WINTER– 16 EXAMINATION

Model Answer Subject Code: 17442

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.

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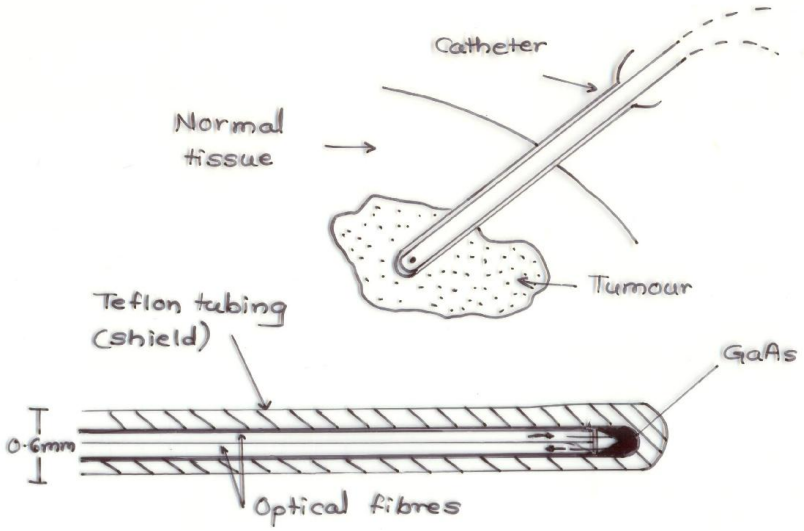
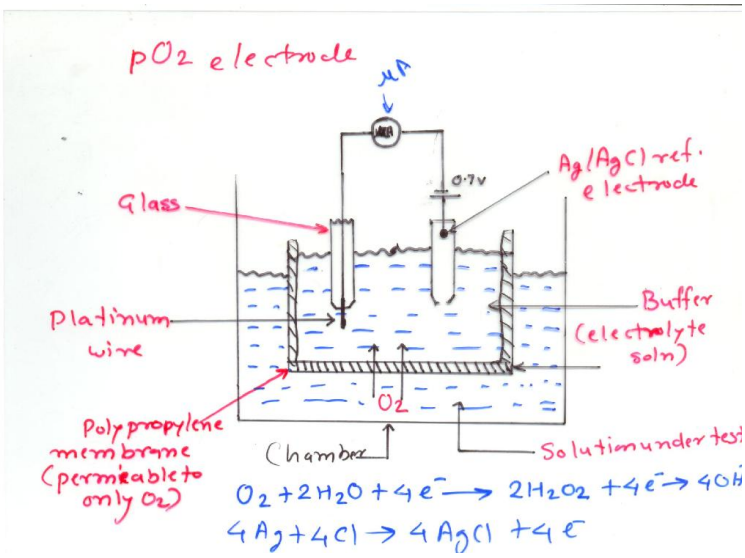
Q. No.	Sub .Q. N.	Answer	Marking Scheme
Q. 1	**a)**	**Attempt Any Six of the Following.**	**12**
	i)	**List the sources of biomedical signal. (any four)** **Ans :** - ECG (Electrocardiography) - EEG (Electroencephalography) - EMG (Electromyography) - PCG (Phonocardiography) - BP (Blood Pressure) - ERG (electroretinography)	**1/2 mark each**
	ii)	**Give four specifications of medical instrument system.** **Ans : Consider any Medical Instrument for Medical Instru. System and write down its specifications** **specification :** For Ex. X-Ray Machine Specification: YZ 300C, 300mA MIDICAL DIAGNOSTIC X-RAY MACHINE with fixed Table MAIN TECHNICAL PARAMETER 1. Single bed with single tube 2. Rotary anode X-ray tube unit tangential annular tubes 3. Single-phase full-wave rectification high-voltage generator 4. Power volage(V) photograph kilovolt(kV), infinitely variable control and electric mechanism	**1/2 mark each**

		5. Be equipped with the manostat for the filament of X-ray tube and space charge complementor 6. Photographic volume, kV, mA and s, subsection, grading and interlock protection 7. Adopt the digital circuit timer. Grading according to R10 pririty coefficient, which is exact in time control. 8. High-voltage primary uses the zero controlled circuit of silicon-controlled rectifier of large power 9. Photographic bed can move in length and breadth. 10 The photographic bed, upright and vibrating ray-filter are in a whole without top and bottom track	
	iii)	**List any two flow transducer.** **Ans :** **List any 2 Types of flow transducer that are used for Biomedical applications** - Electromagnetic Flowmeter - Ultrasonic Doppler Flowmeter -Orifice plate flow transducer. - Variable Area - Rotameters - Venturi Tubes - Velocity Flowmeters - Turbine Flowmeter - Positive Displacement Flowmeter - Mass Flowmeters - Thermal Flowmeter	**1 mark each**

	iv)	**Draw constructional sketch of optical transducer.** **Ans :**  **Or Consider any other relevant diagram**	**2 marks**
	v)	**Draw a labeled diagram of Po_2 electrode.** **Ans :**  **Fig : Po_2 electrode.**	**2 marks**

	vi)	**Give any four bio – potential electrode.** **Ans : any four biopotential electrode** I) Surface electrodes: a) Metal plate electrode -Metal disc electrode -Disposable electrode b) Suction electrode c) Floating electrode II) Internal electrode : - Needle and wire electrodes III) Microelectrodes : - Metal microelectrodes - Supported microelectrodes - Micropipet electrodes IV) Disposable Electrode	**1/2 mark each**
	vii	**List two types of thermocouple and state Seeback effect.** **Ans :** **Types of thermocouples : (any two)** - J type thermocouple - K type thermocouple - R type thermocouple - S type thermocouple - T type thermocouple **Seeback Effect :** The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. (or any other relevant statement)	**1 mark** **1 mark**

	viii	**List optical transducer. (any two)** **Ans :** i) Photo- emmissive Cells Types of Photo- emmissive Cells and these are - Vacuum Type Photocell - Gas Filled Type - Photomultipliers ii) Semi – Conductor Photoelectric Transducer These include : - Photoconductive Cells - Phototransistors - Photovoltaic Cell - Photothyristors	**1 mark each**
	b) **i)**	**Attempt any TWO of the following :** **Give brief classification of physiological transducer. Also list application of each type of X'ducer.** **Ans :** <u>1 Active and passive transducers</u> 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 <u>2 Analog & digital transducers</u> 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. <u>3 Primary & secondary transducers</u>	**8 Marks** **classificatio n =2marks ,**

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.

