Summer – 16 EXAMINATION

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.

Q. 1 A) Attempt Any Three. **12**

a) Define.1) Biomaterial 2) Biocompatibility (02 mark for definition)

Ans: 1) Biomaterial: A natural or synthetic material (as a polymer or metal) that is suitable for introduction into living tissue especially as part of a medical device (as an artificial heart valve or joint)

2) **Biocompatibility:** Ability of a material to perform with an appropriate host response in a specific application.

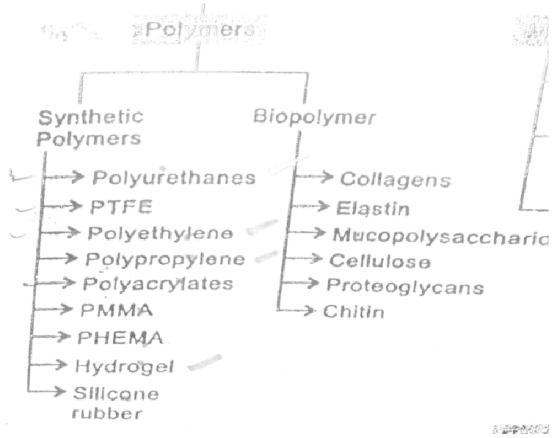
Or

Biocompatibility: It is the ability of material to be in contact with a living system without producing an adverse effect.

b) Give classification of polymers. List biomedical application of polymers

(Classification two marks, application two marks each)

Ans: Classification of polymers**:**

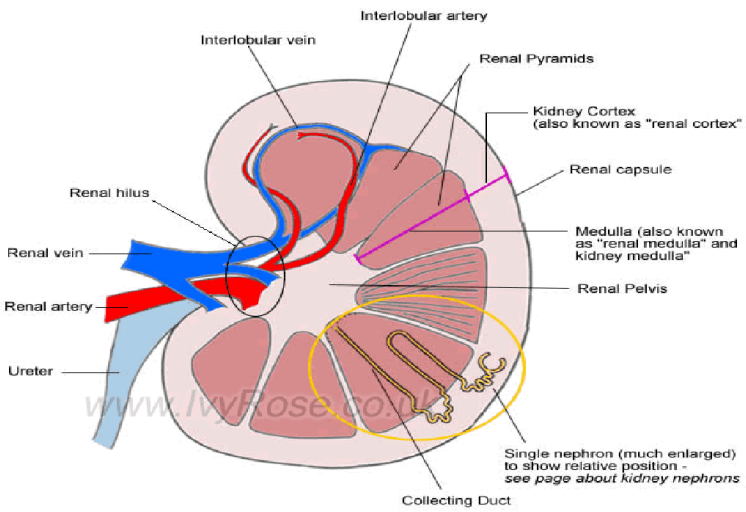


Polymer	*Specific properties*	*Biomedical uses*
Polyethylene	Low cost, easy processibility, excellent electrical insulation properties, excellent chemical resistance, toughness and flexibility even at low temperatures	Tubes for various catheters, hip joint, knee joint prostheses
Polypropylene	Excellent chemical resistance, weak permeability to water vapors, good transparency and surface reflection	Yarn for surgery, sutures
Tetrafluoro-ethylene	Chemical inertness, exceptional weathering and heat resistance, nonadhesive, very low coefficient of friction	Vascular and auditory prostheses, catheters, tubes
Polyvinyl-chloride	Excellent resistance to abrasion, good dimensional stability, high chemical resistance to acids, alkalis, oils, fats, alcohols, and aliphatic hydrocarbons	Flexible or semi-flexible medical tubes, catheter, inner tubes, components of dialysis installation and temporary blood storage devices.
Polyacetals	Stiffness, fatigue endurance, resistance to creep, excellent resistance to action of humidity, gas and solvents	Hard tissue replacement
Polymethyl methacrylate	Optical properties, exceptional transparency, easy thermo-formation and welding	Bone cement, intraocular lenses, contact lenses, fixation of articular prostheses, dentures
Polycarbonate	Rigidity and toughness upto 140°C, transparency, good electrical insulator, physiological inertness	Syringes, arterial tubules, hard tissue replacement
Polyethylene terephthalate	Transparency, good resistance to traction and tearing, resistance to oils, fats, organic solvents	Vascular, laryngeal, esophageal prostheses, surgical sutures, knitted vascular prostheses
Polyamide	Very good mechanical properties, resistance to abrasion and breaking, stability to shock and fatigue, low friction coefficient, good thermal properties, good chemical resistance, permeable to gases	PA 6 tubes for intracardiac catheters, urethral sound; surgical suture, films for packages, dialysis devices components, PA66 heart mirtal valves, three way valve for perfusion, hypodermic syringes, sutures
Polyurethane	Exceptional resistance to abrasion, high resistance to breaking, very high elasticity	Adhesives, dental materials, blood pumps, artificial heart and skin

c) Draw labeled structure of kidney.

