Question Paper

Exam Date & Time: 30-Nov-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

Biomaterial-characterization techniques [BME 4052]

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

Descriptive

Answer all the questions. Section Duration: 180 mins

Answer all the questions

1A) Compare the mechanical properties of materials and predict the change in properties of materials with inclusion type of crystal defects. (3)

1B) Distinguish between the hardness of a material and the tensile strength of a material. (3)

1C) Sudipta *et al* developed PMA-RITC-PTX-CDDP-NPs for delivery of hydrophilic and hydrophobic drugs to treat breast cancers. The group demonstrated the action of the drug (PTX) on MCF-7 cells. The drug targets the nucleus of cells and by using fluorophores which stains the nucleus (blue, Hoechst 33342) and Tubulin (green, anti-tubulin antibodies). The group demonstrated the action of nanoparticles. Interpret the results shown in figure 1 given below and draw your conclusion. Explain in detail the method the group used to image the cells using fluorophores. (4)

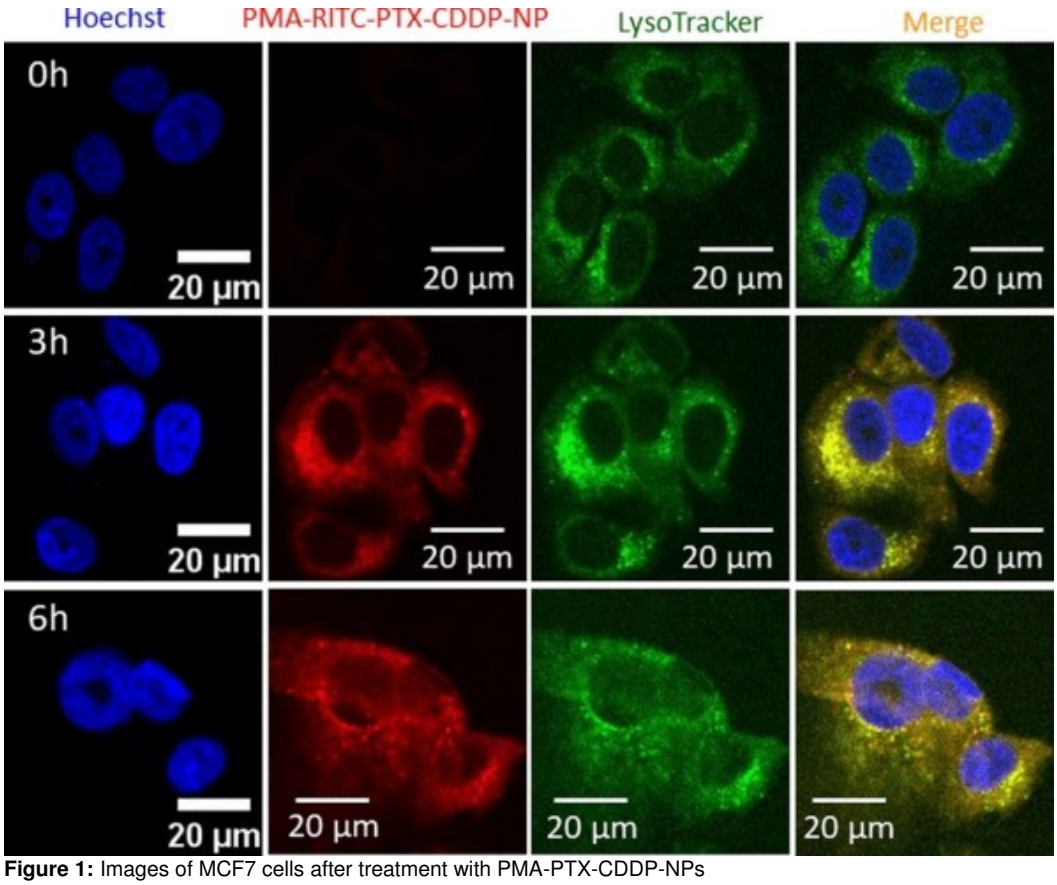
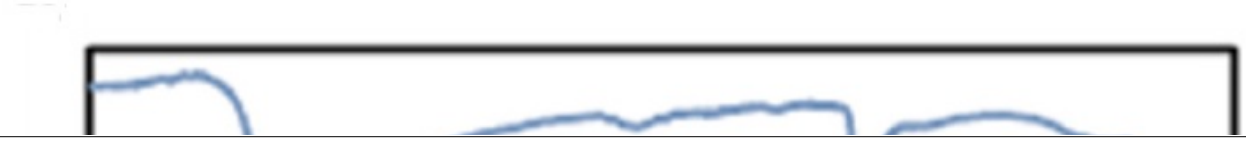


