Question Paper

Exam Date & Time: 21-May-2022 (10:00 AM - 01:00 PM)

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

VI Semester End Semester Examination

BIOMATERIALS [BIO 4055]

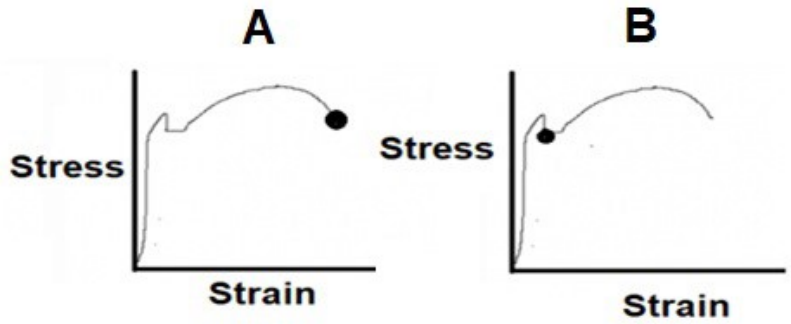
Marks: 50 **Duration: 180 mins.**

Descriptive Questions

Answer all the questions. Section Duration: 180 mins

1) Label the points A & B shown in stress strain curve. Explain (2)

A)



B) A cylindrical tensile specimen has an initial diameter and length of d_0=5 mm and L_0=400mm, respectively. It is loaded axially with a F=1200N force and the sample stretches to a total length L=402mm and poisson's ratio= 0.8. Assuming that the material is liner elastic, calculate the numerical value for Engineering stress, in MPa, Young's Modulus, Engineering strain and decrease in its diameter. (4)

C) A poly-assembled monolayer (PAM) material is modified using following functional groups, **1.** Nonreactive group **2.** Sulfhydryl group **3.** Phenyl **4.** Carboxyl group. Match each of these group to one of the contact angles (**a.** 115° **b.** 105° **c.** 92° **d.** 81°) measured using goniometer. Your answer should be based on the molecular compositions of each PAM explaining the principle of experiment. (4)

2) How does MTT assay determine cell viability? (3)

A)

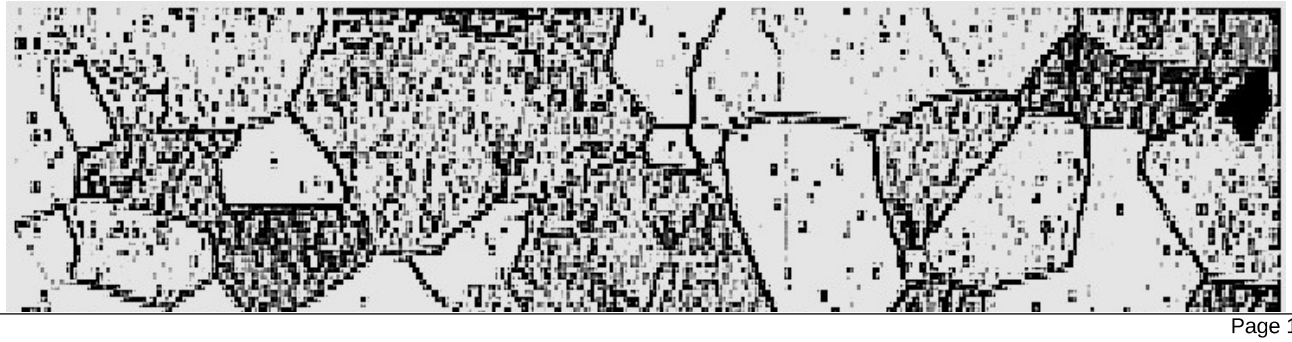
B) Compare the rules of cell proliferation and apoptosis in an animal to the rules that govern human behaviour in society. What would happen to an animal if its cells behaved like people normally behave in our society? Could the rules that govern cell proliferation be applied to human societies? (3)