Application : (any two)

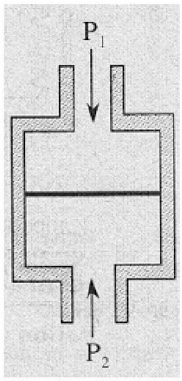
application = 2 marks

Sr. No.	Types of Transducer	Application
1.	Potentiometer device	displacement
2.	Resistance strain guage	Force , torque , displacement
3.	Resistance thermometer	Temperature , radiant heat
4.	Thermistor	Temperature
5.	Photoconductive cell	Photosensitive relay
6.	Variable capacitance pressure guage	Displacement , Pressure
7.	Magnetic circuit transducer	Pressure , Displacement
8.	Differential transformer	Pressure , force , displacement , position
9.	Photoemissive cell	Light , radiation

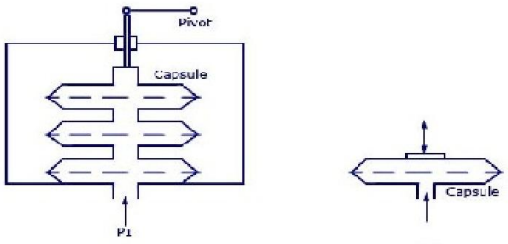
10.	Photomultiplier tube	Light , radiation , photosensitive relays.	
11.	Thermocouple	Temperature , heat flow , radiation.	
12.	Piezoelectric pickup	Sound , vibrations , acceleration , pressure changes.	
13.	Photovoltaic	Light meter , solar cell	

ii) Give Types of diaphragm with neat sketch describe working principle of corrugated diaphragm. Also list application.

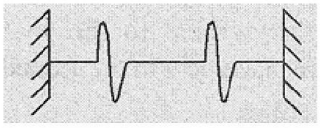
Ans :



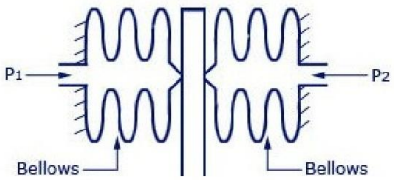
Flat diaphragm



Capsule



Corrugated diaphragm



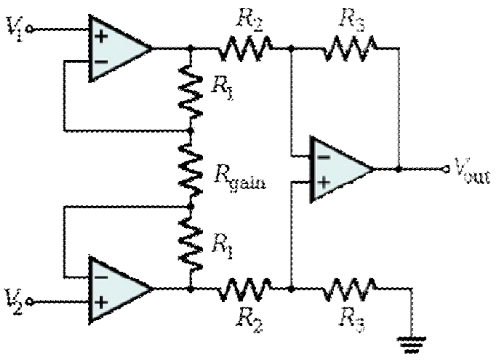
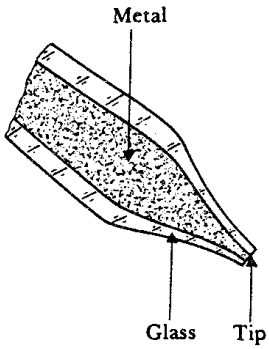
Bellows

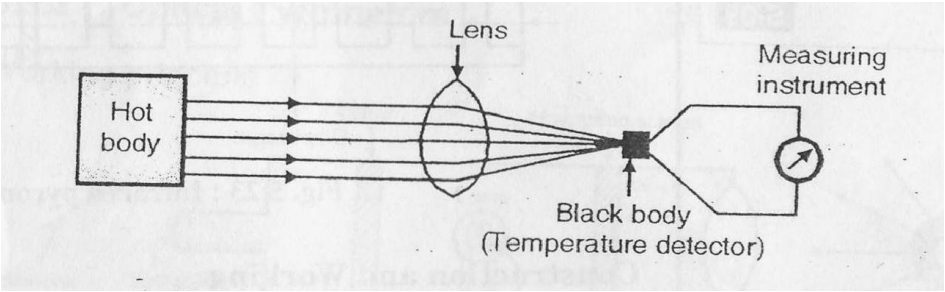
Fig : Types of diaphragm

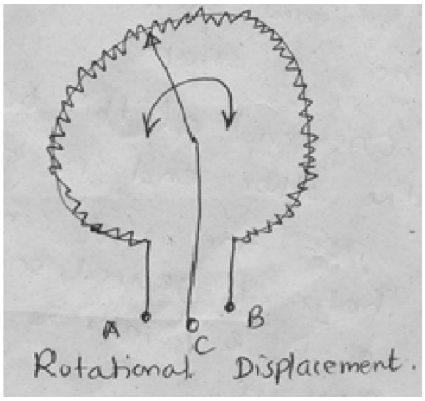
Diagram = 2 marks

Corrugated diaphragm: The pressure to be measured is applied to the diaphragm, causing it to deflect, the deflection being proportional to applied pressure. The movement of diaphragm depends on its thickness and diameter. The unknown pressure is applied to one side of a diaphragm. The edge of the diaphragm is rigidly fixed and causes a deflection on account of the applied pressure. The displacement of the diaphragm may be measured to determine the value of applied pressure, P. Corrugated diaphragm gives a better deflections, typically 2 percent of the diaphragm diameter.

