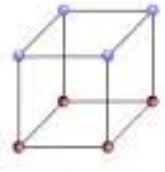
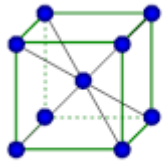
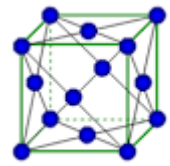
WINTER– 2018 EXAMINATION

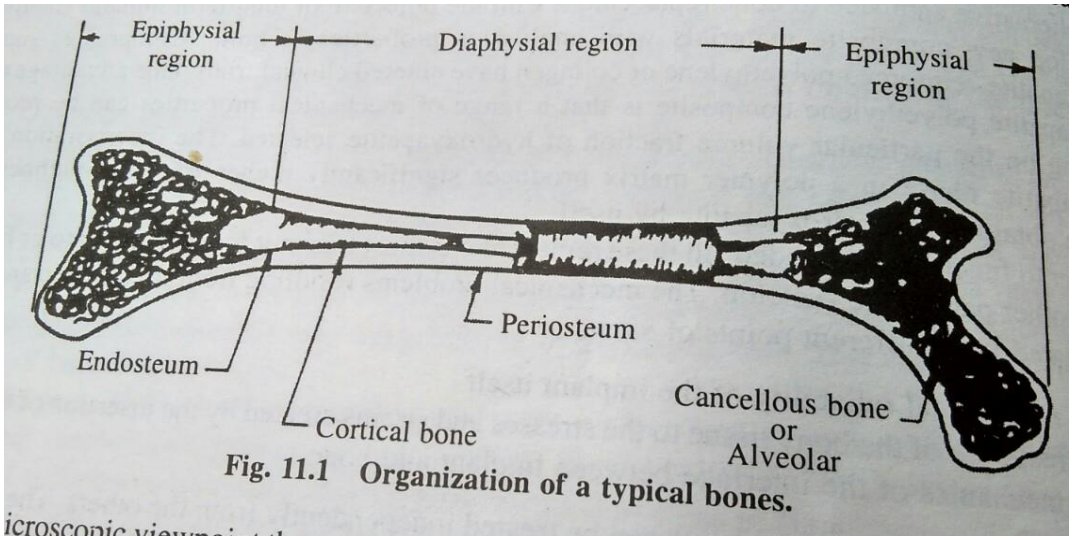
Model Answer **Subject Code:** 22219

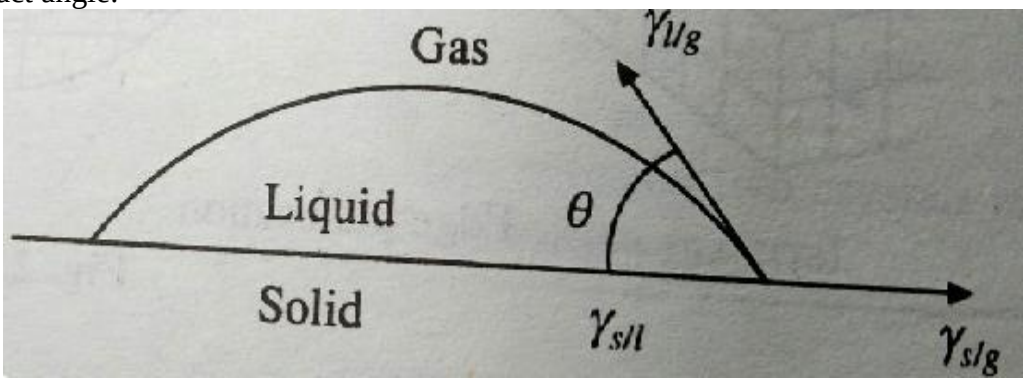
Important Instructions to examiners:

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.

<table>
<tr><th>Q. No.</th><th>Sub Q. N.</th><th>Answer</th><th>Marking Scheme</th></tr>
<tr><td>1.</td><td></td><td>Attempt any FIVE of the following:</td><td>10 M</td></tr>
<tr><td></td><td>a</td><td>Draw any two types of crystal structure of solids.
Ans:
There are three basic crystal structures.
<table>
<tr><th>Sr. No.</th><th>Types of crystal structure of solids</th><th>Image</th></tr>
<tr><td>1</td><td>Simple cubic has an atom located at each corner.</td><td>  </td></tr>
<tr><td>2</td><td>Body centered cubic has an additional atom at the Centre of cubic.</td><td> 
Cubic body centered (bcc)</td></tr>
<tr><td>3</td><td>Face centered cubic has an additional atoms on each center of face plane.</td><td> 
Cubic face centered (fcc)</td></tr>
</table>
Table: Crystal structure of solids</td><td>02 M</td></tr>
<tr><td></td><td>b</td><td>List any two applications of stainless steel.
Ans:
Applications of stainless steel:
1. Hip nails
2. Bone plates
3. Intramedullary pins</td><td>02 M</td></tr>
</table>

