Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q 1. a) Attemt any SIX of the following : (12)

(i) Define biometrics.

(2 marks for Definition)

Ans : The branch of science that includes the measurement of physiological variables and parameters is known as biometrics.

(ii) List any four sources of biomedical signals.

(1/2 mark each)

Ans : - ECG (Electrocardiography)

- EEG (Electroencephalography)

- EMG (Electromyography)

- PCG (Phonocardiography)

- BP (Blood Pressure) or

1. Bio-electric signals:-These are unique to the biomedical system. They are generated by nerve cells and muscle cells. Their basic source is the cell membrane potential. The most common examples of bioelectric signal are the ECG and EEG.
2. Bio-acoustic signals: These signals are obtained from sounds created by Biological system and provide information about underlying phenomenon .Eg. Flow of blood in heart through valves, flow of air in lungs.
3. Bio-mechanical signals:-These signals are obtained from mechanical function of biological system it includes all types of motion and displacement signal.Eg.Motion of chest wall.
4. Bio-chemical signals: - These types of signals are obtained from the measurements of chemical compositions. Eg- composition of various ions, partial pressure of oxygen or co2 in living tissues or from sample.
5. Bio-magnetic signals:-In bioelectric signals, some organs produce very weak electromagnetic signals; measurement of these signals is called “Bio-magneticsignals.”
6. Bio-optical signal:- These signals are generated as result of optical function of the biological system, occurring either naturally or induced by the measurement process. Eg.blood oxygenation may be estimated by measuring the transmitted /back scattered light from a tissue at different wavelength.
7. Bio-impedance signal:- The impedance of the tissue is a source of important information concerning its composition, blood distribution and blood volume etc.The measurement of galvanic skin response is typical example of this type of signal.

(iii) Define flow transducer. (2 marks for Definition)

Ans : Flow transducer is a measuring device that calculates volume by dividing flow by time. Flow transducers are used to measure air and liquid flow velocity.

(iv) Give any two advantages of thermocouple.

(1 mark each)

Ans :

- Low cost.
- It has rugged construction.
- Temperature range -270 to 2700 ℃.
- Bridge circuits are not needed for measurement.
- It offers good reproducibility.
- Speed of response is high.
- Measurement accuracy is quite good.

(v) Define chemical transducer.

(2 marks for Definition)

Ans :

A chemical transducer is a device that transforms chemical information, ranging from the concentration of a specific sample component to total composition analysis, into an analytically useful signal.

(vi) List different surface and internal types of electrodes.

(Surface electrode = 1 mark , Internal electrode = 1 mark)

Ans :

Types of Surface Electrode:-

a) Metal plate electrode

-Metal disc electrode

-Disposable electrode

b) Suction electrode

c) Floating electrode

Types of Internal Electrode:-

a) Probe electrode
b) Needle electrode
c) Coaxial electrode
d) Coiled electrode

(vii) State any two disadvantages of RTD.

(1 mark each)

Ans :

Disadvantages of RTD :

- Less accurate
- High cost
- Low sensitivity.
- They are affected by contact resistance.
- Require power supply and bridge circuit.
- Large size than that of thermocouple.
- Mechanical vibrations produces an error.

(viii) Draw a labeled diagram of radiation thermometry.

(2 marks for Diagram)

Ans :

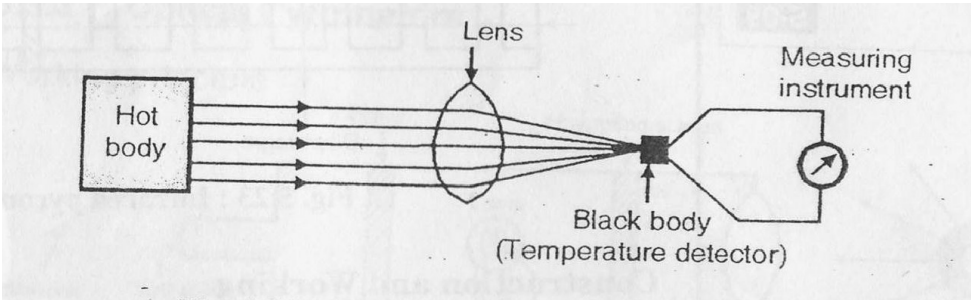


Fig : Radiation thermometry.

b) Attempt any TWO of the following : **(8)**

(i)Classify transducers based on :

(1) process used

(2) physical or chemical principle used

(2 mark each)

Ans :

1 Active and passive transducers

Active transducers convert an input physical quantity in to electrical output without any external supply. Ex Themocouple

Passive transducers require external power supply. Ex RTD

2 Analog & digital transducers

Analog transducers convert an input physical quantity into analog output which is a continuous function of time Ex Thermistors

Digital transducers convert an input physical quantity into discrete steps of electrical output which is in the form of pulses. Ex Rotary encoder.

3 Primary & secondary transducers

Primary transducers are detectors which sense a physical phenomenon.

The displacement given by bourdon tube is applied to the core of LVDT to convert displacement into proportional electrical quantity. Here LVDT is secondary and bourdon tube is primary.

4 Transducers and inverse transducers

Transducers are devices which convert nonelectrical quantity into electrical quantity. Ex Thermistor

Inverse transducers are those which convert electrical quantity into nonelectrical quantity.

Ex Piezoelectric transducers.

5 Based on Application

Temperature: RTD, Thermocouple, Thermistor

Pressure: Piezoelectric

Displacement: LVDT

Force: Straingauge, loadcell

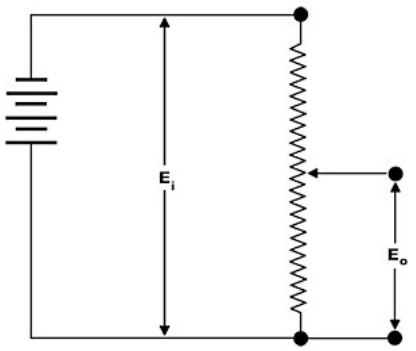
6 Physical transducer : It converts Physical quantity into electrical signal. Example – Thermocouple , RTD

Chemical transducer : It converts chemical quantity into electrical signal. Example – pH electrode.

(ii) Describe working principle of linear potentiometer.

(Diagram 2 marks + Explanation 2 marks)

Ans :



Ei-Input voltage, Eo-output voltage

Any resistance element that changes its resistance as a function of a physical variable can be used as a transducer for that variable.

Potentiometer convert rotary motion or displacement into a change of resistance. Linear potentiometer can be used to convert linear displacement into a resistance change.