Working = 1 mark

		Application Corrugated diaphragm : Corrugated diaphragm are used in mechanical devices for measurement of deflection. It gives a relatively greater output. If combined with a high magnification linkage, Corrugated diaphragm can be used for direct operation of mechanical indicators.	**application = 1 mark**
	iii	**Draw diagram of instrumentation amplifier. List four application.** **Ans :**  **Fig : Instrumentation amplifier** **Applications of Instrumentation Amplifier:-** 1) Data acquisition from low output transducers. 2) Medical instrumentation system 3) Current/ votlage monitoring 4) Audio appliences involving weak auio signals or noisy environment. 5) High speed signal conditioning for video data acquisition and imaging 6) High frequency signal amplification in cable RF system.	**Diagram = 2 marks ,** **Application = 2 marks**
Q.2		**Attempt any FOUR of the following :**	**16 Marks**
	a)	**With neat constructional details describe working of supported micro electrode.** **Ans:**  **Fig : Micro electrode.**	**Diagram = 2 marks**

		The metal microelectrode is essentially a subminiature version of the needle electrode. In this case, a strong metal such as tungsten is used. One end of this wire is etched electrolytically to give tip diameters on the order of a few micrometers. The structure is insulated up to its tip, and it can be passed through the membrane of a cell to contact the cytosol. The advantage of these electrodes is that they are both small and robust and can be used for neurophysiologic studies. Their principal disadvantage is the difficulty encountered in their fabrication and their high source impedance.	**Working = 2 marks**
	b)	**Draw and explain a neat diagram of radiation thermometery.** **Ans :**  **Fig : Radiation thermometry.** When physical contact with the medium to be measured is not possible or impractical due to very high temperature(above 1400 ℃), pyrometers are used for temperature measurement. - The operation of pyrometer is based on the principal of thermal radiation. Radiation pyrometer measured the radiant heat emitted of reflected by hot object. - Thermal radiation is electromagnetic radiation emitted as a result of temperature. - In industry where the high temperature of vapors or liquids destroys temperature measuring instruments like thermocouples, thermistors and thermometers, in that case pyrometer are used. Working – Pyrometer work on the principle of thermal radiation, which state that, the energy radiated by a hot body is a function of its temperature. The operation of thermal radiation pyrometer is based on blackbody concept. The total thermal radiation is emitted by blackbody.	**Diagram = 2 marks** **Explanation = 2 marks**
	c)	**Describe any four general difficulties while designing the instrumentation system.** **Ans :** General difficulties while designing the instrumentation system are as follows : 1) Inaccessibility of the signal source. 2) Variability of Physiological parameters. 3) Interference among physiological System. 4) Transducer interface problem	**1 mark each**

	d)	**Describe thermal convection method for flow measurement.** **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.	**Description = 4 marks**
		e) With neat construction describe working of angular potentiometer. **Ans :**  **Fig : Angular Potentiometer.** Rotary position sensors provide electrical outputs relative to shaft rotation in order to precisely measure angles. 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. These devices are used in multiple position sensing applications, including: 1)gear position 2)automotive position sensing, including throttle position, steering wheel position, and pedal position 3)industrial control 4)valve control	**Diagram = 2 marks** **Explanation = 2 marks**
	f)	**Draw labelled diagram of reference electrode and explain its working.** **Ans :**	

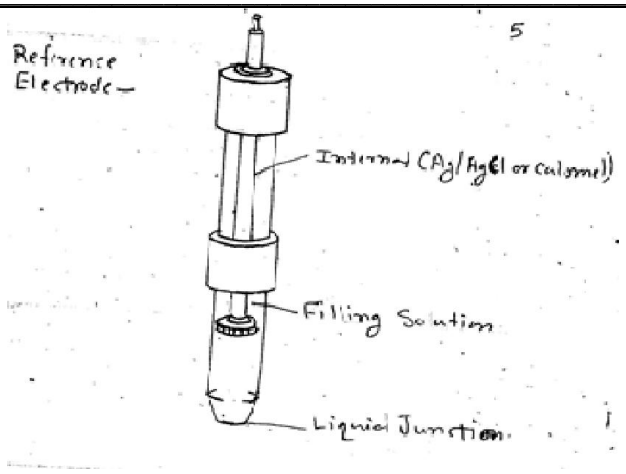


Fig: Reference Electrode

Diagram = 2 marks

- 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.

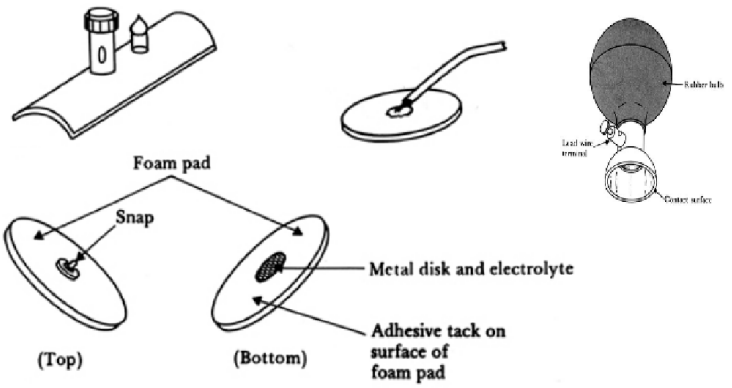
Explanation = 2 marks

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.3		**Attempt any FOUR of the following :**	**16 Marks**
	a)	**Define Biometrics and list any four sources of biomedical signal.** **Ans :** **Biometrics**: The branch of science that includes the measurement of physiological variables and parameters is known as biometrics.	**Defination = 2 marks**

		Sources of biomedical signal : (any four) - ECG (Electrocardiography) - EEG (Electroencephalography) - EMG (Electromyography) - PCG (Phonocardiography) - BP (Blood Pressure)	**sources = ½ mark each**
	b)	**List requirements of biomedical amplifier. (any eight)** **Ans** : **(any eight)** **Requirements of biomedical amplifier are as follows :** 1) High input impedance -greater than 10 MΩ 2) Safety: protect the organism being studied careful design to prevent macro and micro shocks. 3) Isolation and protection circuitry to limit the current through the electrode to safe level 4) Output impedance of the amplifier should be low to drive any external load with minimal distortion. 5) Gain greater than 1000 greater than 1000 6) Rapid calibration of the amplifier in laboratory conditions. 7) BioAmplifiers are required to increase signals strength while maintaining fidelity. 8) Some bio amplifiers have additional requirements that are application specific.	**½ mark each**
	c)	**Describe metal plate surface electrode with a neat labelled diagram.** **Ans :** **Fig : Metal Plate Surface Electrode** 	**Diagram = 2 marks**

This category includes electrodes that can be placed on the body surface for recording bioelectric signals. The integrity of the skin is not compromised when these electrodes are applied, and they can be used for short-term diagnostic recording such as taking a clinical electrocardiogram or long-term chronic

recording such as occurs in cardiac monitoring. These electrodes consist of a metallic conductor in contact with the skin with a thin layer of an electrolyte gel between the metal and the skin to establish this contact. Metals commonly used for this type of electrode include German silver (a nickel-silver alloy), silver, gold, and platinum. Sometimes these electrodes are made of a foil of the metal so as to be flexible, and sometimes they are produced in the form of a suction electrode to make it easier to attach the electrode to the skin to make a measurement and then move it to another point to repeat the measurement. These types of electrodes are used primarily for diagnostic recordings of bio-potentials such as the electrocardiogram or the electroencephalogram.

