

(Duration: 3 hours)

Max.Marks:80

- N.B:** (1) Question No.1 is compulsory
 (2) Answer any three questions from Q.2 to Q.6
 (3) Figures to the right indicate full marks.

- 1 a) Prove that $\log\left(\frac{2+3i}{2-3i}\right) = 2i \tan^{-1}\left(\frac{3}{2}\right)$ 5
- b) Prove that every square matrix can be uniquely expressed as sum Hermitian and skew Hermitian matrix. 5
- c) If $z = x^2y + y^2$, $x = \log t$, $y = e^t$, find $\frac{dz}{dt}$ at $t = 1$. 5
- d) Find the n^{th} derivative of $\frac{x}{(2x+3)(x+2)}$ 5
- 2 a) Prove that $\sin^5 \theta = \frac{1}{16}(\sin 5\theta - 5 \sin 3\theta + 10 \sin \theta)$ 6
- b) If $u = f\left(\frac{y-x}{xy}, \frac{z-x}{xz}\right)$, then show that 6
- $$x^2 \frac{\partial u}{\partial x} + y^2 \frac{\partial u}{\partial y} + z^2 \frac{\partial u}{\partial z} = 0$$
- c) Test for consistency the following system & solve them if consistent 8
- $$x_1 - 2x_2 + x_3 - x_4 = 2, \quad x_1 + 2x_2 + 2x_4 = 1, \quad 4x_2 - x_3 + 3x_4 = -1$$
- 3 a) Prove that $(1 + i\sqrt{3})^n + (1 - i\sqrt{3})^n = 2^{n+1} \cos \frac{n\pi}{3}$ 6
- b) Find the extreme values of the function $x^2y - 3x^2 - 2y^2 - 4y + 3$ 6
- c) Find the real root of $x^3 - 2x - 5 = 0$ correct up to three places of decimal using Newton-Raphson Method. 8

- 4 a) If $x + iy = \cot\left(\frac{\pi}{6} + i\alpha\right)$ P.T $x^2 + y^2 - 2\frac{x}{\sqrt{3}} = 1$ 6
- b) Expand $\tan^{-1}(x)$ in powers of $(x - \frac{\pi}{4})$. 6
- c) If $\cos^{-1}\frac{y}{b} = \log\left(\frac{x}{n}\right)^n$, then prove that 8
- $$x^2y_{n+2} + (2n + 1)xy_{n+1} + 2n^2y_n = 0$$
- 5 a) Separate real and imaginary parts of $(1 + i)^{1-i}$ 6
- b) Solve the following equations by Gauss Jacobi's Iteration method: 6
- $$15x + 2y + z = 18, 2x + 20y - 3z = 19, 3x - 6y + 25z = 22.$$
- c) Solve: $x^{10} + 8x^5 + 15 = 0$. 8
- 6 a) If $u = \tan^{-1}\left(\frac{x^2+y^2}{x-y}\right)$ Prove that 6
- $$x^2 \frac{\partial^2 u}{\partial x^2} + 2xy \frac{\partial^2 u}{\partial x \partial y} + y^2 \frac{\partial^2 u}{\partial y^2} = -2\sin^3 u \cos u$$
- b) i) Prove that $\sinh^{-1}(\tan \theta) = \log\left[\tan\left(\frac{\pi}{4} + \frac{\theta}{2}\right)\right]$ 6
- ii) If $u = \log\left(\frac{x}{y}\right)$, then find $xu_x + yu_y$
- c) If $A = \begin{pmatrix} 4 & 3 & 1 & 6 \\ 2 & 4 & 2 & 2 \\ 12 & 14 & 5 & 16 \end{pmatrix}$ find non-singular matrices P and Q such that PAQ is in 8
- normal form and find its rank.
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(2 Hours)

[Total Marks: 60]

- N.B.: (1) Question No. 1 is **compulsory**.
 (2) Attempt **any three** questions from Q.2 to Q.6.
 (3) Assume **suitable** data wherever **required**.
 (4) Figures to the right indicate marks.

