



WINTER- 14 EXAMINATION

Subject Code: **17543**

Model Answer

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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.



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1A) Attempt any three(12marks)

a) Explain what you mean by biocompatibility.(4 marks)

- The term biocompatibility means:
 - Acceptance of artificial implant by surrounding tissue and body as whole
 - It should not irritate the surrounding structure
 - It should not provoke abnormal inflammatory response
 - It should not lead to causing cancer
- (The words may change but the meaning should be same, relevant answer should be given marks)

b) Give two applications and two mechanical properties of stainless steel and its alloys.

(Any two, 1 mark each)

Mechanical Properties of stainless steels in surgical implants

Material	Condition	Ultimate tensile strength(Mpa)	Yield strength (Mpa)	Elongation in 2 in, min. %
316	Annealed	515	205	40
	Cold finished	620	310	35
	Cold worked	860	690	12
316L	Annealed	505	195	40
	Cold finished	605	295	35
	Cold worked	860	690	12

(Any two, 1 mark each)


Application of stainless steel:

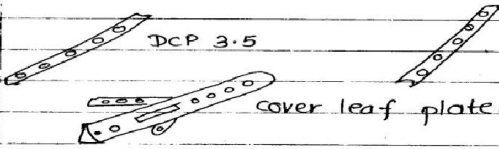
- Stainless steel is basically used in orthopedic implants, the major uses include fracture fixation and joint replacement
- They are used in replacement of hip joints, ankle joints, knee joints, leg lengthening spacers, intramedullary pins, femur shafts, bone plate etc.
- The uses of these alloys for fabrication of mandibular staple bone plates, heart valves and many devices with neurosurgical application have been investigated.
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



• Applications of stainless steel:

- Non-absorbable needles
 - Straight needles (discovered because of risk of injury)
 - J-shaped needles (available for working in deep holes)

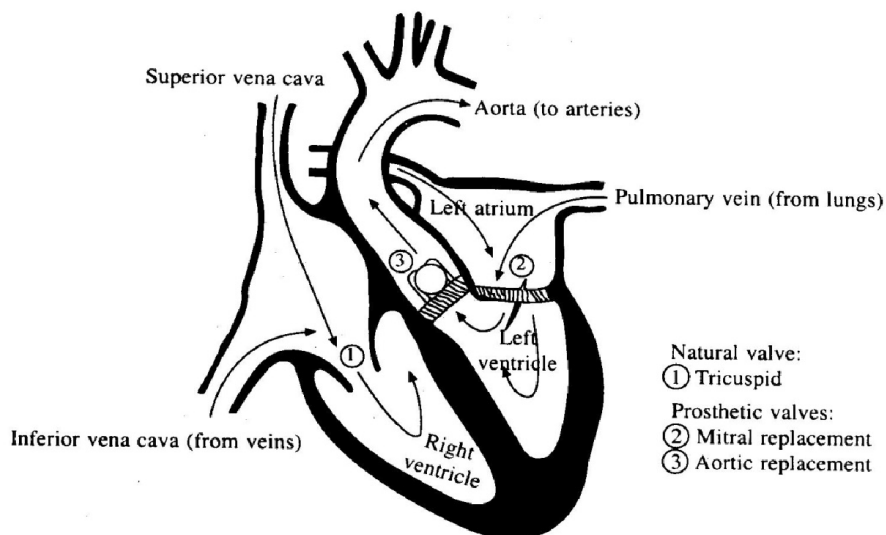
→ Pacemaker:  case made from stainless steel.

→ Bone Plates:

DCP 3.5 one third tubular or plate with collar
cover leaf plate.

→ Catheter wires (made from stainless steel) 

→ Metallic Heart valve 

c) Sketch the schematic of heart illustrating prosthetic heart valve.



(Proper labeled diagram, with the specified names of valves should be given full marks. 1 mark for heart diagram and 1 mark for each valve)

d) State the meaning of oral implants. (4 marks)

-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.
- Second are implants used for the first group as subperiosteal and endosseous devices.



B) Attempt any one: .(6 marks)

a) Give the constituents (composition) of dentine and state its mechanical properties.