Explanation = 2 marks

d) Compare thermister and RTD. (any four point)

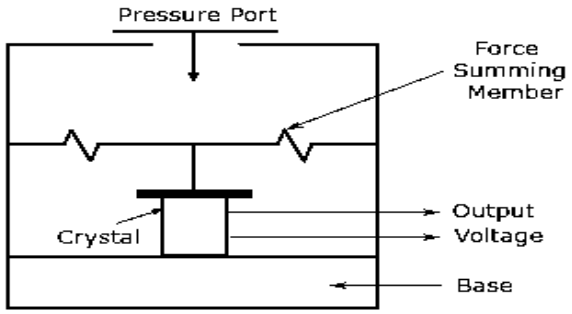
Ans :

Sr. No.	Parameter	RTD	Thermistor
1)	Principle	the resistance of certain wire varies with temperature	The resistance of certain metal oxides varies with variation in temperature
2)	Material	Platinum, tungsten, copper, nickel etc.	Manganese, cobalt, iron oxides
3)	Accuracy	Less accurate	More accurate
4)	Temp. range	-270 ^{0}C to 2800 ^{0}C	-150 ^{0}C to 300 ^{0}C
5)	Cost	High cost	Low cost

1 mark each

e) Describe working of piezoelectric transducer.

Ans :



Piezo-Electric Transducer

4 marks

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.

f) Describe blood glucose sensor with neat diagram.

Ans :

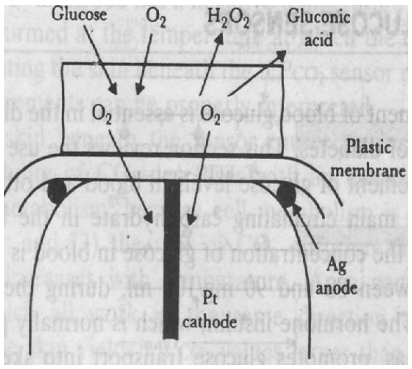


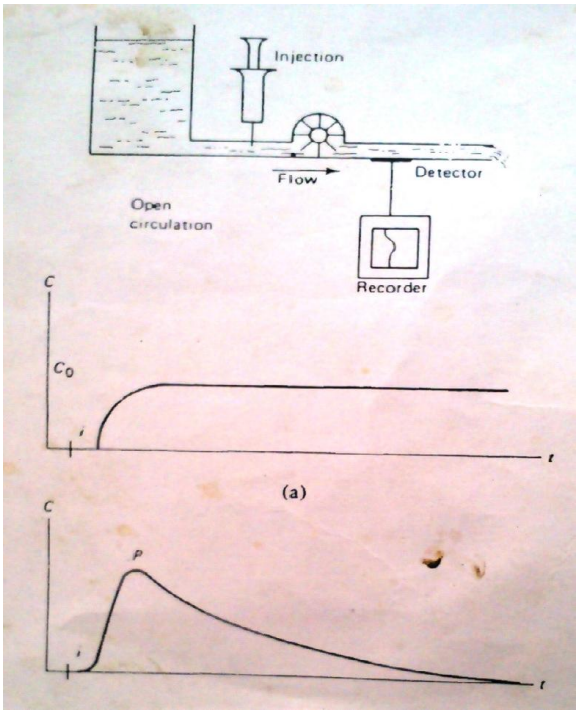
Fig : Blood Glucose Sensor

Diagram = 2 marks

The principle behind glucose meter is base on reaction that are analyses by electro chemical sensor on strip there are layer plastic base plate of other layer containing chemical. There is layer containing two electrode silicon or other similar metal there is also layer of immobilize enzyme glucose oxides and other layer containing micro crystalline potatiomterrycynide specifically the reaction of interested is between glucose and glucose oxides the glucose in blood sample react with the glucose oxides to form gluconic acid.

Explanation = 2 marks

$$\text{Glucose} + O_2 \xrightarrow[\text{Glucose oxidase}]{} \text{Gluconic acid} + H_2O_2$$

Q.4		Attempt any FOUR of the following :	16 Marks
	a)	**Describe indicator dilution method for flow measurement.** **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, $$F \text{ (litres / minute)} = \frac{I \text{ (milligrams / minute)}}{Co \text{ (milligrams / litre)}}$$  **Fig : Indicator dilution method of flow measurement.**	**4 marks**
	b)	**Draw and justify characteristics of LVDT transducer.** **Ans :**	

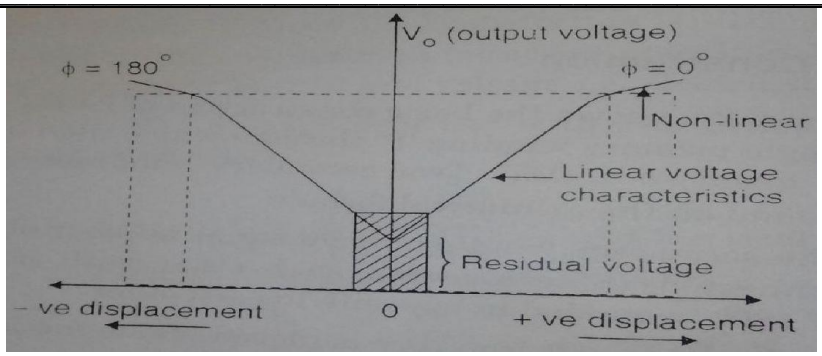


Fig : Characteristics curve of LVDT.

Diagram = 2 marks

Case 1: When there is no displacement.

When there is no displacement attached to the core i.e. the core is at normal (NULL) positoon, the flux linking with both the secondary windings are equal.