Figure 1: Images of MCF7 cells after treatment with PMA-PTX-CDDP-NPs

2A) Zhu *et al* developed multifunctional mitoxantrone copper (MTO-Cu(II)) nanolocks with GSH as the key for synergistic ferroptosis and anti-chemotherapeutic resistance. Zhu characterized the synthesized nanoparticles using FTIR and the results are shown below. Interpret the results shown in the figure and draw your conclusion. (4)



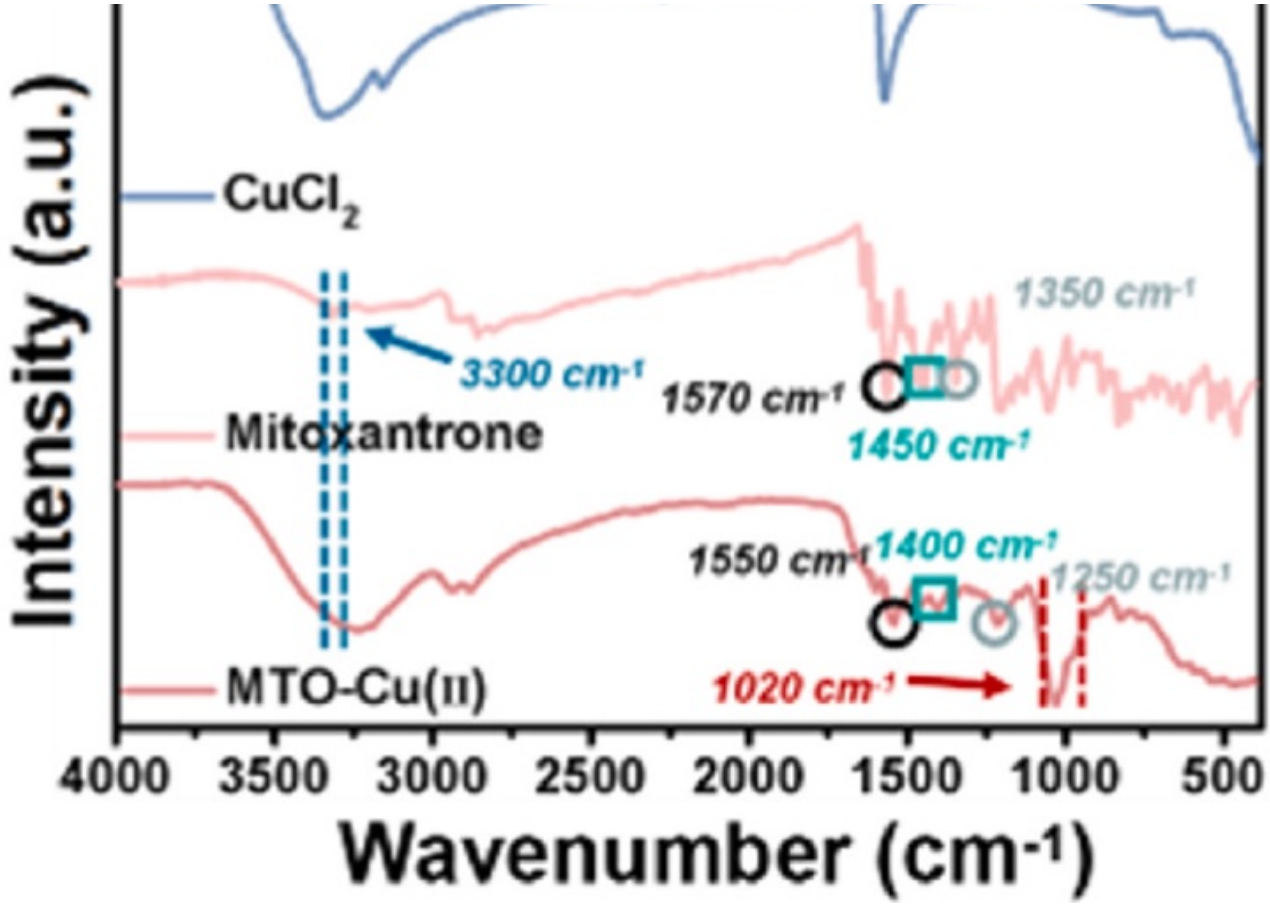


Figure 2: FTIR spectra of CuCl2, Mitoxantrone (MTO), and MTO-Cu(II) nanolocks.

Table 1: IR peaks of MTO-Cu(II) nanolocks

1570 Cm^{-1}	C=O
3300 Cm^{-1}	N-H
1250 Cm^{-1}	Cu-O-Cu
1400 Cm^{-1}	N-O-Cu
1020 Cm^{-1}	Metal-ligand

2B) Anwar characterized a nanoparticle with a simple cubic geometry using XRD. The following table shows the reflections acquired by Anwar. X-ray wavelength (= 1.54060 Å, CuKα1). Index the reflection shown in the table. Note: For simple cubic 7, 14 are forbidden number (3)

