L-1/T-1/ME Date: ~~23/04/2024~~ 25/5/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

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

Sub: **PHY 105** (Structure of Matter, Electricity & Magnetism and Modern Physics)

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**.

1. (a) Define single crystal, polycrystal, primitive cell, Bravais and non-Bravais lattices. **(6)**

   (b) Draw the crystal structures of the space lattice systems having unit cell characteristics of $\alpha = \beta = \gamma = 90°$? Also, draw the crystal structures of BaO and ZnS mentioning lattice points per unit cell. **(22)**

   (c) Niobium with atomic mass 93 crystallizes in body centered cubic structure and has a density of 8.55 g/cc. Calculate its atomic radius. **(7)**

2. (a) What are Miller indices? How to calculate it? **(6)**

   (b) Derive the expression relating interplanar spacing, d_{hkl} and Miller indices for cubic structure. Explain why the $d_{100} : d_{110} : d_{111}$ for simple cubic, body centered cubic, and face centered cubic crystals are different? **(22)**

   (c) Why the X-ray diffraction peaks are different for KCl and KBr though their crystal structure are same? **(7)**

3. (a) Define crystal defects and mention some uses of these in engineering materials. **(6)**

   (b) (i) Derive the expression for bond energy of an ionic crystal and find the energy for equilibrium separation. (ii) How the energy bands are formed in solid? **(22)**

   (c) In a NaCl crystal, the equilibrium distance between ions is 0.281 nm. Find the cohesive energy per ion in forming the NaCl crystal. Given that, ionization energy for Na is +5.14 eV, electron affinity of Cl is –3.61 eV, Madelung constant for NaCl is 1.748 and exponent $n \approx 9$. **(7)**

4. (a) Define magnetic field ($\vec{B}$). State (i) Biot-Savart law, (ii) Ampere's law. **(10)**

   (b) (i) Obtain an expression for the torque acting on a current carrying loop placed in a magnetic field. (ii) Also show that the potential energy of magnetic dipole, $U = -\vec{m}.\vec{B}$, where $\vec{m}$ represents the magnetic dipole moment. **(18)**

   (c) A circular coil of radius 40 mm consists of 250 turns of wire in which the current is 20 mA. What is the magnetic field at the center of the coil? **(7)**

Contd P/2

PHY 105/ME

SECTION – B

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

5. (a) Define the terms: Electric field, and electric dipole moment. **(7)**

(b) (i) Show that the electric field due to an infinite line of charge at a point is $E = \frac{\lambda}{2\pi\varepsilon_0 y}$, where λ is the linear charge density and y is the perpendicular distance of the point from the line. (ii) Deduce Coulomb's law of electrostatics from Gauss' law. **(12+8=20)**

(c) Calculate the force between two free electrons spaced 1Å apart. ($1Å = 10^{-10}$ m) **(8)**

6. (a) State Faraday's law of electromagnetic induction. **(5)**

(b) (i) Show that the energy stored in magnetic field is given by $U_B = \frac{1}{2}Li^2$. Where the symbols have their usual meaning. (ii) A circuit contains an inductance 'L' and a resistance 'R' placed in series with a cell of emf 'V'. Find the equation for the growth of the current. What is the time constant of the circuit? **(7+13=20)**

(c) A solenoid has an inductance of 50 H and a resistance of 30 Ω. It is connected to a 100 V battery. How long will it take for the current to reach one half of its final value? **(10)**

7. (a) Describe the characteristics of the photoelectric effect. What are the differences between the photoelectric effect and the Compton effect. **(12)**

(b) Derive an expression for the change in wavelength due to Compton scattering. **(14)**

(c) Ultraviolet light of wavelength 2500Å falls upon a silver photocathode. If the photoelectric threshold wavelength for silver is 5500Å, calculate the least potential difference that must be applied between the anode and the photocathode to prevent electrons from the photocathode. **(9)**

8. (a) What are the basic features of the liquid drop model and shell model of the nucleus? **(12)**

(b) Derive Weizsacker's Formula for binding energy per nucleon based on the liquid drop model only. **(14)**

(c) A city requires on average, 200 MW of electric power per day, and this is to be supplied by a nuclear reactor with an efficiency of 25%. Using U^{238} as a nuclear fuel, calculate the amount of fuel required for one day's operation. The energy released per fission of U^{238} nuclide is 200 MeV. **(9)**

L-1/T-1/ME Date: ~~04/05/2024~~ 19/05/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

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

Sub: **CHEM 109** (Chemistry I)

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**, including Question No. 1 (One).

