SUMMER– 17 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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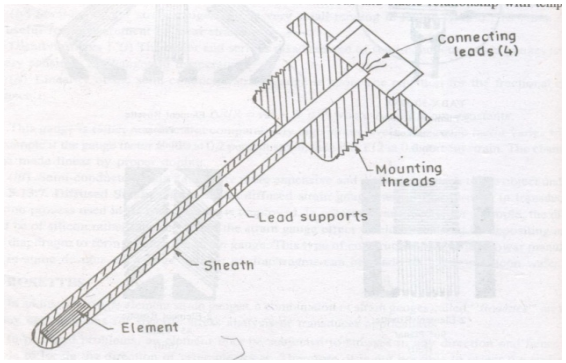
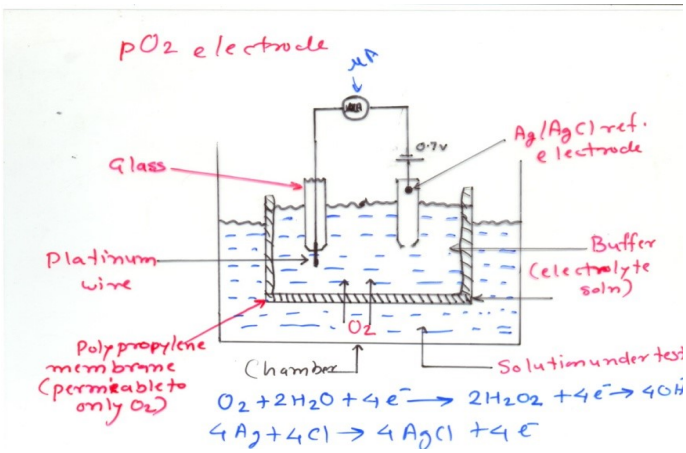
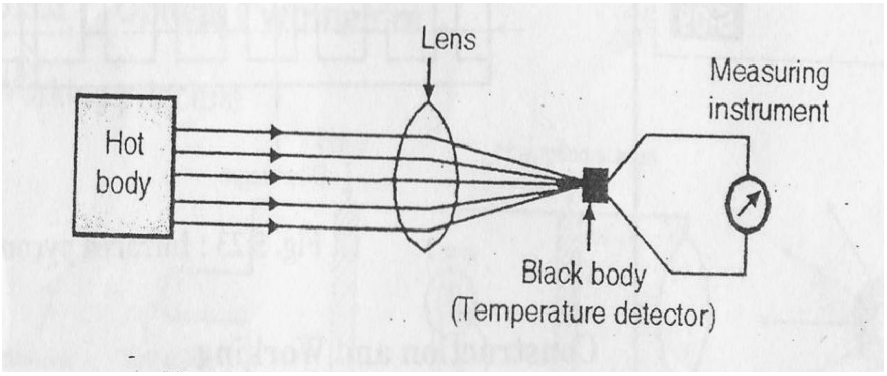
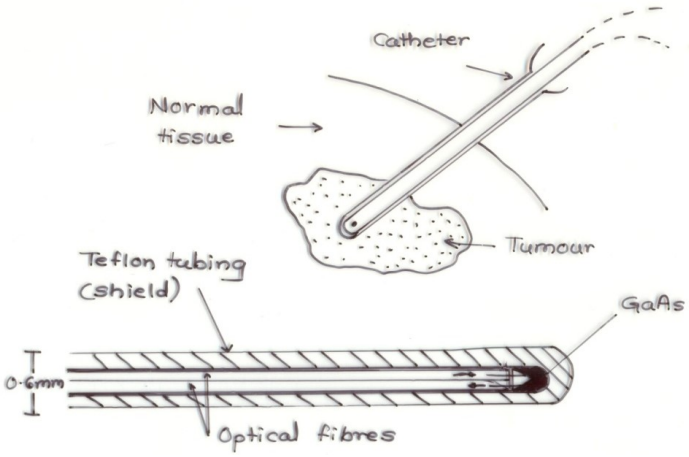
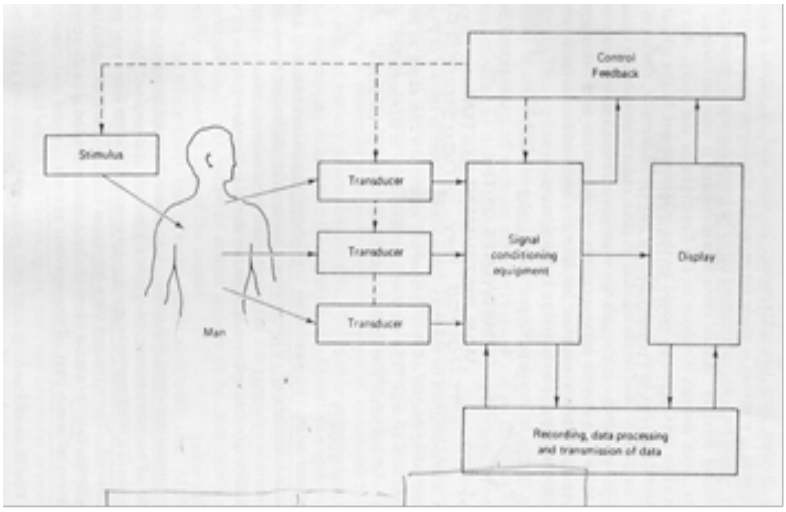
Q. No.	Sub Q.N	Answer	Marking Scheme
Q. 1	**a) i)**	**Attempt Any Six of the Following.** **List any four sources of biomedical signals.** **Ans :** - ECG (Electrocardiography) - EEG (Electroencephalography) - EMG (Electromyography) - PCG (Phonocardiography) - BP (Blood Pressure) - ERG (Electroretinography)	**12** **1/2 mark each**
	ii)	**List four constraints of Man Instrumentation system.** **Ans :** General constraints in design of Man 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	**1/2 mark each**
	iii)	**Describe the principle of electromagnetic blood flowmeter with the help of Faraday's law of electromagnetic induction.** **Ans :** **Faraday's law :** When an electrical conductor is moved through a magnetic field a voltage is induced in the conductor proportional to the velocity of its motion. The same principle applied when moving conductor is not a wire but another column of conductive fluid that flows through a tube located in magnetic field.	**2 marks**
	iv)	**Draw the constructional diagram of RTD.** **Ans:**  **Fig : RTD**	**2 marks**