$$Sin^2\theta = \frac{\lambda^2}{4a^2}(h^2 + k^2 + l^2)$$

Table 2: XRD reflections of the nanoparticles

2θ
38.40
44.50
64.85
77.90
81.85
111.20

2C) Gang Zhong *et al* synthesized Prussian blue@PAMAM (PB@@PAMAM) and prussian blue@PAMAM@Angiopep-2 (PB@@PAMAM@angiopep-2) particles to cross the blood-brain barrier for treatment of Alzheimer's disease by selective mitophagy of microglia cells. Gang et al characterized the particles using DLS and Zeta potential and the results are given below. Based on the figure 3 shown below make your conclusion on the results shown (3)

figure 3 shown below make your conclusion on the results shown.

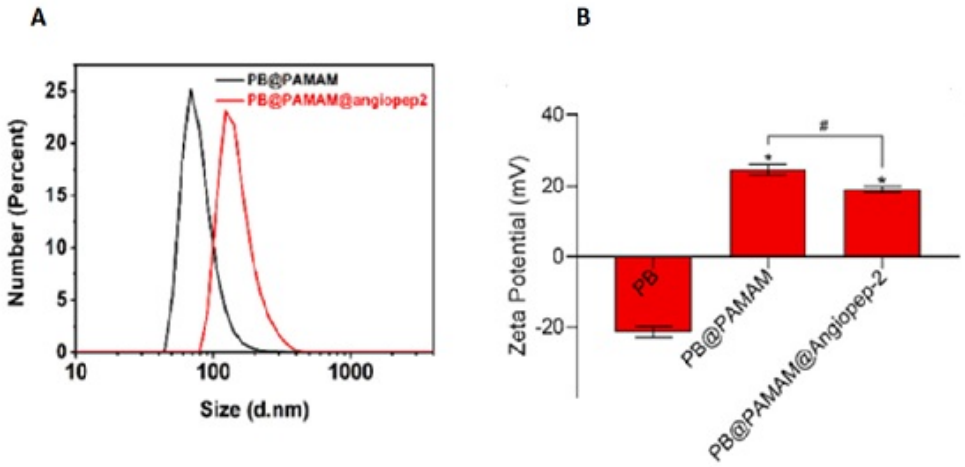


Figure : (A) Hydrodynamic sizes of nanoparticles, (B) Zeta potential

PB: : Prussian blue
PB@PAMAM : Prussian blue/polyamidoamine (PAMAM) dendrimer
PB@PAMAM@Angiopep-2 : Prussian blue/polyamidoamine (PAMAM) dendrimer/angiopep-2 (PPA)

Figure 3: The DLS and Zeta potential Measurements.