		4. Heart valves 5. Cardiac pacemaker electrodes 6. Screws 7. Nuts, bolts 8. Orthopedic implants (knee, hip, ankle joint replacement).	
	c	**Define the term biomaterials and give its any two examples.** **Ans:** **Definition of biomaterials:** A synthetic material used to replace a part of a living system or to function in intimate contact with living tissue **OR** It replaces a part or function of the body in safe reliable, economic and physiologically acceptable manner. **Examples of biomaterials:** 1. Polymers 2. Metals 3. Ceramics 4. Composites	**01 M** **01 M**
	d	**Define the term wear and give its any two types.** **Ans:** **Definition of wear:** Wear is loss of material from a surface by means of some mechanical action. Wear can occur due to various reasons and thus have different types. **Types of wear:** 1. Abrasive wear 2. Adhesive wear 3. Fatigue wear	**01 M** **01 M**
	e	**State the need of cardiac pacemaker.** **Ans:** **Need of cardiac 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.	**02 M**
	f	**Suggest implants for following disorder:** **i. To improve appearance of damaged eyes or to change colour or enhance eye colour.** **Ans:** Contact lenses **ii. Treatment of oral basement.** **Ans:** Subperiosteal or Endosseous implant	**01 M** **01 M**
	g	**List any two applications of collagen in dentistry.** **Ans:** **Applications of collagen in dentistry:** 1. Prevention of oral bleeding 2. Support of regeneration of periodontal tissues	

		3. Promotion of healing of mucosal lining 4. Prevention of migration of epithelial cells 5. Dressing materials 6. Carrier substance for immobilization of various active substances used in dentistry. 7. Decreased seepage of blood during periodontal mucoginvival surgery.	**02 M**
2.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**List any four properties of carbon.** **Ans:** **Properties of carbon:** 1. The carbons are inert ceramic materials. 2. In the quasi-crystalline forms, the degree of perfection of the crystalline structure and the morphological arrangements of the crystallites and pores are important in determining the properties of carbons. 3. All the carbons, currently of interest for use in medical devices have the quasi - crystalline turbostatic structure. 4. Carbon has good biocompatibility with bone and other tissues. 5. It also has high strength and an elastic modulus close to that of bone and so do not suffer from fatigue. **OR** *Property* / *Graphite* / *Glassy* / *Pyrolytic* Density (g/ml) / 1.5-1.9 / 1.5 / 1.5–2.0 Elastic modulus (GPa) / 24 / 24 / 28 Compressive strength (MPa) / 138 / 172 / 517 (575[a]) **Table: Properties of carbon**	**04 M**
	b	**Draw a neat labelled structure of bone.** **Ans**  Fig. 11.1 Organization of a typical bones. **Fig: Structure of bone**	**04 M**
	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	**Explain the concept of contact angle method used for surface testing with neat diagram.** **Ans:** **Concept of contact angle method:** 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.  **Fig: Contact angle method**	**02 M** **02 M**
3.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**List any four applications of Titanium based alloy.** **Ans:** **Applications of Titanium based alloy:** 1. Orthopedic implants (knee, hip, ankle joint replacement) 2. Making cardiovascular devices 3. Dental implants 4. Surgical implants 5. Production of hip prostheses. 6. Making of fracture equipment. 7. Manufacturing of implants. 8. Making of bone screws and plates.	**04 M**
	b	**Suggest type of implant for the following:** **i. Site of missing or extracted teeth to restore original function.** **Ans:** Endosseous implant **ii. Mandibular reconstructions.** **Ans:** Urethane coated Dacron mesh tray **iii. To provide support for dentures.** **Ans:** Subperiosteal and Transosteal implants **iv. To stabilize fractured bones until natural healing process have restarted sufficient strength.**	**01 M** **01 M** **01 M** **01 M**

