero B.M.     (15 marks)

(e) How would you prepare cis-[PtCl$_2$(Py)(CO)]from [PtCl$_4$]$^{2-}$ if the
order of *trans*-effect is CO > Cl > Py (pyridine).                  (20 marks)

2. (a) An octahedral complex (**B**) with the empirical formula
CoBr$_3$·4NH$_3$·2H$_2$O 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.               (20 marks)

(b) PtCl$_2$ reacts with two moles of ethylenediamine to give a square

    -planar Pt(II) complex **X**. When a solution of **X** (1 mole) reacts with

    an excess of AgNO$_3$, AgCl (2 moles) is precipitated. Draw the structure of **X**.

                                                          (15 marks)

(c) (i) State the Jahn Teller Theorem.

    (ii) [Cu(NH$_3$)$_6$]$^{2+}$ has four Cu-N bonds with a bond length of 207 pm and two Cu-N

      bonds with a bond length of 262 pm. How many d-electrons are there in the $d_z^2$

      and d$_{x^2-y}$2 orbitals ?                                              (15 marks)

(d) Define the following as applied in the study of molecular symmetry.
    (i) Axis of rotation
    (ii) Order of an axis of rotation                                    (10 marks)

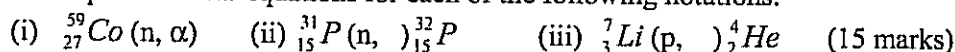(e) Consider the planar aromatic molecule with three benzene rings as shown below.
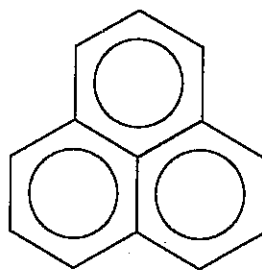


(i) Copy the above structural formula on to your answer sheet and indicate all the axes of rotation of the molecule in standard notation (clearly indicating the order of axis) on it.

(ii) What is the symmetry point group of this molecule?
Briefly explain your answer. (24 marks)

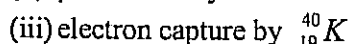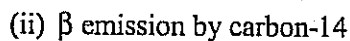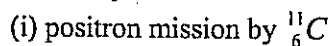(f) A non-planar molecule has an improper rotation axis of order seven, i.e. $S_7$.

(i) In standard notation list all possible distinct improper rotational symmetry operations of the molecule that can be performed about this axis.

(ii) Which operation/s listed above is/are equivalent to the identity operation?

(16 marks)

3. (a) Write complete nuclear equations for each of the following notations:

(i) $^{59}_{27}Co$ (n, $\alpha$)     (ii) $^{31}_{15}P$ (n, )$^{32}_{15}P$     (iii) $^{7}_{3}Li$ (p, )$^{4}_{2}He$     (15 marks)

(b) Write balanced equations for the following nuclear reactions.

(i) positron mission by $^{11}_{6}C$

(ii) $\beta$ emission by carbon-14

(iii) electron capture by $^{40}_{19}K$     (15 marks)

(c) $^{225}_{88}Ra$ decays with a half-life of 15 days to produce $^{225}_{89}Ac$.
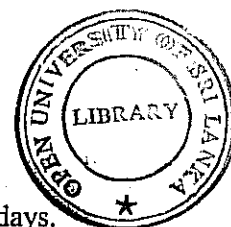
Answer the following questions:

(i) Identify the type of decay involved in the above process.
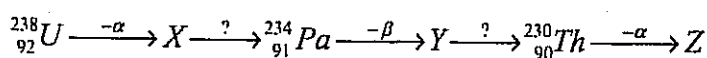
(ii) Calculate the decay constant ($\lambda$)

(iii) Calculate the percentage of Radium-225 that will remain after 5 days.

(iv) Calculate the time taken to decay 75% of the original sample. (30 marks)

(d) Below is a part of the (4n+2) decay series

$$^{238}_{92}U \xrightarrow{-\alpha} X \xrightarrow{?} {}^{234}_{91}Pa \xrightarrow{-\beta} Y \xrightarrow{?} {}^{230}_{90}Th \xrightarrow{-\alpha} Z$$
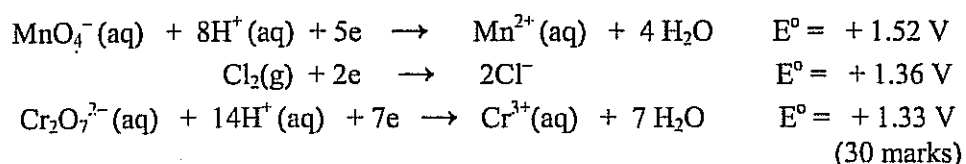
Complete the portion of the series by adding missing particles, and mass numbers and atomic numbers of X, Y, Z. (15 marks)

(e) (i) Acetic acid is not an acid in $H_2SO_4$. Explain

(ii) What is meant by an "amphoteric solvent". Give two examples.

