

Name: Kiran KumariRoll no.: 224106015

BT-620 BIOSENSORS: QUIZ-I

Date: 26.08.2022

**Instructions:** Total marks: 10. Each of the 09 questions carries 01 mark. An additional 01 mark will be awarded to the students submitting the answer sheet within 3.30 pm (Sharp).

1. Identify the performance factor(s) for biosensors that attribute to their functional traits from the following list:

- (A) ☒ Selectivity  
 (B) ☐ Cost  
 (C) ☒ Portability  
 (D) ☐ Design  
 (E) ☐ Market  
 (F) ☒ Sensitivity

(1)

2. Write the word/phrase against each acronym letter of "ASSURED", the criteria World Health Organization has suggested. Zero mark will be awarded for an incomplete or incorrect answer against any acronyms.

A: Affordable S: Sensitive S: Specific U: User-friendly  
 R: Rapid & Robust E: Equipment-free D: Delivered to End User

3. In PTC thermistor:

- (A) ☒ Resistance increases with increasing temperature  
 (B) ☐ Resistance decreases with increasing temperature  
 (C) ☐ Resistance increases with decreasing temperature  
 (D) ☐ Resistance decreases with decreasing temperature  
 (E) ☐ Resistance does not change with decreasing temperature  
 (F) ☐ Resistance does not change with increasing temperature

(1)

Identify the correct answer.

(0.5)

4. Fill the gaps each with an appropriate word:

Organophosphates irreversibly inhibit acetylcholinesterase, which hydrolyses acetylcholine, the neurotransmitter of the parasympathetic nervous system.

✓ 5. The sensitivity of calorimetric biosensors could be increased by increasing temperature output by the enzymatic reaction steps. Fill the gaps each with an appropriate word.

✓ 6. In SPR phenomenon, if the evanescent field intensity decayed over a distance of 80 nm from the interface, then what would be the wavelength of the incident light?

- (A) ☐ 160 nm  
 (B) ☒ 200 nm  
 (C) ☐ 240 nm  
 (D) ☐ 280 nm  
 (E) ☐ 300 nm  
 (F) ☐ None of the above.

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7. Identify the correct relations among the amount of charge(C) developed, piezoelectric coefficient (d), force applied along the x-direction ( $F_x$ ), the number of stacked elements (n), and crystal dimensions a, b for a longitudinal effect in piezoelectric materials from the following equations:

- (A)  $C_x = d_{xy} F_x n a/b$   
(B)  $C_x = d_{xx} F_x n b/a$   
(C)  $C_x = 2d_{xx} F_x n a/b$   
(D)  $C_x = d_{xx} F_x n$   
(E)  $C_x = 2d_{xy} F_x n$   
(F)  $C_x = d_{xy} F_x n$

(1)

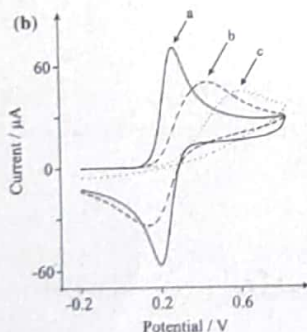
8. Identify the correct answer(s) without making any assumption from the following statements:

For oxidation of a target analyte on the electrode surface, the

- (A)  $F_F > E$  of LUMO of the target  
(B)  $F_F > E$  of HOMO of the target  
(C)  $F_F > E$  of HOMO and LUMO of the target.  
(D)  $F_F < E$  of LUMO of the target  
(E)  $F_F = E$  of LUMO of the target  
(F)  $F_F < E$  of HOMO of the target

The terminology/symbols follow the usual meaning as discussed in the classes.

9. From the cyclic voltammogram below, correlate the pattern of the graphs with the correct reaction(s):



- (A) a → quasi-reversible  
(B) a → non-reversible  
(C) a → reversible  
(D) b → reversible  
(E) b → irreversible  
(F) b → quasi-reversible  
(G) c → reversible  
(H) c → quasi-reversible

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**Instructions:**

Answer all the questions. Answers must be specific and concise. Ambiguous and verbose answers will carry no marks even if the answer is identified somewhere in the write-up. Questions are self-explanatory; hence no queries are responded during the exam time. Each of the questions carries 3 marks. Total marks 30.

