SUMMER – 2022 EXAMINATION

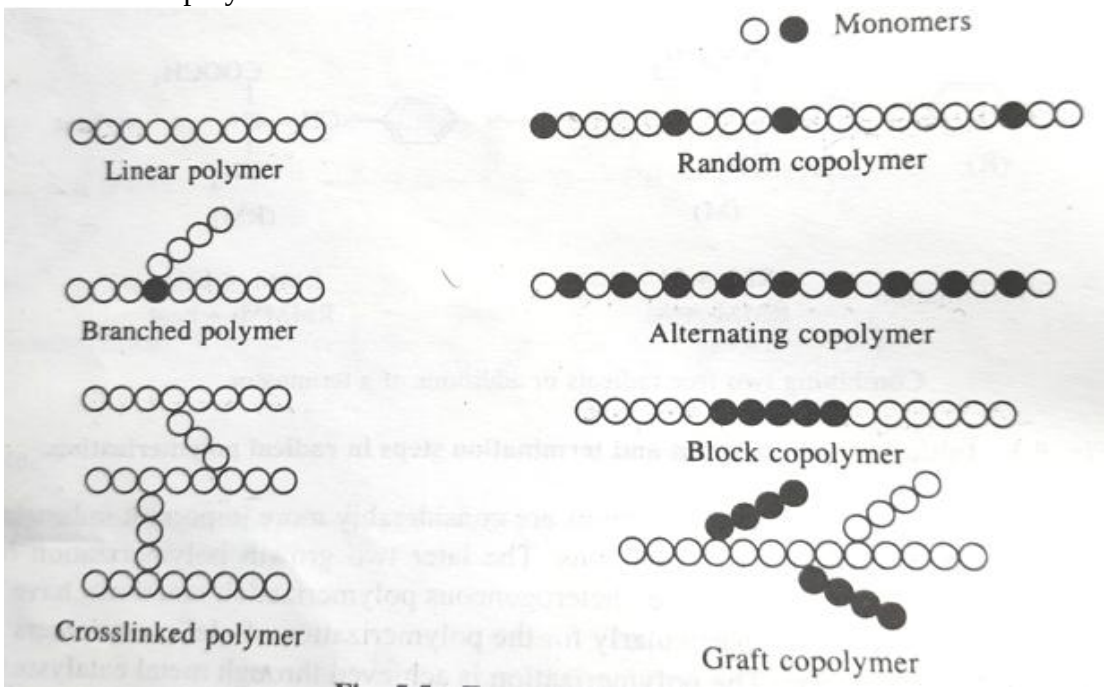
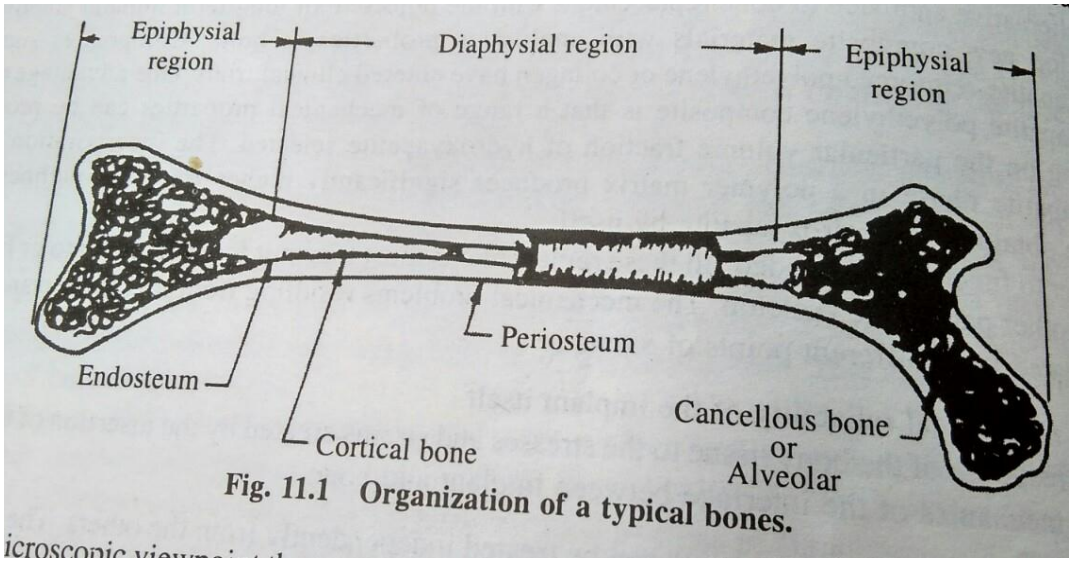
Subject Name: Applications of Biomaterials **Model Answer** **Subject Code: 22219**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