1. (a) An aqueous solution of sugar or glucose will boil at a temperature higher than pure water at atmospheric pressure. Explain the fact with your knowledge of boiling point elevation due to adding non-volatile and nonelectrolyte solute in water. **(10)** (CO1)

   (b) Compare the membrane solution and vapor pressure theory of osmosis through the semipermeable membrane. **(10)** (CO2)

   (c) For a typical consecutive reaction, the reaction profile depends on the rate constants of the consecutive steps. Sketch the typical reaction profiles and justify the statement. **(10)** (CO3)

   (d) A fourth or higher order chemical reaction is improbable. Justify the statement. **(5)** (CO4)

2. (a) Define hydration enthalpy and lattice enthalpy. Explain that both parameters control the solubility of ionic solids in polar solvents. **(15)**

   (b) Deviations of experimental value with theory for colligative properties for electrolytes are very common. Identify the origins of such deviations. **(12)**

   (c) In countries with cold weather, car coolant usually consists of ethylene glycol, a non-volatile and nonelectrolyte solvent. Calculate the boiling and freezing points of a 25.0 mass % ethylene glycol solution in water. Use the normal boiling and freezing points of water at 1 atm pressure. [K_b = 0.51 °C/m, K_f = 1.86 °C/m] **(8)**

3. (a) The concept of half-life of a chemical reaction can be applied for the determination of the order of a reaction-justify. **(15)**

   (b) Using Lindemann's hypothesis, explain that the order depends on the reactant concentration. **(12)**

   (c) For a first-order reaction, the rate constant is 10^{-3} min^{-1} and the concentration of the reactant is 0.2 mol dm^{-3}. How much reactant will be converted into the products in 200 min? **(8)**

4. (a) Derive the phase rule for a condensed system using the concept of equilibrium. **(15)**

   (b) Differentiate the eutectic point and melting point with an appropriate phase diagram. **(12)**

   (c) Draw the schematic diagram of a bomb calorimeter and explain the working principle. **(8)**

Contd P/2

CHEM 109/ME

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 two experimental pieces of evidence supporting the wave model and two for the particle model of an electron. Outline the energy level diagrams valid for the electrons in both B^{3+} and Be^{3+} ions. **(10)** (CO1)

   (b) Explain de Broglie's relation for a matter of wave and interpret each term involve in it. Describe that Bohr's principle of quantization of angular momentum of a moving electron can be derived from de Broglie's concept of standing waves. **(10)** (CO2)

   (c) An electron in the 6^{th} energy level of an H atom drops to a lower energy level; the atom emits a photon of wavelength 410 nm. (i) Calculate the amount of ΔE required for this transition due to 1 mole of H atoms. (ii) Predict to what energy level did the electron move? **(10)** (CO3)

   (d) How would you differentiate between probability distribution and radial probability distributions of 1s and 2s orbitals? **(5)** (CO4)

6. (a) What is effective nuclear charge (Z_{eff})? How Z_{eff} does affect the atomic radii along a period? Rank the following set of ions in order of decreasing size, and explain your ranking: K^+, S^{2-} and Cl^-. **(10)**

   (b) Categorize the nature of high spin and low spin complex formation for a transition metal cation Fe^{3+} in presence of CN^- and H_2O ligands. **(10)**

   (c) Draw and explain the potential energy curve for the bond formation in H_2. **(10)**

   (d) Explain why $AlCl_3$ is covalent but AlF_3 is not. **(5)**

7. (a) The cyanide ion (CN^-), is assume to have molecular orbitals resembling those of a diatomic homonuclear molecule. Compose the molecular orbital configuration and bond order of cyanide ion. Is a substance of the ion diamagnetic or paramagnetic? **(15)**

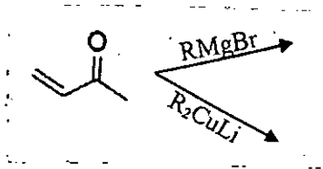
   (b) Predict the hybridization, geometry and shape of the following compounds suing VSEPR model: IF_2^-, CS_2, $XeOF_4$ and NH_4^+. **(10)**

   (c) Illustrate the Born-Haber cycle for the formation of MgO (s) from its constituent elements and explain how the lattice energy of MgO can be determined using this cycle. **(10)**

8. (a) What is meant by the extent of dissociation of weak acid? Calculate the pH of a solution that contains 1.00 $moldm^{-3}$ HCN ($K_a = 6.20\times10^{-10}$) and 5.00 $moldm^{-3}$ HNO_2 ($K_a = 4.01\times10^{-4}$). Also calculate the concentration of cyanide ion in this solution at equilibrium at 25 °C. **(10)**

   (b) Explore hydrolysis reactions of the ionizable protion of the subsequent salts and hence predict whether the solutions will be nearly neutral, basic, or acidic: **(10)**
   (i) NH_4I, (ii) $NaNO_2$, (iii) $FeCl_3$, (iv) $Ba(NO_3)_2$, (v) CH_3COOK.