1. (A) Draw the general configuration of biosensors indicating clearly each of the parts with proper label. Marks: 1 (figure) + 1 (labels)
- (B) Name the criterion for sample source that supports commercial success of biosensors in the field of clinical analysis. Mark: 1
2. (A) If the oxidation potential of a redox enzyme is +0.2V, identify the compound potential from the following list that suits best as mediator for transferring electrons from the redox centre of the enzyme to the electrode: (a) +0.1V; (b), +0.2V; (c), +0.3V; (d), 0.0V; (e), -0.1; (f), -0.2V; (g), -0.3V. Mark: 1
- (B) State two important factors that control the penetration of an electron transport mediator (ETM) close to the enzyme active center inside the protein matrix in 2<sup>nd</sup> generation amperometric biosensors. Marks: 2
3. If the enthalpy change of an enzymatic reaction associated with the conversion of 2000 g of a target analyte substrate to 1 mol of the product is -100 kJ/mol, the heat capacity of the system is 1 kJ/K.Kg, Seebeck coefficient is 0.01 V/K, then estimate the output potential difference ( $\Delta V$ ) of a thermopile, with one pair of the thermocouple. Marks: 1 (answer) + 1 (reference equation) + 1 (steps with units).
4. (A) Draw the Kretschmann configuration commonly used in SPR sensors and indicates its parts with proper labels. Mark: 1 (figure) + 0.5 (labels)
- (B) Calculate the refractive index change caused by the binding of COVID-19 on its specific antibody at the SPR sensor surface if the characteristic refractive index increment value is  $0.3 \text{ cm}^3 \text{ g}^{-1}$  and the change in concentrations of the virus particles on the sensitive layer is  $0.1 \text{ g/cm}^3$ . Mark: 0.5 (answer) + 1 (base equation + units)
5. Different operational modes could be created by cutting the piezoelectric material. Name the modes, indicate the relations between the applied force and accumulated charge in materials of each mode, and draw their corresponding diagrams. Marks: 1 + 1 + 1
6. What are BAW and SAW piezoelectric sensors? Identify a major difference between them. Marks: 1 (BAW) + 1 (SAW) + 1 (the difference; only the first answer will be considered if multiple answers are given).
7. The following redox reaction occurs at the reactive center of an enzyme:  

$$\text{Substrate (2H)} + \text{FAD-oxidase} \rightarrow \text{product} + \text{FADH}_2\text{-oxidase}$$

Based on this first reaction step, show the corresponding electrochemical reactions takes place in each of the three generations of amperometric biosensors. Marks: 1 + 1 + 1
8. (A) When we can call a redox enzyme a molecular transducer? Mark: 1
- (B) Calculate the surface coverage of an electroactive enzyme immobilized over a graphite electrode from the following information: Faraday constant  $9.65 \times 10^4 \text{ C/mol}$ , number of electrons involved in the reaction 01, the charge obtained by integrating the CV peak current area  $9.65 \times 10^5 \text{ C}$  and the surface area of the electrode  $1 \text{ cm}^2$ .  $\Gamma = \frac{Q}{nFA}$
- Marks: 1 (formula) + 1 (answer with correct unit)
9. (A) State four immobilization strategies of biorecognition proteins over electrode surfaces. Marks: 2
- (B) What is the application of Laviron equation in the characterization of 3<sup>rd</sup> generation enzyme electrodes? Mark: 01
10. Draw with proper labels the thermopile transducer-based flow injection calorimetric biosensor used to detect organophosphate pesticides. Marks: 1.5 (diagram) + 1 (clarity of the diagram) + 0.5 (proper labels of the parts).

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Name: Kiran KumariRoll no.: 224106015

BT-620 BIOSENSORS: QUIZ-II

Date: 04.11.2022

**Instructions:** Total marks: 10. Each of the 09 questions carries 01 mark. An additional 01 mark will be awarded to the students submitting the answer sheet within 3.30 pm (Sharp).

1. Identify the advantage that could be gained by miniaturising biofuelcell for biosensing applications:

(A) Selectivity  
(B) Sensitivity  
(C) Reproducibility  
(D) Simple operation  
(E) Accuracy  
(F) Functional stability

2. The Lower the difference between the redox potential of the substrate and the anode potential, the higher the metabolic energy gain for the bacteria and higher the MFC voltage.

Fill the above gaps by using the terms from the following list: Lower, Higher.

Conditions: only one word per gap by placing the words in the gaps. Zero mark will be awarded even one gap is incorrectly filled.

3. Make correction(s) in the following statement by correcting only two words (correcting more than two words lead to zero marks):

The coulombic efficiency is defined as the ratio of total coulombs actually transferred to the anode from the substrate, to maximum possible coulombs if all substrate removal produced current.

Show the corrections in the above statement itself by striking off the wrong words and writing the right words above the respective wrong words.