(iii) Describe differentiate amplifier with neat labeled diagram.

(Diagram 2 marks + Explanation 2 marks)

Ans :

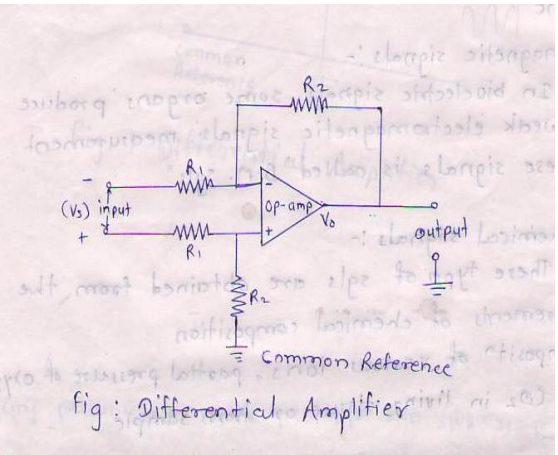


fig : Differential Amplifier

1) The signal from the transducer is a very low level signal. It has to be amplified using the differential amplifier.
2) All amplifiers used in biomedical application are isolation amplifiers. It is mandatory for any biomedical equipment for the purpose of patient safety to have isolation from the mains supply.

Q. 2) Attempt any FOUR of the following : **(16)**

a) Classify bioelectrodes. Give application of each electrode.

(Classification = 2 marks , Application = 2 marks)

Ans :

Classification of Bioelectrodes :

(i) Surface Electrodes

(ii) Internal / Deep seated electrodes

Application of electrode :

- Surface electrodes pick up potentials from surface of tissue.

- Internal electrodes are inserted inside a live tissue or cell.

b) Describe constructional diagram of thermistor.

(Diagram 2 marks + Explanation 2 marks)

Ans :

Thermistors are inexpensive, rugged, reliable and responds quickly. Because of these qualities thermistors are used to measure simple temperature measurements, but not for high temperatures. Thermistor is easy to use, cheap, durable and respond predictably to a change in temperature. Thermistors are mostly used in digital thermometers and home appliances such as refrigerator, ovens, and so on. A thermistor is easily obtainable temperature sensitive resistor, thermistor working principle is, it's resistance is depends upon temperature. When temperature changes, the resistance of the thermistor changes in a predictable way. The benefits of using a thermistor is accuracy and stability. Thermistors are available in different shapes like rod, disc, bead, washer, etc. This article gives an overview of thermistor working principle and applications.

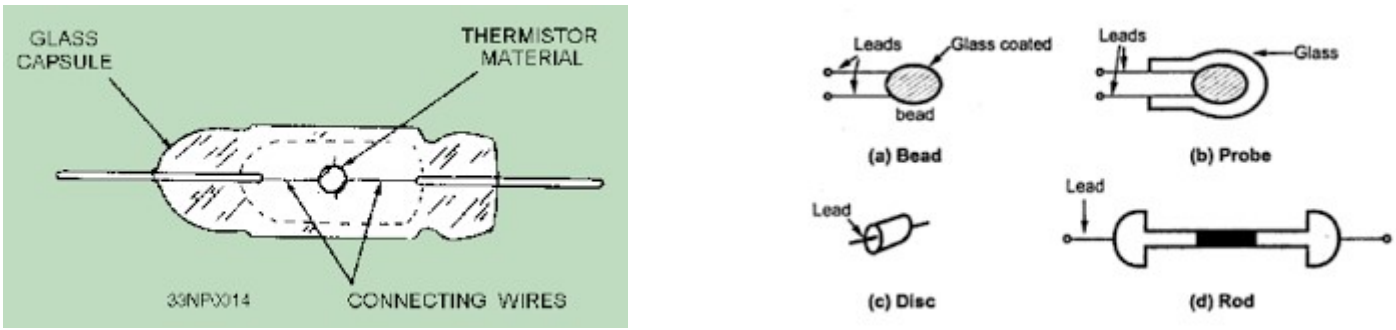
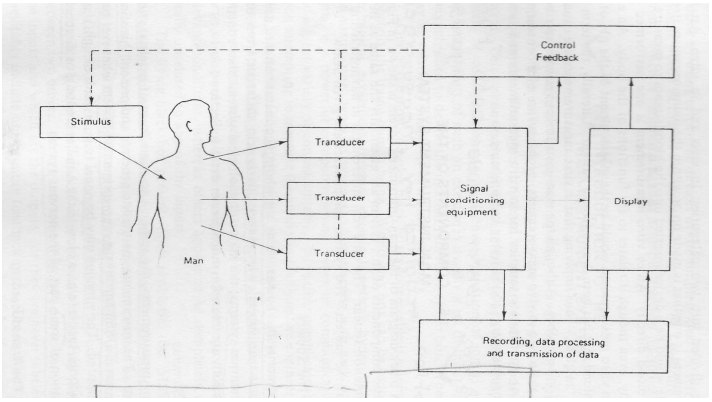


Fig : Thermistor

c) Draw and explain block diagram of biomedical instrumentation system.

(Diagram 2 marks + Explanation 2 marks)

Ans :



System components are given below:-

i) The subject – The subject is human being on whom the measurements are made.

ii) Stimulus – The instrument used to generate and present this stimulus to the subject is a vital part of man – instrument system when responses are measured.

Stimulus may be visual (e. g. flash of light), auditory (e.g. a tone), tactile (e.g. a blow to the Achilles tendon) or direct electrical stimulation of some part of nervous system.

iii) The Transducer – A device capable of converting one form of energy or signal to another. Here each transducer is used to produce an electrical signal that is analog of the phenomenon. Transducer may measure temperature, pressure, flow or any other variables found in body.

iv) Signal condition equipment – The part of instrumentation system that amplifies modifies or in any other way changes the electric output of transducer is called signal conditioning Equipment. It also combines or relates the output of two or more transducers output signal is greatly modified with respect to the input.

v) Display Equipment –

Electric output of signal conditioning equipment must be converted into a form that can be perceived by one of mans senses and can convey information. Obtained by measurement in meaningful way. Input to display device is modified electric signal and its output is some is form of visual, audible or possible tactile information here display equipment may include graphic pen recorder.

vi) Recording Data – Processing & Transmission equipment -

It is often necessary to record the measured information for possible latter use or to transmit it from one location to another on-line digital computer mau be part of this system where automatic storage or processing data is required.

vii) Control devices –

A control system is incorporated where it is necessary or desirable to have automatic control of stimulus, transducers or any other part of man instrument system.

d) Describe indicator dilution method of flow measurement.