Q. No.	Sub Q. N.	Answer	Marking Scheme
1.		**Attempt any FIVE of the following:**	**10 M**
	a	**List types of biomaterials.** **Ans:** **Types of biomaterials:** 1. Polymers 2. Metals 3. Ceramics 4. Composites	**02 M**
	b	**Give any two applications of Cr alloy.** **Ans:** 1. The manufacture of orthopedic implants, especially for implants of heavy-loaded joints, such as knee and hip. 2. Making dental root implants (Dental implants). 3. Making surgical tools. 4. Making bone plate and screws for fraction fixation.	**02 M**
	c	**Define biomaterial.** **Ans:** **Definition of biomaterial:** A synthetic material used to replace a part of a living system or to function in intimate contact with living tissue. **OR**	**02 M**

		It replaces a part or function of the body in safe reliable, economic and physiologically acceptable manner.	
	d	**Write any two applications of biomaterial.** **Ans:** **Applications of biomaterial:** 1. Joint replacements 2. Bone plates 3. Bone cement 4. Artificial ligaments and tendons 5. Dental implants for tooth fixation 6. Blood vessel prostheses 7. Heart valves 8. Skin repair devices (artificial tissue) 9. Cochlear replacements	**02 M**
	e	**Enlist different materials used in sutures.** **Ans:** **Materials used in sutures:** 1. Synthetic polymers 2. Collagen 3. Polypropylene 4. Polyamide (Nylon) 5. Polyethylene 6. Silicon 7. Wax 8. PTFE 9. Gelatin	**02 M**
	f	**Name the most widely used biomaterials in cardiovascular implants.** **Ans:** **Biomaterials used in cardiovascular implants. (Any Two)** 1. Titanium 2. Silicon rubber 3. Teflon (PTFE) 4. Polypropylene 5. Pyrolytic carbon 6. UHMPE **7.** Dacron	**02 M**
	g	**List two biomaterials used in dental implants.** **Ans:** 1. Titanium, Cobalt-Chromium-Molybdenum-Based Alloy 2. Iron-Chromium-Nickel-Based Alloys) 3. Ceramics (Aluminum, Titanium and Zirconium oxide, Bioactive and biodegradable ceramics) 4. Carbon & silicon 5. Polymers and Composites (Polymethylmethacrylate (PMMA), Polyethylene (UHMW-PE), Polytetrafluoroethylene (PTFE), Silicone rubber, Polysulfide etc.	**02 M**
2.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**Give the types of polymer chains with their neat sketches.** **Ans:** **Types of polymer chains:** 1. Monomers	