(04 marks for diagram)

Ans:



d) List four biomaterials used in dental implants (01 mark for each biomaterial)

Ans:

1. Titanium & Titanium –6

2. Aluminum-4Vanadium (Ti-6AI- 4V)

3. Ti, Cobalt-Chromium-Molybdenum-Based Alloy

4. Iron-Chromium-Nickel-Based Alloys),

5. Ceramics (Aluminum, Titanium and Zirconium oxide, Bioactive and biodegradable ceramics)

6. Carbon Carbon & carbon silicon,

7. Polymers and Composites (Polymethylmethacrylate (PMMA), Polyethylene (UHMW-PE), Polytetrafluoroethylene (PTFE), Silicone rubber, Polysulfide etc

B) Attempt any one (06)

a) State the material used in filling and restoration in tooth. Give its mechanical properties.

(Three materials 03 marks.03 properties o3 marks)

Ans:- Dental filling material :

1) Gold foil.

2) Platinum

3) Aluminum:

4) Tin and iron.

5) Lead and tungsten.

Dental restoration material: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]**)**

2) composite resin : (also called white fillings)

3) Glass Ionomer Cement:.

4) Resin modified Glass-Ionomer Cement (RMGIC)

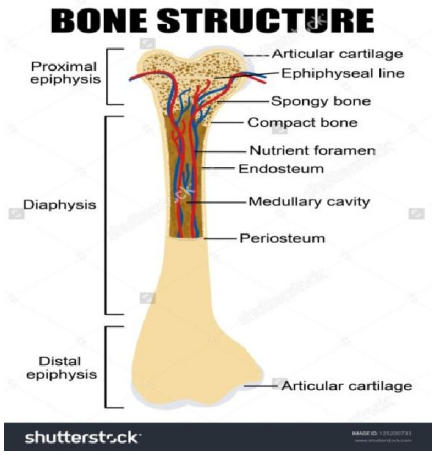
MECHANICAL PROPERTIES OF FEELING AND RESTORATION MATERIAL:

Amalgam	Compressive Strength(MPa)	Tensile Strength(MPa)
Lower Copper	343	60
Admix	431	48
Single composition	510	64

b) Draw and explain structure of bone state factors affecting bone formation.

(Draw & explain 04 marks. Factors affecting 02 marks)

Ans:



Factors affecting bone formation:

1) Vascular in growth: Fibronocetin, endothelielcell growth factor**.**

2) Bone formation: Insulin like growth factor somatomedinc, platelet-derived growth factor .Fibroblast growth factor .Insulin, bone derived growth factor, bone morphogenetic protein.

Q.2. Attempt any four of the following. 16 marks

a) Define contact angle and give young's equation.

(Define.02 marks, equation 02 Marks)

Ans: Contact angle: The contact angle is the angle, conventionally measured through the liquid, where a liquid–vapor interface meets a solid surface. It quantifies the wettability of a solid surface by a liquid via the Young equation.

Young's equation: If the solid–vapor interfacial energy is denoted by γ_{SG}, the solid–liquid interfacial energy by γ_{SL}, and the liquid–vap or interfacial energy (i.e. the surface tension) by γ_{LG}, then the equilibrium contact angle θ_{C} is determined from these quantities by Young's Equation:

$$\gamma_{\mathrm{SG}} - \gamma_{\mathrm{SL}} - \gamma_{\mathrm{LG}} \cos\theta_{\mathrm{C}} = 0$$

The contact angle can also be related to the work of adhesion via the Young–Dupré equation:

$$\gamma(1 + \cos\theta_{\mathrm{C}}) = \Delta W_{\mathrm{SLV}}$$

Where ΔW_{SLV} is the solid - liquid adhesion energy per unit area when in the medium V.

b) Describe invitro method used to test biomaterials biologically (Describe 04 marks)

Ans:- The vitro test of biomaterial:

1) Tissue culture method: 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.Thease 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 culture test: Materials problem in cardiovascular devices are primarily those of inadequate biological performance. This is due to the acute nature of host response.Thease 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.

c) List properties of alumina (any 04 (01 marks, for each property)

Ans:1) Chemically stable and corrosion resistant.