(Diagram 2 marks + Explanation 2 marks)

Ans :

The indicator or dye dilution methods are the only method of blood flow measurement that really measures the blood flow and not the blood velocity. In principle, any substance can be used as an indicator if it mixes readily with the blood and its concentration in the blood can be easily determined after mixing.
The principle of the dilution method is shown in figure. The indicator is injected in to the blood flow continuously, beginning at time t, at a constant infusion rate I (grams/minute). The detector measures the concentration downstream from the injection point. At a certain time after the injection, the indicator begins to appear, the concentration increases, and finally it reaches a constant value, C0 (milligrams per litre). From the measured concentration and the known injection rate. I, the flow can be calculated as,

$$F\ (\text{litres / minute}) = \frac{I\ (\text{milligrams / minute})}{C_0\ (\text{milligrams / litre})}$$

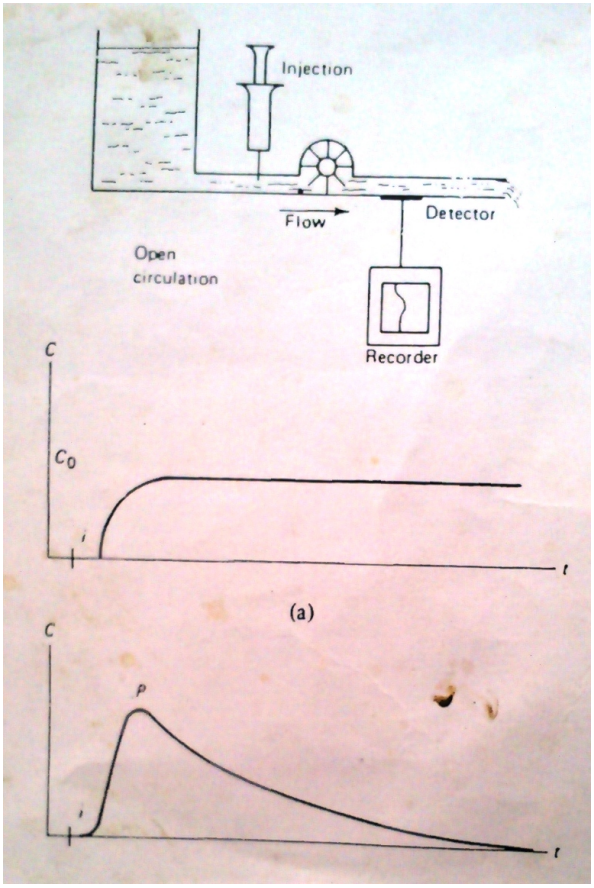


Fig : Indicator dilution method of flow measurement.

e) An unbounded strain gauge as a resistance of 6kΩ and gauge factor of 3.6 . what will be the change in resistance due to 3000 microstrain ?

Ans :

R = 6000 ohms
Gf = 3.6
strain = $\Delta L/L = 3000$
ΔR= unknown

Formula:

$$Gf = \frac{\Delta R/R}{\Delta L/L}$$ **1mark**

$$3.6 = \frac{\Delta R/6000}{\Delta L/L}$$

$$3.6 = \frac{\Delta R/6000}{3000}$$ **1 mark**

Therefore $\Delta R = 3.6 \times 3000 \times 6000$

Change in resistance = 64800000 micro ohms **OR**
Change in resistance = 64.8 ohms **2 marks**

f) Describe PO_2 electrode with a neat labeled diagram.

(Diagram 2 marks + Explanation 2 marks)

Ans :

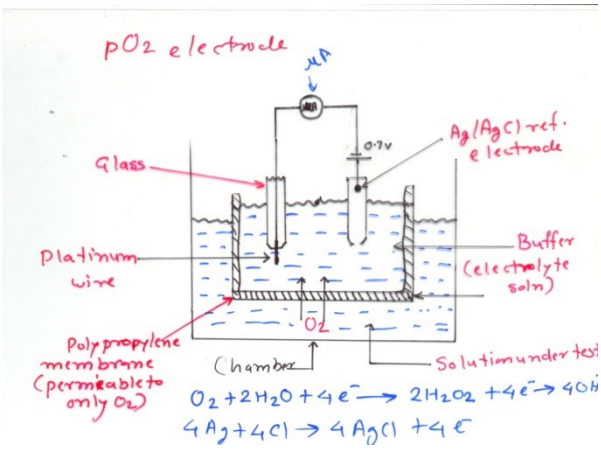


Fig : PO_2 Electrode

The PO_2 electrode is known as Clark electrode after its inventor and it is an O_2 sensor for blood. The electrode arrangement consists of two chambers and they are separated by polypropylene membrane i.e. permeable to O_2. The blood sample is injected into lower sample chamber as shown in the figure. The upper chamber contains the electrode. The O_2 in the blood permits the polypropylene membrane and reacts chemically with a phosphate buffer contained in the upper chamber. The buffer maintains the solution pH at a constant level. The O_2 combines with water in the buffer producing electrons proportion to the number of O_2 molecules according to the formula:

$$O_2 + 2H_2O + 4e^- \rightarrow 4[OH]^+$$

The electron current is measured by the ammeter. It is directly proportional to PO_2. Electrons on the left side of the equation are produced by a source voltage that polarizes the electrode and has value 0.7V. This voltage is called polorographic voltage. The electrode is called Clark's polorographic electrode. The meter scale is calibrated in units of PO_2 in the blood. This electrode current depends on current blood in the solution rather than membrane potential as it was in pH measurement.

Q. 3) Attempt any FOUR of the following : **(16)**

a) Name the source organ involved in following biomedical signals :

(i) EOG

(ii) EMG

(ii) ECG

(iv) EEG

(1 mark each)

Ans : Source organ involved in following biomedical signals are :

(i) EOG : Eyes

(ii) EMG : Muscles

(ii) ECG : Heart

(iv) EEG : Brain

b) Draw and explain instrumentation amplifier.