- (any 6 constituents, 3 marks)

Constituents^a

Ca²⁺
PO₄³⁻ as P
Na⁺
K⁺
Mg²⁺
CO₃²⁻
F⁻
Cl⁻
P₂O₇⁴⁻
Ash^b
Organic
H₂O^c

(any 3 mechanical properties, 3 marks)

	Density (g/cm ³)	Compressive Strength (MPa)	Young's Modulus (GPa)	Thermal Conductivity (W/mk)
Dentine	1.9	138	13.5	0.59

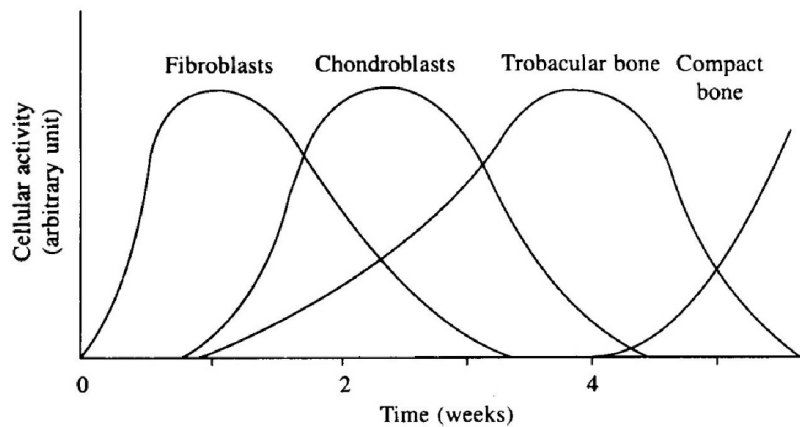
b) Give in detail the sequential cellular event taking place in bone healing.

(Diagram 2 marks, explanation 4 marks)

- Upon bone fracture a certain sequence of cellular events is observed for healing bones. There are basically three types of cellular activities : fibroblastic, chondroblastic and osteoblastic.
- Fibroblast from the periosteum and surrounding tissues proliferate vigorously into the region of fracture within 1 or 2 days. During the same period capillaries being proliferating into the wound invading the fibrous callus prior to actual new bone formation. Within the first week osteogenic cells begin to migrate from the peripheral regions towards the bone fracture
- After about a week, the level of mucopolysaccharides begins to decrease while collagen production by fibroblasts, chondroblasts and osteoblasts becomes significant.
- In a little more than 1 week collagen fibers bridge the entire gaps of the fracture and the pH returns to normal. Osteoblasts begin to form new trabecular bone in the marrow.



- After 2 weeks a collagen matrix replaces the entire clot and chondroblasts are seen in the region between the matrix and the advancing bone growth.
- After a week or two the uptake of calcium and phosphorous into the wound area increases which is attributed to the increased rate of bone mineral deposition.
- By the third and fourth weeks the major activity is the replacement of chondroblasts by trabecular bone and after 5-6 weeks the major activity is the remodeling of the bone trabeculae with the deposition of compact bone.



Cellular events in bone healing

2. Attempt any four: (16 marks)

a) State the meaning of point defect and give its types

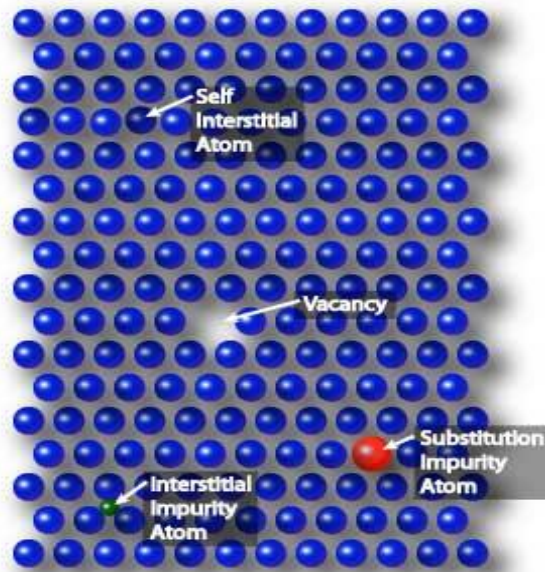
(Explanation of point defect 2 mark, four types- 2 M)

- **Point defects** are where an atom is missing or is in an irregular place in the lattice structure. Point defects include self interstitial atoms, interstitial impurity atoms, Self interstitial impurity atoms, substitutional atoms and vacancies.

