L-1/T-1/NCE Date: ~~28/04/2024~~ 25/5/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B.Sc. Engineering Examinations 2022-2023

Sub: **NCE 101** (Materials Science Fundamentals)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) Classify each of the following materials as to whether it is a metal, ceramic or polymer:

(i) aluminum oxide (ii) polyvinyl chloride (iii) cast iron.

Justify your choice. **(12)**

(b) (i) On the basis of ionic radii of Fe^{2+} = 0.077 nm, Fe^{3+} = 0.069 nm, and O^{2-} = 0.140 nm, predict the crystal structure of Fe_3O_4.

(ii) Which type of interstitial site will the Fe^{2+} ions occupy?

(iii) Which type of interstitial site will the Fe^{3+} ions occupy?

(iv) What fraction of the total interstitial sites will be occupied? **(8+5+5+5)**

2. (a) Sketch within a cubic unit cell the following planes: (i) $(0\bar{1}\bar{1})$ (ii) $(11\bar{2})$ (iii) $(\bar{1}1\bar{1})$ **(9)**

(b) Draw the atomic arrangements of the (110) and (111) planes of an FCC unit cell. Show the planar densities of the (110) and (111) planes and also show the linear density of the [110] direction for the FCC crystal structure. From the above illustrations, justify that slip occurs on the most densely packed crystallographic planes and, in those planes, along directions having the greatest atomic packing. **(6+10+10)**

3. (a) A 85 wt% Ag – 15 wt% Cu alloy is heated to a temperature within the (β + liquid) phase region. If the composition of the liquid phase in 80 wt% Ag, determine:

(i) the temperature of the alloy

(ii) the composition of the β phase

(iii) the amount of both phases and

(iv) sketch the microstructure of the alloy at room temperature by using 2 cm diameter circular fields.

Use the supplied copper-silver phase diagram in Figure for Question No. 3(a). **(4+4+8+9)**

Contd..... P/2

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(Contd..... Q. No. 3)

(b) 'An alloy of eutectic composition forms a microstructure consisting of alternating layers of the two solid phases'. "The performance of a eutectic alloy is superior to that of a single phase region alloy". Justify the above statements. **(10)**

4. (a) Illustrate the following defects that can exist in crystal lattices and microstructures:
(i) vacancy (ii) frenkel defect (iii) edge dislocation (iv) grain boundary
Which defects are the most favourable sites for the nucleation and growth of a precipitate? Explain. **(8+7)**

(b) Phosphorus (P) is diffused into a thick slice of silicon (Si) with no previous phosphorus in it at a temperature of 1100°C. If the surface concentration of the P is 1×10^{18} atoms/cm^3 and its concentration at 1 μm below the surface is 1×10^{15} atoms/cm^3, how long must the diffusion time be? D = 3.0×10^{-13} cm^2/sec for P diffusing in Si at 1100°C. Use the following tabulation of error function values: **(15+5)**

erf z	z
0.9981	2.2
0.9990	z
0.9993	2.4

Symbols do have usual meaning.
Identify the type of above diffusion and justify your choice.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) From the tensile stress-strain curve of a metal given below, find out the following: **(20)**
   (i) Modulus of elasticity
   (ii) Yield strength at a strain offset of 0.002
   (iii) Tensile strength
   (iv) Ductility in percent elongation
   (v) Modulus of Resilience.

(b) Tensile stress-strain curves of three hypothetical materials are shown below. Which material would you suggest for manufacturing springs? Justify your answer. **(15)**

6. (a) Suppose the grain size of an alloy is reduced from 20 μm to 20 nm. How will this affect the yield strength of the sample? Explain the underlying mechanism. **(10)**

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(Contd..... Q. No. 6)

(b) The yield strength of copper is to be increased by adding an alloying element. Atomic mass of copper is 63.5. Which element would you recommend, from the table below, in order to get the maximum strengthening effect? Justify your answer. **(10)**

Table for Q. No. 6(b)

Element	Atomic mass
Zn	65.4
Al	27.0
Ni	58.7
Sn	118.7
Be	9.0
Si	28.1

(c) A metal single crystal is subjected to a tensile load. It is oriented in such a manner that the normal to the slip plane and the slip direction are at 47° and 44° respectively, with the tensile axis. Will an applied stress of 35 MPa cause the single crystal to yield? If not, calculate the stress necessary to cause yielding of the crystal. **(15)**

[Given: Critical Resolved Shear Stress = 30 MPa]

7. (a) What type of steels would you suggest for manufacturing the following: **(12)**

i) Body of a car

ii) Crankshaft of a car

iii) Razor blade.