(Diagram 2 marks + Explanation 2 marks)

Ans :

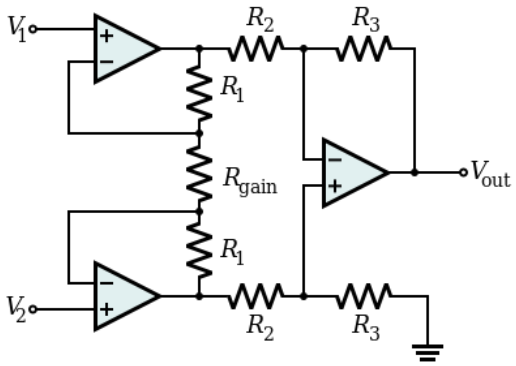


Fig : Instrumentation amplifier

Instrumentation amplifier is a kind of differential amplifier with additional input buffer stages. The addition of input buffer stages makes it easy to match (impedance matching) the amplifier with the preceding stage. Instrumentation are commonly used in industrial test and measurement application. The instrumentation amplifier also has some useful features like low offset voltage, high CMRR (Common mode rejection ratio),high input resistance, high gain etc. A circuit providing an output based on the

difference between two inputs (times a scale factor) is given in the above figure. In the circuit diagram, opamps labelled A1 and A2 are the input buffers. Anyway the gain of these buffer stages are not unity because of the presence of R1 and Rg. Op amp labelled A3 is wired as a standard differential amplifier. R3 connected from the output of A3 to its non inverting input is the feedback resistor. The voltage gain of the instrumentation amplifier can be expressed by using the equation below.

$$\text{Voltage gain (Av)} = Vo/(V2-V1) = (1 + 2R1/Rg) \times R3/R2$$

c) Draw neat labeled diagrams of fibre optic sensors.

(4 marks for diagram)

Ans :

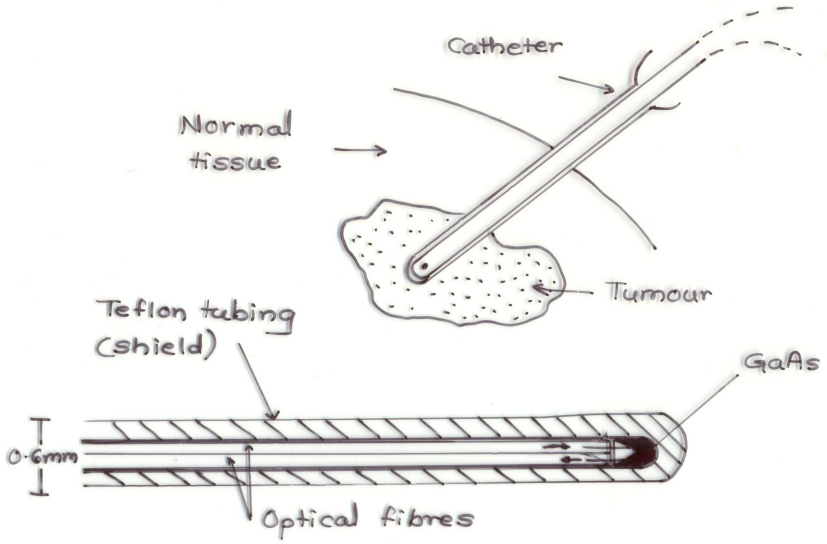


Fig : Fibre optic sensors.

d) List different properties of bioelectrodes.

(1 mark each)

Ans :

- They should be good conductors.
- They should have low impedance.
- They should not polarize when a current flows through them.
- Potentials generated at the metal electrolyte (jelly) surface should be low.
- They should establish a good contact with the body and not cause motion.
- They should not cause itching, swelling or discomfort to patient.
- They should be chemically inert.
- They should be mechanically rugged.
- They should be easy to clean.

e) What is LVDT? Describe how pressure can be measured using LVDT with a suitable diagram.

(4 marks)

Ans :

LVDT : The most widely used inductive transducer to translate linear motion (displacement) into electrical signals is called as Linear Variable Differential Transformer (LVDT).

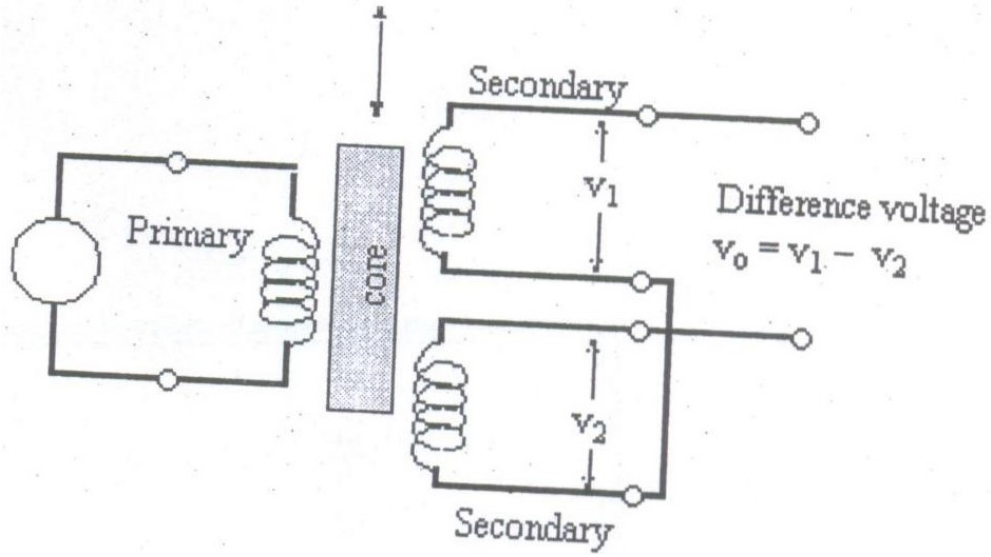


Fig : Construction of LVDT

Note : Core of LVDT is connected to free end of Bourdon tube, then it is possible to measure the pressure.

LVDT can be used for the measurement of displacement. In this the moving part can be attached to the core of the transformer. When the displacement occurs the core moves upward and downward. As shown in above diagram the potential that will be developed in the secondary windings will be dependent of the position of the core between primary and secondary coil. As a result when core moves some potential is developed in the secondary which will be proportional to the displacement. The exact displacement can be calculated by suitably calibrating the LVDT for unit length and developing potential.

f) Describe electrode used to measure hydrogen ion concentration in the blood with suitable diagram.

