

Sensors

22CMP065

Semester 1 2022/23

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 questions.

Use a **SEPARATE ANSWER BOOK** for **EACH QUESTION**

All questions carry equal marks

1. Answer **ALL** parts

- a) Many factors need to be considered when designing a biosensor for clinical use, Explain the benefits and limitations of laboratory-based vs point-of-care testing. **Include clinical examples** of each in your answer.

[8 marks]

- b) Surface acoustic wave (SAW) and quartz crystal microbalance (QCM) are two types of acoustic sensor. Using relevant biosensing examples, explain the benefits and limitations of each of these with reference to the information that can be obtained from each.

[8 marks]

- c) When sensing from blood or similarly complex fluid, fouling of the sensing surface often limits the performance of the sensor over time. Discuss in detail the importance of '*diffusion*', '*adsorption*' and the '*electric double layer*' in surface sensing.

[9 marks]

2. Answer **ALL** parts

- a) The Beer-Lambert is intrinsic for absorbance-based spectroscopy quantification methods. Explain why this law might not hold for all systems. In your answer address any assumptions that are often made to compensate.

[6 marks]

- b) Evanescent waves can be used for sensing applications in a) surface plasmon resonance and b) fibre optic UV sensing. Explain the key components of each, using schematics where appropriate.

[8 marks]

- c) Compare and contrast the properties, and production of antibodies and Aptamers when used as bio recognition elements in sensors.

[5 marks]

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[5 marks]

- d) Mie theory predicts the optical extinction of homogeneous spherical particles. The equation that describes the extinction cross section of a particle is given below:

$$C_{ext}(\lambda) = \frac{24\pi^2 R^3 \epsilon_m^{3/2}}{\lambda} \frac{\epsilon''(\lambda)}{(\epsilon'(\lambda) + 2\epsilon_m) + \epsilon''(\lambda)^2}$$

Identify the key parameters in the equation that determine the wavelength at which light is absorbed and scattered.

[6 marks]

3. Answer **ALL** parts

- a) Draw and illustrate the method used to create Aptamers, making sure you include the stages that enhance the selectivity of the aptamer.

[12 marks]

- b) Consider a resistive pulse sensor, each analyte that passes through the sensor produces a signal. With the aid of diagrams where appropriate, describe the signal, what information can be ascertained from it and the relationship between applied voltage and pulse (blockade) magnitude AND Pulse frequency

[13 marks]

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