Equal e.m.f. are induced in both secondary windings when the core is at null position:

$$V_{s1} > V_{s2}$$

Justification = 2 marks

Hence the output voltage v_o at null position is zero.

Case 2: When there is positive displacement:

When there is positive displacement applied to the core i.e. the core is moved to left of null position, more flux links with winding S_1 than winding S_2.

Here e.m.f. induced with winding S_1 is greater than winding S_2, that is

$$V_{s1} > V_{s2}$$

Hence the output voltage $V_o = V_{s1} - V_{s2}$ and the output voltage is in phase with the input primary voltage.

Case 3: When there is negative displacement

When there is negative displacement applied to the core. The core is moved to right of null position, more flux links with winding S_2 than winding S_1.

Here e.m.f. induced with winding S_2 is greater than S_1. That is

$$V_{s2} > V_{s1}$$

Hence the output voltage $V_o = V_{s2} - V_{s1}$ and is 180^0 out of phase with the input primary voltage.

c) Describe internal electrode with neat diagram.

Ans:-

Electrodes can be placed within the body for bio-potential measurements. These electrodes are generally smaller than skin surface electrodes and do not require special electrolytic coupling fluid, since natural body fluids serve this function. There are many different designs for these internal electrodes. Basically these electrodes can be classified as needle electrodes, which can be used to penetrate the skin and tissue to reach the point where the measurement is to be made, or they are electrodes that can be placed in a natural cavity or surgically produced cavity in tissue. A catheter tip or probe electrode is placed in a naturally occurring cavity in the body such as in the gastrointestinal system. A metal tip or segment on a catheter makes up the electrode. The catheter or, in the case where there is no hollow lumen, probe, is inserted into the cavity so that the metal electrode makes contact with the tissue. A lead wire down the lumen of the catheter or down the center of the probe connects the electrode to the external circuitry.

Explanation = 2 marks

Types of Internal Electrode:-

1) Probe electrode
2) Needle electrode
3) Coaxial electrode
4) Coiled electrode

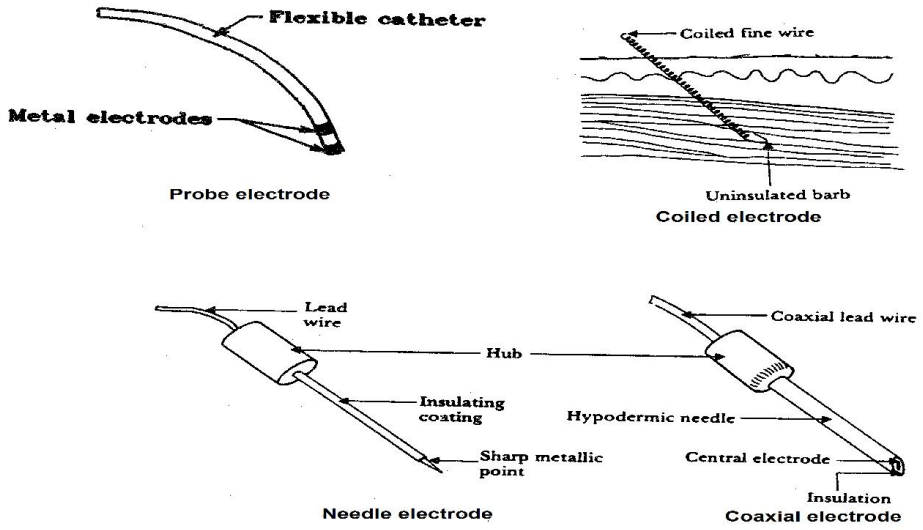
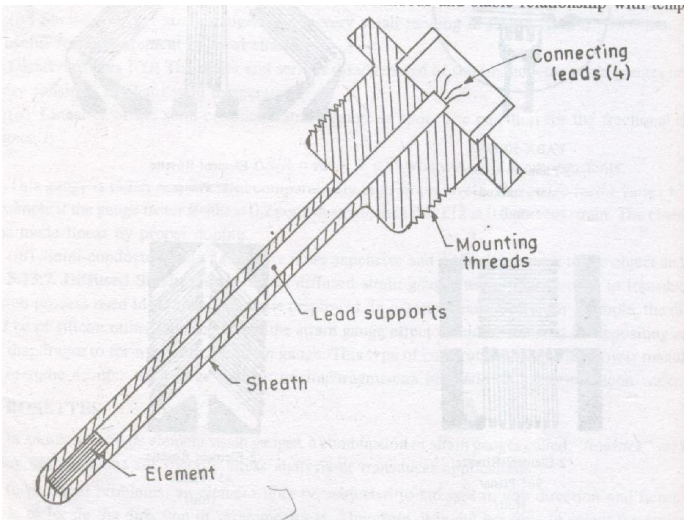
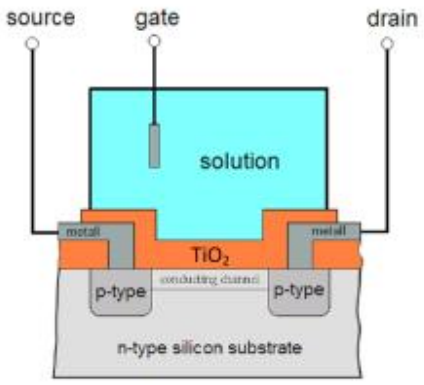
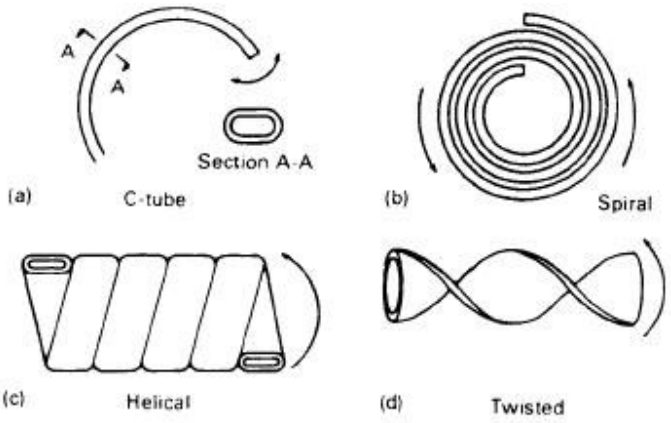