(Diagram 2 marks + Explanation 2 marks)

Ans :

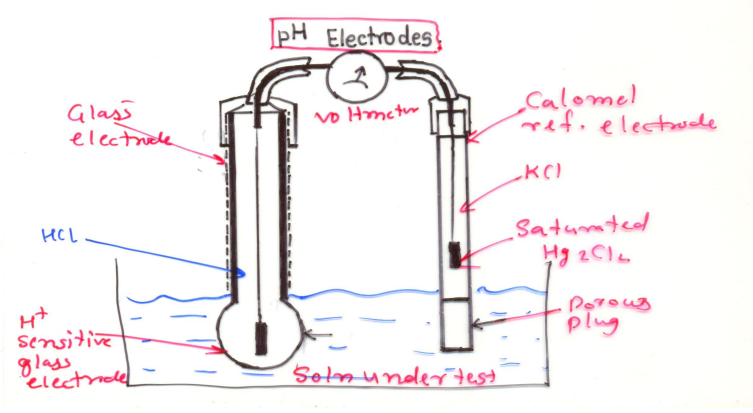


Fig : pH electrode

The pH electrode consists of a reference terminal and an active terminal. The reference terminal uses a metal. In this case Ag/AgCl in KCl solution. The salt bridge consisting of fiber wick saturated with KCL is inert to the solution under test. However, it maintains the KCl at a potential of the solution and keep the reference terminal potential essentially the same regardless of the solution under test. The active terminal is similar in concentration to reference electrode but its tip is made up of glass membrane which is sensitive to H^+ ions and thus to pH of the solution. The pH sensitive glass consists of a hydrated gelatinous glass layer. Its membrane potential is proportional to the pH of solution in which it is dipped. Thus the potential difference between two electrodes is a measure of pH.

The potential (V) of the glass electrode can be expressed by Nernst equation

$V = V_o – (2.3036RT/F)\ \Delta pH$

Where, V_o is the standard potential

R is gas constant

T is temperature in Kelvin

F is Faraday's constant

ΔpH is pH value deviated from 7

Q. 4) Attempt any FOUR of the following : **(16)**

a) What is plethysmography? Describe how it is useful to record blood volume.

(4 marks)

Ans :

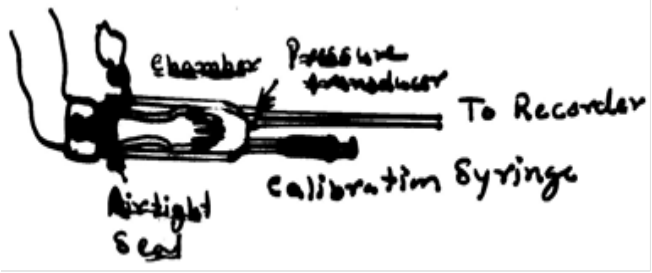


Fig : Plethysmography

- Plethysmography

The measurement of blood flow is the measurement of volume changes in any part of the body that results from pulsation of blood occurring with each heart beat. Such measurements are useful in the diagnosis of arterial obstruction as well as for pulse wave velocity measurement. Instruments measuring volume changes or providing outputs that can be related to them are called plethysmographs and the measurement of these volume changes is called as plethysmography.

A true plethysmography is one that actually responds to changes in volume, such an instrument consist of rigid cup or chamber placed over the limb in which volume changes are to be measured.

The cuff is tightly sealed to the member to be measured so that any changes of volume in the limb reflect as pressure changes inside the chamber.

Either fluid or air can be used to fill the chamber. Plethysmography may be designed for constant pressure or constant volume within the chamber. Hence pressure or displacement transducer must be included to respond to pressure changes within the chamber to provide the signal that can be calibrated to represent the volume of the limb.

The type of plethysmography can be used in two ways:

I) If the cuff placed upstream from the deal, it is not inflated; the output signal is simply a sequence of pulsation proportional to the individual volume changes with each heart beat.

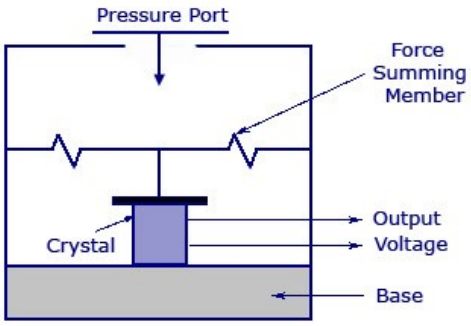
The plethysmography can be used to measure the total amount of blood flowing into the limb being measured.

II) By inflating the cuff to a pressure just above venous pressure, arterial blood can flow past the cuff, but venous blood cannot leave. The result is that the limb increases its volume with each heart beat by the volume of the blood entering during that bit.

b) Describe working of piezoelectric transducer with a neat labeled diagram.

(Diagram 2 marks + Explanation 2 marks)

Ans :



Piezo-Electric Transducer

Asymmetrical crystalline materials such as :Quartz, Rochelle salt, Barium Titanate and PZT(Lead Zirconate Titanate) produce an EMF when they are placed under stress. This property is used in piezoelectric transducers where a crystal is placed between a solid base and force summing member.

When an external force appears on the top the crystal, it produces an EMF across the crystal, which is proportional to the magnitude of the applied pressure. This is self generating type of transducer.

c) Describe electrode-electrolyte interface with neat diagram.

(Diagram 2 marks + Explanation 2 marks)

Ans :

At an electrode electrolyte interface Electrode discharges some metallic ions into electrolytic solution this can results in two different conditions either Increase in free electrons in electrode and increase in positive cations (electric charge) in solution or ions in solution combine with metallic electrodes that decrease in free electrons in electrode and decrease in positive cations in solution. As a result, a charge gradient builds up between the electrode and electrolyte and this in turn creates a potential difference.
- Current flow from electrode to electrolyte : Oxidation (Loss of e-)
- Current flow from electrolyte to electrode : Reduction (Gain of e-).

For both mechanisms, (Oxidation = Loss of e-, and reduction = Gain of e-), two parallel layers of oppositely charged ions are produced; i.e. the electrode double layer.