		2. Linear polymer 3. Random copolymer 4. Branched polymer 5. Alternating copolymer 6. Crosslinked polymer 7. Block copolymer 8. Graft copolymer	**02 M**
			**02 M**
		Fig: Polymer chains	
	b	**Sketch the labelled structure for organization of typical bones.** **Ans:**  Fig. 11.1 Organization of a typical bones.	**04 M**
		Fig: Labelled structure for organization of typical bone	
	c	**Describe the concept of tissue grafting.** **Ans:** **Concept of tissue grafting:** Transplantation involves the removal of cells, tissues or organs from one part of the body and then placing them into another part or another individual. If the graft is	

		returned to the same patient it is termed as autograft, while if it is placed in another individual of the same species, it is termed an allograft or homograft. Tissue transferred to another species is termed as xenograft or heterograft. Autografts are of two types; if it is placed in the same anatomic location from which it is derived, it is termed orthotropic, while if the location of the implant is different from the original site, it is termed Heterotropic.	**04 M**
	d	**List the surface properties and describe any one in detail.** **Ans:** **Surface properties of biomaterials:** 1. Surface Energy 2. Contact Angle 3. Electrokinetic Theory **1. Surface Energy:** Surface energy is a measure of the extent to which bonds are unsatisfied at the surface of material. At the surface, there is an asymmetric force field, which results in a net attraction of surface atoms in to the bulk. This tends to deplete the surface of atoms putting the surface in tension. Metals and ceramics have surfaces with high surface energies ranging from 10^2 to10^4 ergs/cm^2. In contrast, most polymers and plastics have much smaller surface energies, usually<100 ergs/cm^2. The surface energy values are subject to much experimental variation due to adsorption of gases or organic species. **2. Contact Angle:** When a liquid drop is placed onto a solid surface or another liquid surface two things may happen. The liquid may sit on the surface in the form of a droplet or it may spread out over the entire surface. Which event occurs depend on the interfacial free energies of the two substances. At equilibrium contact angle or Young-Dupree equation describes**:** $\gamma s/g = \gamma s/l + \gamma l/g \cos \theta$, where γs/g, γs/l and γl/g are the interfacial free energy between the solid and gas; solid and liquid, liquid and gas respectively and θ the contact angle. **3. Electrokinetic Theory:** When a material with a charged surface is placed in a solution with ions, a diffused layer of oppositely charged ions (counter ions) appears close to the surface. The electrical double layer is the Stern theory, which describes the change in potential Ψ as the distance from the surface increases. The distance from the surface is Debye length γ. Materials acquiring charge due to many reasons, example: Metals develop a surface potential due to surface oxidation. The presence of the electrical double layer gives rise to electrokinetic phenomena when either the particles or the medium moves. The streaming potential and electro osmosis owe their existence to the electrical double layer. Electro osmosis is observed when an electrical potential is applied to the opposite ends of porous plug in a liquid medium. A flow of liquid through plug occurs. The streaming potential is the converse. Forced motion of liquid through a porous plug generates an electrical potential, called Zeta potential (ζ). The Zeta potential is the electrical potential at the plane of shear in the liquid. Measurements of ζ potential have been useful for determining characteristics of blood vessels. The surface properties are among the most important material properties that a biomaterial possesses. This is due to the fact that when a device is implanted into tissues, the surface chemistry will determine to a large extent how the material and the tissues, or fluids interact.	**02 M** **02 M**
3.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**Describe mechanical properties of stainless steel.** **Ans:**	

Sr. no	Condition	Ultimate Tensile Strength (MPA)	Yield Strength (MPA)	Elongation (%)
Grade 1 (316 Type Stainless Steel)				
1	Annealed	515	205	40
2	Cold- finished	620	310	35
3	Cold-worked	860	690	12
Grade 2 (316 L Type Stainless Steel)				
1	Annealed	505	195	40
2	Cold- finished	605	295	35
3	Cold-worked	860	690	12

Table: Mechanical properties of stainless steel **04 M**

b **Draw and explain the concept of teeth composition.** **02 M**

Ans:

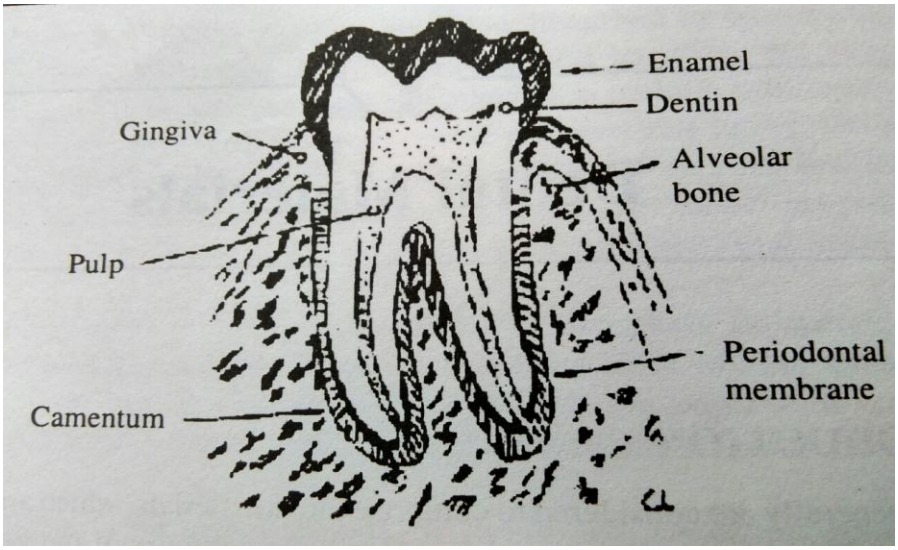


Fig: Structure of tooth

Constituents[a]	*Dentine*	*Enamel*
Ca^{2+}	27.0	36.0
PO_4^{3-} as P	13.0	17.7
Na^+	0.3	0.5
K^+	0.05	0.08
Mg^{2+}	1.1	0.44
CO_3^{2-}	4.5	2.3
F^-	0.05	0.01
Cl^-	0.01	0.30
$P_2O_7^{4-}$	0.08	0.022
Ash[b]	70	97.0
Organic	20	1.0
H_2O[c]	10	1.55

Table: Teeth composition **02 M**

	c	**Give the need of pacemaker and enlist biomaterials used in it.** **Ans:** **Need of pacemaker:** The rhythmic beating of the heart is due to triggering pulses that originate in an area of specialized tissue in the right atrium of the heart. This area known as the Sino-arterial node. In abnormal situation, if this natural pacemaker cases to function or becomes unreliable or if the triggering pulse does not reach heart muscle because of blocking by damaged tissues, the natural and normal synchronization of the heart action gets disturbed. When monitored, this manifests itself through a decrease in the heart rate and changes in the ECG waveform. By giving external electrical stimulation impulses to the heart muscle, it is possible to regulate the heart rate. These impulses are given by an electronic instrument called a pacemaker. **Biomaterials used in pacemaker:** 1. Titanium and its alloy 2. Stainless steel and its alloy 3. Lithium- carbon 4. Silicone rubber or Polyurethane 5. Nickel- cobalt alloy 6. Platinum- iridium	**02 M** **02 M**
	d	**List properties and applications of acrylic polymers.** **Ans:** **Properties of acrylic polymers:** 1. High strength and toughness. 2. Highly biocompatible material. 3. Excellent light transparency (92% light transparency). 4. High index of refraction (1.49). 5. Excellent chemical resistivity. **Applications of acrylic polymers:** 1. It is used for making contact lenses. 2. Implantable ocular lenses. 3. Bone cement for joint fixation. 4. Dentures and maxillofacial prostheses. 5. It is suitable for the repairs of cranial defects.	**02 M** **02 M**
4.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**Explain the factors involved that influence bone formation and resorption.** **Ans:** **Factors affecting in bone formation:** **1. Vascular in growth:** Fibronectin, endothelial cell growth factor (ECGF) **2. Bone formation:** Insulin-like growth factor (IGF-1) somatomedin c, platelet derived Growth factor (PDGF), Fibroblast growth factor (FGF) IL-1, ECGF, insulin, bone derived growth factor (BDGF II and I) bone morphogenetic protein (BMP). **3. Bone resorption:** IL-1, Osteoclast-activating factor: (OAF), parathyroid hormone, PDGF, transforming growth factor B (TGF-B), tumor necrosis factor (TNF), and prostaglandin E2.	**04 M**
	b	**Describe the properties and applications of the hydrogels.** **Ans:** **Properties of hydrogel:** 1. Hydrogel have inherently weak mechanical properties.	