	v)	**Draw diagram of pO_2 electrode and label its parts.** **Ans :** 	**2 marks**
	vi)	**State function of electrode jelly used to place an electrode on the patient's body.** **Ans:-** Jellies have been used to facilitate a more intimate contact between the subject's skin and the recording electrodes. Thus reducing the skin contact impedance.	**2 marks**
	Vii)	**State four materials used for manufacturing of thermocouple.** **Ans :** materials used for manufacturing of thermocouple are : - Copper - Iron - Platinum - Rhodium - Iridium - Constantan, combination of 60% copper and 40% nickel - Chromel , combination of 10 % chromium and 90 % nickel - Alumel , combination of 2% aliminium and 90% nickel, silicon and manganese.	**1 / 2 mark**
	viii)	**State seebeck effect.** **Ans:** When any conductor is subjected to a thermal gradient, it will generate a voltage. This is now known as the thermoelectric effect or Seebeck effect. **OR** If a closed circuit is formed of two dissimilar metals having two junctions which are at different temperatures then emf is induced.	**2 marks**
	b) **i)**	**Attempt any TWO of the following :** **Define Accuracy, Precision, Calibration, Linearity w.r.t. measurement system.** **Ans :** **- Accuracy:** It is the algebraic difference between the indicated value and the true or theoretical value of the measurement. Practically it is expressed as percentage of full scale output. OR Degree of closeness with which measured value approaches to true value.	**8 Marks** **1mark each**