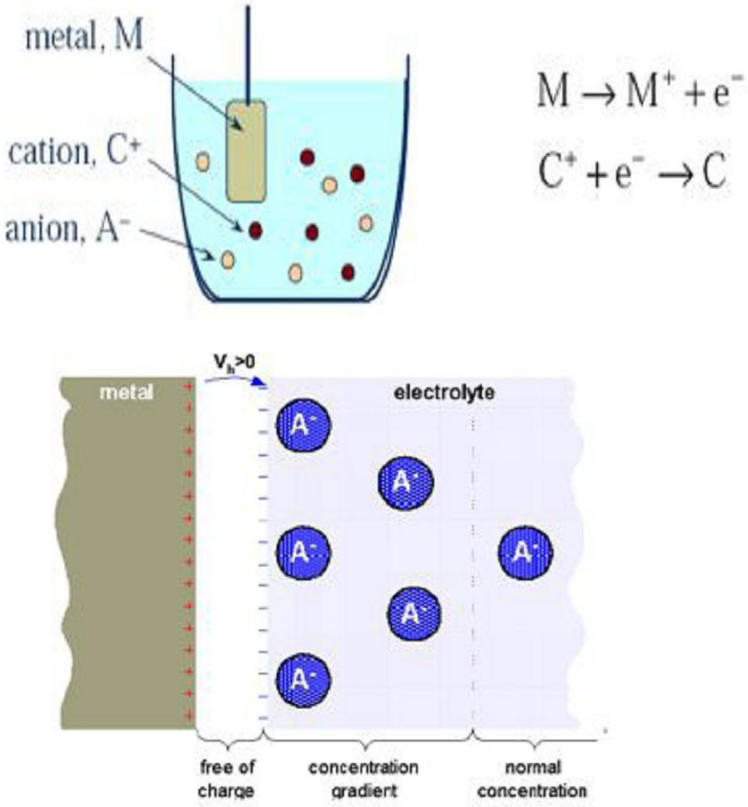


Fig : electrode-electrolyte interface

d) Draw constructional diagram of RTD. Describe characteristics of RTD with graphical representation.

(Diagram of RTD = 2 marks , characteristics of RTD = 1 mark , graphical representation = 1 mark)

Ans :

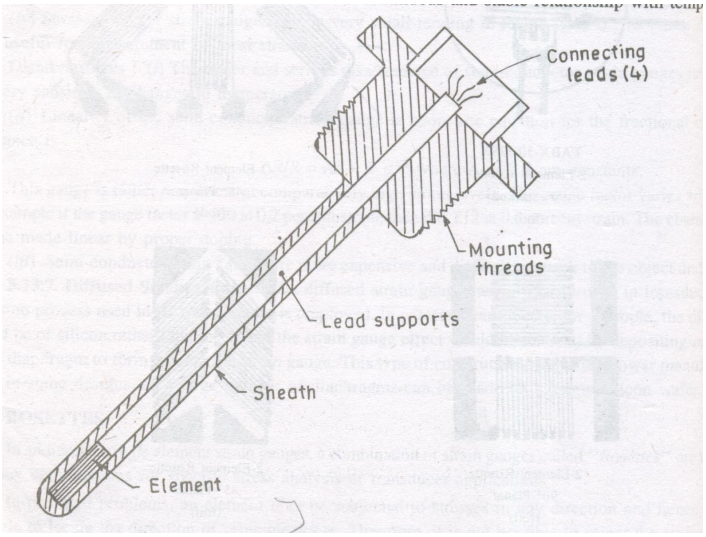


Fig : Constructional diagram of RTD

Characteristics of RTD:-

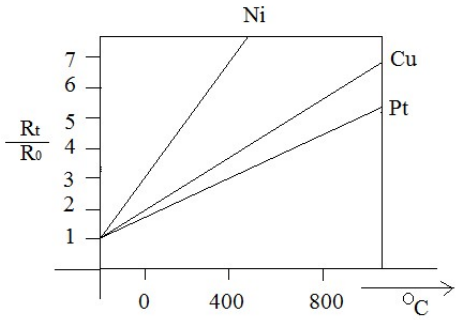


Fig : Graphical representation of RTD

The characteristics of the RTD are as shown above. As the temperature increases the factor Rt/R0 value for different materials shows different pattern of changing. This factor generally increases with the temperature.

The RTD is a wire resistor enclosed ina protective sheath of glass, quartz, porcelain or stainless steel, depending upon the range of temperature and the pressure of air inside the sheath.-Material used for construction RTD:

-Platinum

-Nickel

-Copper

- Tungsten

e) Differentiate between active and passive transducer.

(Active transducer = 2 marks , Passive transducer = 2 marks)

Ans :

-**Active transducer:**

1 Transducer that converts one form of energy directly into another that is it does not require external power supply. It is self generating transducer.

2 Eg. Photovoltaic cell, thermocouple etc.

3 This transducer develops their own voltage and current. The energy required for production of an output signal is obtained by physical phenomena being measured.

-**Passive Transducer:**

1 The transducer which requires energy to be put it in order to translate changes due to measurand. It requires external power supply.

2 Eg: LVDT, Strain gauge.

f) Describe basic structure and importance of reference electrode.

(Diagram 2 marks + Explanation 2 marks)

(Or consider any other electrode PO2, PCO2)

Ans :

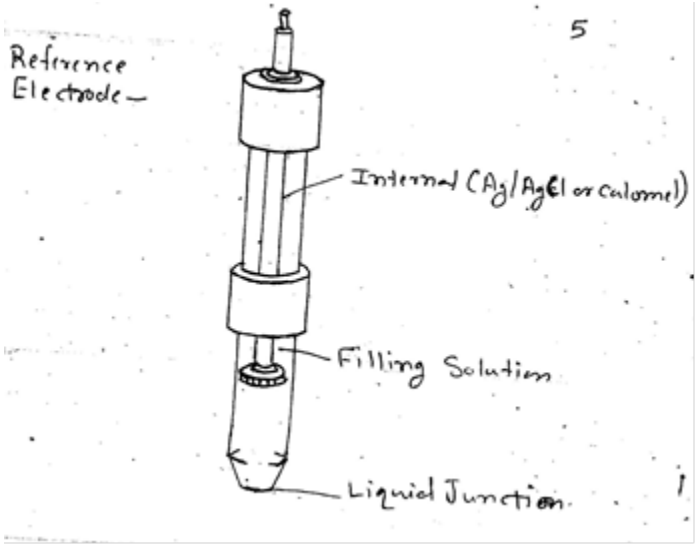


Fig: pH Electrode

- Ag/AgCl electrode:

In this electrode, the ionic side of interface is connected to the solution by an electrolyte bridge. For this a dilutee potassium chloride (KCl) filling solution which forms a liquid junction with the sample solution is used. The electrode can be used as reference electrode, if the KCl solution is also saturated with precipitate of silver chloride. The electrode potential for Ag/AgCl reference electrode depends on concentration of KCl. For electrode with a 0.01 mole solution of KCl has an electrode potential of 0.343V. Whereas for 1 mole solution the potential is only 0.236V.