		2. The soft, rubbery nature. 3. These polymers may have low or zero interfacial tension with surrounding biological fluids and tissues. 4. It is transparent when wet. 5. It can be easily machined while dry and it is very pliable when wet. **Applications of hydrogel:** 1. It is used in making contact lenses. 2. It is used for synthetic articular cartilage in reconstructive joint surgery. 3. It is used in drug delivery system. 4. Making maxillofacial implants for jaw and chin augmentation. 5. It is used for making artificial skin.	**02 M** **02 M**
	c	**Describe the testing and evaluation process for dental implant.** **Ans:** **The testing and evaluation process for dental implants:** 1. First, materials are tested for toxicity by implantation subcutaneously in rats for periods of time up to 30 days and through tissue culture tests. 2. The second step is to test the devices in an animal model. Of all animals, the baboon is considered the most preferred experimental animal in dental-implant studies, since its physiology and immunological responses are very similar to those of humans. 3. In general, the clinical condition of dental implants is evaluated by using radiographs, gingival tone, pocket depth and mobility. A stereo-photogrammetric method of measuring the extent of tissue changes and mobility of sub periosteal implants technique utilizes stereo photographs to measure quantitatively, the extent of tissue swelling or resorption, as well as, migration of dental implants to an accuracy of 16 μm.	**04 M**
	d	**Enlist different materials used in contact lenses.** **Ans:** **Materials used in contact lenses: (Any Four)** 1. Silicon rubber 2. Hydrogel 3. Polyacrylate 4. PHEMA 5. PMMA 6. Polymers	**04 M**
	e	**Write short note on biological tolerance of implant metals.** **Ans:** **Biological tolerance of implant metals: (Any Four)** 1. **Iron**: The adult human body contains approximately 4 to 5 g of iron. Metabolically active iron is contained in circulating hemoglobin (about 66%), myoglobin (3%) and in heme containing enzymes less than 10% or is attached to transferrin in transit through the plasma. The remainder is held in storage either in ferritin, which is found in greater quantities in the liver, spleen and bone, or it is stored as insoluble intracellular granules of hemosiderin. The balance of iron in the body is maintained by adsorption at approximately 1mg/day, with a similar quantity being lost per day. 2. **Cobalt**: It is an essential trace element and the function is confined to its role in vitamin B12. A daily intake of 3μm of vitamin B12 is adequate. Free cobalt has no obvious function and there is no apparent mechanism for controlling its uptake into or loss from the body. Eighty percent of dietary intake is unabsorbed and excreted in the faces unabsorbed and urinary excretion of the remainder is relatively fast. In cases of raised dietary cobalt levels it is possible for the cobalt absorbed to be located in the muscles of the heart leading in some cases to cardiomyopathy. It is not a particularly	