- Q.1 Attempt any **FIVE** (All questions carry equal marks) **(15)**
- What is the probability of an electron being thermally excited to conduction band in Silicon at 20°C if the band gap is 1.12 eV. (Given: $k=8.6 \times 10^{-5} \text{eV/K}$)
 - Draw the following with reference to cubic unit cell:
(121), (100) and (011)
 - Explain why an extensively thin film appears black in reflected light.
 - What are the properties of matter waves?
 - Explain at least three applications of super capacitors.
 - Explain different phases of liquid crystal.
 - State de Broglie's hypothesis. Deduce an expression for the wavelength of de Broglie's matter waves.
- Q.2 (a) State the conditions of Maxima and Minima in Newton's rings and derive expression for the diameter of dark ring in reflected light system. **(08)**
- (b) Explain with neat diagram construction of Bragg's X-ray spectrometer and explain the procedure to determine crystal structure using it. Calculate the maximum order of diffraction if x-ray of wavelength 0.819Å is incident on a crystal with lattice spacing of 0.282nm. **(07)**
- Q.3 (a) Discuss Heisenberg's Uncertainty principle and prove that electrons cannot reside inside the nucleus of an atom using the same principle. **(08)**
- (b) Explain the construction and working of Light Emitting Diode with the help of diagrams. State the merits, demerits and applications. **(07)**
- Q.4 (a) Calculate electron and hole concentration in intrinsic silicon at room temperature if its electrical conductivity is $4 \times 10^{-4} \text{ mho/m}$. (mobility of electron = $0.14 \text{ m}^2/\text{V-s}$ & mobility of hole = $0.04 \text{ m}^2/\text{V-s}$) **(05)**
- (b) Write the expression for Schrodinger's time dependent equation of matter waves and derive Schrodinger's time independent equation. **(05)**
- (c) A wedge-shaped film of solution which had refractive index 1.28 was observed normally. The distance between successive bands was 0.15cm. The angle of wedge was 0.01° . Determine the wavelength of light used. **(05)**

- Q.5 (a) Discuss the importance of critical temperature in superconductors. Differentiate between Type I and Type II superconductors. (05)
- (b) Show that Fermi energy level is placed in the center of the energy band gap in intrinsic semiconductor. (05)
- (c) Show that group velocity of matter waves is equal to particle velocity. (05)
- Q.6 (a) What is Meissner Effect? With the help of this effect show that superconductors are diamagnetic in nature. (05)
- (b) Find the minimum thickness of the soap film which appear yellow (wavelength 5896 Å) in reflection when it is illuminated by white light at an angle of 45° . Given refractive index of the film is 1.33. (05)
- (c) An electron is bound in one dimensional potential well of width $2A^0$ that of infinite height. Find its energy value in the ground state and in first two excited states. (05)
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Duration: 3 hours

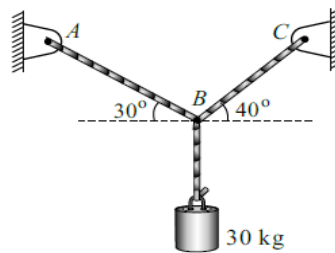
Total Marks : 80

Note :

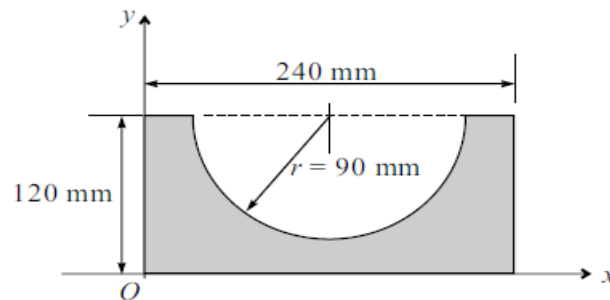
- Question No.1 is compulsory.
- Solve ANY THREE questions from the remaining five questions.
- Figure to the right indicates full marks.
- Assume suitable data wherever required, but justify the same.
- Take $g = 9.81 \text{ m/s}^2$.

