



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED CHEMISTRY

CHEMICAL SENSORS AND BIOSENSORS

SCH 6130

End of Semester Examination Paper

DECEMBER 2024

This examination paper consists of 6 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: None

Examiner's Name: Dr P. Ncube

External Examiner: Dr. G. Mehlana

INSTRUCTIONS

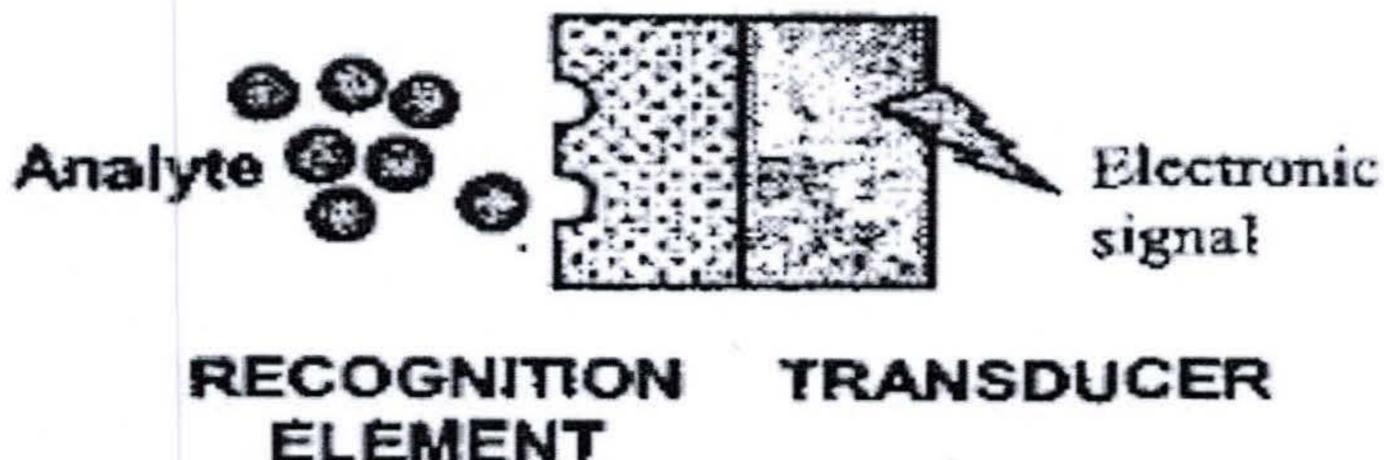
1. Answer Any four (4) questions from the five (5) provided
2. Each question comprises various sub questions
3. Each question carries 25 marks
4. Use of calculators is permissible

MARK ALLOCATION

QUESTION	MARKS
1.	25
2.	25
3.	25
4.	25
5.	25
TOTAL ATTAINABLE MARKS	100

QUESTION ONE

1. The following diagram is an illustration of a chemical or biosensor.



- (a) Use the illustration to name the two elements of a sensor. [2]
- (b) What is the function of each element named in part (a)? [4]
- (c) Use the illustration to describe the difference between a chemical sensor and a biosensor. [4]
- (d) Describe **five (5)** analytical parameters used to measure the performance of chemical sensors. [3 x 5]