		toxic metal and although there are theoretical and experimental grounds for assuming that cobalt based alloys could be quite toxic upon implantation, there is little evidence that they have any adverse effects on implantation in humans. Indeed these alloys offer very good biocompatibility properties, largely on account of the excellent corrosion resistance. 3. **Chromium:** Like many of the transition metals, chromium is both an essential dietary element that is required in low concentrations (blood level average 2.8µg/100 g) and also a toxic substance if present in the raised amounts. Chromium compounds are only poorly absorbed after oral ingestion and storage of chromium (III) is largely confined to the reticuloendothelial systems. The hexavalent chromium ion is able to pass the plasma membrane freely, both in and out of the cell and the reduction takes place mainly in the mitochondria. The mechanism of chromium toxicity is not entirely clear but it has been suggested that the in vivo reduction from hexavalent to trivalent states may be important. 4. **Molybdenum:** It is an essential dietary element and has its highest concentration in the liver at 1 to 3 ppm. It is necessary for the function of certain enzymes. There are three principal molybdenum containing metallo-enzymes: xanthine oxidase, aldehyde oxidase and sulfite oxidase. In contrast to many metals, molybdenum is quite readily absorbed from the intestinal tract, excretion largely being via the kidneys. Molybdenum is toxic in large doses; the symptoms of toxicity include diarrhea, coma and cardiac failure, and inhibition of activity of ceruloplasmin, cytochrome oxidase, glutaminase, and choline esterase and sulfite oxidase. High levels of molybdenum can also interfere with calcium and phosphorus metabolism. 5. **Nickel**: It is an essential element of limited biological activity with a wide-ranging distribution. In humans, it has a level of approximately 10 mg in adult human tissues. A normal blood level of nickel is around 5mg/l. In human inhalation of nickel may lead to renal effects but observation of toxicity are largely confined to carcinogenesis and hypersensitivity. It is sufficient to note here that nickel carcinogenesis in experimental animal is well established. While these facts are of some concern, their reference to implantation is not yet clear. Contact dermatitis for nickel and nickel alloys has been well established. 6. **Manganes**e: It is at a level of 12 to 20 mg in a 70 kg man, and the normal blood level is 7.0 to 28.0µg/ml. A higher concentration of manganese occurs in pituitary gland, pancreas, liver, kidney and bones, and accumulation occurs in hair. Within the cell manganese is associated with the mitochondria and it is largely protein bound in plasma. It is a co-factor for a number of enzymes; among them are carboxylases and phosphatases. Manganese is one of the least toxic trace elements. The divalent form is supposed to be more toxic than trivalent form. It has been shown that injected manganese elimination from the human body can be described by a curve with two exponents, the more rapid pathway having a half-life of 4 days while 70% of the manganese had an average half-life of 39 days. 7. **Titanium:** Unlike nickel, titanium has a very good reputation for biocompatibility. Titanium and its compounds are not carcinogenic in experimental animals or in humans.	**04 M**
5.		**Attempt any <u>TWO</u> of the following:**	**12 M**
	a	**Describe in-vivo and in- vitro methods to test biomaterials.** **Ans:** **In -vitro method to test biomaterials:** 1. **Tissue culture:** The growth of portion of the intact tissue without prior cellular dissociation. This method usually utilizes a substrate rather than a suspected technic; exposure to biomaterial is similar to that for true cell culture.	

		2. **Cell culture:** Roth of initially free dissociated cell. These cells may be grown in to solution or on ager or other media substrate. Exposure to biomaterials may be through direct contact with the bulk materials, contact through an ager. 3. **Organ culture:** The growth of intact organ in vitro. This may vary from the use of fetal bone implant, which can survive without external support system to the use of whole, adults, perfused organs such as kidney or heart. 4. **Blood contact test:** Materials problem in cardiovascular devices are primarily those of inadequate biological performance. This is due to the acute nature of host response. These tests are generally comparative type and examine either coagulation times or homeless rate in either static or dynamic system during or after contact with the foreign material. **In -vivo method to test biomaterials:** After in- vitro test techniques to test new implant materials in extended times whole animal test is done. The site chosen is usually soft tissue. For joint replacement application, implantation is also performed in cortical bone. Specialized site such as the corneas are used for materials for limited applications. Commonly used expected applications are rabbit, dog, cat, sheep, goat, etc. Most popular sites are: Subcutaneous, Intramuscular, Intraperitonial (E.g. Supraspinatus), Transcortical (E.g. Femur), and Intramedullary (E.g. Femur and tibia). Tests are divided into two types: **1. Non Functional Test:** Implant is of arbitrary shape, perhaps in the form required for later mechanical tests of material response and floats passively in the tissue site. Focus on direct interaction between the substance of the material and chemical and biological species of the implant environment. **2. Functional Test:** Test of this type is obviously of much greater complexity and cost than the nonfunctional type. For total joint replacement, design of implant would be as per the animal requirement. Design, fabrication, mechanical testing and implantation may be more difficult than final production of device for human use. In addition to implantation, it is required that material be placed in functional mode with its wide experience in human implant service. Total hip joint replacement design has been made and tested in cats, dogs, sheep and goat.	**03 M** **03 M**
	b	**Explain the followings:** **i) Oral implants** **ii) Dental implants** **Ans:** **i) Oral implants:** Many people have partial dentures to replace one or several teeth. Therefore successful long term dental implants for these applications would solve many problems and provide aesthetic appeal for a large number of people. Oral implants fall primarily into two categories: First are artificial teeth and dental appliances which support and anchor artificial teeth, the other types of implants are totally implanted. They include devices for repairing damaged or diseased mandible to support for rebuilding the alveolar ridge and packing for stimulating the growth of bone to correct lesions associated with periodontal diseases. **ii) Dental implants:** A dental implant is an artificial tooth root that is placed into your jaw to hold a replacement tooth or bridge. (Dental implants are devices that are placed securely into the jawbone in order to restore or replace missing teeth). Dental implants may be an option for people who have lost a tooth or teeth due to periodontal disease, an injury, or	**03 M**