		Ans: Temporary fixation devices	
	c	**List any two materials used for following implants:** **i. Cardiovascular implants.** **Ans:** 1. Titanium 2. Silicon rubber 3. Teflon (PTFE) 4. Polypropylene 5. Pyrolytic carbon 6. UHMPE 7. Dacron **ii. Opthalmic implants.** **Ans:** 1. Silicon rubber 2. Hydrogel 3. PMMA 4. PHEMA 5. Polyacrylate 6. Polymers	**02 M** **02 M**
	d	**List any four applications of acrylic polymer.** **Ans:** **Applications of acrylic polymers** 1. It is used extensively in medico-surgical application as contact lenses. 2. Implantable ocular lenses. 3. Bone cement for joint fixation. 4. Dentures and maxillofacial prostheses. 5. It is used for treatment for coxarthropathy & in hip arthroplasties. 6. It is suitable for the repairs of cranial defects.	**04 M**
4.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**Explain the process of total hip replacement.** **Ans:** **Process of 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. 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.	**04 M**
	b	**List any two properties and applications of alumina.** **Ans:** **Properties of alumina:** 1. It is insoluble in water & slightly soluble in strong alkali and acid.	

2. Chemically stable and excellent corrosion resistant.
3. High melting point. **02 M**
4. Highest hardness.
5. Highest mechanical strength
6. Good biocompatibility.
7. High wear resistance & reasonable strength.

Applications of alumina:

1. The implant devices are prepared from purified alumina.
2. High density alumina is used in load bearing hip prostheses.
3. Dental implant. **02 M**
4. Orthopedic uses of alumina consist of hip & knee joints, tibial plates, femur shaft, shoulders, radius, vertebra, leg lengthening spacer & ankle joint prosthesis.
5. Reconstructive maxillofacial surgery to cover bone defects.
6. Porous alumina is also used in teeth roots.

c **List mechanical properties of bone.**

Ans:

	Direction of test	**Modulus of elasticity (Gpa)**	**Tensile strength (Mpa)**	**Compressive strength (Mpa)**
Leg bone	Longitudinal			
Femur		17.2	121	167
Tibia		18.1	140	159
Fibula		18.6	146	123
Arm bones	Longitudinal			
Humerus		17.2	130	132
Radius		18.6	149	114
Ulna		18	148	117
Vertebrae	Longitudinal			
Cervical		0.23	3.1	10
Lumbar		0.16	3.7	5
Spongy bone		0.09	1.2	1.9
Skull	Tangential Radial	-	-	- 97

Table: Mechanical properties of bone **04 M**

d **List materials used for following:**

i. Contact Lenses

Ans:

1. Silicon rubber
2. Hydrogel
3. Polyacrylate
4. PHEMA
5. PMMA
6. Polymers

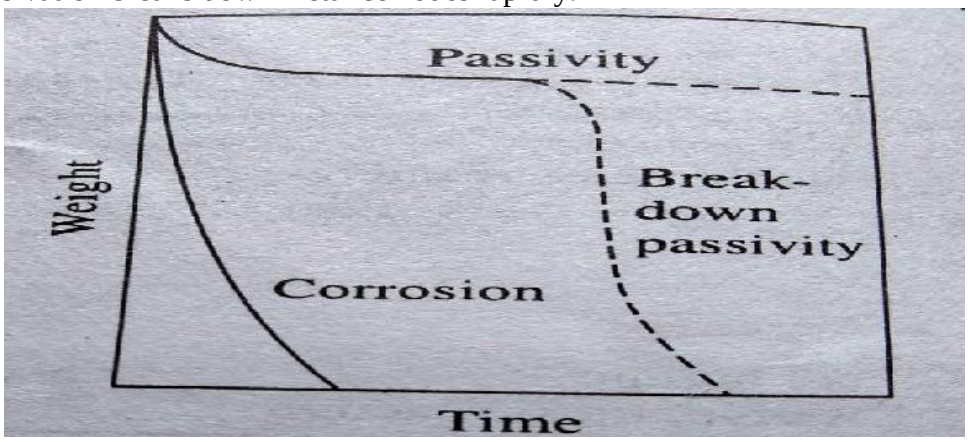
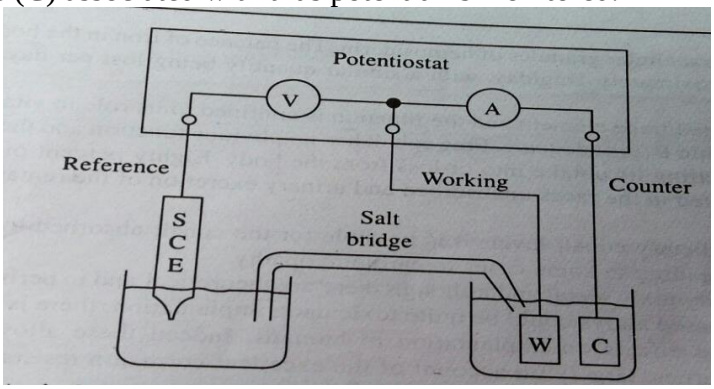
02 M