Provide justification in favour of your selection.

(b) A small screw-bolt assembly is tightly fixed inside a hole at the middle of a sheet having a surface area of 1 m^2. The surface area of the screw-bolt assembly is about 2 cm^2. The whole assembly is exposed to outdoor atmosphere. Consider the following cases:

(i) The screw and bolt are made from brass, while the sheet is made from mild steel.

(ii) The screw and bolt are made from mild steel, while the sheet is made from brass.

Explain the form and severity of corrosion that you anticipate in each of the above cases. **(15)**

(c) How can you prevent crevice corrosion? **(8)**

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8. (a) Show that the refractive index of an insulator depends on the square root of its dielectric constant. **(10)**

(b) Discuss the optical behaviour of bulk metals when exposed to the following radiations. The wavelengths of the radiations are shown in the parenthesis. Justify your answer. **(12)**

(i) Radio wave $(10^{2}\,m)$

(ii) Microwave $(10^{-3}\,m)$

(iii) Visible light $(0.6\times10^{-6}\,m)$

(iv) UV radiation $(10^{-8}\,m)$

(v) γ-ray $(10^{-13}\,m)$

(c) Saphire (Al_2O_3) is a colourless mineral. But ruby, which is basically Al_2O_3 containing a small amount of Cr_2O_3, exhibits a bright red colour. Explain the reasons using electronic band structure. **(13)**