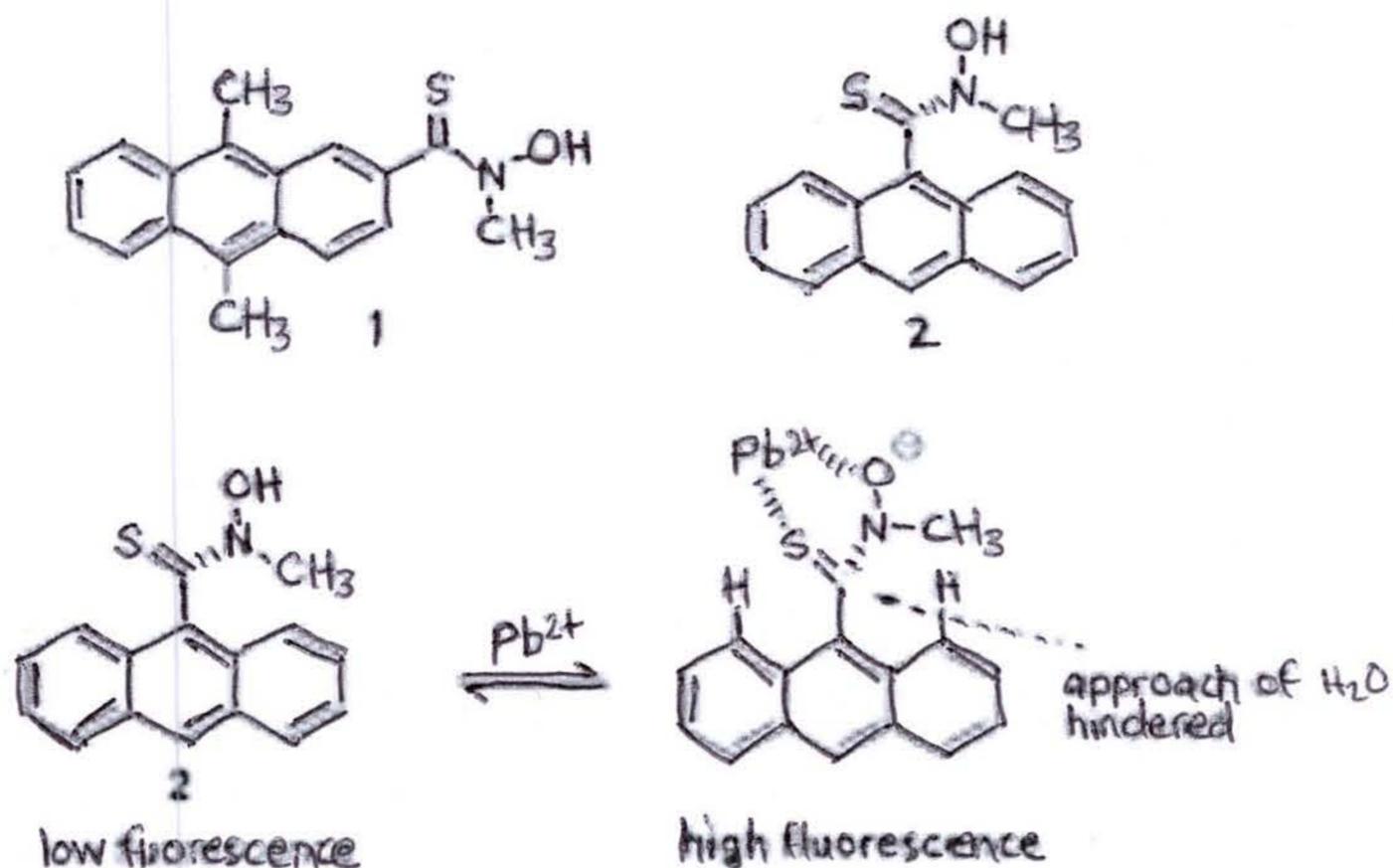
QUESTION TWO

- 2 (a) What are the desired characteristics of a sensor? List any five (5) and give a briefly explain why a chemical sensor should possess the characteristic. [15]
- (b) Chemical sensors can give qualitative or quantitative information about a sample. State the qualitative and quantitative information obtained from chemical sensors. [5]
- (c) Copy and complete the table below by giving the transducer principle and the measured quantity for each type of electrochemical sensor.

Sensor	Transducer principle	Measured quantity	
Potentiometric	Energy conversion		[1]
Amperometric			[2]
Conductometric			[2]

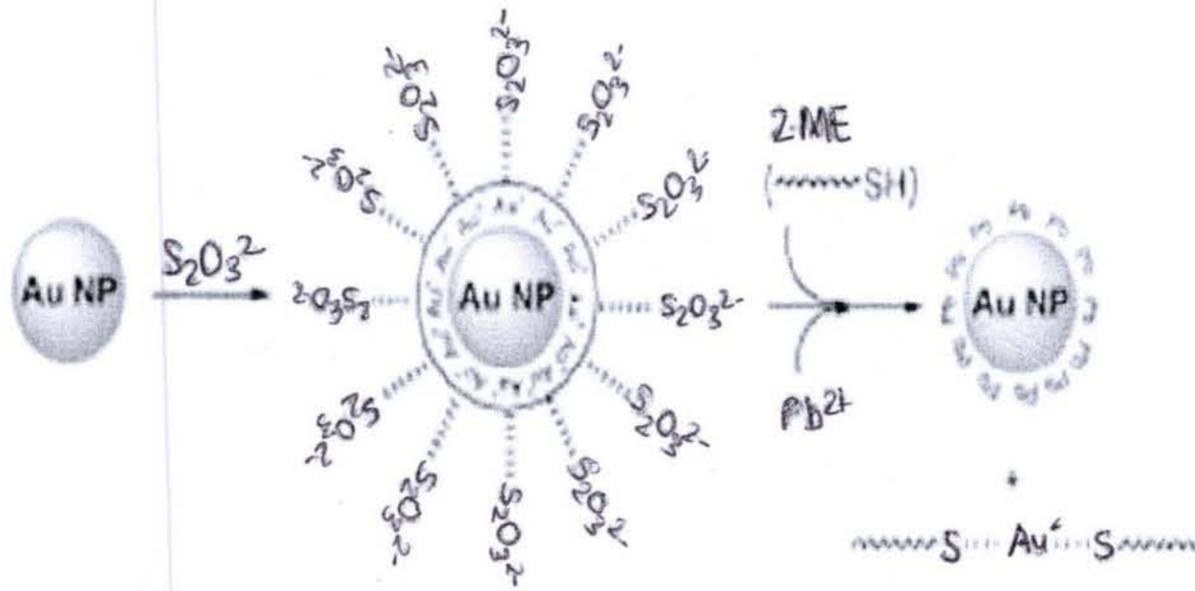
QUESTION THREE

3. The schematic below shows small organic molecules 1 and 2 used for sensors for the detection of Pb^{2+} ions. The second part of the scheme shows the mechanism of sensing with molecule 2.