Q.1 Solve ANY FOUR questions from the following. (Each question carries 5 marks). 20

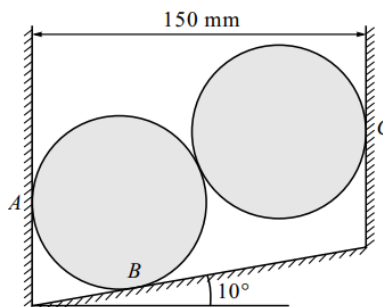
- a) Determine the tension in cord AB and BC for the equilibrium of the 30 kg block as shown in the figure.



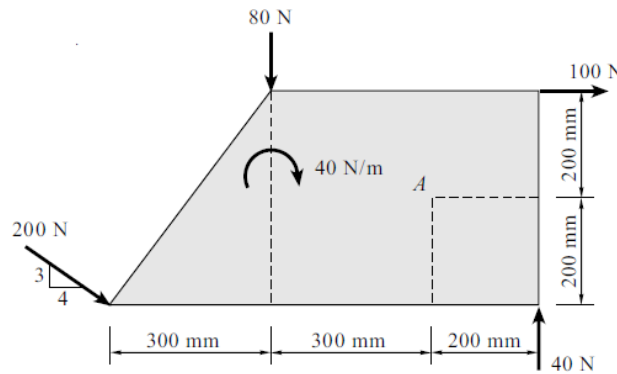
- b) Define the Instantaneous Centre of Rotation and write the properties of Instantaneous Centre of Rotation.
- c) Acceleration of a particle moving along a straight line is represented by the relation $a = t^3 - 2t^2 + 7$. At $t = 1$ second, velocity of the particle is 3.58 m/s and displacement is 9.39 m. Determine the velocity and displacement at $t = 2$ seconds.
- d) Define laws of friction.
- e) Determine the centroid of the shaded area.



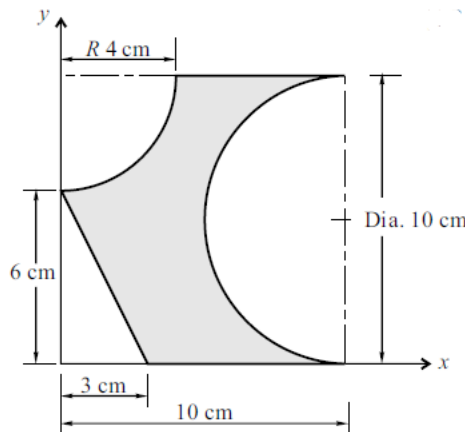
Q.2 a) Two identical cylinders of weight 200 N and diameter 100 mm are placed as shown in figure. Determine the support reactions at A, B and C. 8



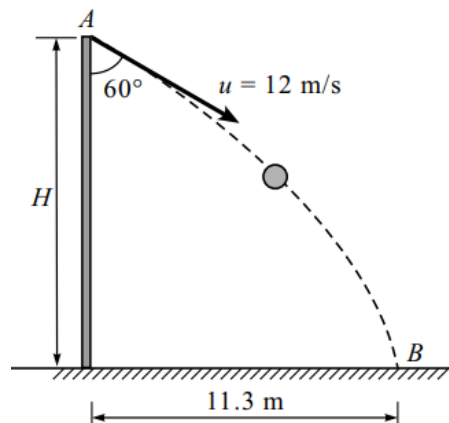
- b) Calculate the resultant of the given force system and locate it with respect to the point of action of 200 N force. 6



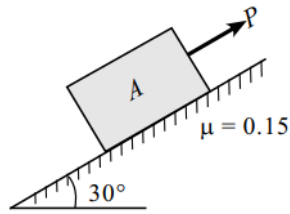
- c) Determine the “x” and “y” coordinates of the Centroid for the shaded area shown. 6