Diagram = 2 marks

Fig : Internal Electrode

	d)	**Describe working of RTD with neat sketch.** **Ans :**  **Fig : Constructional diagram of RTD** The RTD is a wire resistor enclosed in a 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 are Platinum , Nickel , Copper , Tungsten. The construction is typically such that the wire is wound on a form (in a coil) on notched mica cross frame to achieve small size, improving the thermal conductivity to decrease the response time and a high rate of heat transfer is obtained. In the industrial RTD's, the coil is protected by a stainless steel sheath or a protective tube. So that, the physical strain is negligible as the wire expands and increase the length of wire with the temperature change. If the strain on the wire is increasing, then the tension increases. Due to that, the resistance of the wire will change which is undesirable. So, we don't want to change the resistance of wire by any other unwanted changes except the temperature changes.	**Diagram = 2 marks** **Explanation = 2 marks**
	e)	**List performance characteristics of transducer.** **Ans :** **Static Characteristics :** Accuracy , Sensitivity , Range , Linearity , Precision , Resolution ,	**1 mark for each characteristic**

		Sensitivity , Drift , Linearity , Reproducibility , Hysteresis , Span , Noise , Threshold **Dynamic characteristics :** Fidelity , Speed of response , Dynamic error , Dead time **(Any four characteristics)**	
	f)	**Describe working of ISFET (Ion – sensitive FET) with neat sketch.** **Ans :**  **Fig : ISFET(ion sensitive field effect transistor)** An ISFET's source and drain are constructed as for a MOSFET. The gate electrode is separated from the channel by a barrier which is sensitive to hydrogen ions and a gap to allow the substance under test to come in contact with the sensitive barrier. An ISFET's threshold voltage depends on the pH of the substance in contact with its ion-	**Diagram = 2 marks ,** **Explanation = 2 marks**

		sensitive barrier. WORKING: An ISFET is an ion-sensitive field-effect transistor used for measuring ion concentrations in solution; when the ion concentration (such as H^+)changes, the current through the transistor will change accordingly. Here, the solution is used as the gate electrode. A voltage between substrate and oxide surfaces arises due to an ion sheath.The surface hydrolysis of Si–OH groups of the gate materials varies in aqueous solutions due to pH value. Typical gate materials are SiO_2, Si_3N_4, Al_2O_3 and Ta_2O_5.The mechanism responsible for the oxide surface charge can be described by the site binding model, which describes the equilibrium between the Si–OH surface sites and the H^+ions in the solution. The hydroxyl groups coating an oxide surface such as that of SiO_2 can donate or accept a proton and thus behave in an amphoteric way as illustrated by the following acid-base reactions occurring at the oxide-electrolyte interface: $\equiv Si–OH + H_2O \leftrightarrow \equiv Si–O^- + H_3O^+$ $\equiv Si–OH + H_3O^+ \leftrightarrow \equiv Si–OH_2^+ + H_2O$	
Q. 5		**Attempt any Four of the following :**	**16 Marks**
	a)	**Draw the labelled diagram of different types of Bourden tube. (four type)** **Ans :**  **Fig : Types of Bourdon tubes.** **(or any other relevant diagram)**	**1 mark each**

b) **Describe ultrasonic flow transducer with neat sketch.**

Ans :

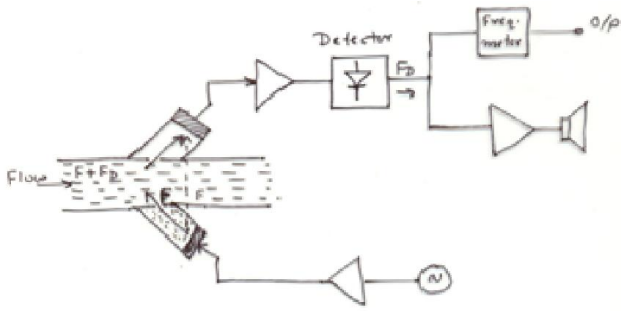


Fig : Ultrasonic flow meter.

Diagram = 2 marks

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.

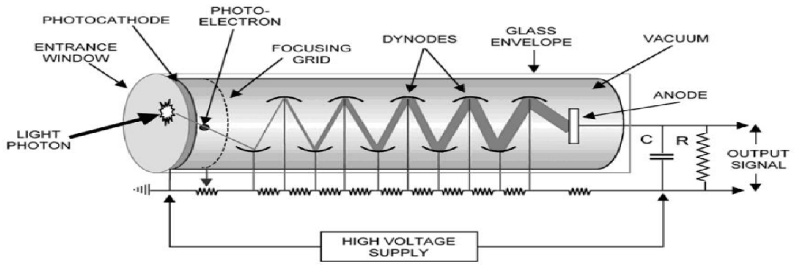
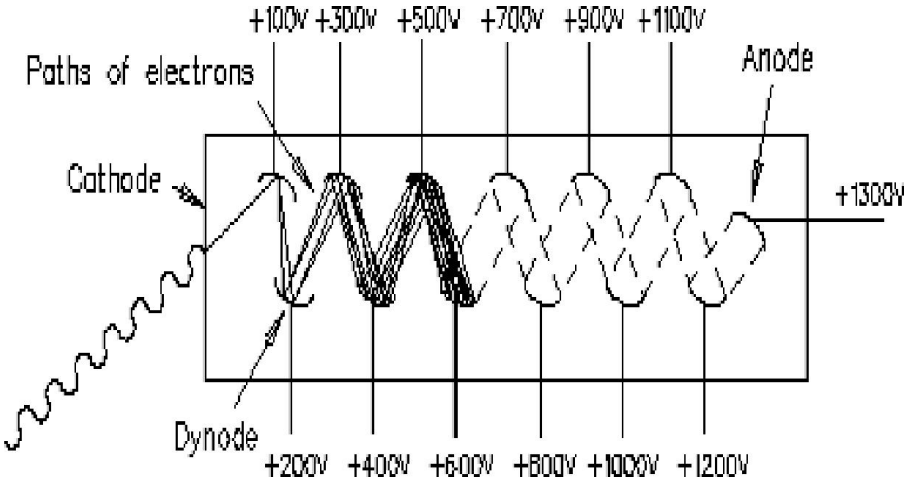
Explanation = 2 marks