Vacancies : There are several important kinds of lattice point defects such as lattice vacancies which arise from some of unoccupied lattice points that is atoms are missing.

Interstitial impurity atoms : If atoms are squeezed in so as to occupy positions between lattice points then lattice interstitial arises.

- **A substitutional impurity atom**
- **A self interstitial atom**



b) Give any four names of international and national organizations of different countries which set standards for biomedical materials and devices.

(any four, 1 M each)

- ISO – International Standards Organization
- ASTM – American Society for Testing Materials
- BSI – British Standards Institute
- AISI – American Institute of Steel and Iron
- BIS – The Bureau of Indian Standards

c) Draw the structure of hydrogels and list any four.

(Hydrogel diagram 2 M, any two names of hydrogels 1 M each)

- Hydrogels are polymer which derived its name from their affinity for water and incorporation of water into their structure.

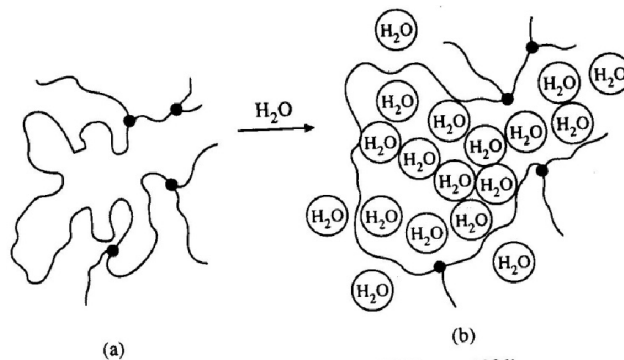




figure (a). hydrogel in normal state (b) Hydrogel after incorporation of water in it.

Various types of hydrogels are:

<i>Name</i>
Poly(2-hydroxyethyl methacrylate)
Poly(methacrylic acid)
Poly(N, N-dimethyl-aminoethyl methacrylate)
Poly(acrylamide)
Poly(N-vinyl pyrrolidone)
Poly(vinyl alcohol)
Poly(ethylene oxide)
Hydrolyzed poly(acrylonitrile)
Polyetherurethane based on polyethylene oxide
Polyelectrolyte complex

d) Give the categorization of ceramic materials on the basis of their reactivity with the environment.

(4marks)

- The types of ceramic materials used in biomaterial application may be divided into three classes according to their chemical reactivity with the environment (i) completely resorbable (ii) surface reactive (iii) nearly inert

- Nearly inert ceramics, eg. alumina and carbons show little chemical reactivity even after thousands of hours of exposure to the physiological pH and therefore show minimal interfacial bonds with living tissues.

- Surface reactive bioglass ceramics exhibits an intermediate behavior. In these ceramics, surface provides bonding sites for the proteinaceous constituents of soft tissues and cell membrane, producing tissue adherence.

- The more reactive materials are resorbable one, like calcium phosphate that release ions from the surface over a period of time as well as provide protein bond site. The ions released, aid in yielding mineralized bone, growing from the implant surface.

e) List four types of prosthetic heart valves and draw any 2 among them.

(listing four types- 2 marks, draw any 2 diagrams- 2 marks)

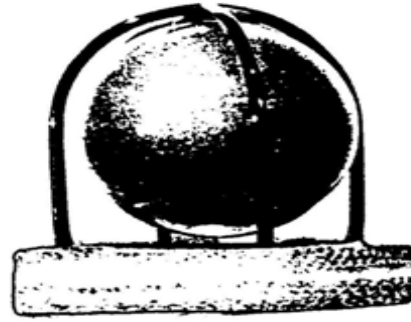
- The four types of heart valves are:

- Disk- in –cage
- ball- in –cage
- tilting disk
- porcine aortic valve

Diagram of the heart valves:



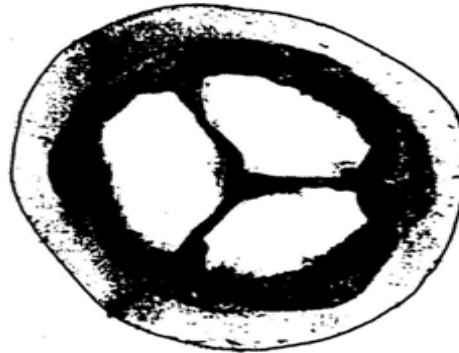
(a)



(b)



(c)



(d)

A designs of prosthetic heart valves: (a) disk-in-cage, (b) ball-in-cage, (c) tilting disk and (d) porcine aortic valve).

f) State the meaning of the term 'dental amalgam' and give its two mechanical properties.