- Q.3 a) A ball is thrown with a speed of 12 m/s at an angle of 60° with a building strikes the ground 11.3 m horizontally from the foot of the building. Determine the height of the building. 8

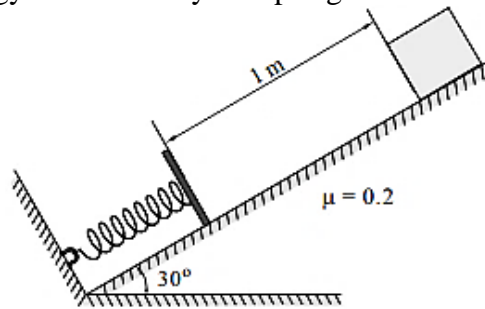


- b) A block of 1000 N is placed on an inclined surface. Determine the force required to prevent the sliding of the block down the plane if the coefficient of friction between the block and surface is 0.15. 6

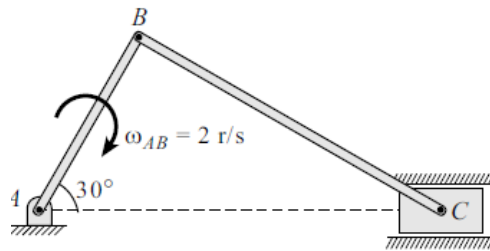


- c) A particle follows the path $y = 0.4x^2$ with a constant speed of 200 m/s at a rate of 0.8 m/s^2 . Determine the acceleration of the particle. **6**

- Q4** a) A 20 N block is released from rest. It slides down a rough incline having coefficient of friction 0.2 and compresses the spring having modulus 1000 N/m. Determine the maximum compression of the spring and the distance moved by block when the energy is released by the spring. **8**

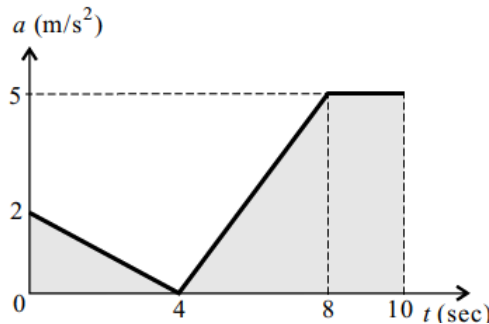


- b) At the instant shown, locate the ICR and determine the angular velocity of rod BC and the velocity of the piston C. (Take $AB=10.3 \text{ m}$, $BC=0.8 \text{ m}$) **6**

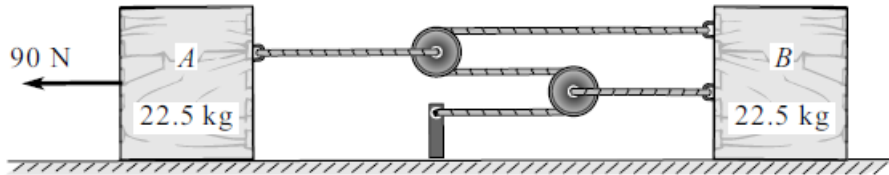


- c) A ball is thrown vertically down on a smooth horizontal floor with a velocity of 10 m/s from which it bounces to a height of 3 m. If the coefficient of restitution is 0.7. Find the maximum height it can reach after hitting the ground. **6**

- Q5.** a) The a-t curve is shown for a particle moving in a straight line. Draw the v-t and s-t diagram for 0-10 sec, if the particle has started from rest from the origin. **8**