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.

	c)	**Describe working of photomultiplier tube with neat sketch.** **Ans :**  **OR**  **Fig:The photo multiplier tube** The photo multiplier tube is the one part of detector .Which is used for convert light photons into electrons . The PMT consist of photocathode , dynodes, anode . The photocathode which is used for convert light photons into electrons and these electrons passes towards the dynodes .The dynodes are used for increases the number of electrons (multiplication of the electrons). The separate high voltage supply required for charging the dynodes .the dynodes are made of using metallic material and on which positive charge . finally all electrons passes toward the anode and generate electrical signal at the output of the anode.	**Diagram = 2 marks** **Explanation = 2 marks**

	d)	**Describe how instrumentation amplifier can be used to reduce noise present in an ECG signal.** **Ans :** Steps to reduce noise present in an ECG signal by using Instrumentation amplifier : - Adding a right leg electrode directly linked to the ground of the circuit. (against 60Hz) - Adding a driven right leg electrode for common mode rejection. (against 60Hz) - Adding passive low pass filters in front of the inputs of the instrumentation amplifier (against DC difference between the electrodes and bias current from the inputs) Faraday cage (against 60Hz hum) - Shielded cables for the electrodes (against 60Hz)	**4 marks**
	e)	**Define any four Dynamic characteristics of measurement system.** **Ans :** 1)Speed of Response :- It is defined as the rapidity with which a measurement system responds to changes in the measured quantity. 2) Measuring Lag :- It is the retardation or delay in the response of a measurement system to changes in measured quantity. It is of 2 Types A) Retardation type B) Time delay type. 3)Fidelity :- It is defined as the degree to which a measurement system indicates changes in a measured quantity without any dynamic error. 4) Dynamic Error / Measurement Error :- It is the difference between true value of quantity (under measurement system if no static error is assumed.	**1 mark each**
	f)	**Desribe any four factors that should be considered while designing any man instrumentation system.** **Ans : Consider any 4 factors.** Following factors that should be considered while designing any man instrumentation system are : **1.Inaccessibility of variables to measurement** – It is one of the greatest problems in attempting measurements from a living system is the difficulty in gaining access to the variable being measured.e. g. In cases such as in measurement of dynamic nerochemical activity in the brain it is impossible to place suitable transducer in a position to make measurement. **2. Variability of the Data** – Measurements taken under a fixed set of conditions at one time will not necessarily be the same as similar measurements made under the same conditions at another time. Variability from one subject to another is even greater.	**1 mark each**

3. Lack of knowledge about relationship – Variability in measured values could be better explained it more were known and understand about the interrelationship within the body.

4. Interaction among Physiological Systems – Because of large number of feedback loops involved in the major physiological systems, a severe degree of interaction exists both within a given system and among the major systems.

Result is that stimulation of one part of a given system generally affects all other parts of that system in some way.

For this reason, 'cause and effect' relationships become extremely unclear and difficult to define.

5 Effect of transducer on measurement – In many situation the physical presence of the transducer changes the reading significantly for e.g. a large flow transducer placed in a blood stream partially blocks.

6. Artifacts – Artifacts refers to any component of a signal that is extraneous to the variable represented by the signal. Thus, random noise generated within the measuring instrument electrical interference (including 60 Hz pickup), cross talk, and all other unwanted variations in the signal are considered Artifacts.

7.Energy Limitations – Many physiological measurement techniques require that certain amount of energy be applied to living system in order to obtain measurements. E.g. a resistance measurement requires the flow of electric current through tissue or blood being measured. In some cases this energy level is so low that its effect is insignificant. Energy concentration should also be avoided that might damage cells or affect the measurement.

Q.6 **Attempt any Four of the following :** **16 Marks**

a) **With neat working explain how LVDT is used for displacement measurement.**

Ans :

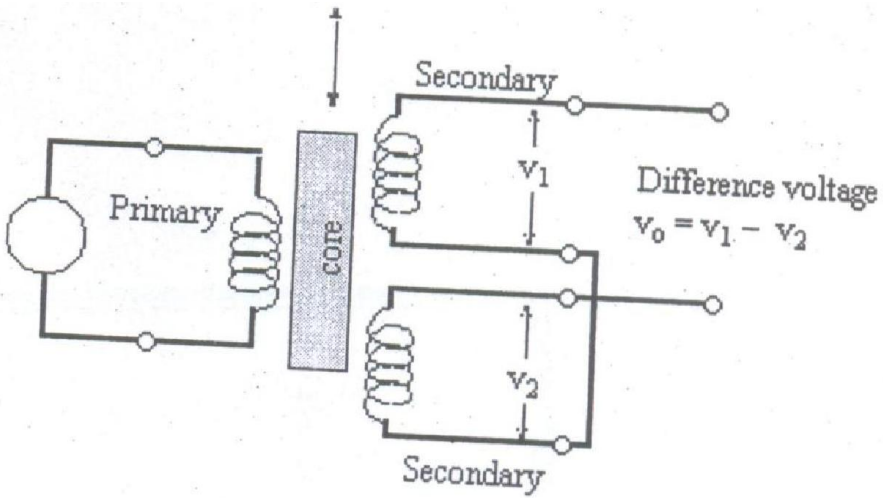
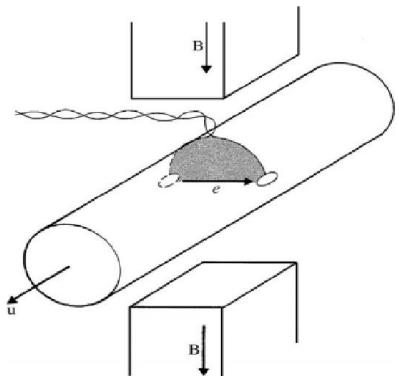


