L-1/T-2/IPE Date : 03/11/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2020-2021

Sub : **CHEM 143** (Chemistry of Materials)

Full Marks : 140 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) Classify lubricants depending on the physical state and explain their properties. **(8)**

   (b) What are the impurities present in lubricants of mineral origin? Describe the dewaxing process of lubricant using one of the solvent system. **(7 1/3)**

   (c) Name some synthetic lubricants and explain their advantages and disadvantages. **(8)**

2. (a) Explain the pigment volume concentration of paint and mention its importance. **(7 1/3)**

   (b) Clarify the functions of binders and additives in a good paint. **(8)**

   (c) Describe the manufacturing process of paint with a flow chart. **(8)**

3. (a) State the physical and chemical definition of glass. **(5 1/3)**

   (b) Mention the various raw materials used for the manufacture of glass materials. **(9)**

   (c) Write the fundamental chemical reactions that occur in the glass manufacturing furnace with respect to temperature. **(9)**

4. (a) Discuss the pitting type of corrosion with examples and how it can be prevented? **(7 1/3)**

   (b) Explain the electrochemical mechanism of corrosion with suitable examples. **(8)**

   (c) Mention the differences between dry and wet corrosion. **(8)**

SECTION – B

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

5. (a) What is polymer material and how is it different from macromolecule? How would you classify polymer based on the mechanical properties? **(2+8=10)**

   (b) What is the structural formula of the following polymers? **(5)**

   (i) Organic polymer (ii) Inorganic polymer (iii) Homopolymer (iv) Co-polymer (v) Syndiotactic polymer

   (c) How does the order or regularity exhibit in different polymers where the successive asymmetric carbon atoms give rise to different forms of d-or l- structures? **(8 1/3)**

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CHEM 143/IPE

6. (a) What are the basic differences between chain and step reactions in the polymerization process? Give an illustration. Explain the mechanistic path of the free radical addition polymerization. **(5+5=10)**

(b) Explain inhibition and retardation of polymerization. Draw a schematic diagram showing the simple comparison of conversion-time plots for normal, inhibited, and retarded free-radical polymerization reactions. **(5+2 ⅓=7 ⅓)**

(c) Functionality is a very useful concept in polymer science. What do you mean by functionality of a polymer? Explain the functionality of **prop-2-en-l-ol** monomer in reactions with (i) styrene, $C_6H_5CH = CH_2$ and (ii) adipic acid, $HOOC-(CH_2)_4-COOH$. **(1+5=6)**

7. (a) What is polymer's number-average (M_n) and weight-average (M_w) molecular weight? Explain with examples. Illustrate a typical molecular weight distribution curve of a polymer sample stating the characteristic positions of M_n and M_w in it. State the significance of PDI of a polymer material. **(4+4+4=12)**

(b) Poly (hexamethylene adipamide) and ((Nylon-6,6) were synthesized by condensation polymerization of hexamethylenediamine and adipic acid in 1:1 mole ratio. Write down the chemical formula of the polymer material and hence calculate the acid equivalent of the polymer whose average DP is 440. **(4 ⅓)**

(c) Define glass transition temperature (T_g) of a polymer. How plasticizer can affect the T_g of it? Consider a new polymer that has softening temperature of 60 °C. If the softening temperature of the material is indeed a melting transition then show schematically the results that would be expected from the polymer in the following experiments (a) Specific volume (v) as a function of temperature (T); (b) differential scanning calorimetry; (c) Young's modulus (E) as a function of temperature (T); (d) X-ray diffraction (e) viscoelastic relaxation with time. (The experiments are carried out in the temperature range 50-70 °C.) **(2+5=7)**

8. (a) Define mercerization. How does it help to manufacture viscose rayon? Write the chemical reactions involved in the formation of viscose rayon from cellulose wood pulp. **(1+2+7=10)**

(b) What do you mean by vulcanization of natural rubber? Why is it so important? How vulcanization can be carried out? **(4+4=8)**

(c) What is ebonite? Discuss some superior properties of vulcanized rubber over the unvulcanized rubber. **(5 ⅓)**

L-1/T-2/IPE **Date: 19/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **PHY 163** (Waves and Oscillations, Physical Optics and Wave Mechanics)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Explain the terms phase space, phase point and ensemble in statistical mechanics. **(7)**

   (b) A one-dimensional simple harmonic oscillator is in equilibrium with a heat reservoir at absolute temperature T. Deduce the expression for the partition function of the system. Hence find out the expression for mean energy. **(20)**

   (c) Based on question (b), what would be the values of average energy in the limiting cases of high and low temperatures? Justify whether they are in agreement with classical theory. **(8)**