3A) Abhishek wants to extract hydrophobic cinnamic acid from cinnamon. Abhishek extracted the cinnamic acid from cinnamon using a solvent. Abhishek wants to purify the extracted mixture and wants to quantify the amount of cinnamic acid in the extract. Propose a method that can be used by Abhishek to purify the compound. Illustrate and discuss in detail the components, principle and method used to quantify the compound of your proposed solution. (4)

3B) A compound has a mass of 14000 amu. Propose the mass analyzer that should be used to detect the mass of the compound. Justify your answer and write the reason why other types of mass analyzer cannot be used. Explain the working of the proposed mass analyzer with suitable illustrations. (3)

3C) Illustrate the autocorrelation trace for large (700 nm) and small particles (50 nm) and explain how the autocorrelation function helps in determining the hydrodynamic radius of a particle (3)

4A) Figure 4 shown below represents the thermogravimteric analysis of a compound X. Interpret the figure and draw your conclussion on the TGA curve. Explain the workings of the microblance used in TGA. (3)

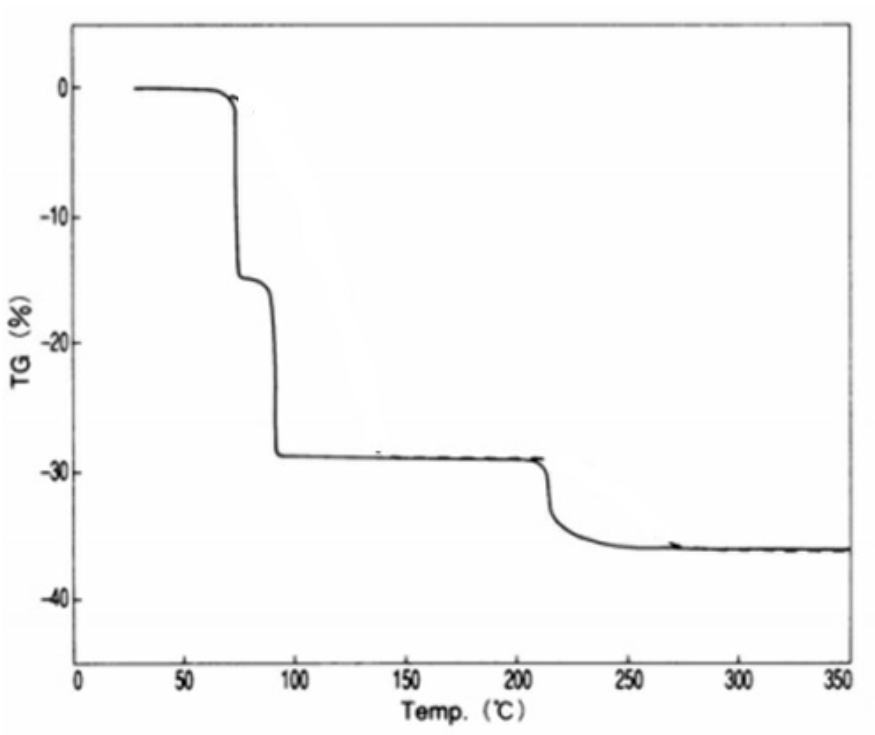


Figure 4: TGA traces of compound X

4B) A researcher working for a vaccine company developed three vaccine formulations. The vaccine is intended to be used in regions with minimum cold storage. Figure 5 shown below shows the differential scanning calorimetry (DSC) characterization of the three formulations. Analyze the figure and suggest which of the three formulations you will recommend. Explain the rationale behind your answer and the principle behind the working DSC. (4)