OR

Hg/HgCl (Calomel) electrode:

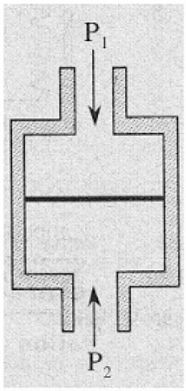
The calomael is another name of mercurous chloride. It is the chemical combination of mercury and chloride ions.The interface between mercury and mercurous chloride generates the electrode potential by placing the calomel side of interface in the KCl filling solution, an electeolytic bridge is formed in the sample solution from which measurement is to be made.
It is stable over a long period of time same as Ag/AgCl electrode. The electrode potential of calomel electrode is dependend on the concentration of KCl and electrode with a 0.01 mole solution of KCl has an electrode potential 0.300V whereas, a saturated KCl solution about 3.5 moles has a potential of only 0.247V.

Q. 5) Attempt any FOUR of the following : **(16)**

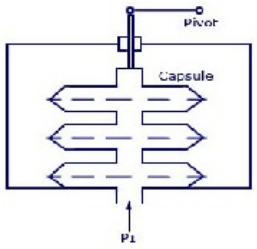
a) Draw diagram of flat, corrugated, capsule and bellows type diaphragm.

(1 mark for each diagram)

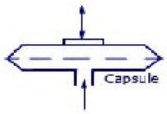
Ans :

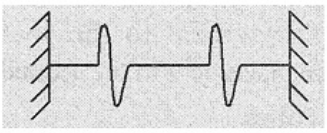


Flat diaphragm

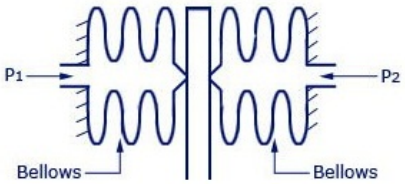


Capsule





Corrugated diaphragm



Bellows

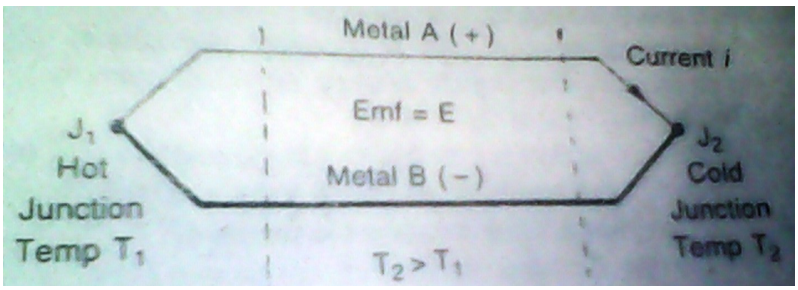
b) Describe flow measurement by thermal convection.

(4 marks for Description)

Ans : Thermal velocity sensors depend on convective cooling of a heated sensor and are therefore sensitive only to local velocity. A hot object in colder-flowing medium is cooled by thermal convection. The rate of cooling is proportional to the rate of the flow of the medium. This principal is often used for measurement of blood velocity. In one of the method an electric heater is placed between two thermocouples or thermistors that are located some distance apart along the axis of the vessel. The temperature difference between the upstream and the downstream sensor is a measure of blood velocity.

c) Describe working principle of thermocouple. (4 marks)

Ans :



The operation of the thermocouple is based on the seebeck effect. When the heat is applied to junction (hot junction) of two dissimilar metals, an emf is generated which can measured at the other junction (cold junction).
The two dissimilar metals form an electric circuit, and a current flows as a result of the generated emf.
This current will continue to flow as long as $T_1 > T_2$. Metal B is describe as –ve with respect to a metal A if current flows into it at the cold junction.
The emf produces is function of the difference in temperature of hot and cold junctions

d) Enlist different required characteristics of bioelectric signal amplifier.

(1 mark each)

Ans :

Characteristics of bioelectric signal amplifier are as follows :

1) Low output impedance
2) High input impedance
3) High CMRR
4) High accuracy
5) High sensitivity
6) High operating range
7) High stability
8) Low non-linearity
9) Low hysteresis
10) High resolution
11) High degree of repeatability.

e) Differentiate static and dynamic characteristics of transducer.

(static two points- 2 marks, dynamic two points -2 marks)

Ans :

Static characteristics: When the instrument is used to a measured a quantity that do not vary with respect to time than it is called as static characteristics. The qualities of measurement of an unvarying process condition are stated in terms of accuracy, repeatability, precision and sensitivity

e.g. Accuracy , sensitivity

Dynamic Characteristics :When the instrument is used to a measured a quantity that vary with respect to time thaen it is called as dynamic characteristic. Instead of unvarying measurand the instrument is required to measure an input which is likely to change from instant to instant the dynamic response behavior of the instrument becomes important.

e.g. Fidelity, speed of response

f) Explain basic objectives of an instrumentation system.

(1 mark each)

Ans :

Basic objectives of an instrumentation system are :

1) Inaccessibility of the signal source

2) Variability of Physiological parameters
3) Interference among physiological System
4)Transducer interface problem.

Q. 5) Attempt any FOUR of the following : **(16)**

a) Draw and explain types of Bourdon tubes.

(1 mark each)

Ans :

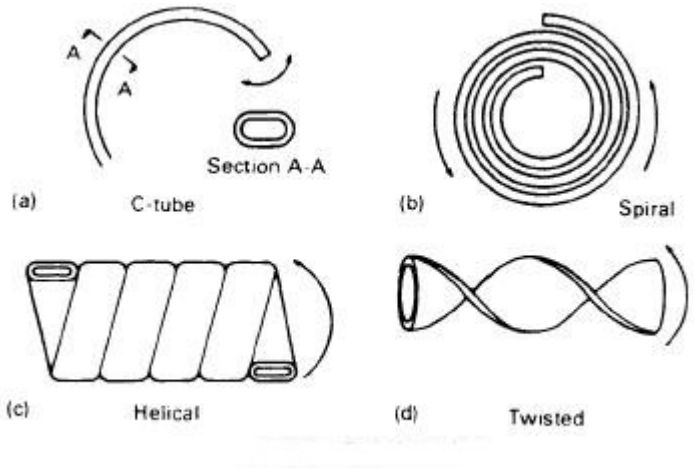


Fig : Types of Bourdon tubes.

(or any other relevant diagram)

(a) C type of Bourdon tube is made up of an elliptically flattened tube bent in such a way as to produce the 'C' shape. One end of this tube is closed or sealed & the other end is opened for the pressure to enter.

