X/TY

Reg. No: 24BAIT0014

VIT
Vellore Institute of Technology

Final Assessment Test – November 2025

Course: **BHST302L - Materials in Healthcare**

Class NBR(s): **0965**

Slot: **C1+TC1**

Time: **Three Hours**

Max. Marks: **100**

EEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM ALPRACTICE

ON'T WRITE ANYTHING ON THE QUESTION PAPER

eral Instruction: Draw neat and properly labelled diagrams/tables/figures wherever necessary.

Os	CO Statements
01	Know the different types of biomaterials and their healthcare applications.
02	Recognize the bulk and surface properties of the biomaterials for the selection of healthcare applications.
03	Identify the characterization techniques of the biomaterials
04	Identify the host's response to these biomaterials
05	Recognize the various applications of biomaterials in tissue engineering, drug delivery, and biosensing fields

- Blooms Taxonomy Level (1 – Remember, 2 – Understand, 3 – Apply, 4 – Analyse, 5 – Evaluate, 6 – Create)

Answer ALL Questions

(10 X 10 = 100 Marks)

a) Using either a labelled sketch of the human anatomy or a well-structured table, illustrate where and how (i) Permanent implants (ii) temporary implants (iii) engineered scaffolds find applications within the body, with one example of material used for each implant. Also specify if they are bioinert, bioactive or biodegradable. **[6] CO1 BL1/ BL2**

b) Define revision surgery in relation to biomedical implants. List atleast 3 major causes major causes that lead to revision surgeries. **[4]**

a) A patient is diagnosed with arterial blockage, and a shape-memory stent is inserted via angiography. While metallic stents are effective in restoring blood flow, they often exhibit poor endothelialisation and are susceptible to infection. To overcome these challenges, the stent surface is coated with silk fibroin, further loaded with the antibiotic gentamicin to prevent microbial growth. The following table outlines the various characterization techniques employed to study this modified stent material. Match the property/structure being analysed with the respective characterization technique. **[7] CO2/ CO3 BL2/ BL3**

Technique used for characterization	Structure-Property Evaluation
XRD	Microstructure/Topography of coated and bulk surface
AFM	Phase formed in the material
SEM	Functional group of the coated silk fibroin
TEM	Micro-nano roughness and topography of silk fibroin coated and uncoated surface
UV – VIS spectroscopy	Depth and roughness of coated and uncoated surface with contact method
FTIR	Amorphous or Crystallinity of bulk and silk firoin coating
3D Optical Profilometry	Drug release profile of gentamicin loaded in the coating

b) Following question 2(a), if the same stent is replaced with a 3D bio-printed biodegradable stent using a polyethylene glycol (PEG)-based bio-ink loaded with an antimicrobial drug. How would you characterize the viscosity, haemolysis, and biocompatibility of this PEG bio-ink? **[3]** **CO3** **BL3**

3. Differentiate between SEM and TEM through schematics (at least 5) and explain their working principles in bullets. **[10]** **CO2** **BL1**

4. (a) As soon as an orthopaedic hip implant is introduced into the body, Fluids and cells in the body interact with it through a series of biological events. Describe this process with schematics and outline its key stages. **[5]** **CO4** **BL2/ BL3**

(b) A biomaterial engineer is developing a new ceramic biomaterial for cartilage regeneration. To evaluate its performance, they conduct two assays: one to check cell viability and another to assess early osteogenic activity. Discuss in detail the steps carried out in performing the assays that will be used to test the above. *(in bullets).* **[5]**

5. A 62-year-old female patient sustained severe skin wounds in an accident. The medical team attempted a skin graft from her thigh (autograft), but the graft failed to grow or regenerate properly. In view of this case, answer the below: **CO5** **BL3**

(a) Explain the possible biologically related reasons for the failure of the skin graft. **[2]**

(b) Discuss how tissue-engineered skin substitutes or biomaterials could improve wound healing in such cases. **[6]**

(c) Give suitable examples for tissue-engineered substitutes. **[2]**

6. A research group is developing a scaffold for bone tissue engineering using a naturally derived extracellular matrix material, such as small intestinal submucosa (SIS) or decellularized liver matrix. The group is considering combining the scaffold with a controlled delivery system for growth factors and cells, utilizing natural biopolymers such as gelatin methacrylate (GelMA) hydrogels, nanocellulose, or halloysite nanotubes (HNTs). Their goal is to maximise tissue regeneration, ensure biocompatibility, and promote functionally appropriate cell differentiation. CO4/ CO5 BL3

(a) Discuss the advantages and limitations of using naturally derived materials (such as SIS, liver ECM, GelMA, nanocellulose, or HNTs) as delivery vehicles and scaffolds in tissue engineering. Consider properties such as biocompatibility, mechanical strength, degradation rate, regulatory approval issues, and potential for immune responses. [5]

(b) Propose an engineered design for the scaffold and delivery system, justifying your material choices and method of growth factor/cell delivery. Include how your design mimics the natural extracellular matrix and enhances tissue regeneration. Support your answer with examples from recent research. [5]

7. A biomedical startup is developing a new biosensing device for real-time monitoring of glucose in diabetic patients. They are exploring the use of smart polymeric nanoparticles and hydrogels as delivery vehicles integrated with biosensors. The system is intended to detect glucose concentrations and, if required, trigger the release of insulin upon detecting elevated levels. The polymers under consideration include chitosan, alginate, and synthetic responsive polymers. CO4/ CO5 BL3

(a) Explain the criteria and challenges in selecting polymeric materials for use as delivery vehicles within biosensing systems. Discuss properties such as biocompatibility, responsiveness to stimuli, encapsulation/release efficiency, and integration with electronic components or sensors. [5]

(b) Design a conceptual prototype of a glucose-responsive biosensor integrated with a polymeric delivery vehicle. Justify the choice of polymer, the biosensing mechanism, and the drug release trigger involved. Discuss operational and safety considerations in the design. [5]

Explain the principle and working of a biosensor used in clinical diagnostics, describing the target analyte and detection method. [10] CO5 BL2

a) A 55-year-old patient requires a dental implant after losing a molar due to periodontal disease. The dentist is considering using a titanium implant with a surface modified by nanostructured coatings to improve tissue response. CO2 BL3

(i) Explain how the interaction between the implant surface and surrounding bone and soft tissue cells (osteoblasts, fibroblasts, macrophages) affects osseointegration and healing. [5]