   (c) Consider only the HSAB characteristics in your answers. **(15)**
   (i) What happens when AgF and LiI are placed together into water?
   (ii) Will Fe, Fe^{2+} or Fe^{3+} react more favorably with CO?
   (iii)What are the final products of the following reactions of α, β-unsaturated ketone-



L-1/T-1/ME **Date: 30/03/2024**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

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

Sub: **MATH 161** (Differential Calculus Solid Geometry and Vectors)

Full Marks: 280 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) Define continuity differentiability with examples. **(8)**

   (b) Obtain the successive differentiation of y_n for the function $y = \sin^6 x$. **(12)**

   (c)Apply implicit differentiation for the folium of Descartes $x^3 + y^3 = 3xy$ to (i) find an equation for the tangent line at the point $\left(\frac{3}{2}, \frac{3}{2}\right)$, and (ii) find the point(s) in the first quadrant, which is the tangent line to the Folium of Descartes horizontal. **(16)**

   (d) Evaluate $\lim_{x \to 0^+}\left(-\frac{1}{\ln x}\right)^x$. **(10⅔)**

2. (a) State Leibnitz's theorem. **(6)**

   (b) If $x = \sin\left(\frac{\ln y}{m}\right)$, then find y_n by using Leibnitz's theorem at $x = 0$. **(15)**

   (c) Develop $\cos(a+h)$ for finite Taylor series in power of h with cauchy's form of remainder. **(15)**

   (d) The boundary of a field is a right triangle with a straight stream along its hypotenuse and with fences along its other two sides. Find the dimensions of the field with maximum area that can be enclosed using 1000 ft of fence. **(10⅔)**

3. (a) State Rolle's and Mean value theorem. **(6)**

   (b) If $f(x) = (x-1)(x-2)(x-3)$, x lying in the interval [0,4]. Verify that $f(x)$ satisfy Mean value theorem and find c. **(10)**

   (c) Identify for the function $f(x) = \sin^{-1} x^{2/3}$, (i) the intervals on which f is increasing, (ii) the intervals on which f is decreasing, (iii) the open intervals on which f is concave up and concave down, (iv) the x-coordinates of all critical and inflection points, and (v) sketch the graph. **(20)**

   (d) Find the radius of curvature at $(a, 0)$ of the curve $r = a\sec\theta$. **(10⅔)**

Contd P/2

MATH 161/ME

4. (a) State Euler's theorem for homogeneous function of two variables. **(5)**

(b) Construct the equation of tangent, normal, subtangent, subnormal, length of tangent and length of normal to the curve $y(x-2)(x-3)-x+7=0$ at the point of x-interception. **(15⅔)**

(c) Identify the envelope of the straight line $\frac{x}{a}+\frac{y}{b}=1$, where the parameters a and b are connected by the relation $ab=c^2$, c being a constant. **(13)**

(d) Construct the asymptotes of the curve $(x^2-y^2)y-2ay^2+5x-7=0$ and apply the obtained asymptotes to find the area of a triangle. **(13)**

SECTION – B

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

5. (a) Suppose that a box has its faces parallel to the coordinate planes and the points (4,2,–2) and (–6,1,1) are endpoints of a diagonal. Sketch the box and give the coordinates of the remaining six corners. **(12⅔)**

(b) Define projection. Derive the formula to find the projection of a line segment joining the points $P(x_1, y_1, z_1)$ and $Q(x_2, y_2, z_2)$ on a line with direction consines l, m, and n. Hence find the projection of the line segment joining the points (4, –2, 5) and (2, 1, –3) on the line with direction ratios 6, 2 and 3. **(17)**

(c) If variable line in two adjacent positions has direction cosines (l, m, n) and $(l+\delta l, m+\delta m, n+\delta n)$, show that the small angle $\delta\theta$ between two positions is given by $(\delta\theta)^2=(\delta l)^2+(\delta m)^2+(\delta n)^2$. **(17)**

6. (a) Define plane. Derive the point-normal form of the equation of a plane in vector form. **(12⅔)**

(b) Find the equation of the plane through the point (1,1,2) and perpendicular to each of the planes $2x-2y-4z-6=0$ and $3x+y+6z-4=0$. **(17)**

(c) If the points A, B and C are given by (3, 2, 1), (–2, 0, –3) and (0, 0, –2) respectively. Find the locus of P, if the volume of the tetrahedron $PABC$ = 5. **(17)**

Contd P/3

MATH 161/ME

7. (a) Derive the vector equation, parametric equations and symmetric equations of a line passing through a fixed point and parallel to a given vector in 3D space. **(12⅔)**

(b) Find the angle between the line $\frac{x-2}{3}=\frac{y+3}{3}=\frac{z-1}{1}$ and the plane $2x-3y+4z-7=0$. **(8)**

(c) Find an equation for the line L of intersection of the planes $2x-4y+4z=6$ and $6x+2y-3z=4$. **(11)**

(d) What do you mean by skew lines? Show that the lines $L_1 : x=1+4t,\ y=5-4t,\ z=-1+5t$, $L_2 : x=2+8t, y=4-3t, z=5+t$ are skew. Find the distance between them. **(15)**

8. (a) A rope is attached to a 100 *lb* block on a ramp that is inclined at an angle of 30° with the ground. How much force does the block exert against the ramp, and how much force must be applied to the rope in a direction parallel to the ramp to prevent the block from sliding down the ramp? (Assume that the ramp is smooth.) **(15⅔)**

(b) Prove that $(\mathbf{A}\times\mathbf{B}).(\mathbf{B}\times\mathbf{C})\times(\mathbf{C}\times\mathbf{A})=(\mathbf{A}.\mathbf{B}\times\mathbf{C})^2$. **(20)**

(c) Determine whether the vectors $5i-2j+k, 4i-j+k, i-j$ lies in the same plane. **(11)**