ii. Catheters

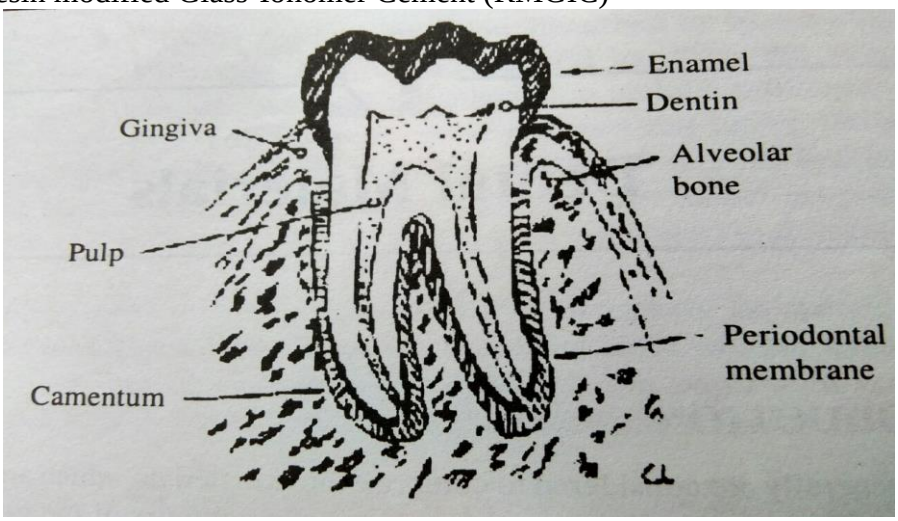
Ans:

1. Red rubber latex or silicone
2. Polyvinyl chloride (PVC) or nylon tubing
3. Soft plastic, silicone rubber and latex

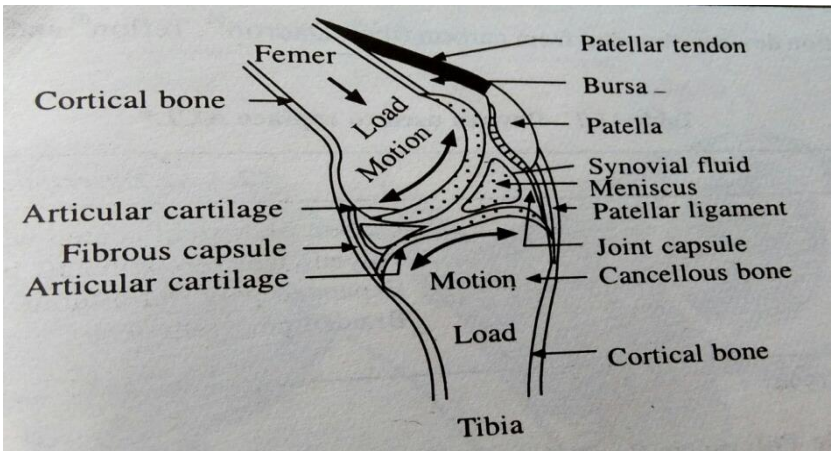
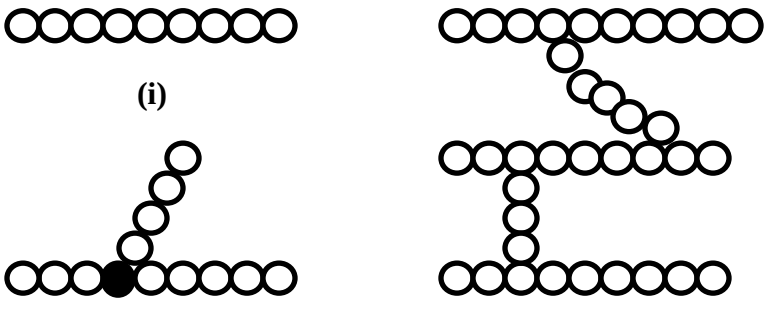
02 M

