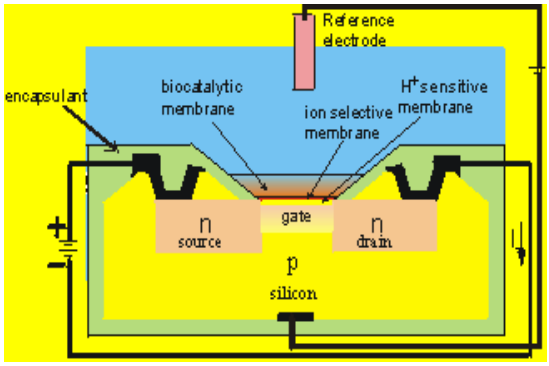
BT308 Bioengineering Midsem Exam 27.02.2024

Instructions: Answer all the questions. Answers must be specific and concise. More than required number of answer for the question will lead to zero marks. Questions are self-explanatory; hence, no queries are responded to during the exam. Each of the questions carries 3 marks. Total marks 30.

1. (a) Draw the general configuration of the ISFET device, indicating its parts with proper labels.
(b) Which of the following is not a terminal of a FET device: (i) Gate, (ii) Drain, (iii) Source, (iv) Membrane element, (v) Body. Marks: 2+1

Ans: (a)



(b) iv.

2. (a) Mention the three main stages of the CRISPR-Cas immune response. (b) State the role of the tracrRNA in the CRISPR-Cas system. (c) Which of the following Cas protein does not have collateral activity: Cas9, Cas12a and Cas13a. Marks: 1x3

Ans: (a) **Adaptation, Expression, Interference (b) the tracrRNA base pairs with the crRNA to form gRNA, and a portion of it is used by the Cas protein as a handle. (c) Cas9.**

3. (a) Why is the radiation from quantum dots " blue-shifted " compared to the bulk semiconducting materials? (b) State two major advantages of quantum dots over traditional organic fluorophores. (c) Larger quantum dots exhibits shorter / longer lifetime because they have more closely/widely spaced energy levels in which the electron-hole pair can be trapped. Identify the correct underlined words. Marks: 1x3

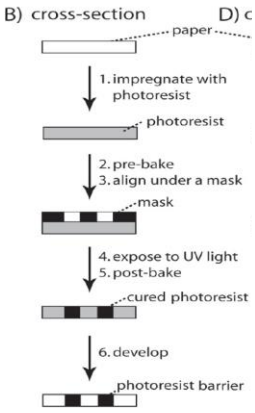
Ans: (a) The band gap of bulk material increased when it is transformed into QD, resulting in shifting of radiation wavelength from longer to shorter level causing blue shift. (b) High stability (100 times more stable than traditional fluorophoes) and stronger radiation (20 times brighter, hence high Quantum yield). (c) Longer, closely

4. (a) State four basic steps involved in SELEX process (Only one word is allowed to write against each of these steps; zero mark will be awarded for the non-compliance). (b) State two key advantages of aptamers over antibody for their commercial biosensing applications. Marks: 2+1

Ans: (a) binding, partition, elution, and amplification. (b) lower cost, higher stability (high shelf-life, reversible), easy (straightforward) synthesis, low batch-to-batch variation [any two fine].

5. (a) Show schematically the photolithography for creating microfluidic channels on a chromatographic paper (All steps must be shown clearly with proper labels). (b) State the type of transport phenomenon occurs in chromatographic paper and assess its Peclét number with respect to 1. Marks: 2+1

Ans: (a)



(b) statistical transport (diffusion/entropy driven); peclet no. <1.

6. (a) Define Non-Newtonian fluid based on a relation among coefficient of viscosity, shear stress and shear rate. (b) Name the fluid from the following list that is suitable to create a turbulent-like instability flows in microfluidic channels: water, oil, glycerin, blood, gas (c) State the major difference between Lab-on-a-chip and Micro Total Analysis Systems. Marks: 1x3

Ans: (a) the viscosity changes with the shear stress, thus the shear stress is not proportionally changes with the shear rate. (b) Blood.(c) LOC integrates one or several laboratory functions on a single chip for analysis purposes. µTAS is more widely applicable than only for analysis purposes.

7. State three mechanisms known for exchanging electrons between bacterial cells and electrodes to generate power in microbial fuel cell devices. Marks: 1x3

Ans: (a) Indirect extracellular electron transfer without recycling, Indirect extracellular electron transfer with redox cycling, Direct extracellular electron transfer, Direct contact by nanowire appendages [any three]

8. (a) If the oxidation potential of a redox enzyme is +0.2V, identify the voltage from the following list that suits best for a mediator in a 2nd generation amperometric biosensors to transfer electrons from the redox centre of the enzyme to the eletrode: +0.1V; +0.2V; +0.3V; 0.0V; -0.1; -0.2V; -0.3V. (b) State the functions of auxiliary and reference electrodes in an electrochemical setup. Marks: 1+2

Ans: (a) +0.3V [in the case of oxidative: $E^0_M > E^0_E$]. (b) Auxiliary electrode passes all the current needed to balance the current observed at the working electrode. Whereas, reference electrode acts as the other half of the cell, has a known potential with which to gauge the potential of the working electrode.

9. (a) Biofuel cell is a thermodynamically…….system. Fill the gap with a right word.

(b)Identify the correct statement: (i) Higher the anode potential, lower would be the metabolic energy gain for the bacteria in the microbial fuel cell. (ii) Upon scaling down the size of a biofuel cell, its ohmic resistance decreases. (iii) High power density is a major challenge to the practical utility of biofuel cells. (iv) The polarization curve used to characterize biofuel cells is a plot of current density versus time of its operation.

(c) Write 2 critical factors that attribute biofuelcell as green energy technology. Marks: 1x3

Ans: (a) Open

(b) (ii)

(c) Biological catalyst, renewable fuel, operated (at 20 to 40 ºC) at room temperature [any two]

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10. (a) Calculate the strength of acetylcholinesterase inhibition by dichlorovos organophosphate pesticide if 0.4V and 0.3V are voltage signals without and with Dichlorvos detected in flow-injection calorimetric biosensors.
(b) Name the reactant used to produce gel from metal alkoxide sols in sol-gel technology.
(c) Which physicochemical factor in solid is closely related to the formation of piezoelectric effect? Show the equation involved in the bulk piezoelectric material with units. Marks: 1x3

Ans: (a) 0.4-0.3 divided by 0.4 = 0.25 or 25%
(b) Water
(c) Dipole moment,

$$\mathbf{p} = \sum_{i=1}^{N} q_i \mathbf{d_i} \ ,$$

Cm/m^3 (Cm is coulomb-meter)

END