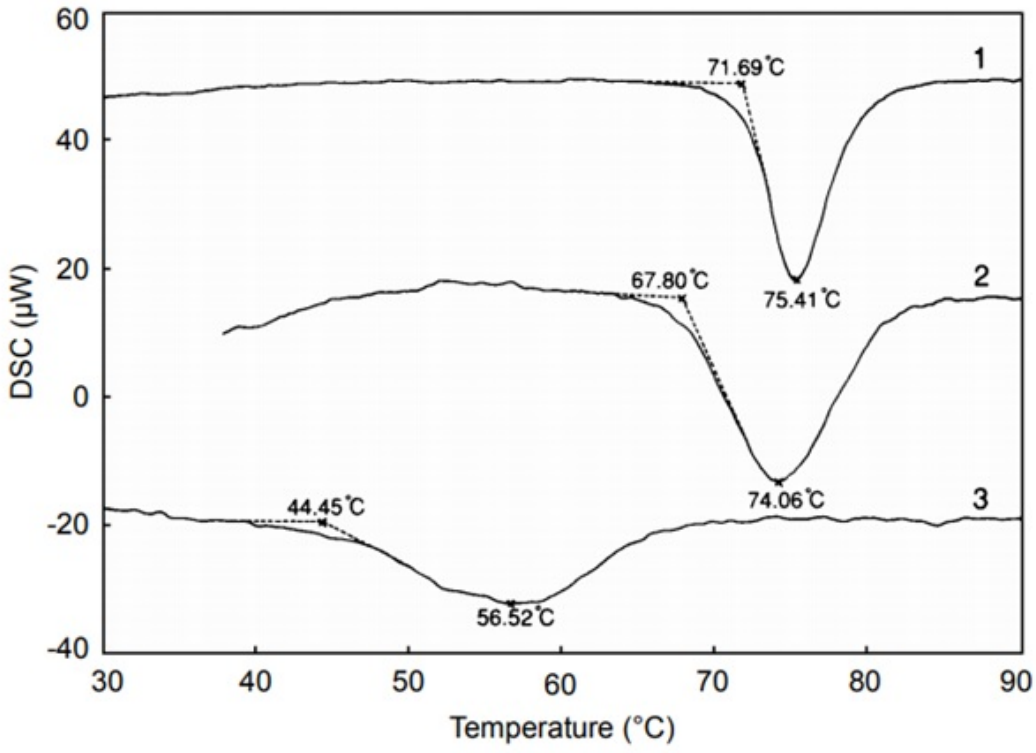


Figure 5: The DSC traces for the three vaccine formulations.

4C) Describe the methods used for temperature calibration of a TGA instruments with illustrations (3)

5A) A Time of Flight (TOF) Mass analyzer in SIMS is not able to resolve two ions of similar charge with small differences in their weight. Propose a method by which the resolution of TOF mass analyzer can be improved with detailed explanation of the method used to improve the resolution. (3)

5B) Compare and differentiate between phase shift and Vertical Scanning Interferometry (VSI) Mode in optical profilometer (3)

5C) A scientist is working on novel semiconductor chips. He encounters a problem with the conductivity of the semiconductor. The scientist performs a XPS depth profiling using X-ray photoelectron spectroscopy (XPS). The result of his analysis is shown in figure 6 below. Analyze the result shown below and illustrate the different layers in the semiconductor chip. (4)

Describe the process of depth profiling using XPS

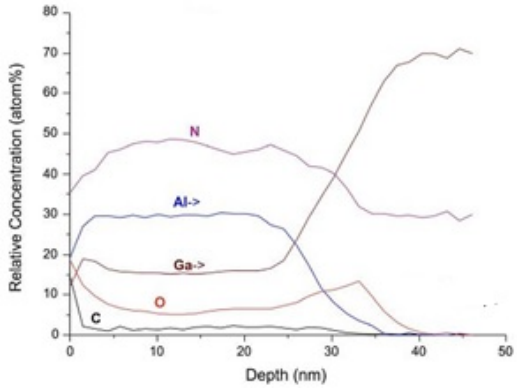


Figure 6: The depth profile of the semiconductor using XPS

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