(iii) Give two examples for an ammonolytic reaction.                    (25 marks)


4. (a) Amorphous silica has a density of about 2.2 g cm$^{-3}$, whereas the
density of crystalline quartz is 2.65 g cm$^{-3}$. Relate the differences in
densities to the structures of the substances.                    (20 marks)

(b) A substance melts with some decomposition at 720 °C. As a solid it
does not conduct electricity; but dissolves in water to form a conducting
solution. Predict the type of bonding in the solid.                    (15 marks)

(c) For each of the following pairs of substances, predict which will have
the higher melting point and give a reason for your choice.
                    (i) Ar, Xe      (ii) $SiO_2$, $CO_2$                    (20 marks)

(d) Use appropriate diagrams to explain why diborane molecule is called
            (i) an electron deficient compound
            (ii) a molecule with unusual bonding.                    (30 marks)

(e) What is more effectively diffracted by crystals: X-rays or visible light?
Give reasons for your answer.                    (15 marks)


5. (a)(i) Sketch the unit cell of CsCl.
        (ii) Calculate the number of $Cs^+$ ions and $Cl^-$ ions in the unit cell.
        (iii) How many formula units are there in a unit cell?                    (30 marks)

(b) An ammonium halide, $NH_4X$ has the CsCl structure at room temperature,
with unit cell length of 4.059 Å. It is transformed to the NaCl structure at
138 °C. If the density of the polymorph is 2.431 g cm$^{-3}$ at room temperature,
identify the substance. Give reasons for your answer.                    (35 marks)

(c) Explain why the conductivity of NaCl at 800 °C just below its melting point
is about $10^{-3}$ ohm$^{-1}$cm$^{-1}$, whereas at room temperature, pure NaCl is an
insulator with a conductivity much less than $10^{-12}$ ohm$^{-1}$cm$^{-1}$.                    (10 marks)

(d) Sketch a sodium chloride lattice with a Schottky defect.
Will such a crystal preserve electroneutrality? Give reasons for your answer.
How do you compare the behaviour of the above lattice with that of a lattice with
" F-centres" in a magnetic field?                    (25 marks)


6. (a) (i) Write a balanced chemical equation for the decomposition of $CaCO_3$.
                What will be the expression for $K_p$?

    (ii) Use the trends in the properties of ions of Group 2 to explain how
            the numerical value of $K_p$ for the above reaction would change if $BaCO_3$
            is used instead of $CaCO_3$.

(iii) What property of barium makes it possible to be used in the
"barium meal" in medical diagnosis?                          (25 marks)

(b) An acidic solution of **potassium permanganate** liberates chlorine
gas when reacted with a sodium chloride solution but an acidic solution
of **potassium dichromate** does not show any effect.

Explain the above observation using the data below.

$$MnO_4^-(aq) \ + \ 8H^+(aq) \ + 5e \ \longrightarrow \ Mn^{2+}(aq) \ + \ 4H_2O \qquad E^o = \ +1.52 \ V$$
$$Cl_2(g) \ + 2e \ \longrightarrow \ 2Cl^- \qquad E^o = \ +1.36 \ V$$
$$Cr_2O_7^{2-}(aq) \ + \ 14H^+(aq) \ + 7e \ \longrightarrow \ Cr^{3+}(aq) \ + \ 7H_2O \qquad E^o = \ +1.33 \ V$$
(30 marks)

(c) A 0.204 g sample of steel was made to react completely with excess
dilute sulphuric acid. The resulting solution required 27.40 $cm^3$ of 0.022 mol $dm^{-3}$
potassium dichromate solution for complete reaction. Calculate the percentage of
iron in the sample of steel.
(Relative atomic mass: K = 39; Cr = 52; O = 16)          (25 marks)

(d) With appropriate equations explain how the oxidative properties of
dichromate ion can be used to detect alcohol in the breath.          (20 marks)

------------------------------------------------------------------------