4. Write the chemical formula of two typical pH sensitive gate materials used in ISFET devices.

Ans:  $\text{Al}_2\text{O}_3$ ,  $\text{Ta}_2\text{O}_5$ ,  $\text{Si}_3\text{N}_4$

5. What is the full form of CRISPR? (must correct the whole string of words).

Ans: Clustered Regularly Interspaced <sup>short</sup> Palindromic Repeats

6. The lifetime of fluorescence is:

(A) longer for smaller QDs  
(B) shorter for bigger QDs  
(C) not effected by sizes of QDs.  
(D) longer for bigger QDs,  
(E) shorter for smaller QDs.

Identify the correct answer(s).

7. Write the full form of SELEX (must correct the whole string of words).

Ans: Systematic Evolution of Ligand by Exponential Enrichment

BT-620 BIOSENSORS: QUIZ-II

Date: 04.11.2022

①

Ans:

- (1) Inexpensive
- (2) More stable at Room temperature (longer shelf life)
- (3) Recognise other molecule such as inorganic molecules while antibodies
- (4) Renewable and stable at high temperature.

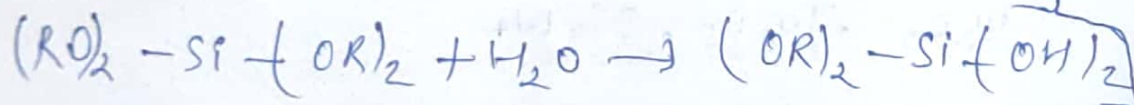
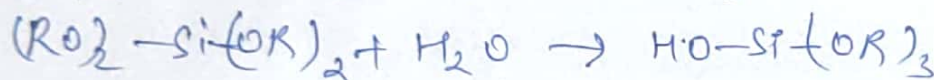
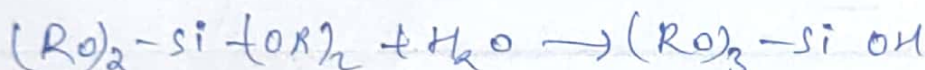
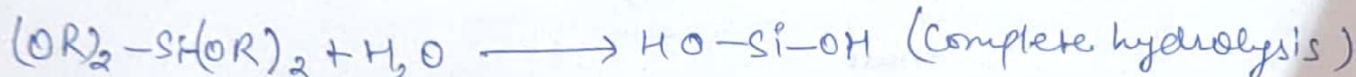
9. Named the key reaction that is utilized to synthesise sol-gel materials from metal alkoxide.

Ans: Wet-chemical techniques

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$\text{Si}(\text{OR})_4 \rightarrow \text{Metal alkoxide (undergo hydrolysis \& polymerisation)}$



Partial  
Hydrolysis

→ These partially hydrolyzed metal oxide ~~groups~~<sup>joined</sup> in 1, 2, 3 dimension to form alkoxide network.  $[Si-O-Si]$

Hydrolysis  $\longrightarrow$  Drying  $\longrightarrow$  Polycarbonation  
(To remove water)



## Department of Biosciences and Bioengineering, IIT Guwahati

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Each of the questions carries 3 marks. Total marks 30.

1. Draw the general configuration of ISFET device indicating clearly its parts with proper labels. Mark: 3

2. (a) Mention the 3 main stages involved in the CRISPR-Cas immune response. (b) State the role of the tracrRNA in the CRISPR-Cas system. (c) State without elaboration, how the CRISPR-Cas complex identifies the target DNA? Mark: 1x 3

3. (a) Define exciton in quantum dots. (b) State the difference between small and large quantum dots of the same materials in terms of fluorescence lifetime and give the reason.

- (c) What are the major advantages of quantum dots over traditional organic fluorophores? Mark: 1x 3

4. Show schematically the SELEX process with proper labels in steps for selecting an aptamer against a target. Mark: 3

5. (a) Define Reynold number through an equation and relate its values to the flow characteristics of fluids. (b) State the significance of Peclet number in operating the microfluidic devices. Mark: 2+1

6. Show schematically the photolithography for creating microfluidic channels on a chromatographic paper surface. All steps must show clearly with proper labels. Mark: 3

7. Depict through a diagram the CRISPR method for detecting viral RNA following SHERLOCK method.  $\rightarrow$  Cas 13 Mark: 3

8. Describe briefly: (a) Molecular Beacons (b) Molecular imprinting technique and (c) Critical steps involved in performing a typical dual-colour DNA microarray analysis. Mark: 1x 3

9. Describe schematically the Lateral Flow Immunoassay for detecting SARS-CoV-2. Mark: 3

10. (a) What is Site-binding model in ISFET? (b) Show the reaction scheme involved in the model. (c) State the relation among threshold voltage, drain to source current and gate-source potential through a suitable equation. Mark: 1x 3

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