2) It is insoluble in water. And slightly soluble in strong alkali and acid.

3) High melting point.

4) Highest hardness.

5) Highest mechanical strength.

d) Describe composition of titanium based alloys.

Ans:- Titanium is a light metal having a density of 4.0505g/cm^3 . Since aluminum is lighter element and vanadium barely heavier than titanium. The density of Ti-6% Al-4% V alloy is very similar to pure titanium.

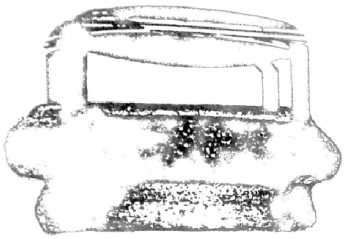
Table 3.7 Composition of Ti Al V alloys (ASTM F136)*

Element	*Composition (w/o)*
Nitrogen, max	0.05
Carbon, max.	0.08
Iron, max.	0.25
Oxygen, max.	0.18
Aluminum	5.5-6.5 (aim 6.0)
Vanadium	3.5-4.5 (aim 4.0)
Other elements	0.1 each max; or 0.40 total
Titanium	remainder

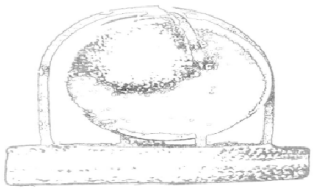
e) List four types of prosthetic heart values and draw two among them.

(List-02 Marks; Diagram-02Marks)

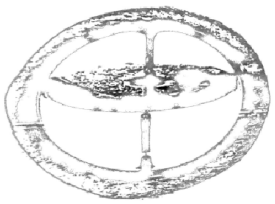
Ans: 1. Disk –in-cage prosthetic heart valve.



2. Ball-in-cage prosthetic heart valve.



3. Tilting disk.



4. Porcine aortic valve.

f) List any four mechanical properties of teeth.

Ans: 1.The hard outer of enamel

2. Lesser degree the softer mid layer of detente.

3. Variation in the hardness of stiffness of human molar enamel.

OR

Table 12.2 Mechanical properties of enamel and dentin*

	Density (g/cm^3)	*Compressive Strength (MPa)*	*Young's Modulus (GPa)*	*Thermal conductivity (W/mk)*
Enamel	2.2	241	48	0.82
Dentin	1.9	138	13.5	0.59

*Adapted from Park (1984)

Q. 3. Attempt any FOUR of the following 16

a) Give significance of biocompatibility.

Ans: Biocompatibility is related to the behavior of biomaterials in various contexts. The term refers to the ability of a material to perform with an appropriate host response in a specific situation. The ambiguity of the term reflects the ongoing development of insights into how biomaterials interact with the human body and eventually how those interactions determine the clinical success of a medical device (such as pacemaker, hip replacement or stent). Modern medical devices and prostheses are often made of more than one material so it might not always be sufficient to talk about the biocompatibility of a specific material.

Biocompatibility is the capability of a prosthesis implanted in the body to exist in harmony with tissue without causing deleterious changes.

b) Classify biomaterials in brief.

(04 marks)

Ans:- :- **Biomaterial**: It replaces a part or function of the body in safe reliable, economic and physiologically acceptable manner

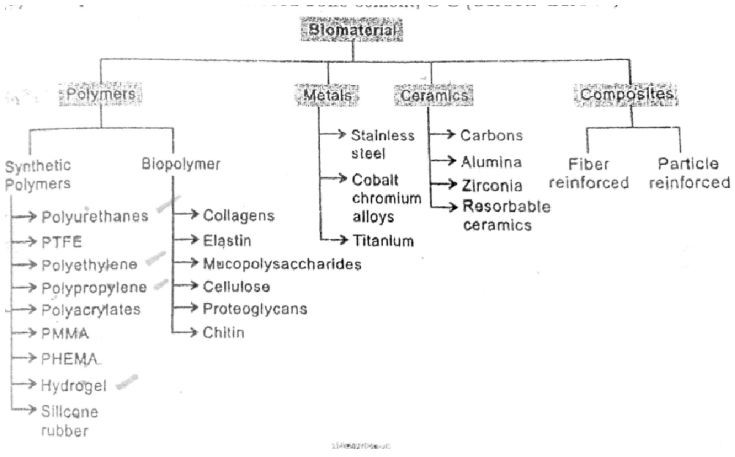
Biomaterial can be classified as follows:

a)Polymers:Polysers,polymides,silicon,rubber,polyether,collagen,elastin,mucopolysaccharides,chitinother polysaccharides,polyurethane,rubber,nylon,polytetrafloroethylene.

b) Metals: stainless steel, cobalt-chromium,itanium alloys, etc.

c) Ceramics: Alumina, zirconia, calcium phosphate

d) Composites: Fiber rainforceds,bone cement,C-C wire.



c) Give four bio applications of Zirconia.

(01 mark for each application)

Ans: Zirconium-containing compounds are used in many biomedical applications including

1) Dental implants

2) Zirconia ceramics are employed to develop new shoulder prosthesis,

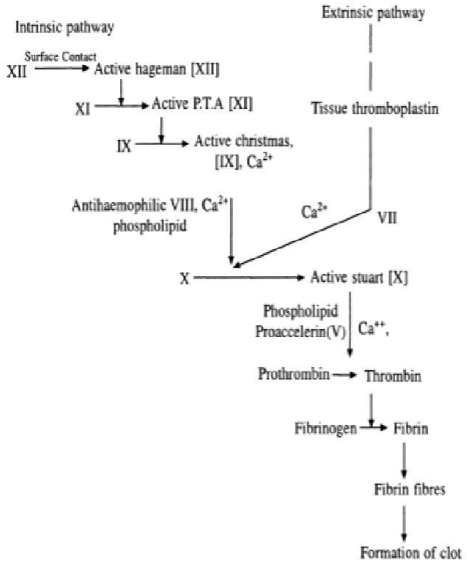
3) Knee and hip replacements,

4) middle-ear ossicularchain reconstruction.

Zirconium cyclosilicate is under investigation for oral therapy in the treatment of hyperkalemia. It is a highly selective oral sorbent designed specifically to trap potassium ions over other ions throughout the gastrointestinal tract.

d) **Describe formation of blood clot**. 4

Ans:- A clot that has formed inside a blood vessel is referred as a thrombus or an embolus depending on whether the clot is fixed or floating, respectively. Two separate routes for activation of the cofactors leading to blood clotting are known as the extrinsic and intrinsic pathways.The extrinsic pathway is so named because it requires a substance not normally present in the blood for activation.Tissue factor is a lipoprotein found in the endothelial cells that line the vascular system and other organs.Damage to tissues or vessels releases tissue factor, which activates factor VII to VIIa in the presence of calcium. Factor VIIa is a protease that converts factor X to Xa. All the factors in the intrinsic pathway are available in circulation.Factor XII undergoes a conformational change when exposed to collagen, basement membrane or a variety of other foreign surfaces. Once activated XIIa initiates a series of reactions.The central event in clotting is the cleavage of fibrinogen in the presence of the proteolytic enzyme thrombin to a fibrin monomer, and its polymerization to form a fibrin polymer.A fibrin clot is cross-linked fibrinogen in a three-dimensional structure in conjunction with platelets and other wound factors. The generation of fibrin from fibrinogen and thrombin from prothrombin are a part of the common pathway of coagulation. Prothrombin is cleaved to thrombin by a complex of factor Xa, factor Va, phospholipid, and calcium. Factor Xa is a serine protease that attacks prothrombin while factor Va is a cofactor that accelerates the reaction.



e) Describe composition of materials used as bone substitute. 4

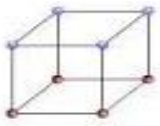
Ans: There is a wide range of synthetic materials that have been proposed as bone graft substitute: metals such as Tantalum, Titanium, Iron, or Magnesium; polymers such as polylactides, polyglycolides, polyurethanes, or polycarpolactones; and ceramic such as silicate based classes, calcium sulphate hemihyadtre (plaster of parries)and dehydrate (gypsum)and calcium phosphate among these material those based on calcium attractive due to their similarity to bone composition.