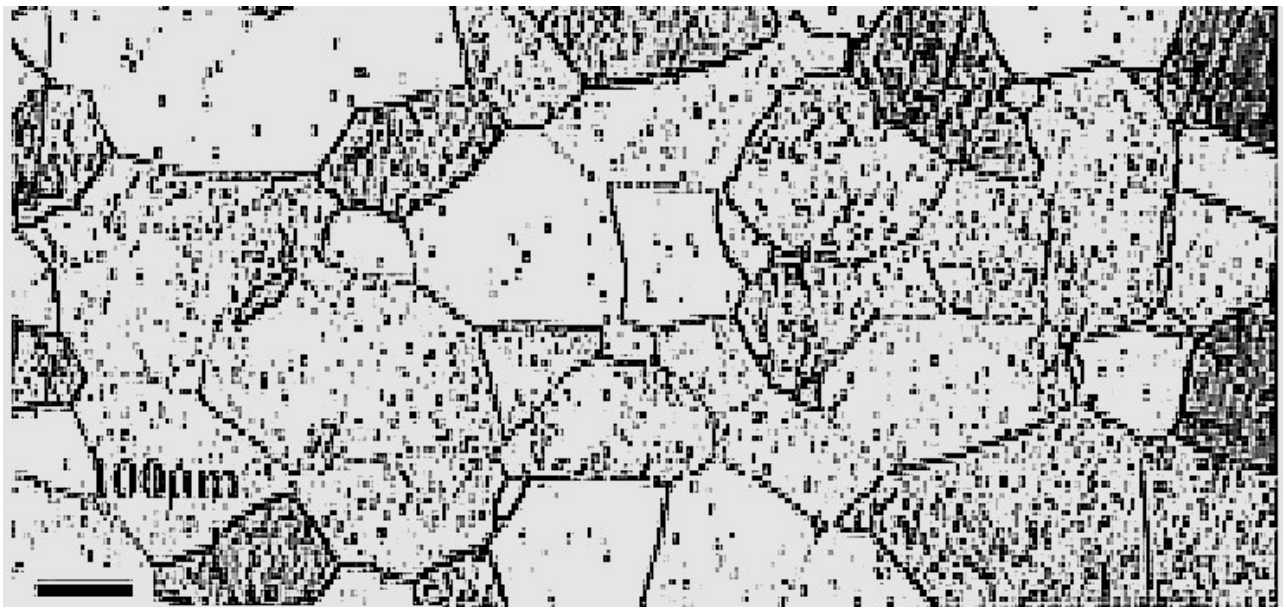
C) How is unidirectional movement of lamelapodium maintained? (4)

3) Calculate the number of Co ions released in a year from whole of stent (28 mm dia) made of CoCrMo alloy. The alloy has 50% of Co. The wear rate of the material is 0.14 mm/yr and all the atoms become ionised. Density of Co=8.83 gm/cc, Atomic weight = 58.93. (4)

A)

B) Determine the ASTEM grain size number n and grain diameter for the given photomicrograph. Micrograph dimensions: 4/3 in, Magnification 500 X. (2)



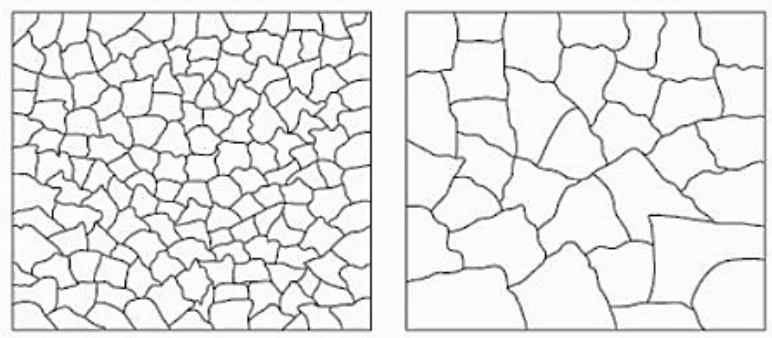


C) Material B an alloy of Material A is a second-generation biomaterial. Would you recommend alloying with aluminum (very strong atomic bonding observed between Al and Material A) or alloying with cobalt (changes the overall phase from a cubic structure to hexagonal close packed). Which would be better to create Material B? (4)

4) A piece of window glass fails at 70 MPa (10^4 psi). Calculate the largest size elliptic crack which is responsible for the low strength. The stress concentration factor (sigma / sigma a) can be expressed as $2\sqrt{c/r}$, where c is the crack depth (2c if away from surface) and r is the crack tip radius. (3)