(explanation of amalgam 2 M, any 2 properties 2 marks)

- Dental amalgam has traditionally been employed for cavity filling.
- It is obtained by missing silver-tin-copper alloy powder with liquid mercury.
- The mixture is a paste that hardens as mercury dissolves on the surface of the alloy.

Mechanical properties of dental amalgam

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



Q.3 Attempt any four.

a) List name of four techniques used for surface analysis of biomaterials.

Ans.-1. Electron spectroscopy for chemical analysis (ESCA)(1 Mark each=04)

2. Infrared spectroscopy (IR)
3. Contact angle method.
4. Secondary Ion mass spectroscopy.(SIMS)
5. Microscopy i) Scanning electron microscopy.(SEM)
ii) Transmission electron microscopy.

b) Give the meaning of sterilization and state need for the same.

Ans: - Sterilization is a term referring to any process that eliminates or kill **(02 marks)**

all forms of life, including transmissible agents such as fungus, bacteria, viruses, spore forms etc. present on a surface.

Need of sterilization:- (02 Mark)

Sterilization destroys all microorganisms on the surface of an article or in a fluid to prevent disease transmission associated with the use of that item. Medical device that have contact with sterile body tissues or fluids are considered critical items. These items should be sterile when used because any microbial contamination could result in disease transmission. Such items include surgical instruments, biopsy forceps, and implanted medical devices

c) Give four applications of silicon rubber.(1 Mark each=04)

Ans.-1. Catheters made from silicon rubber is perfect for long term parenteral nutrition.

2. The replacement of destroyed or diseased finger joints with silicon prostheses is carried routinely.
3. Silicon rubber is used for the replacement of carpal bones.
4. Silicon rubber is also used in toe prostheses.
5. It is used in capping temporomandibular joints.

6. Other applications of silicon rubbers such as artificial bladder, sphincters and testicles are being investigated.

d) State the need for cardiac pacemaker.

(04 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 ceases 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.

e) List the four biomaterials used in total joint replacement. (1 Mark each=04)

Ans: - The following biomaterials used in total joint replacement.

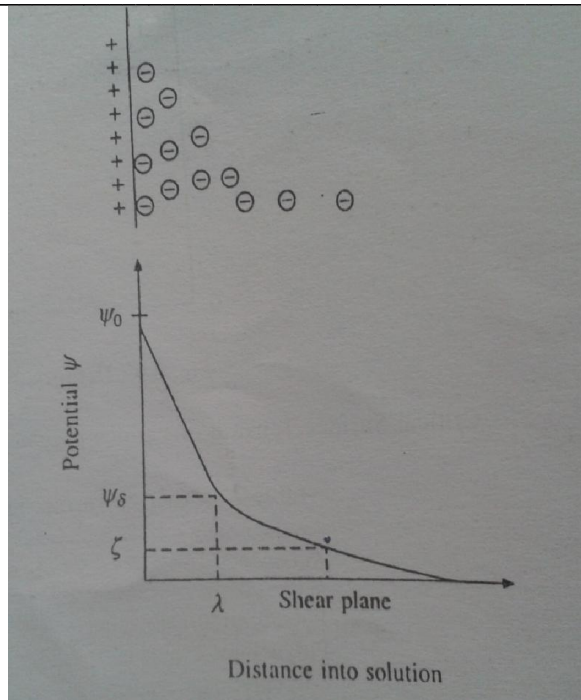
- | | | |
|--------------------------|-----------------|------------------------|
| 1. Stainless steel 316L | 7. Ti-6VAl-4V. | 13. Zirconia. |
| 2. Cobalt – based alloys | 8. Ti-5Al-2.5Fe | 14. Calcium phosphate. |
| 3. Cast Co- Cr-Mo | 9. Ti –Al-Nb. | 15. Bioglasses |
| 4. Wrought Ca.-Ni-Cr-Mo | 10. Bioinert. | 16. PMMA. |
| 5. Wrought Co-Cr-W-Ni. | 11. Carbon. | 17. UHMWPE/HDPE |
| 6. Cp-Ti | 12. Alumina | 18. PTFE |