Fig : Construction of LVDT

Diagram 2 marks

		LVDT is the most widely used inductive transducer to translate linear motion (displacement) into electrical signals. 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.	**Explanation 2 marks**
	b)	**A platinum RTD has a resistance of 100 Ω at 25˚C.** **i) Find its resistance at 65˚C. The resist temp coefficient of platinum is 0.00392 Ω / Ω˚C** **ii) If the RTD has resist 07 150 Ω calculate the temp.** **Ans :** (a) using the linear approximation , the resistance at any temperature Θ°C is $Rt=Ro(1+ \alpha \Delta t)$ Given , Resistance at 65°C is , R65 =100 [1 + 0.00392 (65-25)] **R65 = 115.68 Ω** (b) Suppose t is the unknown temperature , 150 = 100 [1+0.00392 (t - 25)] 150 = 100 [1+0.00392t - 0.098] 150 = 100 [0.902 + 0.00392t] 150 =90.2 +0.392t	**(4 marks)** **2 marks** **2 marks**

		59.8 = 0.392t **t=152.55 °c**	
	c)	**Describe electromagnetic transducer with neat diagram.** **Ans :** $$e = \int_0^{L_1} \mathbf{u} \times \mathbf{B} \cdot d\mathbf{L}$$ where **B** = magnetic flux density, T **L** = length between electrodes, m **u** = instaneous velocity of blood, m/s  OR any other relevant diagram The electromagnetic flow meter measures instantaneous pulsatile flow of blood. It operates with any conductive liquid, such as saline or blood. The meter is placed such that the part of body through which the blood is to be determine like limb is subjected to the electric field. The flow meter depends on the movement of blood, which has a conductance similar to that of saline. Faraday's law of induction gives the formula for the induced emf. When blood flows in the vessel with velocity **u** and passes through the magnetic field **B**, the induced emf **e** is measured at the electrodes.	**Diagram 2 marks** **Explanation 2 marks**
	d)	**With neat labelled diagram explain working of P_{co2} electrode.** **Ans :**	

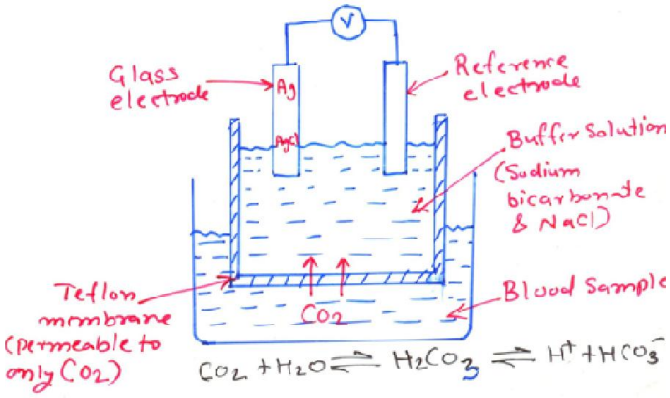


Fig : PCO_2 electrode

Diagram 2 = marks

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.

Explanation = 2 marks

e) Draw a bridge amplifier. State its working.

Ans:

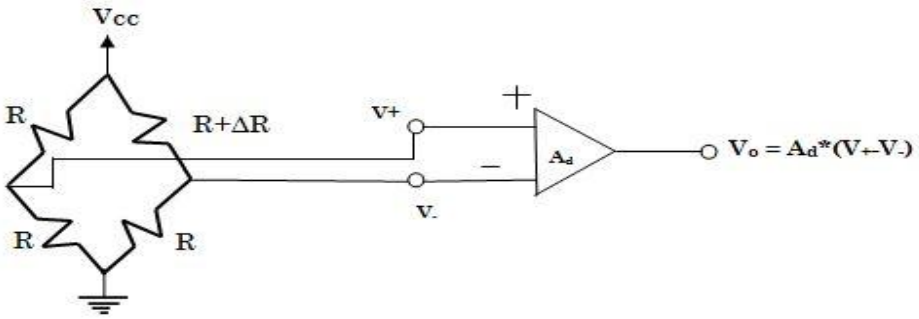


Fig : Bridge Amplifier

Diagram = 2 marks

In the figure shown above the resistance shown as R+ΔR can be any sensor such as platinum resistor, strain gauge, thermistor, e.t.c . The resistors labeled as R are reference resistors with which the varying resistance can be measured. Since the opamp is in open loop configuration the output of opamp is given as

$$V_o = A_d*(V_+-V_-)$$

Where A_d is open loop differential gain of opamp. The current flowing through the input

working = 2 marks

terminals of an op amp will be zero(except for small bias currents) due to infinite input resistance of opamp. let $\Delta R/R = \delta$,The output voltage of op amp reduces to $V_o = A_d*V*(-\delta)/4$. When all the resistors are matched i.e. $\delta=0$, output voltage goes to zero.

f)

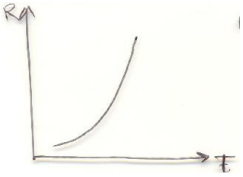
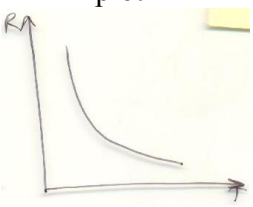
i) **Give types of thermistor and difference between them with respect to** — **4 marks**

1) Ch^r (Characteristics)

2) Relation between resistance and temp.

Ans :

There are 2 types of thermistor : a) PTC type thermistor b) NTC type Thermistor

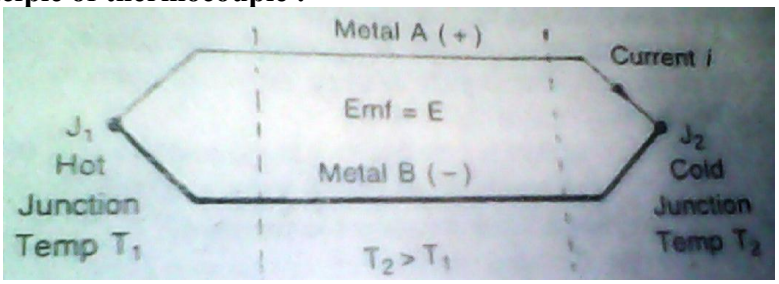
PTC	NTC
• resistance versus temperature plot 	• resistance versus temperature plot 

2 marks

ii)State working principle of thermocouple.

Ans :

Working principle of thermocouple :



2 marks

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.