		- Precision: The precision of a measurement system, related to reproducibility and repeatability, is the degree to which repeated measurements under unchanged conditions show the same results. OR Agreement within a group of measurement. **- Calibration :** The comparison of specific values of input and output of an instrument with corresponding reference standard. **- Linearity**: It is the degree to which variation in the output of an instrument follows the input variation. Basically it reflects that the output is in some way is proportional to input.	
	ii)	**Describe working of Radiation Thermometry with a neat diagram.** **Ans :**  **Fig : Radiation Thermometry** The basis of radiation thermometry is that there is a known relationship between the surface temperature of an object and its radiant power. This principle make it possible to measure the temperature of body without physical contact with it. When physical contact with the medium to be measured is not possible or impractical due to very high temperature (above 1400° C), Radiation Thermometry 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** **Working = 2 mark**
	iii)	**State the basic requirements of a bio-amplifier. (any eight points)** **Ans:** Basic requirements of biopotential amplifiers : 1. Biopotential amplifiers must have high input impedance so that they provide minimal loading of signal being measured. Input impedance that least 10 M ohm 2. Biopotential amplifiers should have isolation and protection circuitry, so that the	**1 / 2 marks each**

		current through the electrode circuit can be kept at safe levels and any artifact generated by such current can be minimize. 3. Output Impedance of amplifier must be low with respect to the load impedance, and the amplifier must be capable of supplying the power required by load. Load is usually an indicating or recording device. 4. Biopotential amplifiers must have high gains of the order of 1000 or greater biopotential signals usually have amplifiers of the order of few miili volts or less such signals must be amplified to levels compatible with recording & display devices. 5. Biopotential differential amplifier must have high common mode rejection ratio to minimize artifact due to the common mode signal. 6. Final requirement for biopotential amplifiers that are used both in medical applications & in the laboratory is that they make quick calibration possible. 7. BioAmplifiers are required to increase signals strength while maintaining fidelity. 8 Some biopotential amplifiers have additional requirements that are application specific.	
Q.2		**Attempt any FOUR of the following :**	**16 Marks**
	a)	**Describe Polarizable and Nonpolarizable electrodes.** **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.	**2 marks** **2 marks**
	b)	**With help of a neat labeled diagram give constructional details of GaAS semiconductor temperature probe.** **Ans :**  -The figure shows GaAs semiconductor temperature probe. Small prism shape sample of single crystal undopped GaAs is epoxid at the end of two side by side optical fibers. The sensors of fibers are quite small and compatible with biological implementation been sheathed. One fiber transmits light from a LED source where it is passed through GaAs and collected by other fiber for detection in the read out.	**Diagram = 2 marks** **Explanation = 2 marks**

		Some of the optical power travelling through semiconductor is absorbed by the process raising valance band electron across forbidden energy gap into the conduction band because the forbidden energy gap is a sensitive material for temperature. Amount of power absorbed is increased with temperature. This non metallic probe is particularly suitable for temperature measurement in the strong electromagnetic heating field used in heating tissue for cancer therapy. Single sensor probe with an outer diameter of 0.6mm and 4 point temperature sensor probe of 1.1mm diameter based on this technique are commercially available.	
	c)	**Draw block diagram of Man Instrumentation system. State the function of any two blocks.** **Ans :**  **Fig : Man Instrumentation system.** 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. iii) 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. iv) 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	**Diagram = 2 marks** **any 2 blocks function = 2 marks**

include graphic pen recorder.

v) 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.

vi)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 working of ultrasonic flow meter.

Ans :

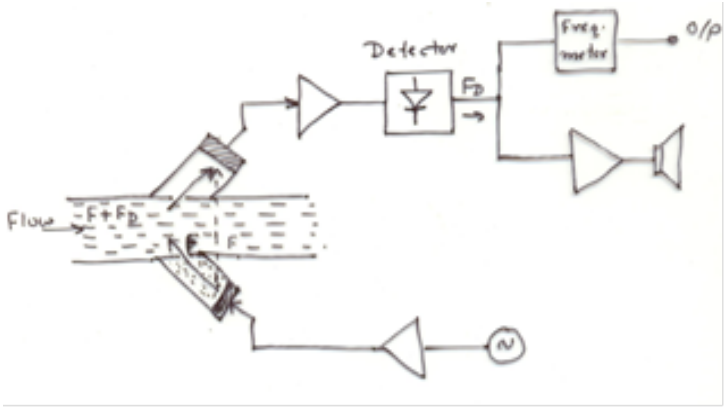


Fig : Ultrasonic flow meter.

Description = 4 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.