		some other reason. Two common dental implants used for the first group as Subperiosteal and Endosseous devices. **Endosteal implants:** Endosteal means 'located within the bone,' and Endosteal implants are named because they are placed within the jaw bone. This is the most commonly used type of implant. Endosteal implant includes screws, cylinders or blades surgically placed into the jawbone. Each implant holds one or more prosthetic teeth. This type of implant is generally used as an alternative for patients with bridges or removable dentures. Two of the main types of Endosteal implants include root form and plate form. **Subperiosteal implants:** Subperiosteal dental implants are sometimes used on patients who cannot accept root form or plate form implants. This type of implant is placed on top of the jawbone under the gums. These types of implants are used for patients who are unable to wear conventional dentures and who have minimum bone height.	**03 M**
	c	**Enlist different methods used for biomaterial surface characterization and explain any one in detail.** **Ans:** **Methods used for biomaterial surface characterization: (Any Three)** 1. Contact angles 2. Scanning force microscopy (SFM) 3. Scanning electron microscopy (SEM) 4. Electron spectroscopy for chemical analysis (ESCA) 5. Secondary ion mass spectrometry (SIMS) 6. Attenuated total reflection infrared (AT-IR) **Scanning electron microscopy (SEM):** 1. The virtual source at the top represents the electron gun, producing a stream of monochromatic electrons. 2. The stream is condensed by the first condenser lens. This lens is used to both form the beam and limit the amount of current in the beam. It works in conjunction with the condenser aperture to eliminate the high angle electrons from the beam. 3. The beam is then constricted by the condenser aperture, eliminating some high angle electrons. 4. The second condenser lens forms the electrons into a thin, tight coherent beam and is usually controlled by the fine probe current knob. 5. A user selectable objective aperture further eliminates high angle electrons from the beam. 6. A set of coils then scan or sweep the beam in a grid fashion , dwelling on points for a period of time determined by the scan speed (usually in the microsecond range). 7. The final lens, the objective, focuses the scanning beam onto the part of the specimen desired. 8. When the beam strikes the sample interactions occur inside the sample and are detected with various instruments. 9. Before the beam moves to its next dwell point these instruments count the number of interactions and display a pixel on a CRT whose intensity is determined by this number (the more reactions the brighter the pixel). 10. This process is repeated until the grid scan is finished and then repeated, the entire pattern can be scanned 30 times per second.	**03 M** **03 M**
6.		**Attempt any <u>TWO</u> of the following:**	**12 M**
	a	**Explain following thermal treatments in detail:** **i) annealing** **ii) forging**	