Q.4 A) Attempt any three. (12)

a) Describe electro kinetic theory. (4 Marks)

Ans: -When a material with a charged surface is placed in solution with ions diffused layer of oppositely charged ions appears close to the surface. The generally accepted theory concerning the electrical double layer is the stern theory, which describes the change in potential as the distance from the surface increases. In a case of positively charged surface, the potential decreases linearly from the value of the surface potential Ψ_0 to $\Psi_0/2.303$. The distance from the surface is termed as Debye length γ . Beyond this distance the potential decreases exponentially to zero. Surface may be charged for a variety of reasons.

The presence of the electrical double layer gives rise to electrokinetic phenomena when either the particle or medium moves. The streaming potential and electroosmosis owe their existence to the electrical double layer. Electroosmosis 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. The zeta potential is the electrical potential at the plane of shear in the liquid. Measurement of zeta potential have been useful for determining characteristics of blood vessels.



Electrical double layer at the surface of a solid

b) Give four properties of zirconia.

Ans:- (1 Mark each =04)

1. Use temperatures up to 2400°C
2. High density
3. Low thermal conductivity (20% that of alumina).
4. Chemical inertness.
5. Resistance to molten metal's.
6. Ionic electrical conduction.
7. Wear resistance.
8. High fracture toughness.
9. High hardness.
10. High refractive index.

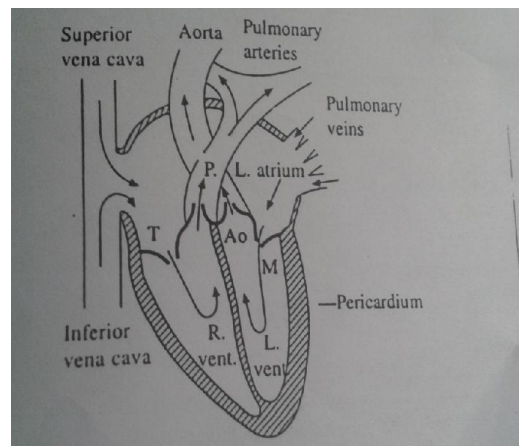
c) Give the function of heart with the help of neat and labelled diagram.

(02 mark explanation ,02 mark for diagram)

Ans:- The heart is a specialised muscle that contracts regularly and continuously, pumping blood to the body and the lungs. The pumping action is caused by a flow of electricity through the heart that repeats itself in a cycle. If this electrical activity is disrupted - for example by a disturbance in the heart's rhythm known as an '**arrhythmia**'- it can



affect the heart's ability to pump properly. The heart has four chambers - two at the top (the atria) and two at the bottom (the ventricles). The normal trigger for the heart to contract arises from the heart's natural pacemaker, the SA node, which is in the top chamber (see the diagram, right). The SA node sends out regular electrical impulses causing the atrium to contract and to pump blood into the bottom chamber (the ventricle). The electrical impulse then passes to the ventricles through a form of 'junction box' called the AV node (atrio-ventricular node). This electrical impulse spreads into the ventricles, causing the muscle to contract and to pump blood to the lungs and the body.



Chambers of heart

d) Comment on osteoblasts and osteoclasts found in bone marrow . (02+02 Mark)

Ans:-osteoblasts and osteoclast are found within bone marrow and on bone surface osteoblasts are basophilic ,cubical cells responsible for synthesizing bone matrix and regulating bone mineralization. These cells are involved in the synthetic production of type I collagen, glycosaminoglycans, alkaline phosphatase and phosphoprotein. Bone development and bone mass are controlled by close interaction between bone formation by osteoblasts and bone resorption by osteoclasts which are regulated by both systemic and local mechanism .

osteoclast produce the specific collagen fibers and closely control their direction and mineralization .The osteoclast are known to be attracted by mineralized bone matrix ,attaching strongly to the matrix and forming a microenvironment for its absorbing activity.