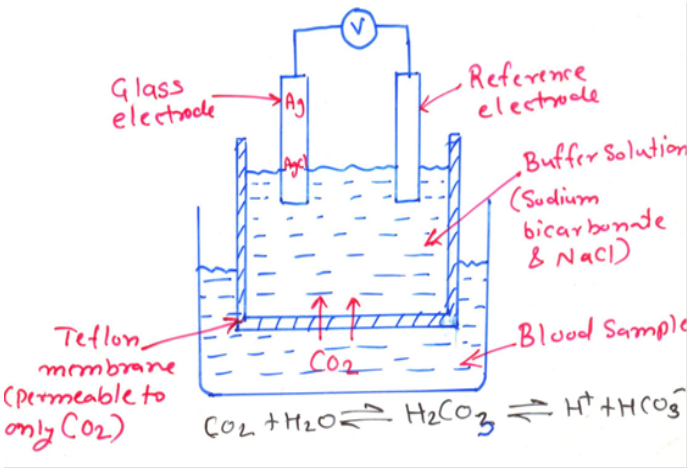
When blood flow in the direction of energy transmission the transmit time is shorted. If it flows in opposite direction the transmit time will be lengthen.

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.	
	e)	**A unbounded strain guage has a resistance of 2000 and gauge factor of 3.2, what will be the change in resistance due to 1000 microstrain?** **Ans:** **Given,** R = 2000 Gf = 3.2 strain = Δ L/L = 1000 Δ R= unknown Fomula: $Gf = \frac{\Delta R/R}{\Delta L/L}$ $3.2 = \frac{\Delta R/2000}{\Delta L/L}$ $3.2 = \frac{\Delta R/2000}{1000}$ Therefore Δ R = 3.2 x 1000 x 2000 Change in resistance = 6.4 ohms	**(1 mark)** **(3 marks)**
	f)	**Describe pCO_2 electrode with a neat labelled diagram.** **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	**Diagram = 2 marks** **Explanation= 2 marks**

		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.	
Q.3		**Attempt any FOUR of the following :**	**16 Marks**
	a)	**Define :** **(i) Bio-magnetic signals** **(ii) Bio-chemical signals** **(iii) Bio-mechanical signals** **(iv) Bio-acoustic signals** **Ans :** **(i) Bio-magnetic signals :** some organs produce very weak electromagnetic signals; measurement of these signals is called "Bio-magnetic signals. Ex. Brain, heart and lungs are organs producing magnetic signals **(ii) Bio-chemical signals :** These types of signals are obtained from the measurements of chemical compositions. Ex- composition of various ions, partial pressure of oxygen or co2 in living tissues or from sample. **(iii) Bio-mechanical signals :** These signals are obtained from mechanical function of biological system it includes all types of motion and displacement signal. Ex. Motion of chest wall. **(iv) Bio-acoustic signals :** These signals are obtained from sounds created by Biological system and provide information about underlying phenomenon .Ex. Flow of blood in heart through valves, flow of air in lungs.	**1 mark each**
	b)	**Describe phase sensitive amplifier.** **Ans :** The use of phase sensitive detector permits setting the LVDT core to its center position and determining directional changes regardless of which side of the center the core is displaced. In this detector the oscillator voltage and voltage derived from the LVDT are added before rectification. With the core in its central position, the oscillator voltage, corrected for phase shift by the adjustment of C, is fed to the indicator to bring it to mid scale by adjusting R. as the core is displaced from central position, the voltage e0 after amplification, adds to or subtract from the oscillator voltage. Depending On the magnitude and phase of e0 which in turn depends on the magnitude and direction of the displacement.	**4 marks**
	c)	**Describe electrode skin interface with neat diagram.** **Ans :** -In coupling an electrode to the skin, we generally use a transparent electrolyte gel. Therefore there are two interfaces one is in between electrode and electrolyte (gel) and the other is in between electrolyte and tissue. -Ehe: half cell potential of electrode-electrolyte interface. Cd,Rd: Represents impedance of interface (electrode-electrolyte). Rs: Resistance of electrolyte (Gel). -Epidermis is semipermeable to ions, so if there is difference on ionic concentration across this membrane, there is potential difference called Ese. -Parallel combination of Ce and Re is represented electric impedance of epidermis. This impedance reduces fro, 200kΩ at 1Hz to 200Ω at 1MHz. -Rs Is the pure resistance of dermis and subcutaneous layer.	**Explanation = 2 marks**