		iii) tempering **Ans:** 1. **Annealing process:** The toughness of a material can be increased by thermal treatment below melting temperature of a phase for a pre-determined period of time followed by controlled cooling this process is called annealing. On the other hand, once the heat treatment step is completed the alloy is rapidly cooled to obtain quenched material. Liquids are normally poured into moulds to be cast into ingots, for the fabrication of some medical devices. Cast alloys can then be processed in a number of ways depending on the desirable mechanical properties of the final product. Drawing is used to pull an ingot into wire or into sheets of metal. A sheet can be pressed by placing it between a male and female die to from a cuplike structure, which can be further, processed by machining or forging. 2. **Forging process:** Forging involves heating a metal and then using a series of pairs of dies to change stepwise the shape of the part. Cast structure is relatively weak because grain size is large. The controlling the cooling rate used to solidify liquid solutions can control grain size. However, there are additional posts forming treatments that are used to improve mechanical properties. 3. **Tempering process:** Tempering is a partial annealing used to toughen brittle strong alloys such as cutting edges. Tempering involves the rapid cooling or quenching of a heated metal surface. Precipitation hardening is the formation of oxides and carbides that act to raise ultimate strength and yield point without affecting the modulus.	**02 M** **02 M** **02 M**
	b	**Explain the followings:** **i) Joint replacement** **ii) Total hip replacement** **Ans:** **i) Joint replacement:** The femoral component consists of a fairly thin, rigid shell with an attached fixation system to bone. The geometry of the femoral shell requires a stiff, high strength, low wear rate material such as metal. The femoral component is fixed to the cortical bone of the femoral shaft. The fixation system may be either PMMA cement or a biological ingrowth type. The tibial portion consists of a broad plateau covering the tibia, consisting of a stiff metal tray supporting a polymeric or fiber reinforced polymer. Repeated tensile loading may cause failure of PMMA-bone interface TKR utilizes a limited number of metallic alloys including cobalt-chromium and titanium alloy. Cobalt-chromium alloy combined with ultrahigh molecular weight polyethylene (UHMWPE) remains the contact surfaces of choice, despite some adverse effects on biocompatibility and mechanical problems. These include creep and fatigue of UHMWPE component due to high stresses and repeated loading and wear of polymeric contact surface due to adhesion of the polymeric surface to the metal. High stresses and repeated loading and wear of polymeric contact surface due to adhesion of the polymeric surface to the metal. **ii) Total hip replacement:** A hip replacement consists of femoral component that is a ball mounted on a shaft & an acetabular component having a socket into which ball is placed. Cobalt - Chromium & Titanium-Aluminum-Vanadium alloys or alpha alumina are used by different manufacturer for the femoral component & high molecular weight polyethylene to cover the socket. Several design types with different stem lengths are available. Boutin (1974) had reported several hundred successful clinical cases using a ceramic ball on a metallic stem femoral component & a matching alumina acetabular component.	**03 M** **03 M**

		Boutins devices were all fixed in the bony tissues with standard PMMA cement. Subsequently the HDHMW polyethylene cups were introduced along with ceramic balls attached to metallic stem. The number of alternative combinations of materials are use in total hip replacement include Metal- Metal, Metal- HDHMW polyethylene, Ceramic- HDHMW polyethylene, Ceramic- Ceramic.	
	c	**Describe the properties and applications of silicone rubber polymer.** **Ans:** **Properties of silicon rubber: (Any Six)** 1. Good biocompatibility 2. Good thermal stability 3. Physiological inertness 4. Easy processibility 5. Excellent electrical insulation property 6. Flexibility 7. Low cost **Applications of silicon rubber: (Any Six)** 1. Used to make catheters. 2. Replacement of destroyed or diseased finger joints. 3. Replacement of carpal bones, toe prostheses and capping temporomandibular joints. 4. Breast augmentation. 5. Maxillofacial surgery (includes nasal supports, jaw augmentation, orbital floor repair, and chin augmentation). 6. Artificial bladder, sphincters and testicles. 7. Making artificial heart valves. 8. Drug delivery system. 9. Middle ear prosthesis.	**03 M** **03 M**