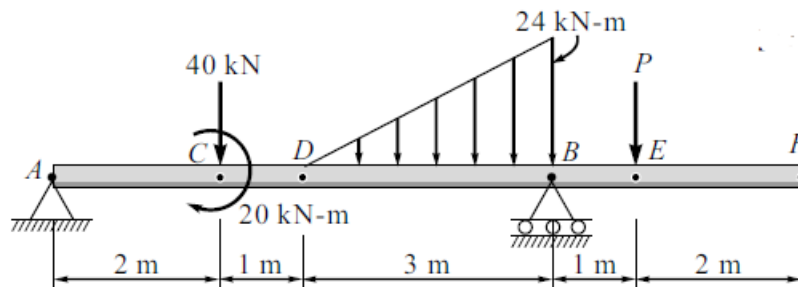


- b) For the system shown in figure, determine the acceleration and velocity of block A after it has moved 2.7 m when pulled by 90 N. **6**

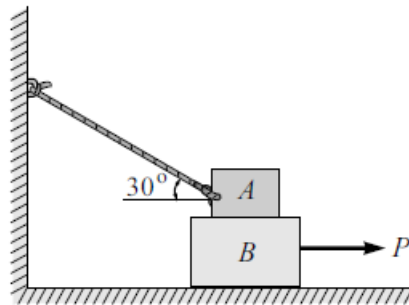


- c) A force $F = 3i - 4j + 12k$ N acts at a point "A (1,-2,3) m. Calculate (i) Moment of the force about the origin. (ii) Moment of the force about a point B(2,1,2). 6

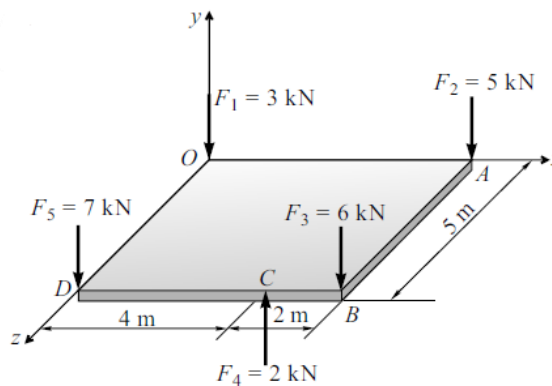
- Q6** a) A beam is loaded and supported as shown in figure. Find the support reactions at support B and Force P if the reaction at support A is zero. 8



- b) Block A weighs 40 kN and the block B weighs 60 kN. The coefficient of friction between A and B is 0.3 and between B and the floor is 0.25. Determine the value of "P" for holding the system in equilibrium. 6



- c) Determine the resultant of the system of parallel forces and the position on X-Z plane. 6



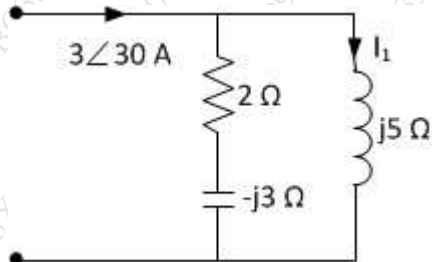
(3 Hours)

[Total Marks: 80]

- N.B.: (1) Question No. 1 is **Compulsory**.
 (2) Attempt any **three** questions out of the remaining **five**.
 (3) Each question carries 20 marks and sub-question carry equal marks.
 (4) Assume suitable data if required.

1. Attempt any Four (20)

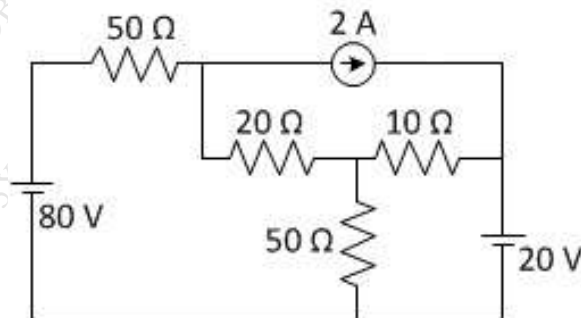
- (a) Explain parts of DC machines and their function. Diagrams are not expected (5)
- (b) If a voltage of $v=200\sin(314t - 20^\circ)$ V is being applied to an impedance. A current of $5\angle 30^\circ$ A flows through the circuit. Find resistance, reactance and pf of the circuit. (5)
- (c) A three phase star connected load has a pf 0.8 lag. Two wattmeters are connected to measure power input. Total power in the circuit is 10KW. Find readings of each wattmeter. (5)
- (d) A voltage of 200V is being applied to an impedance containing resistance of 20 ohm in series with capacitive reactance of 10 ohm. Find admittance of the circuit and hence calculate current using admittance. (5)
- (e) Find the current in inductor for the circuit shown. (5)