Q. 4 A) Attempt any Three

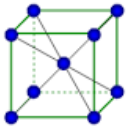
a) Describe the crystal structure of solids. 4

Ans: There are three basic crystal structures.

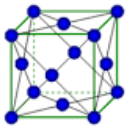
1. Simple cubic has an atom located at each corner.



2. Body centered cubic has an additional atom at the Centre of cubic.



3. Face centered cubic has an additional atoms on each centre of face plane.



b) Give the significance of biocompatibility of polymers. 4

Ans:-Biocompatible polymers are synthetic or natural polymers used to replace part of a living system or to function in intimate contact with living tissue. Biocompatible polymers are intended to interface with biological system to evaluate, treat, augment or replace any tissue, organ or function of the body.

Synthetic polymers present an attractive avenue for biocompatible biomaterials because of their well studied syntheses and modifiable properties. Polymeric materials such as polymers are good substitute for the traditional metal alloys.

c) State the different function of lungs.

(Any four 01 Mark each)

Ans:- 1.The lungs' main function is to help oxygen from the air we breathe enter the red cells in the blood. Red blood cells then carry oxygen around the body to be used in the cells found in our body. The lungs also help the body to get rid of CO_2 gas when we breathe out. There are a number of other jobs carried out by the lungs that include:

2. Changing the pH of blood (whether the blood is more acid or alkali) by increasing or decreasing the amount of CO_2 in the body.

3. Filtering out small gas bubbles that may occur in the bloodstream.

4. Converting a chemical in the blood called angiotensin I to angiotensin II. These chemicals are important in the control of blood pressure.

d) Explain the hip orthosis.

Ans: Hip orthoses are beneficial for treatment **of** many medical condition and injuries. These conditions can be:

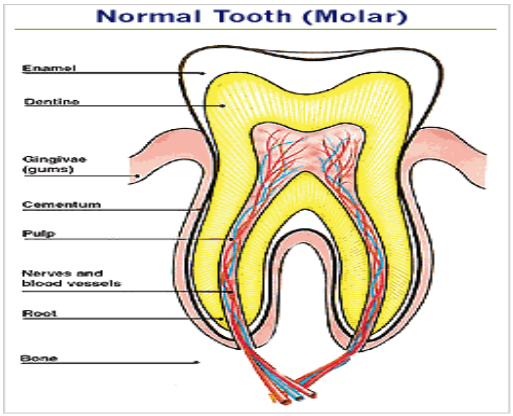
1. Hip fracture.
2. Hip Dislocation.
3. Post-operative.
4. Osteo-arthritis.
5. Developmental Dysplasia of the Hip.
   Cobalt- chromium and titanium –aluminum –vanadium alloys or alpha alumina are used by different manufacture for the femoral component.

B) Attempt any ONE

a) Give the structure of tooth. Compare the mechanical properties of enamel of dentin.

(structure -03 Marks; mechanical properties-03 Marks)

Ans:



The tooth has two anatomical parts. The crown of a tooth is that part of the tooth which is covered with enamel and this is the part usually visible in the mouth.

The root is the part embedded in the jaw. It anchors the tooth in its bony socket and is normally not visible.

Enamel The hard outer layer of the crown. Enamel is the hardest substance in the body.

Dentine Not as hard as enamel, forms the bulk of the tooth and can be sensitive if the protection of the enamel is lost.

Pulp Soft tissue containing the blood and nerve supply to the tooth. The pulp extends from the crown to the tip of the root.

Cementum The layer of bone-like tissue covering the root. It is not as hard as enamel.

Structures around the tooth

Periodontal ligament: Made up of thousands of fibres which fasten the cementum to the bony socket. These fibres anchor the tooth to the jaw bone and act as shock absorbers for the tooth which is subjected to heavy forces during chewing.

Oral Mucosa: This is the term ussed to describe the moist tissue that lines the mouth.

Gingivae (gums): Soft tissue that immediately surrounds the teeth and bone. It protects the bone and the roots of the teeth and provides an easily lubricated surface.

Bone: Provides a socket to surround and support the roots of the teeth.

Nerves and blood supply: Each tooth and periodontal ligament has a nerve supply and the teeth are sensitive to a wide variety of stimuli. The blood supply is necessary to maintain the vitality of the tooth.