An osteoclast is a type of cell that digests tissue

osteoblasts and osteoclasts are type of cell the human body uses to repair broken bones osteoclasts break down old bone tissue allowing osteoblasts to replace it with new material. Together these cells facilitate bone remodeling and bone growth .

Osteoblasts are single nucleated cells that operate in groups to form bone. They produce calcium and phosphate mineral deposits that form a very dense hard shell around a bone fracture ,The shell is known as a bone callus osteoclasts breakdown the mineral deposits from the osteoblasts by releasing acid and collagenase enzymes .The broken down material is then released into the bloodstream .The process of bone repair takes months.osteoblasts and osteoclasts continually work to rebuild fractured bone until it is completely healed.



B) Attempt any one.

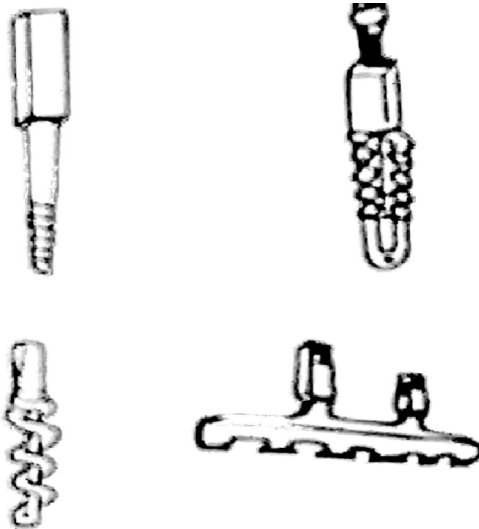
a) List three uses of collagen in dentistry. Draw three types of self tapping dental implant.

Ans:-The uses of collagen in dentistry are given below. **1 Mark each =03**

1. Collagen is used for prevention of oral bleeding.
2. It is used to support of regeneration of periodontal tissues.
3. It is used for promotion of healing of mucosal lining.
4. It is also used for prevention of migration of epithelial cells.
5. Collagen has also been used as a carrier substance for immobilization of various active substances used in dentistry.
6. Dressing materials containing collagen have been employed effectively to promote of defects in oral mucous membrane.

Self tapping dental implant are given below

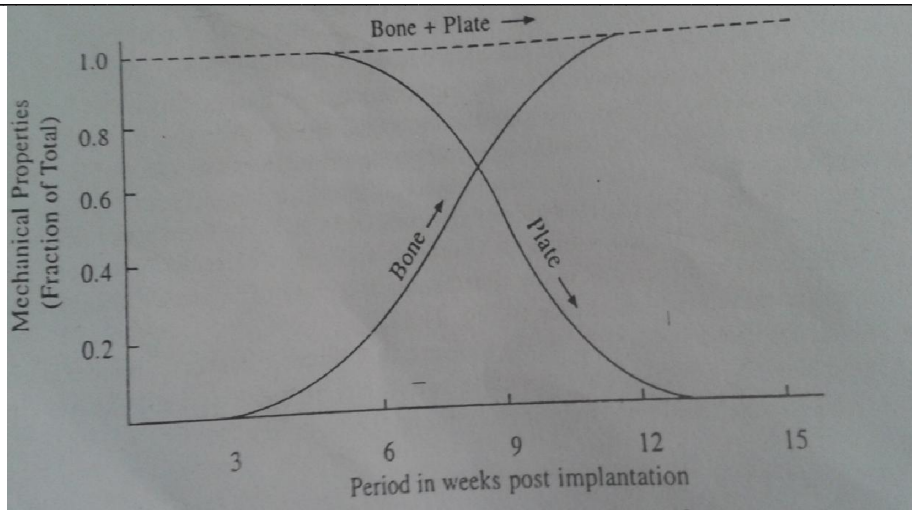
1 Mark each=03



Various designs of self tapping dental implants

b) Sketch graphically bone healing assisted by resorbable bone plate and explain it.