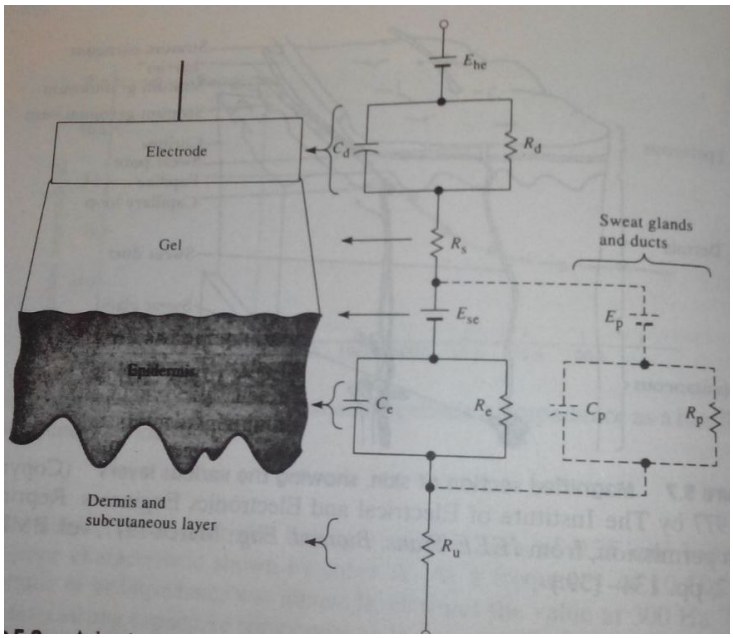


Fig : Electrode-skin interface.

Diagram = 2 marks

d) Differentiate between Thermister and RTD.

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
6)	Type	These are PTC type RTD	These are PTC and NTC type thermistor.

4 mark

(Any 4 points of each type)

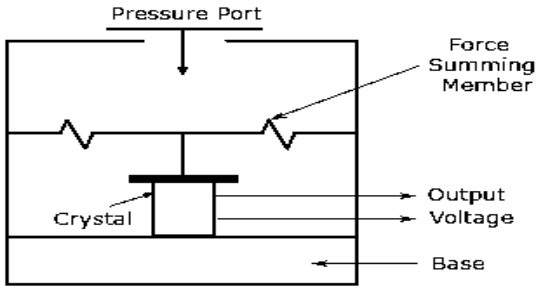
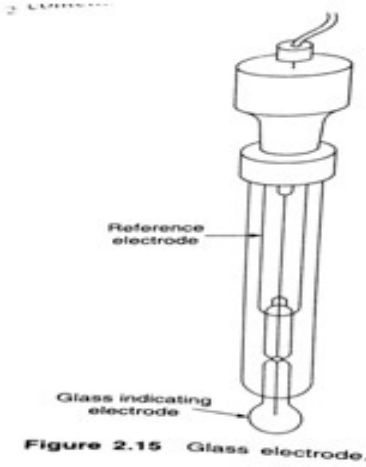
e) Describe how pressure can be measured using piezoelectric transducer.

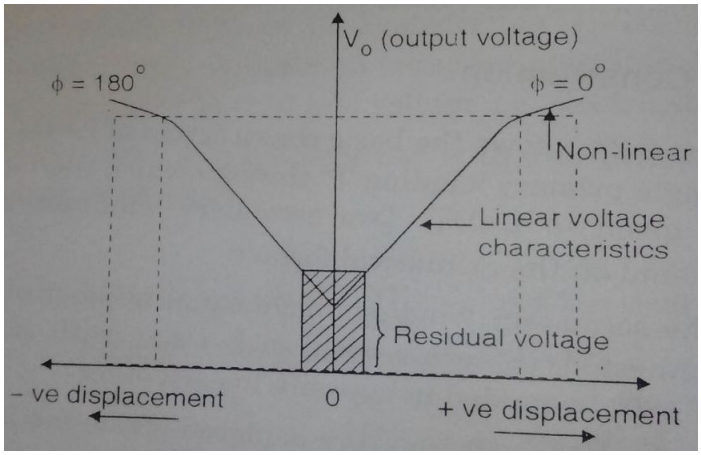
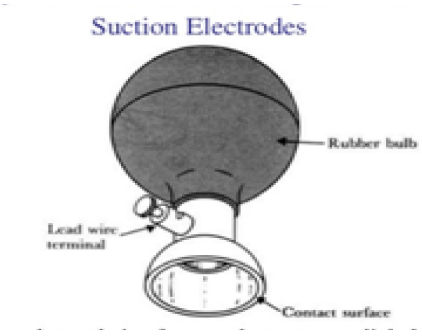
Ans :