(b) In Spiral type of Bourdon tube, free end is wounded several times. When the pressure is applied from inlet then the amount movement is proportional to angle subtended by total arm.

(c) Helical Bourdon tube is wounded in form of Helix. It transmits only circular motion of tip to pointer which is directly proportional to applied pressure.

(d) In Twisted Bourdon tube, one end of tube is fixed and other end is free for application of twist. As pressure is applied to free end, it gives rotation at end. As pressure is removed free end try to retain its original position.

b) A platinum RTD has a resistance of 100Ω at 25 ˚C. Find its resistance at 65 ˚C. Resistance temperature coefficient of platinum is 0.0392 unit. Also find the temperature, if RTD has resistance of 150Ω.

Ans :

(a) using the linear approximation , the resistance at any temperature Θ°C is

$$R_t = R_o(1 + \alpha \Delta t)$$ **1mark**

Given , Resistance at 65°C is ,

$R_{65} = 100 [1 + 0.00392 (65-25)]$

$R_{65} = 115.68\ \Omega$ **1 mark**

(b) Suppose t is the unknown temperature ,

$150 = 100 [1+0.00392 (t - 25)]$ **1 mark**

$150 = 100 [1+0.00392t - 0.098]$

$150 = 100 [0.902 + 0.00392t]$

$150 = 90.2 + 0.392t$

$59.8 = 0.392t$

t=152.55 °c **1 mark**

c) Describe with neat diagram, ultrasonic flow meter.

(Diagram 2 marks + Explanation 2 marks)

Ans :

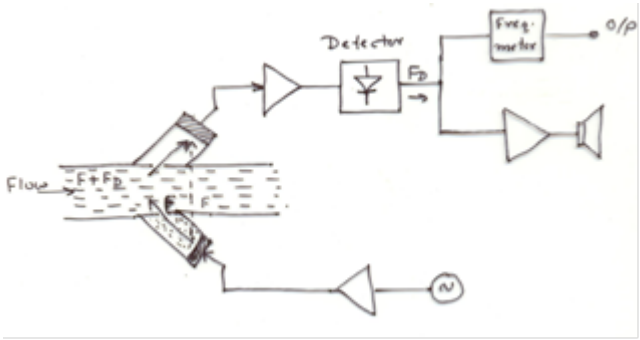


Fig : Ultrasonic flow meter.

-In ultrasound blood flow meter a beam of ultrasonic energy is used to measure velocity of flowing blood. This can be done in two ways. In transist time ultrasonic flow meter pulsed beam is directed to a blood vessel through a shallow angle and it's transmit time is measured.

When blood flow in the direction of energy transmission the transmit time is shorted. If it flows in opposite direction the transmit time will be lengthen.

The ultrasonic flow meter based on Doppler principle and oscillator operating at frequency of several MHz excites piezoelectric transducer. This transducer is coupled through a wall of exposed blood vessels and sends the ultrasonic beam with frequency floating through blood.

Small part of transmitted energy is scattered back and is received by second transducer arranged opposite to first one. Because the scattering occurs mainly as a result of moving blood cells, reflected signal has a different frequency due to Doppler Effect. This frequency is either f + fd or f - fd depending on the direction of flow. The Doppler component fd proportional to the velocity of flowing blood A fraction of transmitted ultrasonic energy, however, reaches the second transducer directly, with the frequency being unchanged.

After amplification of the composite signal the Doppler frequency can be obtained at the output of the detector as the difference between direct and scattered signal components. With the blood velocity in the range normally encountered the Doppler signal is typically in the low frequency range.

Because of the velocity profile of the flowing blood the Doppler signal is not a narrow band noise therefore from the loud speaker or earphone the Doppler signal of pulsation blood flow can be heard as characteristics swish. When the transducers are placed in

a suitable mount which defines the area of blood vessels frequency meter is used to measure Doppler frequency can be calibrated in flow rate units.

d) Describe PCO_2 electrode in detail.

(Diagram 2 marks + Explanation 2 marks)

Ans

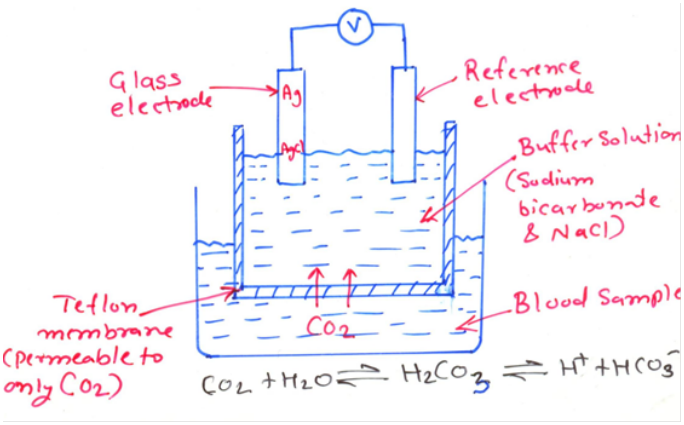


Fig : PCO_2 electrode

The pH electrode is used as a component of a PCO2 electrode to measure the partial pressure of CO2 by the arrangement as shown in the figure. Sample chamber with one side made of silicon rubber membrane or Teflon membrane is in contact with another chamber containing sodium bicarbonate solution into which is dipped a pH electrode.

Blood or other fluid for which PCO2 is to be measured enters a sample chamber. It comes in contact with Teflon or Silicon rubber membrane this membrane separates the fluid from sodium solution but it is permeable to CO2 into the solution. CO2 combines with H2O so as to produce free hydrogen ions.

e) Compare polarizable and non-polarizable electrodes.

(Polarizable electrodes = 2 marks , Non-Polarizable electrodes = 2 marks)

Ans :

- -Polarizable electrodes: Perfectly Polarizable electrodes are those in which no actual charge crosses the electrode-electrolyte interface when a current is applied, acts like a capacitor

Eg: Platinum electrode.

-- Non-polarizable electrodes: Perfectly Non-polarizable electrodes are those in which current passes freely across the electrode-electrolyte interface, acts like a resistor.

Eg: Silver Chloride electrode, Calomel electrode.

f) List four advantages of thermistor over RTD.

(1 mark each)

Ans :

- More accurate
- Low cost
- Small size
- Fast response over narrow temperature range.
- Good sensitivity in NTC region.
- It has both positive and negative temperature.
- It requires simple circuitry
- Available in various shapes. Eg. Beads, chips, rods, and washers.
- Excellent long term stability characteristics.