2. (a) Mention a few differences between boson and fermion. **(7)**

   (b) Derive the Fermi-Dirac distribution law for a system of particles. **(20)**

   (c) Calculate the relative number of atoms of hydrogen gas present in ground state and first excited state at temperatures 30 K and 6000 K. **(8)**

3. (a) Write down the postulates of quantum mechanics. **(7)**

   (b) From a one-dimensional time dependent Schrödinger equation, find the time independent Schrödinger equation. Show that the normalization of wave function is independent of time. **(20)**

   (c) A particle is moving in a one-dimensional box (of infinite height) of width 15 Å. Calculate the probability of finding the particle within an interval of 0.5 Å at the centre of the box, when it is in its first excited energy. **(8)**

4. (a) What are the differences between interference and diffraction of light? **(7)**

   (b) Draw a schematic diagram of Young's double slit experiment and hence show that the fringe spacings for the consecutive bright or dark fringes are same. **(20)**

   (c) A viewing screen is separated from a double-slit source by 1.5 m. The distance between the two slits is 0.030 mm. The second-order bright fringe (m = 2) is 4.5 cm from the center line. **(8)**

   (i) Determine the wavelength of the light.

   (ii) Calculate the distance between adjacent bright fringes.

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SECTION – B

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

5. (a) Explain Fresnel and Fraunhofer classes of diffraction of light. **(7)**

(b) Define reflection and transmission gratings with sketch. What is grating constant? Derive the equation of dispersive power of a transmission grating. **(20)**

(c) The separation of sodium lines (mean λ = 5893 Å) in the second order spectrum of transmission grating containing 5100 lines per cm is 3.5 minutes for normal incidence. What is the difference in wavelengths of the two lines? **(8)**

6. (a) Explain the terms polarization of light, plane of polarization and plane of vibration. Mention some applications of polarization. **(8)**

(b) State the Malus law and hence derive equation for intensity of light transmitted by the analyzer. Explain when $\theta = 0°$ and $\theta = 90°$. At what angle is light inside crown glass completely polarized when reflected from water, as in a fish tank? Water has $n_1 = 1.34$, and crown glass has $n_2 = 1.53$. **(17)**

(c) Define double refraction, ordinary ray and extra-ordinary ray of light with schematics. Explain how optic axis of a crystal control the double refraction phenomenon. **(10)**

7. (a) Explain your understanding about damped oscillations. Which type of damping motion should be set in door closer? Justify your answer. Discuss the effect of damping on the natural frequency of an oscillator. **(10)**

(b) If the mass of a spring m is not negligible but small compared to the mass M of the object suspended from it, then show that the period of the simple harmonically oscillating spring is $T = 2\pi\sqrt{\frac{M + \frac{m}{3}}{k}}$, where the symbols have their usual meaning. From the above equation, mention the effect of spring mass in the oscillation. **(18)**

(c) A 0.25 kg block oscillates on the end of the spring with a spring constant of 200 N/m. If the oscillation is started by elongating the spring 0.15 m and giving the block a speed of 3 m/s. Find the amplitude of the oscillation and maximum speed of the block. **(7)**

8. (a) What is phase velocity? Find the relation between group velocity and phase velocity. When does the group velocity become equal to the phase velocity? **(8)**

(b) Define energy density and energy current of a plane progressive wave. Obtain expressions for them. **(18)**

(c) A harmonically moving transverse wave on a string has a maximum particle velocity and acceleration of 3 ms^{-1} and 90 ms^{-2}, respectively. The velocity of the wave is 20 ms^{-1}. Establish the equation of the wave. **(9)**

L-1/T-2/IPE **Date: 15/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **MATH 193** (Vector, Matrix and Coordinate Geometry)

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** questions.

1. (a) If $\mathbf{A} \times \mathbf{B} = \mathbf{0}$, **A** and **B** are not null vectors, then check whether **A** and **B** are parallel or not. **(10)**

(b) Are the vectors $\mathbf{V}_1 = (4, 1, -2)$, $\mathbf{V}_2 = (-3, 0, 1)$, and $\mathbf{V}_3 = (1, -2, 1)$ linearly independent? **(12)**

(c) Find the equation of a straight line which passes through two given points A and B having position vectors **a** and **b** with respect to an origin 0. **(12)**

(d) Do the vectors $\mathbf{A} = 3\mathbf{i} + \mathbf{j} - 2\mathbf{k}$, $\mathbf{B} = -\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$, and $\mathbf{C} = 4\mathbf{i} - 2\mathbf{j} - 6\mathbf{k}$ form a triangle? If so, then find the lengths of the medians of the triangle. **(12⅔)**

2. (a) The following forces act on a particle P: **(15)**

$\mathbf{F}_1 = 2\mathbf{i} + 3\mathbf{j} - 5\mathbf{k}$, $\mathbf{F}_2 = -5\mathbf{i} + \mathbf{j} + 3\mathbf{k}$, $\mathbf{F}_3 = \mathbf{i} - 2\mathbf{j} + 4\mathbf{k}$ and $\mathbf{F}_4 = 4\mathbf{i} - 3\mathbf{j} - 2\mathbf{k}$, measured in pounds. Find the resultant of the forces, and the magnitude of the resultant. Also check their coplanarity.