- (a) (i) What class of chemical sensors are molecules 1 and 2? [2]
- (ii) Use the given mechanism to explain the mechanism of a fluorescence chemical sensor. [10]

- (b) Over the past decade, the use of nanoparticle based sensors has grown. Below is an example of a nanoparticle based sensor used detect Pb^{2+} ions.



- (i) Name three types of nanoparticle-based sensing systems that have been used as sensors. [3]
- (ii) Explain the advantages brought about by the use of nanoparticles in sensing systems when compared to small molecule-based sensors? [5]
- (c) Sensors have been widely used in environmental monitoring of heavy metals such as Pb, Cd and Hg. Name and explain one other application of fluorescent and colorimetric sensors. [5]

QUESTION FOUR

4 (a) Describe the principle of each of the following types of bio-sensors.
Give one example of an application of each type.

(i) Enzyme biosensors [10]

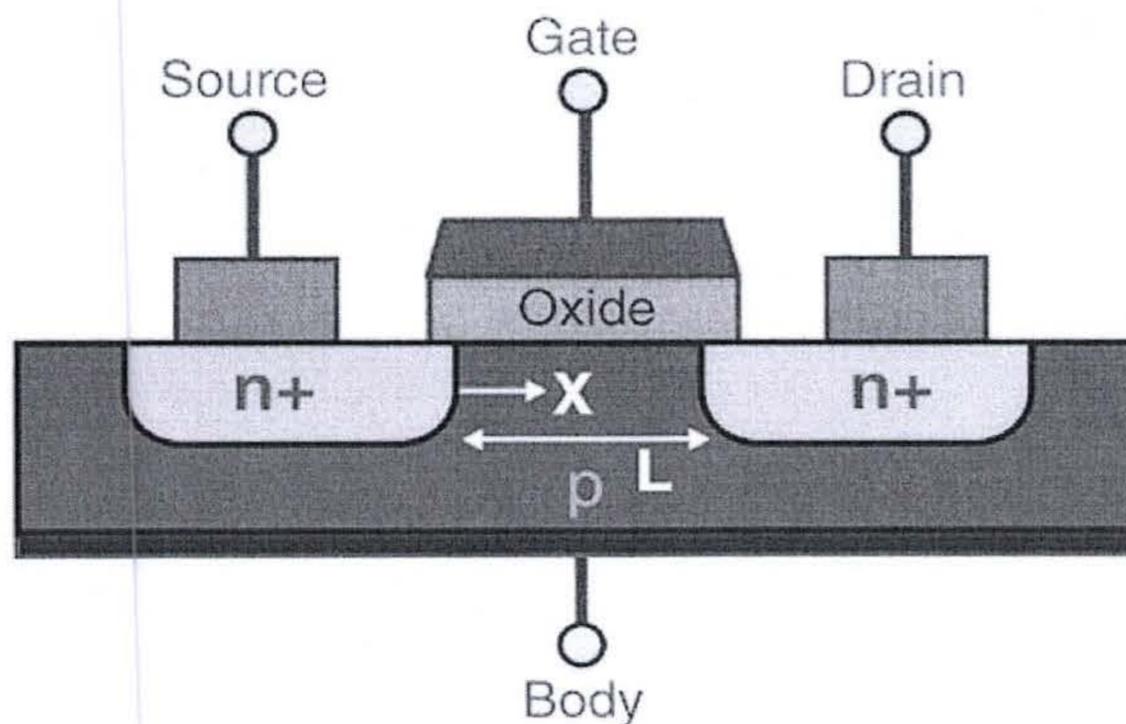
(ii) Nucleic acid biosensors [10]

(b) In the classification of bio-sensors, most of the sensor can also be further classified as electrochemical or optical. Explain how this is often the case. [5]

QUESTION FIVE

5 (a) The diagram below illustrates the field effect transistor (FET).

(b)



(a) Is the FET used as the recognition element or the transduction element in chemical sensor design? [2]

- (b) Use the diagram above to describe the working principle of the field effect transistor (FET) as applied in chemical sensors. [10]
- (c) Describe the piezoelectric effect. What is the requirement for a material to be piezoelectric? [5]
- (d) Describe the working principle of a surface acoustic wave (SAW) sensor. [8]

*****END OF QUESTION PAPER*****