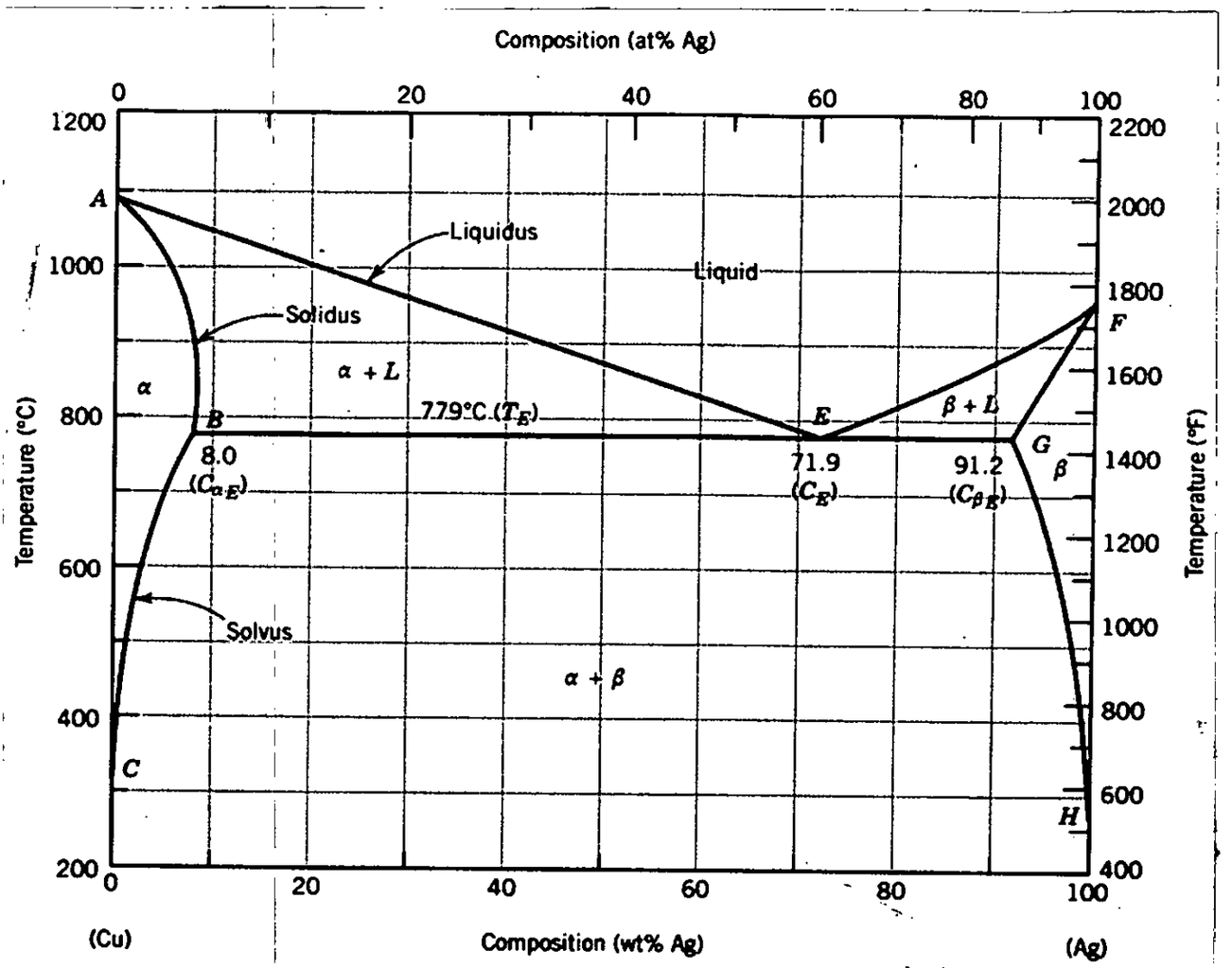

Figure for Question No. 3(a): The copper-silver phase diagram

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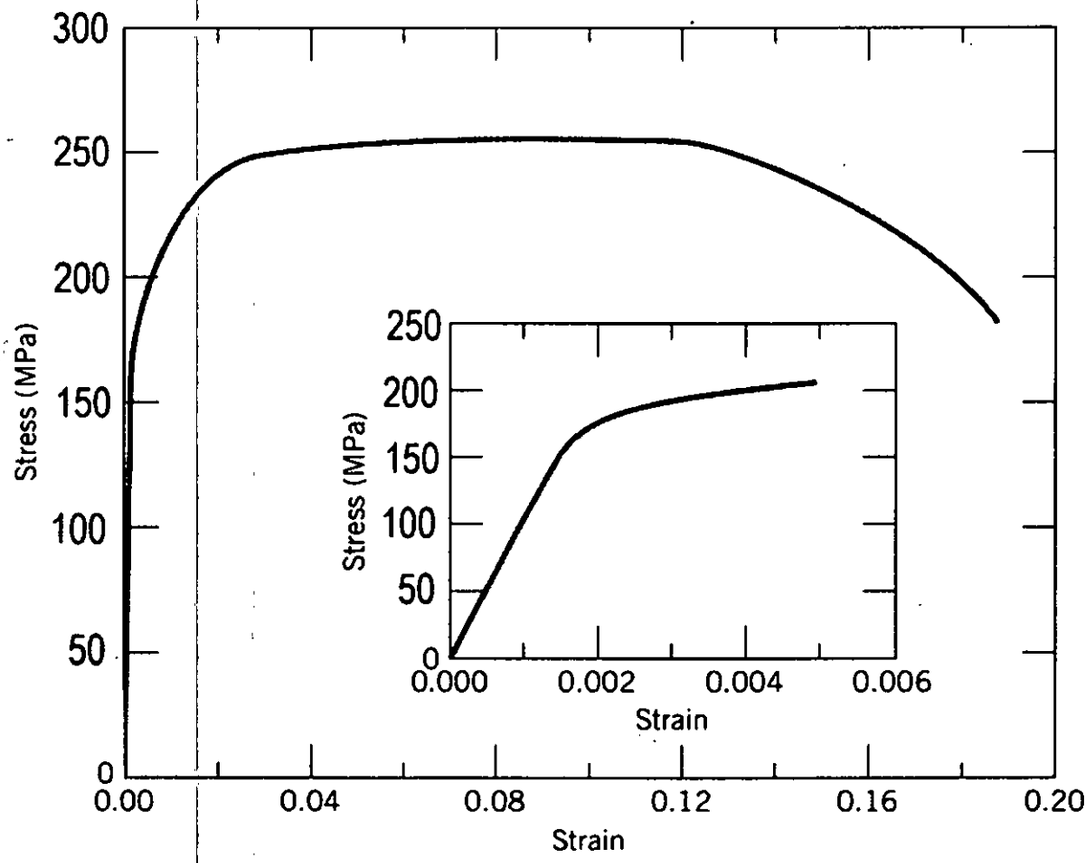