Ans:- (03 mark for diagram, 03 mark for explanation)



Bone healing assisted by resorbable bone plate

The purpose of temporary fixation 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 .screws 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 thelimbs are very large ,femoral and tibial plates must be very strong.one major drawback of the healing by rigid plate fixation is the weakening of the underlying 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 resorbablematerial for sboneplate. As thestrength of the fracture site increases due to healing processes, the resorption of the implant beigns to take place .The gradual reducation of strength of implapnt 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 absorbtion rate and microstructure. There is no need for second operation in removing these plates.



Q.5) Attempt any four

16 marks

a) A strip of rubber originally 75 cm long is stretched until it is 100 mm long.

What is the tensile strain? (comment on its unit)

Ans. Given: Original length of strip = 75cm

2marks

Length of strip after stretching = 100mm ie 10cm

Strain = stretched length / original length

$$10\text{cm}/75\text{cm} = 0.1333$$

2 marks

If there is an increase in length of material line, the normal strain is called tensile strain. Strain has no units because it is a ratio of lengths.

(Additional info) In graph it is represented in percentage

b) Give four application of alumina.

Any4(4 marks)

Ans. In orthopaedic - Hip and knee joints,

tibial joints,

femur shafts,

shoulders,

vertebra,

leg lengthening spacer,

ankle joint prostheses.

In Dental – alumina is used as a filler.

c) Give four applications of Acrylic polymer.

Any4(4 marks)

Ans. 1) Acrylic polymer 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.

d) State the meaning of temporary fixation device and give its 2 examples.(2M+Example 2M)

Ans. Temporary fixation devices are implanted temporarily to stabilize fractured bone until natural healing processes have restored sufficient strength so that the implant can be removed.

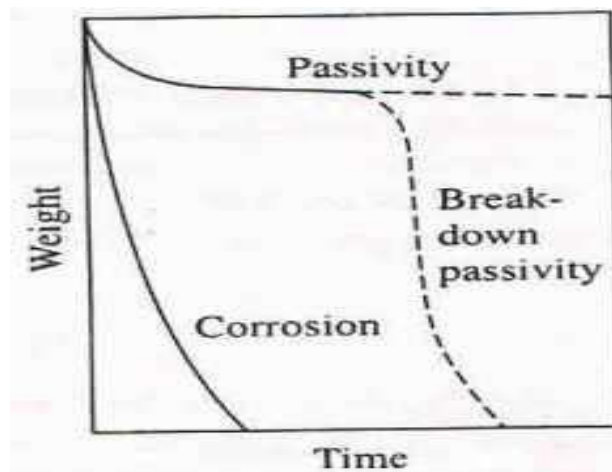
These devices include pins, nails, wires, screws, plates, intramedullary devices.

Eg. The bone plates are used for joining bone fragments together during healing of load-bearing bones. The plates provides rigidity for the fixation of the fracture.

e) State how corrosion is measured and give the effect of corroded metallic implant on surrounding tissue.

Ans. The rate of corrosion can be assessed using various methods. **(any one method) 2marks**

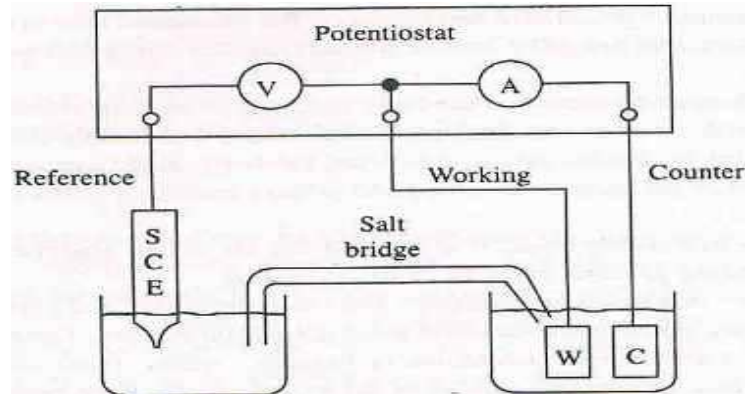
- 1) The traditional test for the corrosion rate is the measurement of weight change of a sample in a solution with time. On passivation weight loss is minimum. However when the passivation breaks down metal corrodes rapidly which is shown in fig below.