(b) Find an equation for the plane determined by the points $P_1(2, -1, 1)$, $P_2(3, 2, -1)$ and $P_3(-1, 3, 2)$. **(15)**

(c) A rigid body is rotating about an axis through the point $(3, -1, -2)$. If the particle at the point $(4, 1, 0)$ has velocity $4\mathbf{i}-4\mathbf{j}+2\mathbf{k}$ and at the point $(3, 2, 1)$ has velocity $6\mathbf{i}-4\mathbf{j}+4\mathbf{k}$, find the magnitude and direction of the angular velocity of the body. **(16⅔)**

3. (a) Supercomp Ltd produces two computer models PC1086 and PC1186. The matrix A shows the cost per computer (in thousands of BDT) and B the production figures for the year 2021 (in multiples of 10,000 units). Find a matrix C that shows the shareholders the cost per quarter (in millions of BDT) for raw materials, labor, and miscellaneous. **(15)**

	PC1086	PC1186	
A =	1.2	1.6	Raw Components
	0.3	0.4	Labor
	0.5	0.6	Miscellanious

and

	Quarter 1	2	3	4	
B =	3	8	6	9	PC1086
	6	2	4	3	PC1186

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MATH 193/IPE

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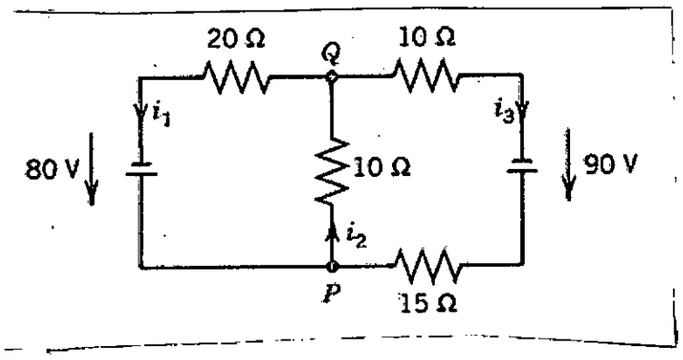
(b) Find the inverse of $B = \begin{pmatrix} -1 & 1 & 2 \\ 3 & -1 & 1 \\ -1 & 3 & 4 \end{pmatrix}$ using Gauss-Jordan elimination technique. **(15)**

(c) Using Kirchhoff's law and showing the following details, find the currents **(16⅔)**



4. (a) Suppose that three industries are interrelated so that their outputs are used as inputs by themselves, according to the consumption matrix. **(20)**

$$A = (a_{jk}) = \begin{pmatrix} 0.1 & 0.5 & 0 \\ 0.8 & 0 & 0.4 \\ 0.1 & 0.5 & 0.6 \end{pmatrix},$$

Where a_{jk} is the fraction of the output of industry k consumed (purchased) by industry j. Let p_j be the price charged by industry j for its total output. Show that this leads to $\mathbf{Ap} = \mathbf{p}$, where $\mathbf{p} = [p_1, p_2, p_3]^T$, and find a solution $\mathbf{p}$ with nonnegative p_1, p_2, p_3.

(b) Reduce $A = \begin{pmatrix} 1 & -2 & 1 & 3 \\ 4 & -1 & 5 & 8 \\ 2 & 3 & 3 & 2 \end{pmatrix}$ into normal form N. Find the nonsingular matrices B and E such that BAE = N. Also find the rank. **(26⅔)**

SECTION – B

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

5. (a) Transform the equation $5x^2 + 4xy + 2y^2 - 2x + 4y + 4 = 0$ to one in which there is no term involving x, y and xy by suitable translation and rotation of axes. **(26⅔)**

(b) Show that the straight lines whose direction cosines are connected by the relations $al + bm + cn = 0$ and $fmn + gnl + hlm = 0$ are parallel if $\sqrt{af} \pm \sqrt{bg} \pm \sqrt{ch} = 0$ and perpendicular if $\frac{f}{a} + \frac{g}{b} + \frac{h}{c} = 0$. **(20)**

Contd P/3

MATH 193/IPE

6. (a) Find the equation of the plane which is perpendicular to the plane $5x+3y+6z+8=0$ and which contains the line of intersection of the planes $x+2y+3z-4=0$ and $2x+y-z+5=0$. **(23)**