Figure for Question No. 5a

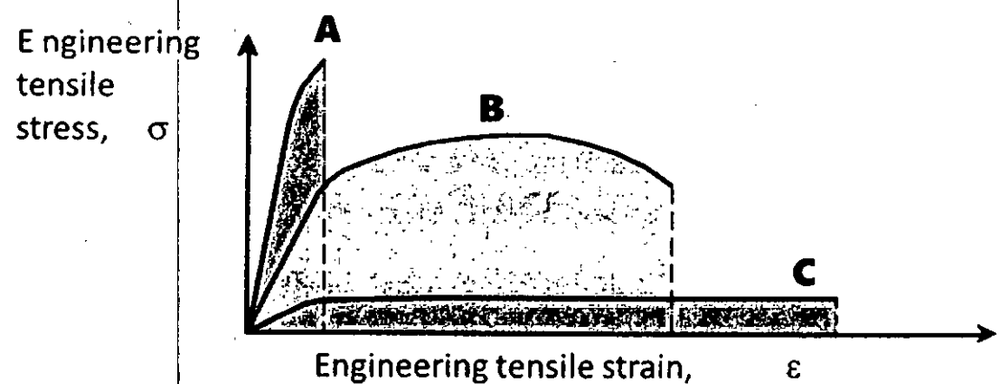

Figure for 5b

19/05/2024

L-1/T-1/NCE Date: ~~18/04/2024~~

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **MATH 112** (Calculus)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

Symbols used have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) A function $f(x)$ is defined by **(12)**

$$f(x)=\begin{cases}\dfrac{1}{x+2}, & x<-2\\ x^2-5, & -2<x\le 3\\ \sqrt{x+13}, & x>3\end{cases}$$

Find (i) $\lim_{x\to -2} f(x)$, (ii) $\lim_{x\to 0} f(x)$, (iii) $\lim_{x\to 3} f(x)$.

Also discuss the continuity and differentiability of $f(x)$ at $x=-2$ and sketch the graph of $f(x)$.

(b) Determine whether the following limit exists. If so, find its value. **(10)**

$$\lim_{(x,y)\to(0,0)}\left(x^2+y^2\right)\ln\left(x^2+y^2\right)$$

(c) State Leibnitz's theorem. If $y=\sin\left(m\sin^{-1}x\right)$, show that **(13)**

$\left(1-x^2\right)y_{n+2}=(2n+1)xy_{n+1}+\left(n^2-m^2\right)y_n$. Also find $y_n(0)$.

2. (a) Write down the Taylor's finite series with Lagrange's form of remainder. Expand $\sin x$ in power of $(x-\pi/2)$ in a finite series with the form of Lagrange's remainder. **(12)**

(b) State first mean value theorem with its geometrical interpretation. Discuss the applicability of first mean value theorem for the following function in the interval (-1, 1): **(11)**

$$f(x)=\begin{cases}x\sin\left(\dfrac{1}{x}\right), & x\neq 0\\ 0, & x=0\end{cases}$$

(c) State Euler's theorem on homogeneous functions. Using Euler's theorem, **(12)**

If $u=\log_e\left(\dfrac{x^4+y^4}{x+y}\right)$, show that $x\dfrac{\partial u}{\partial x}+y\dfrac{\partial u}{\partial y}=3$, using Euler's theorem.