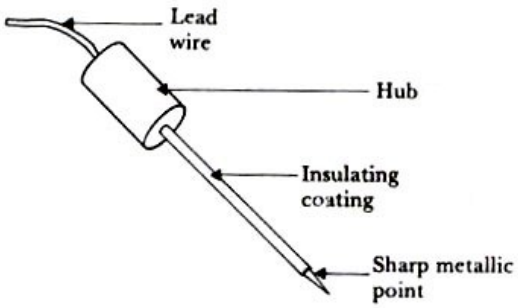
Asymmetrical crystalline materials such as :Quartz, Rochelle salt, Barium Titanate and PZT(Lead Zirconate Titanate) produce an EMF when they are placed under stress. This property is used in piezoelectric transducers where a crystal is placed between a solid base and force summing member.

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

4 marks

		generating type of transducer.  Piezo-Electric Transducer	
	f)	**Describe electrode used to measure hydrogen ion concentration in the blood with suitable diagram.** **Ans :**  **Figure 2.15** Glass electrode. (OR any other relevant diagram) Glass electrode is normally used as a pH electrode.fig shows the glass electrode consists of spherical bulb of 0.5cm diameter. The membrane of thin glass bulb permits the passage of only hydrogen ions in the form of H_2O^+ .Inside the glass bulb Ag/Agcl electrode is immersed in chloride buffer solution. The other side of the bulb is kept at the other solution unknown pH. The measuring circuit and solution being measured is closes through potassium chloride salt bridge and calomel electrode. In this case two arrangements are required one for reference and the other for unknown solution. Nowadays glass electrode and reference electrode are available in the same enclosure.	**Diagram = 2 marks** **Explanation = 2 marks**
Q.4	**a)**	**Attempt any FOUR of the following :** **Describe how thermal convection method is used to measure blood flow.** **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	**16 Marks**

		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.	**4 marks**
	b)	**Why output voltage is not zero at null displacement in the characteristics of LVDT ? justify.** **Ans :**  **Fig : Characteristics curve of LVDT.** When there is no displacement attached to the core i.e. the core is at normal (NULL) position, the flux linking with both the secondary windings are equal. Ideally the output voltage at the null position should be equal to zero. But in actual practice there exists a small voltage at the null position called as Residual voltage. This may be on account of presence of harmonics in the input supply voltage and also due harmonics produced in the output voltage on account of use of iron core. They may be either an incomplete magnetic or electrical unbalanced or both which results in a finite output voltage at the null position. Other cause of residual voltage are stray magnetic field and temperature effect.	**4 marks**
	c)	**Describe suction electrode and needle electrode with the help of diagrams.** **Ans :**  Suction electrodes are frequently used in electrocardiography as the pericordial (chest) leads. There are surface electrodes used for measurement of ECG. It consist of rubber bulb and contact surface. Due to vaccum electrode stick to the skin of patient.	**2 marks**



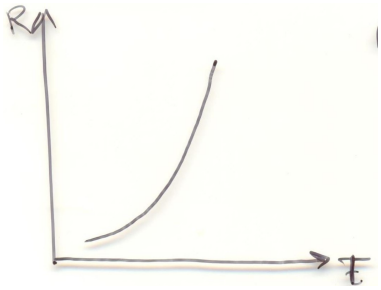
needle electrode

Needle electrodes are used to pick up very smaller amplitude signals. The sensitivity of the needles electrodes is generally higher than the surface electrodes. It is used to penetrate the skin to record bio-potential. It is made up of stainless steel. Available in diameter ranging from 25 to 125 μm. No electrolyte gel is required. It can be used to record EEG potential from a local region of the brain. It can be used to record EMG potentials from a specific group of muscles.

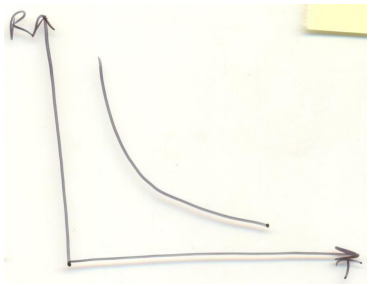
2 marks

d) Describe working of thermister with a neat diagram.