(b) A variable plane is at a constant distance p from the origin O and cuts the axes in A, B and C. Show that the locus of the centroid of the tetrahedron OABC is $\frac{1}{x^2}+\frac{1}{y^2}+\frac{1}{z^2}=\frac{16}{p^2}$. **(23⅔)**

7. (a) Find the distance of the point (2, –3, 6) from the plane $2x+3y+4z=25$ measured parallel to the line $\frac{x}{2}=\frac{y}{3}=\frac{z}{-5}$. **(20)**

(b) Find the length and the equations of the shortest distance between the lines $\frac{x-3}{1}=\frac{y-5}{-2}=\frac{z-7}{1}$ and $\frac{x+1}{7}=\frac{y+1}{-6}=\frac{z+1}{1}$. Also find the points where it intersects the lines. **(26⅔)**

8. (a) Find the equations of the sphere passing through the circle $x^2+y^2+z^2-6x-2z+5=0$, $y=0$ and touching the plane $3y+4z+5=0$. **(23⅔)**

(b) Find the equations of the planes through the line $7x+10y-30=0$, $5y=3z$ touching the ellipsoid $7x^2+5y^2+3z^2=60$. **(23)**

L-1/T-2/IPE Date : 30/10/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2020-2021

Sub : **MME 195** (Engineering Materials 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**.

1. (a) Contrast the characteristics and properties of metals and ceramics materials. **(12)**

   (b) With the help of necessary figures, explain how different structures can be formed by the most efficient packing of spherical atoms. Why do they show different properties despite having the same atomic packing factor? **(13+3=13)**

   (c) Explain the necessity of four axis co-ordinate system in identification of hexagonal crystal direction. Convert the [010] direction into the four-index Miller-Bravais scheme for hexagonal unit cells. **(3+4=7)**

2. (a) Show the effect of decreasing temperature on a typical stress-strain curve of iron and explain the effect of temperature on the relevant mechanical properties. **(15)**

   (b) What is slip process? With the help of necessary figures, demonstrate the microscopic phenomenon of plastic deformation using the motion of an edge dislocation. **(20)**

3. (a) What is plane strain fracture toughness? Explain the effect of various factors on plane strain fracture toughness. **(15)**

   (b) Outline the importance of ductile-brittle transition behavior for materials selection. Using necessary sketch, explain the effect of various metallurgical factors on ductile-brittle transition phenomenon of a material. **(5+15=20)**

4. (a) Why is stainless steel corrosion resistant? Compare the ferritic and austenitic stainless steel in terms of composition, properties and applications. **(15)**

   (b) What is pig iron? Outline the operations of pig iron production in a blast furnace along with the principal reactions of pig iron production. **(20)**

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MME 195/IPE

SECTION – B

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

Graph paper should be provided.

5. Metals A and B of melting points 1085°C and 961.8°C, respectively are mutually soluble in the liquid state (completely) but partially soluble in the solid state. At 779°C a eutectic composition is formed with 28.1% A and 71.9% B. At eutectic temperature the solubility of B in A is 8.0% and that of A in B is 8.8%. Assume that at room temperature, the solubility of each is almost 0%. **(15+12+8)**

   (i) Draw the A-B equilibrium phase diagram to scale on a piece of graph paper labelling all points, lines and areas.

   (ii) For a 60% A- 40% B alloy, determine the compositions and relative amounts of the phase present at 1°C above the eutectic temperature and also for the eutectic micro-constituent and the pro-eutectic phase just below the eutectic temperature?

   (iii) Draw the microstructures of the 97% A- 3% B alloy composition at 800°C and at room temperature.

6. (a) Identify the steel with the carbon concentration (wt %) for which the fraction of total ferrite at room temperature is 0.94. **(8)**

   (b) Normalizing heat treatment results in a stronger and harder steel than is obtained by annealing – explain. **(12)**

   (c) How does bainite structure differ from martensitic structure? Is it possible to produce 100% bainitic structure by continuous cooling of a plain carbon steel? If not, suggest how it can be produced. **(15)**

7. (a) Both gray cast iron and nodular cast iron are solidification products. What is the basic difference between the two production parameters that is responsible to produce graphite flake in gray cast iron and spheroidal graphite in nodular cast iron? Compare the properties and applications of gray cast iron and nodular cast iron. **(15)**

   (b) What is segregation in solidification of a binary isomorphous alloy? Explain, how does segregation give rise to less than the optimal properties? **(12)**

   (c) Compare phase with element. **(8)**

8. (a) Outline a heat treatment process suitable for toughening hyper-eutectoid steel. **(11)**

   (b) Discuss, all the isothermal reactions of the iron-iron carbide equilibrium diagram mentioning the compositions of the phases and the temperatures at which these reactions occur. **(12)**

   (c) Illustrate the microstructural changes that would occur when a 0.2% carbon steel is slowly cooled from fully austenitic region to room temperature. **(12)**