Contd P/2

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3. (a) A cylindrical can, open at the top, is to hold 500 cm^3 of liquid. Find the height and radius that minimize the amount of material needed to manufacture the can. **(12)**

(b) Locate all relative extrema and saddle points of $f(x,y)=4xy-x^4-y^4$. **(12)**

(c) Find the pedal equation of the ellipse $\frac{1}{r}=1+e\cos\theta$. **(11)**

4. (a) If the tangent at (x_1,y_1) to the curve $x^3+y^3=a^3$ meets the curve again at (x_2,y_2), then show that $\frac{x_2}{x_1}+\frac{y_2}{y_1}=-1$. **(11)**

(b) Find the envelope of the family of lines $x\cos\alpha+y\sin\alpha=l\sin\alpha\cos\alpha$, where the parameter is the angle α. **(12)**

(c) Explain different types of asymptotes of a curve. Find all the asymptotes of $y^2(2a-x)=x^3$ and also trace the curve. **(12)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) What is a constant of integration? Why does an answer to an integration problem involve a constant of integration? Explain by using antiderivative. **(5)**

(b) Find the following: **(10+10=20)**

(i) $\int e^{6x}\sin(e^{2x})dx$.

(ii) $\int\frac{dx}{x\sqrt{9x^2+4x+1}}$.

(c) Derive a reduction formula for $I_n=\int\frac{dx}{(a+b\cos x)^n}$ and hence solve $\int\frac{dx}{(1-2\cos x)^4}$. **(10)**

6. (a) List the five properties of definite integrals with examples. **(5)**

(b) Evaluate the following integral using the suitable properties of definite integral: **(10)**

$$\int_0^1\cot^{-1}(1-x+x^2)dx.$$

(c) Evaluate (i) $\beta(x,1)$, (ii) $\Gamma\left(\frac{8}{3}\right)$, (iii) $\Gamma\left(-\frac{7}{2}\right)$ and (iv) $\Gamma(5/4)\cdot\Gamma(-5/4)$. **(10)**

(d) Show that, **(10)**

$$\int_0^{\frac{\pi}{2}}\frac{\sin^{2m-1}\theta\cos^{2n-1}\theta}{(a\sin^2\theta+b\cos^2\theta)^{m+n}}d\theta=\frac{1}{2}\frac{\Gamma(m)\Gamma(n)}{a^mb^n\Gamma(m+n)}$$

Contd P/3

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7. (a) What is "improper" about a definite integral over an interval on which the integrand has an infinite discontinuity? Explain why $\int_a^b f(x)dx$ fails if the graph of $f(x)$ has a vertical asymptote at $x = a$. Discuss a strategy for assigning a value to $\int_a^b f(x)dx$ in this circumstance. **(5)**

(b) Evaluate the improper integral: $\int_0^1 \frac{dx}{x - \sin x}$. **(10)**

(c) Evaluate $\lim_{n\to\infty}\left[\frac{1}{n} + \frac{\sqrt{n^2-1^2}}{n^2} + \cdots\cdots + \frac{\sqrt{n^2-(n-1)^2}}{n^2}\right]$. **(10)**

(d) Apply definite integral to find the total area interior to $y^2 = 2ax - x^2$ and exterior to $y^2 = ax$ lying in the first quadrant. **(10)**

8. (a) Write the formula for finding the volume by disks method perpendicular to x-axis and y-axis.. **(5)**

(b) Find the surface area of the solid obtained by revolving the asteroid $x^{\frac{2}{3}} + y^{\frac{2}{3}} = a^{\frac{2}{3}}$ about x-axis. **(10)**

(c) Use a polar double integral to find the area enclosed by the rose $r = \sin 4\theta$. **(10)**

(d) Use a triple integral to find the volume of the solid within the cylinder $x^2 + y^2 = 9$ and between the planes $z = 1$ and $x + z = 5$. **(10)**

L-1/T-1/NCE **Date: 04/05/2024**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **CHEM 161** (Inorganic Chemistry)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer to **Question no. 1 is Compulsory**.
Answer any **TWO** questions from Questions 2-4.