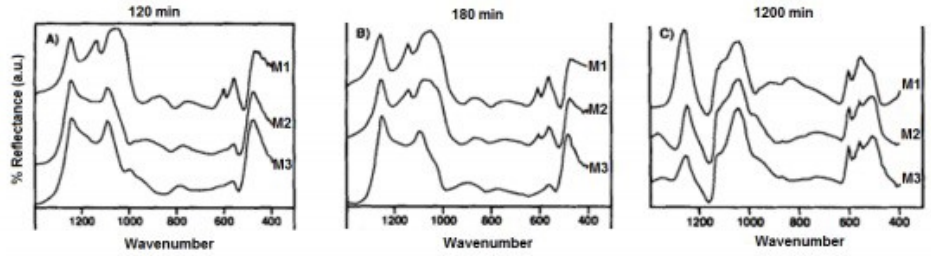
A)

B) You are comparing two different processing methods used for forming Ti6Al4V into a femoral stem of a hip joint prosthesis. The following diagram shows the structures that result from the two methods: (3)



Which of the two processing methods results in a material with a higher ultimate tensile strength? Why?

C) Three different types of bioactive glass (M1, M2 and M3) was implanted in a animal model. Mineralization of each material was measured for different time interval (120 minutes,180 minutes and 1200 minutes). The samples were removed and analysed for IR spectrum, which is shown below, (4)



Groups	Wavenumber Range(cm-1)
Si-O-Si	1175-860
Si-OH	549-470
P-O	600-560

i. Which material begins to form mineralized hydroxyapatite first?

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ii. Which material undergoes the most significant amount of mineralization by 1200 minutes?
iii. A linear relationship between time and mineralization is required for osteogenic differentiation of stem cells during the first day. Which material would you select for your studies and why?

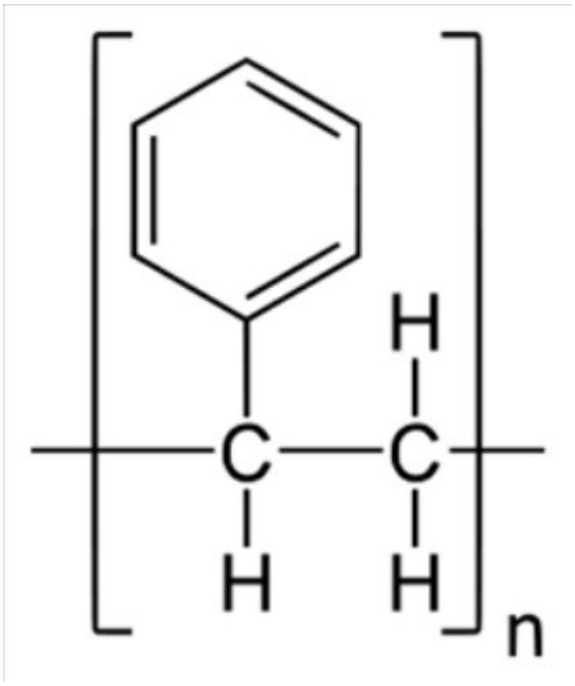
5) UHMWPE is used in knee or hip joint prosthesis. Its molecular weight= $2x10^6$ gm/mol. Monomer repeat unit=-(CH2-CH2-). (3)

A) I. Calculate the number of repeat units

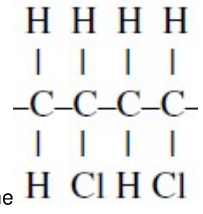
II. Calculate Mn if polydispersity

III. Calculate the length of a stretched chain. Since the tetrahedral structure of the carbon leads to a C-C-C bond length=0.126 nm.

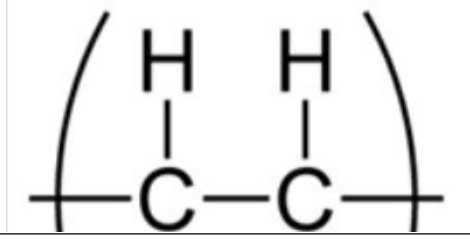
B) The chemical structures of polystyrene, polyvinylchloride and polyethylene is given below. For each polymer, identify if they are amorphous, semi-crystalline, crystalline. Explain. (3)

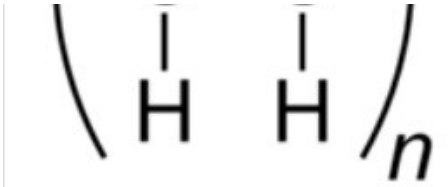


Polystyrene



Polyvinylchloride





Polyethylene

C) Discuss the structure and function of hyaluronic acid with an application. (4)

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