Ans :

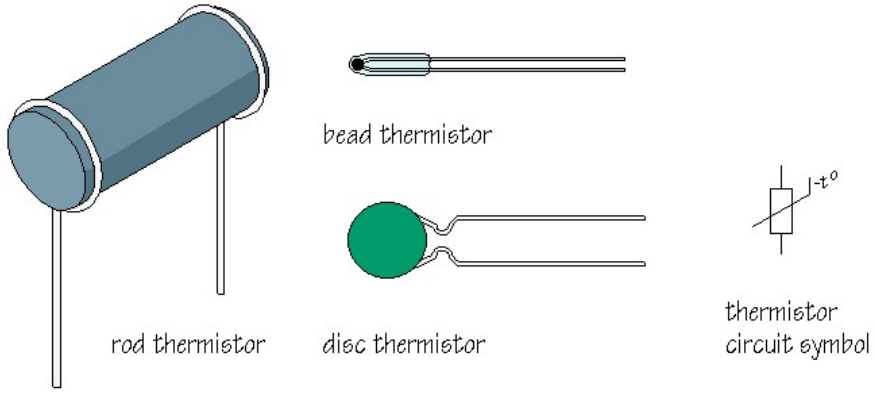


PTC



NTC

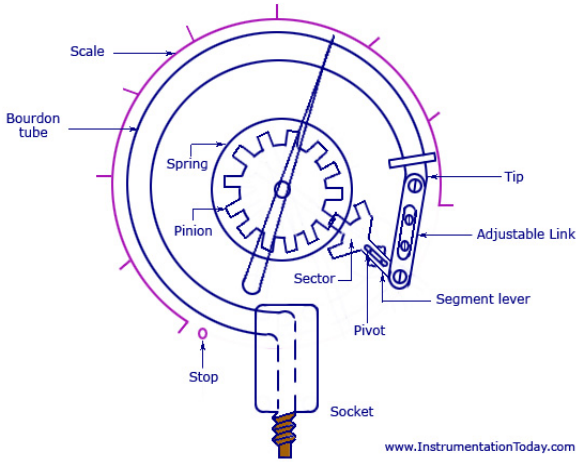
OR



The thermistor acts as the temperature sensor and it is placed on the body whose temperature is to be measured. It is also connected in the electric circuit. When the temperature of the body changes, the resistance of the thermistor also changes, which is indicated by the circuit directly as the temperature since resistance is calibrated against the

Diagram = 2 marks

		temperature. The thermistor can also be used for some control which is dependent on the temperature. The thermistors are made up of ceramic like semiconducting materials. They are mostly composed of oxides of manganese, nickel and cobalt. The resistance of the PTC thermistors increases with the increase its temperature. The resistance of the NTC thermistors decreases with the increase its temperature.	**Explanation = 2 marks**
	e)	**Differentiate between Active and Passive transducers.** **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 This transducer develops their own voltage and current. The energy required for production of an output signal is obtained by physical phenomena being measured. 3. Ex. Photovoltaic cell, thermocouple etc. **-Passive Transducer:** 1 The transducer which requires energy to be put it in order to translate changes due to measurand. 2.It requires external power supply. 3. Ex: LVDT, Strain gauge.	**Any 2 points of each type.**
	f)	**Describe importance of measuring electrode and reference electrode.** **Ans :** **Importance of measuring electrode :** Measuring electrode or active electrode is sensitive to changes in the subject. Measuring electrode are pH and Pco_2. **Importance of reference electrode :** The electrode potential of reference electrode can be any amount as long as it is stable and does not respond to any possible changes in the composition of solution being measured. The good reference electrode is search for most stable electrode stable electrode available. There are two types of electrode which have sufficiently stable interface to act as reference electrode. i) Silver Silver chloride electrode (Ag/ Agcl electrode) ii) Calomel electrode (Hg / Hgcl electrode)	**2 marks** **2 marks**
Q. 5		**Attempt any Four of the following :**	**16 Marks**
	a)	**Draw a labeled diagram of C shape Bourdon tube. Describe its working for pressure measurement.** **Ans :** 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. The free end connected to the pointer with the help of geared sector & pinion. Calibrated scab & pointer is provided to indicate the pressure .The pressure which is to be measured is applied to the Bourdon tube through open end. When the pressure enters the tube, the tube tends This causes the measurement of the free end & the displacement of this end is given to the pointer through mechanical linkage. The pointer moves on the calibrated scale in terms of pressure.	**Explanation = 2 marks**