		4. Hydrogel 5. PTFE 6. Stainless steel	
	e	**How to measure corrosion rate of metals. Explain any one method in detail.** **Ans:** **Corrosion rate of metals:** The rate of corrosion can be assessed using various methods. 1. The traditional test for the corrosion rate is the measurement of weight change of a sample in a solution with time. On passivation weight loss is minimums. However when the passivation breaks down metal corrodes rapidly.  **Fig: Weight loss in corrosion** **OR** 2. Another method employs a potentiostat to impose external potential to a specimen, which is made anodic under conditions of slowly increasing polarization. The technique of linear polarization is utilized for measuring the very small corrosion rate of implant materials in vitro and in vivo. A small current is passed from the implant material (working electrode), at a fixed potential (voltage) through an electrolyte solution to an auxiliary electrode and back through an ammeter to the power supply. The potential difference between the implant material and a reference electrode is measured directly with a potentiometer. In a general a linear relation between current and potential is observed to 10 mV. The corrosion rate is determined from the slope of this line, using the appropriate equation. This technique is very sensitive and accurate for small rates with very small applied current (0.001 A/cm^2). The potential of test specimen or working electrode (W) is measured relative to a saturated calomel electrode (SCE). The potential is controlled by the potentiostat, and the current flow between the working electrode and counter electrode (C) associated with thus potential is monitored.  **Fig:A typical three electrode system for electrochemical testing of corrosion rate**	**02 M** **02 M**
5.		**Attempt any <u>TWO</u> of the following:**	**12 M**

	a	**List surface properties of biomaterials and explain any two.** **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** **02 M**
	b	**Draw neat labelled structure of tooth also list the materials used for filling and restoration.** **Ans:** **Dental filling material:** 1. Gold foil. 2. Platinum 3. Aluminum: 4. Lead and tungsten. 5. Tin and iron. **Dental restoration material:**	**02 M**

		1. Amalgam: is a metallic filling material composed from a mixture of mercury (from 43% to 54%) and powdered alloy made mostly of silver, tin, zinc and copper, commonly called the amalgam alloy 2. Composite resin (also called white fillings) 3. Glass Ionomer Cement 4. Resin modified Glass-Ionomer Cement (RMGIC)  **Fig: Structure of tooth**	**02 M** **02 M**
	c	**List various types of polymers. Also write two applications and two properties of Hydrogel.** **Ans:** **Polymers** **Synthetic polymers**: Polyurethanes, PTFE, Polyethylene, Polypropylene, Polyacrylate, PMMA, PHEMA, Hydrogel, Silicon rubber. **Biopolymers**: Collagens, Elastin Mucopolysaccharides, Cellulose, Proteoglycans, Chitin. **Table: Types of polymers** **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. **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, yet is very pliable when wet.	**02 M** **02 M** **02 M**
6.		**Attempt any <u>TWO</u> of the following:**	**12 M**
	a	**Describe in vivo and in vitro methods to test the biomaterials.** **Ans:** **In vivo method to test the 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) • 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. **In vitro method to test the 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.	**03 M** **03 M**
	b	**Describe knee joint with neat diagram and also explain the process of knee joint replacement.** **Ans:** **Description of knee joint:** Anatomy and physiology of knee joint is more complicated than a hip because of the complex loading pattern of the knee. The knee consists of three long bones, the femur, tibia and fibula and a smaller bone, the patella. These bones are held together by ligaments. The lower end of the femur is expanded to form a curved surface which is covered with articular cartilage. Cartilage to cartilage contact between femur and tibia occurs at two separate locations that are separated by a grove by which anterior and posterior cruciate ligaments (ACL and PCL respectively) are found. ACL and PCL hold these bones together. The fibula is attached to the femur with tibial collateral ligament and to the capsule of the tibia fibular joint. The capsule is filled with synovial fluid that bathes the articulate surface of each bone and maintains a low coefficient of friction between the two surfaces. Synovial fluid is essentially a dialysate of blood	**02 M**

		plasma with added hyaluronic acid. The quadriceps femories muscle and patellar bone are attached through the patellar tendon/ligament. The muscular contractions and length changes in the appropriate muscles transfer the energy to tendons, which results in translation and rotation of bones of the knee. Thus the motion of the tibio-femoral joint is due to a combination of translation and rotation.  **Fig: Knee joint** **Process of knee 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.	**02 M** **02 M**
	c	**Identify and write down the name following polymer chains.**  **(i)** **(ii)** **(iii)** **Ans:** (i) Linear polymer (ii) Branched polymer (iii) Crosslinked polymer	**02 M** **02 M** **02 M**