Table 12.2 Mechanical properties of enamel and dentin*

	Density (g/cm^3)	Compressive Strength (MPa)	Young's Modulus (GPa)	Thermal conductivity (W/mk)
Enamel	2.2	241	48	0.82
Dentin	1.9	138	13.5	0.59

*Adapted from Park (1984)

b) Explain the total knee replacement.

Ans:- Total Knee Replacement (TKR) 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 in growth 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 ultra high 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 metallic.

Q. 5. Attempt any FOUR of the following. 16 Marks

a) Define the concept of corrosion and wear.

(Corrosion-02 Marks; Wear: 02 Marks)

Ans:- Corrosion: It is a degradative process often associated with electrochemical and oxidation reaction of metal in electroytic solution as well as oxidation and degradation of polymeric materials. The primary anodic and cathodic reactions are represented by equations A and B respectively

$$M \rightarrow M^{n+} + ne^-$$

$$1/2\ O_2 + H_2O + 2e^- \rightarrow 2OH^-$$

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. Some of them are listed bellow.

Abrasive wear: It occurs when a hard rough surface slides across a softer surface.

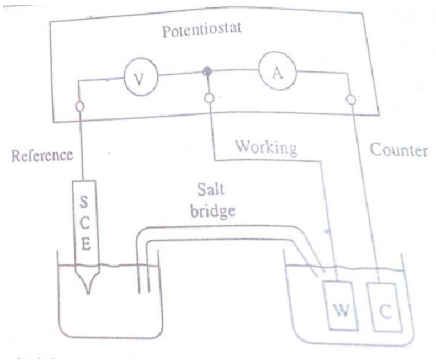
Adhesive wear: It can be found between surfaces during frictional contact and generally refers to unwanted displacement and attachment of wear debris and material compounds from one surface to another.

Fatigue wear: Wear of a solid surface caused by fracture arising from material fatigue.

b) Draw labeled experimental setup used for measurement corrosion rate. List any two effects that effect metallic implants on surrounding tissue.

(Diagram-02 Marks, Any two effect-02 Marks)

Ans:-



The corrosion of metallic implants can affect the surrounding tissues in the three ways:

1. Electrical current may affect the behavior of cell.
2. The corrosion process may alter the chemical environment.
3. The metallic ions may affect cellular metabolism.

c) Metals are less of biocompatible than polymers. Justify your answer.

Ans: - Metallic implants can fail due to fracture loosening or corrosion. A corrosion cell may be developed near the implant due to variety of reason. It releases significant concentration of corrosion products in solution. Polymers are usually in a lower energy state than metals and therefore do not interact with other molecules including tissues. The metals lower their chemical potential by reacting with other materials.

d) List four types of hip replacement devices and draw a neat diagram of two.

(List any four-02 Marks, any diagram-02 Marks)

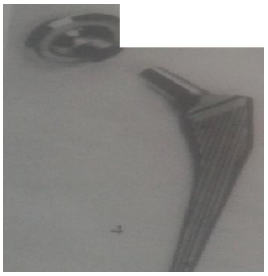
Ans:-Types of total hip replacement devices.

1. Thompson, 316L.

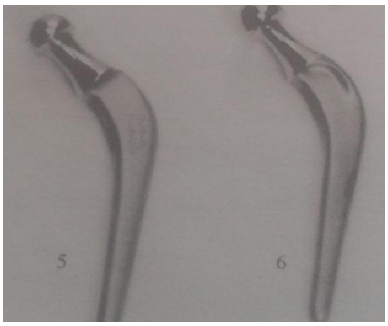
2. Austin Moore, 316L.

3. Bipolar, 316L.

4. Modular bipolar, Ti alloy, Co-Cr head.



5. Charnley Co-Cr.

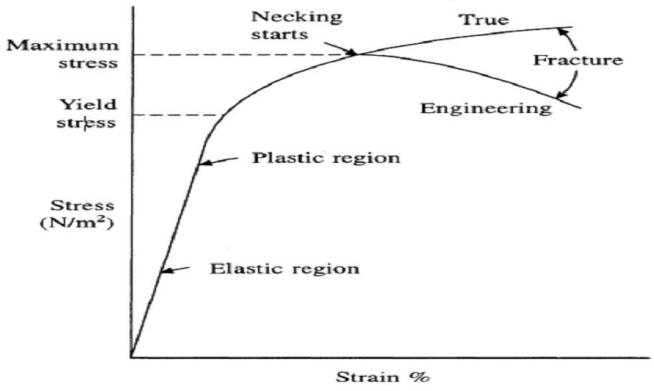


6. Modular, Ti alloy Stem, Co-Cr head.

e) Draw neat labeled stress strain curve for a ductile material.