Weight loss in corrosion.

- 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).



A typical three-electrode system for electrochemical testing of corrosion rates.

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 this potential is monitored.

The corrosion of metallic implant can affect the surrounding tissues in three ways: **2marks**

- 1) Electrical current may affect the behaviour of cells
- 2) The corrosion process may alter the chemical environment.
- 3) The metallic ions may affect cellular metabolism.

f) List four types of total hip replacement devices and sketch any one.(2m+2m)

Ans. 1)Thompson, 316L

2)Austin moore,316L

3)Bipolar 316L.

4)Modular bipolar, Ti alloy stem , co-cr head

5)And 6)Charnley, co-cr .

7) Modular, Ti alloy stem,co-cr head. (any 4)



any one diagram

Types of total hip replacement devices

Q.6 Attempt any four

16

a) List advantages and disadvantages of PMMA and UHMWPE with reference to total knee replacement.(2+2)

Ans. **PMMA:**

Advantages: Excellent chemical resistivity,excellent light transperancy,high refraction index.

Disadvantages: Repeated Tensile loading may cause failure of PMMA It is some what brittle than other polymers.Mechanical stability of PMMA bone cement at implant-bone interface is questioned.

UHMWPE: Advantages- It has extremely long chains with molecular mass between 2 to 4×10^6 longer chain serves to transfer load more effectively to polymer backbone by strengthening intermolecular interactions.This results in very tough material,with highest impact strength and has better abrasion resistance.

Disadvantages: Adverse effects on biocompatilby and mechanical problems like 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.



b) Classify electrometric lenses and state materials used for the same.(2+2)

Ans. The electrometric lenses are of two types,

- 1) silicone rubber
- 2) acrylic rubber.

Most silicone rubber contacts lenses are made of cross linked poly (methyl-phenyl-vinyl siloxanes) which has highest oxygen permeability of all contact lens materials.

The acrylic rubber contact lenses are usually made of cross linked copolymers of n-butyl methacrylate.

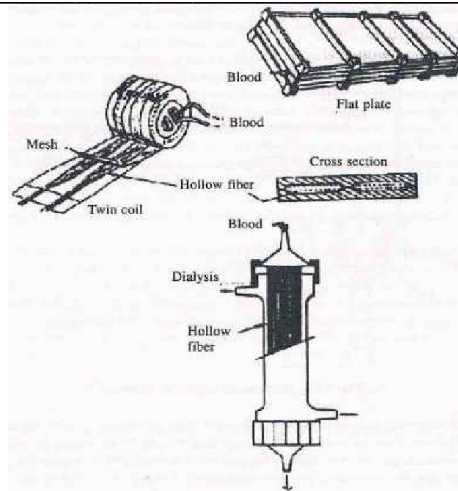
c) Give mechanical properties of ocular tissue. (4marks)

Ans. The mechanical properties of ocular tissues are depicted in below table

Tissue	Ultimate tensile strength(MPa)	Ultimate strain(%)
Cornea (human)	4.8	14.8
Cornea animal(animal)	5.5	32
Sclera (human)	6.9	22

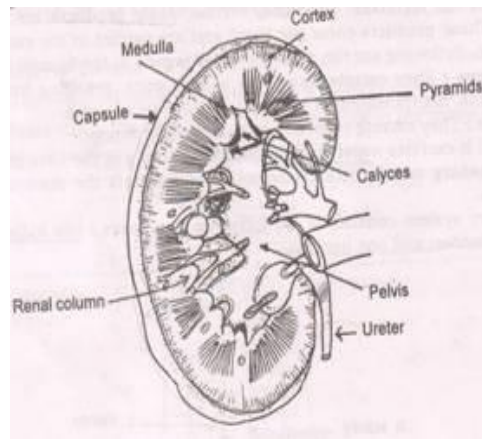
d) Give the classification of dialyzer on the basis of clinical use and draw any one among them.(2M+Draw2M)

Ans. Dialyzer is most important part of the artificial kidney. Various designs of dialyzers are available. These include flat plate, coil-type, hollow fiber etc. (draw any one)



Various designs of hemodialyzers

e) Sketch the labelled structure of the kidney. (Draw 2 + label 2)



Structure of kidney.