24MPC231

Biomaterials 2 (Biomaterials for Drug Delivery)

Semester 2 2024/25 In-Person Exam paper

This examination is to take place in-person at a central University venue under exam conditions. The standard length of time for this paper is **2 hours**.

You will not be able to leave the exam hall for the first 30 or final 15 minutes of your exam. Your invigilator will collect your exam paper when you have finished.

Help during the exam

Invigilators are not able to answer queries about the content of your exam paper. Instead, please make a note of your query in your answer script to be considered during the marking process.

If you feel unwell, please raise your hand so that an invigilator can assist you.

You may use a calculator for this exam. It must comply with the University's Calculator Policy for In-Person exams, in particular that it must not be able to transmit or receive information (e.g. mobile devices and smart watches are **not** allowed).

Answer **ALL THREE** questions.

1. You work for a drug formulation company, and your manager has asked you to lead the development of a delivery system for a new drug used to treat inflammation of the colon. The drug is to be delivered orally and exerts its action in the colon.

(a) (i) Define what is meant by a drug, giving two key characteristics that it should possess. [2 marks]

(ii) Describe what is meant by controlled-release dosage of a drug. [1 mark]

(iii) Give four reasons why controlled release systems are considered more advantageous than conventional dosage forms, in terms of drug concentration in the blood. [4 marks]

(b) Identify five chemical or biological barriers that the delivery system has to overcome in order to release the drug directly in the colon. [5 marks]

(i) Given the barriers outlined above, suggest a coating and describe how it could be used to deliver this drug. [3 marks]

(ii) What limitations do these have and what instructions must be given to patients when administering this drug? [2 marks]

(c) In Figure 1c, the typical concentration of a drug in the blood plasma resulting from a single oral administration of the drug against the time after administration is shown. Copy the graph and mark the following: minimum effective concentration, minimum toxic concentration and therapeutic range. [3 marks]

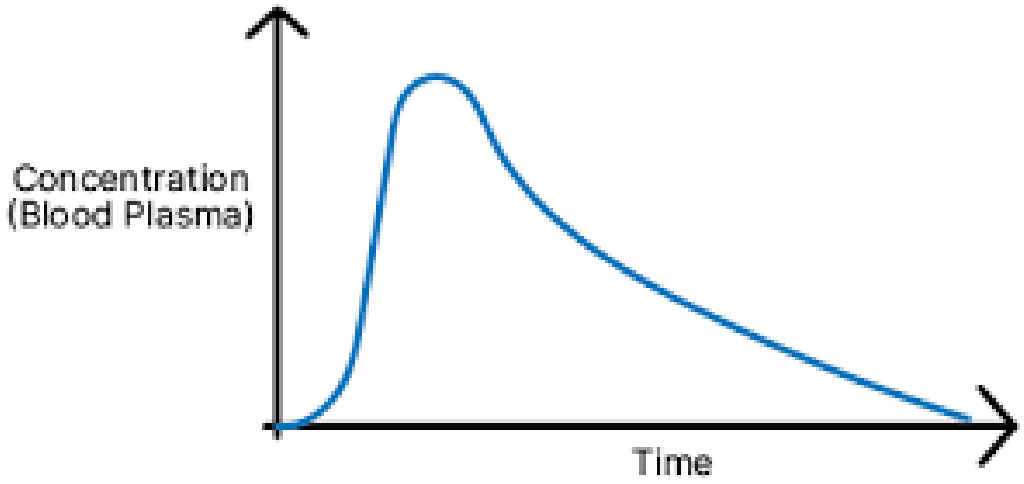

Figure 1c - typical concentration of a drug in the blood plasma resulting from a single oral administration of the drug

2. (a) (i) Describe the two main pathways by which polymeric drug delivery systems can degrade. [4 marks]

(ii) For each of these examples, discuss how degradation can affect the volume, density and mechanical properties of the polymer. [6 marks]

(b) Ring opening and free radical polymerisation can both be used to make polymers for drug delivery. Give one advantage and one disadvantage of each method. [4 marks]

(c) Whilst the number of publications on formulations for drug delivery continues to rise, it can be noted that this does not correlate with therapeutic advances. Discuss 3 possible reasons for this and for each suggest how the situation can be improved. [6 marks]

3 (a) You work for a company that specialises in drug delivery, and you have been asked to investigate the use of a novel acrylic polymer for the delivery of a hydrophobic drug. The polymer is an amphiphilic diblock copolymer that can assemble in aqueous conditions to form higher order structures.

(i) Define the term self-assembly. [2 marks]

(ii) State the main thermodynamic driving force governing this phenomenon. [1 mark]

(iii) You have been approached by a customer who would like to know whether to choose Polymerisation Induced Self Assembly (PISA) or the solvent switch method to prepare suitable polymer particles for the delivery of the drug. List 3 questions that you would need to ask to allow you to select the correct process, explaining how the answers would help your selection. [6 marks]

(b) The biophysicochemical characteristics of particles can affect their applications, with polymer nanoparticles between 10-100 nm typically used *in vivo*.

(i) Discuss how particle size can affect excretion from the body. [2 marks]

(ii) PEGylation is a method commonly used in the preparation of nanoparticles to introduce stealth behaviour. It involves attaching polyethylene glycol to the surface of the particles. State the main advantages that this can provide in a drug delivery system, when compared to a charged polymer particle. [2 marks]

(iii) Describe (using sketches) how nanoparticles can be internalised into cells by pinocytosis. [3 marks]

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(c) Stimuli-responsive polymers have the potential to be used in smart drug delivery systems. Polybetaines (shown in Figure 3c) are a class of temperature responsive polymers that exhibit a UCST in aqueous solution.

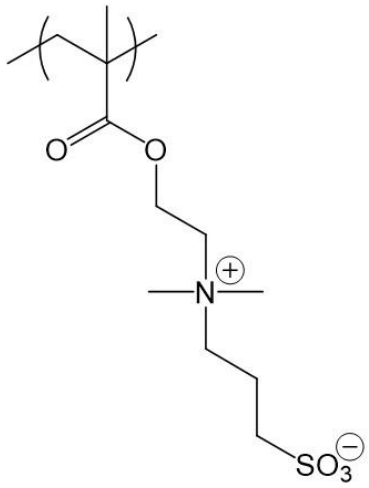

Figure 3c Polybetaine

(i) Define the term UCST. [2 marks]

(ii) State the main thermodynamic driving forces governing this phenomenon. [2 marks]

END OF PAPER

Dr H Willcock