(Diagram- 04 Marks)

Ans:-



Stress-strain curve for ductile material

f) State mechanical properties of bone.

Ans:-

Table 11.3 Mechanical properties of bones*

	Direction of test	Modulus of elasticity (Gpa)	Tensile strength (Mpa)	Compressive strength (Mpa)
Leg bones				
Femur	Longitudinal	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		18.0	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

Q. 6. Attempt any FOUR of the following. 16 marks

a) Draw fig of bone healing assisted by resorbable bone plate and describe it.

(fig- 02 Marks; Decription-02 Marks)

Ans:-

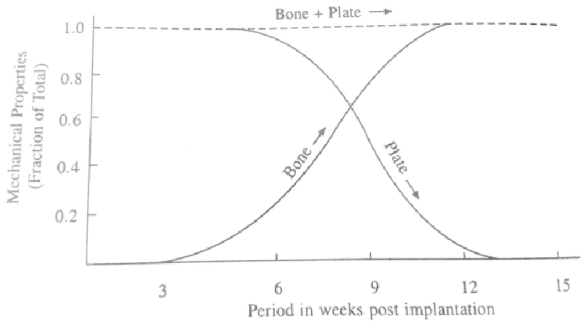


Fig. 11.8 Bone healing assisted by resorbable bone plate.

The purpose of temporary fixatation device is to stabilize fractured bone until natural healing processes restored sufficient strength so that the implant can be removed. These devices include pins, nail, wires, screws, plates and interamedullary devices. Bone plates are used for joining bone fragments together during healing of load bearing bones. The plate provides rigidity for fixation of the fracture .scews are used with the plates to scure them to the bone .There are different types and sizes of fracture plates. The force generated by the muscles in the limbs are very large ,femoral and tibial plates must be very strong.one major drawback of the healing by rigid plate fixatation is the weakening of the underlaying bone such that refracture may occur following removal of the plate. This is largely due to the stress –shield effect.Threfore new material are being evaluated for fabrication of plates with a low axial stiffness and moderate bending and torsional stiffness to facilitate fracture healing without bone atrophy. Another approach is to use a resorbable matcrial for sbone platc. As the strength of the fracture site increases due to healing processes, the resorption of the implant beigns to take place .The gradual reducation of strength of imlapnt transfers an increasingly larger percent of the load to the healing bone .The degration products of such plates must be

biocompatible .the design aspect must involve producing the appropriate combination of initial strength and time dependent performance through the variation in absorption rate and microstructure. There is no need for second operation in removing these plates.

b) State the function of eye shield and list polymers used for its manufacturing.

(Function – 02Mark, List polymer any four-02 Mark)

Ans: These are used in the treatment of basement membrane associated diseases, corneal abrasion and erosion, epithelial defects, cataract extraction, penetrating keratroplasty and other diseases that cause eye inflammation.

Polymers used for manufacturing: 1) Hydrogels 2) polyvinyl 3) Alcohol 4) Silicon rubber 5) Collagen.

c) Classify elastrometric lenses and state material used for the same.

(Classification- 02 Marks; material-02 Marks)

Ans:-

The elastromic lenses are of two types.

1. Silicon rubber.

2. Acrylic rubber.

1. Silicon rubber: Most silicon rubber contact lenses are made of crosslinked poly (methyl-phenyl-vinyl siloxanes) .

2. Acrylic rubber: The acrylic rubber contact lenses are usually made of crosslinked copolymers of n-butyl acrylate with n- butyl methaacrylate.

d) State the function of pacemaker. Give biomaterials used for different parts of cardiac pacemaker.

(Function 02 Marks; Any two biomaterials-02 Marks)

Ans:- 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.

1. Pacemaker Electrode: The electrode is insulated with silicon rubber except tips.
2. Electrode tip: The tip is usually made of noncorrosive nobel metal reasonable mechanical strength such as Pt(10%)Ir alloy.
3. The battery and electronic component of power source are insulated in a polymeric resin.

e) Draw neat labeled structure of heart.

(Diagram 4 Marks)

Ans:-