1. (a) Describe how the LCAO method gives rise to bonding and antibonding orbitals in H_2 molecule. **(5)** (CO1)

   (b) Explain the similarities and dissimilarities between Bohr model and Schrodinger model of an atom. **(10)** (CO2)

   (c) Calculate the shortest wavelength of the electromagnetic radiation emitted by the hydrogen atom in undergoing a transition from the n = 6 level. **(10)** (CO3)

   (d) The bond order of N_2 is greater than that of N_2^+, but the bond order of O_2 is less than that of O_2^+. Analyze your answer using MO diagram. **(10)** (CO4)

2. (a) Draw Lewis structure with resonance hybrid if applicable and predict the geometry of the following ions or compounds using VSEPR model: **(12)**
   ClF_3, H_3COCH_3, H_3O^+, ClO_2^-

   (b) Using Valence Bond Theory, show and discuss the formation of CH_3OH molecule. **(13)**

   (c) Which compound is more polar? Explain the reason to support your answer. **(10)**
   (i) *cis-1, 2*-dichloroethylene and *trans-1, 2*-dichloroethylene
   (ii) CO_2 and SO_2

3. (a) Explain the following: **(12)**
   (i) $AlCl_3$ behaves as an electrovalent compound in aqueous solution
   (ii) Al_2O_3 is amphoteric in nature

   (b) Write short note on different types of silicates. **(13)**

   (c) Why does transition elements form colored compounds? **(10)**

4. (a) Explain the following: **(12)**
   (i) 3s, 3p and 3d orbitals have the same energy in a hydrogen atom but have different energies in a many-electron atom
   (ii) Bohr Model successfully explains the spectra of hydrogen atom

   (b) Define first ionization energy and write down the periodic trends of it. The ions Na^+ and Mg^{2+}, occur in chemical compounds, but the ions Na^{2+} and Mg^{3+} do not. Explain. **(8+5=13)**

   (c) Elements of the sixth period have nearly the same covalent radii as the corresponding elements in the fifth period. Attribute the reason. **(10)**

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CHEM 161/NCE

SECTION – B

There are **FOUR** questions in this section. Answer to **Question no. 5 is Compulsory**. Answer any **TWO** questions from Questions 6-8.

5. (a) List the properties of transition metals that contribute to their effectiveness as catalysts. Then, demonstrate the steps involved in the heterogeneous catalysis of nickel (Ni) in the conversion of alkenes to alkanes. **(10)** (CO2)

   (b) Calculate the crystal field stabilization energy for low spin and high spin complexes of Cr^{2+} ion when crystal field splitting energy is Δ_0. **(10)** (CO3)

   (c) Apply band theory of solids to explain the correlation between properties of metals and valence electron configuration for period 3 metals (Na, Mg & Al). **(10)** (CO4)

   (d) Provide a visual representation that illustrates the formation of both σ and π molecular orbitals from atomic p orbitals. **(5)** (CO1)

6. (a) Carbon monoxide can act as a Lewis base-How? **(10)**

   (b) Apply your understanding of hard and soft acid-base (HSAB) interactions to assess the aqueous solubility trends down the group for silver and lithium halides. **(10)**

   (c) Water can act as an oxidizing and a reducing agent- demonstrate using the HOMO-LUMO concept. **(10)**

   (d) Define Pearson's absolute hardness according to energy gap of HOMO & LUMO. **(5)**

7. (a) Discuss important types of isomerism in coordination complexes. **(10)**

   (b) An enzyme containing Ni^{2+} complex at the active site was found to be diamagnetic, predict the geometry of the complex using valence bond theory and crystal field theory. **(10)**

   (c) Write the systematic names and the number of ions in solution for the following compounds: **(10)**

   (i) $[Co(en)_2Cl_2]NO_3$ (ii) $[Pt(NH_3)_4BrCl]Cl_2$ (iii) $[Co(NH_3)_6][Cl_4Fe]_3$
   (iv) $[Cr(H_2O)_4Cl_2]Cl$ (v) $[Fe(NH_3)_5(NO_3)][SO_4]$

   (d) Sketch structures of all stereo isomers of **(5)**

   (i) $[Pt(NH_3)_2Cl_2]$ (ii) $[Cr(en)_3]^{3+}$ (en = $H_2NCH_2CH_2NH_2$)

8. (a) Discuss the concept of the glass transition temperature and its significance in the formation of amorphous solids, emphasizing how variations in this temperature affect their physical properties. **(10)**

   (b) Examine the classification of solids based on their underlying chemical bonding and intermolecular forces and evaluate how these factors influence the properties and behaviors of various types of solids. **(10)**

   (c) Discuss the various types of catalysis, providing specific examples for each type. **(10)**

   (d) How chemically tempered glass is prepared? **(5)**