2. (a) Prove that two wattmeter method can measure power in three phase circuit. (10)

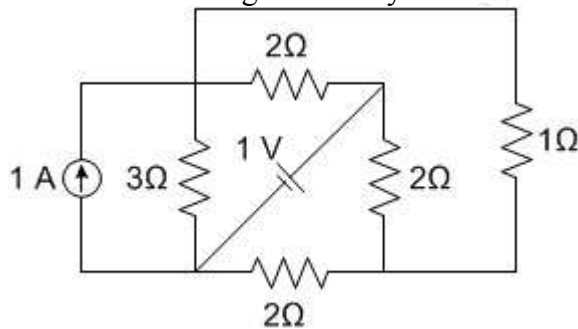
- (b) A balanced 3 phase load connected in delta, draws a power of 10kW at 440V at a power factor of 0.6 load, find the values of circuit elements and the reactive volt amperes. (10)

3. (a) Find current in 10Ω by mesh analysis. (10)

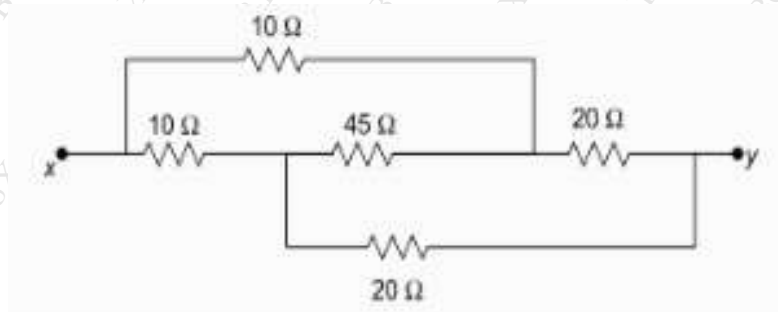


(10)

- (b) Find current through 1 ohm by Thevenin's theorem.



4. (a) An ac circuit consists of pure resistance and an inductive coil connected in series. The power dissipated in the resistance and the coil are 1000W and 200W respectively. The voltage drop across the resistance and coil are 200V and 300V respectively. Calculate the following. (10)
 (i) Value of resistance (ii) current through coil (iii) resistance of coil (iv) impedance of coil (v) total impedance of circuit
 (b) Derive an expression for emf induced in DC machine. (5)
 (c) Explain working of single stack variable reluctance stepper motor. (5)
- 5 (a) Four impedances are connected in series. Voltage drops across three of them are $v_1=282.84\sin(800t-25)V$, $v_2=\cos(800t-2\pi/3)V$, $v_3= -70.71\sin(800t+\pi/6)V$. If the voltage applied across the circuit is $v_r=500\sin(800t+40)V$, find voltage across 4th impedance. (10)
 (b) Find the resistance across x and y. (10)



6. (a) Prove the relation between phase voltage and line voltage in a three-phase star connected system with neat phasor diagrams (10)
 (b) An alternating current of frequency 50Hz has a maximum value of 12A. (10)
 Find the following: (i) Angular frequency in radians/sec;(ii) Equation of instantaneous value of current;(iii) Value of current after 5msec; (iv) RMS value of current and (v) Time taken to reach 9.6A for the first time

Time: 2 hours

marks: 60

Note the following instructions.

1. Question 1 is compulsory. Attempt any three questions out of remaining questions.
2. Draw neat diagrams and write chemical reactions wherever necessary.
3. Assume data, if missing, with justification.
4. Atomic Weight: H=1, C=12, O=16, Ca=20, Na=23, Mg=24, S=32, Cl=35.5

Q.1. Attempt any five.

- a. Differentiate thermoplastic and thermosetting polymers. 3M
- b. Boiling point of H_2SO_4 is greater than $(\text{CH}_3)_2\text{SO}_4$. Give reason. 3M
- c. A 20 ml of wastewater refluxed with 30 ml of potassium dichromate solution and after refluxing excess unreacted dichromate required 18 ml 0.1 N FAS solution. For blank titration with 20 ml of distilled water required 22 ml 0.1N FAS solution. Calculate COD value of wastewater. 3M
- d. Differentiate between bonding and antibonding molecular orbitals. 3M
- e. A hard water sample contains following impurities (in mg/L)
 $\text{Mg}(\text{HCO}_3)_2 = 7.3$; $\text{NaCl} = 77$; $\text{Ca}(\text{HCO}_3)_2 = 4.86$, $\text{MgSO}_4 = 36$
 Calculate temporary, permanent and total hardness of the given sample of water. 3M
- f. Draw molecular orbital picture of pyrrole. 3M
- g. Write statement of Gibb's phase rule. Write any two limitations of phase rule. 3M

- Q.2.a. i) Draw diagram of injection molding of plastic and mention the applications of the process. 4M+2M
 ii) Write the essential structural property of intrinsic conducting polymer and mention suitable example.
- b. i) Define the following terms: A) Phase B) Eutectic point C) Degree of freedom 3M+2M
 ii) Draw orbital diagrams for p_y and $dx^2 - y^2$ orbitals.
- c. 0.5 g of CaCO_3 was dissolved in dilute HCl and diluted to 1000 ml. 50 ml of this solution required 30 ml of EDTA solution for titration. 50 ml of hard water sample required 25 ml of EDTA solution for titration. 50 ml water sample after boiling, filtering requires 10 ml of EDTA solution for titration. Calculate the temporary, permanent and total hardness of water. 4M

- Q.3.a. Draw the diagram for ion exchange process and explain the process with suitable reactions. 6M
- b. i) An alloy of tin and lead contains 25% lead. Find the mass of eutectic in 1 kg of solid alloy if the eutectic contains 64% of tin. Calculate the mass of tin separated out. 3M+2M
- ii) Calculate degree of freedom for following system: in which the products formed in equivalent amounts.
- $$\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$$
- c. Write preparation, properties and uses of Kevlar. 4M

- Q 4.a i) Using Huckel's rule justify whether following compounds are aromatic, antiaromatic and nonaromatic: 3M+3M



- ii) Draw a phase diagram of Pb -Ag and mention the conditions at eutectic point.
- b. i) Define Glass transition Temperature. Discuss any two factors which influence its value? 3M+2M
- ii) Differentiate between ideal gas and real gas.
- c. Explain Electro dialysis process and mention its applications. 4M
- Q 5.a Draw the molecular orbital structure of O₂ molecule and answer the following: 6M
- i) Electronic configuration of molecule.
- ii) Bond order of O₂ molecule.
- iii) Comment on its magnetism.
- b. i) A polymer with 10 chains has 5 molecules of molecular weight 15000 and 5 molecules of molecular weight 10000. Calculate Weight- average molecular weight of the polymer. 3M+2M
- ii) List the drawbacks of Kekule's theory of benzene structure.
- c. Discuss the role of following additives in compounding of plastic: 4M
- I. Plasticizers II. Lubricants

- Q 6.a Draw the phase diagram of one component system. Calculate degree of freedom for areas, curves, and triple point. 6M
- b. i) Explain dipole dipole interaction in HCl. 3M+2M
- ii) Write the reactions involved when hard water is boiled.
- c. Be₂ molecule does not exist. Justify the statement with the help of molecular orbital diagram. 4M