		 Bourdon Tube Pressure Gauge	**Diagram = 2 marks**
	b)	**Describe plethysmography technique used for measurement of flow.** **Ans :** 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 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 inflat 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.	**4 marks**
	c)	**With help of a neat labelled diagram give constructional details of PMT and describe its working.** **Ans :** A photomultiplier tube is a vacuum tube consisting of an input window, a photocathode, focusing electrodes, an electron multiplier and an anode usually sealed into an evacuated glass tube. Light which enters a photomultiplier tube is detected and produce an output signal through the following processes. 1) Light passes through the input window. 2) Light excites the electrons in the photocathode so that photoelectrons are emitted into the vacuum (external photoelectric effect). 3) Photoelectrons are accelerated and focused by the focusing electrode onto the first	**Explanation = 2 marks**

dynode where they are multiplied by means of secondary electron emission. This secondary electron emission is repeated at each of the successive dynodes.
4) The multiplied secondary electrons emitted from the last dynode are finally collected by the anode.

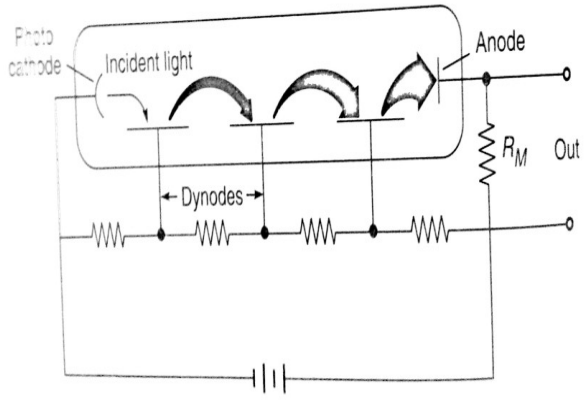


Fig: A photomultiplier tube

Diagram = 2 marks

d) Calculate the gain of the configuration shown in fig No.1 Also calculate the output voltage if V_a= 2mV and V_b= 1mV.

Ans :

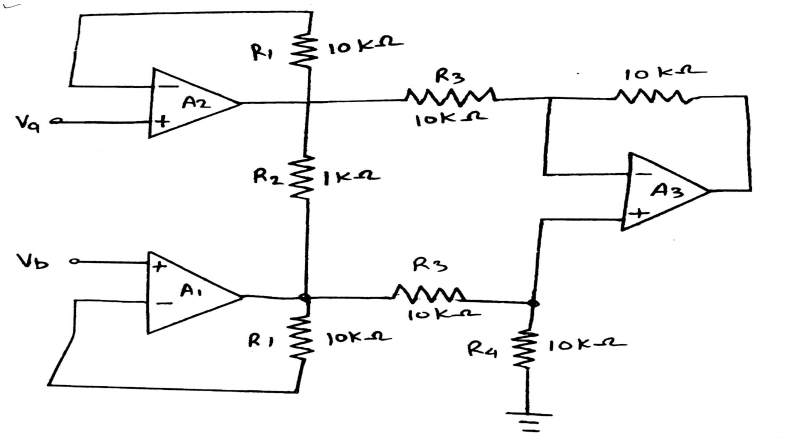


Fig no.1

The overall gain of the instrumentation amplifier is given by

$A_V = [1+2R_1/R_2]\ R_4/R_3$

Here,

R_1= 10kΩ , R_2 = 1kΩ , R_3 = 10kΩ , R_4 = 10kΩ

Gain Av = [1+2*10kΩ/1kΩ]10kΩ/10kΩ

= [1+20]*1

= 21*1

= 21

Gain (Av) = 21

2 marks

Vo = $(V_b - V_a)\ (R_4/R_3)\ (1+2R_1/R_2)$

= (1mV-2mV) (10kΩ/10kΩ) (1+2*10kΩ/1kΩ)

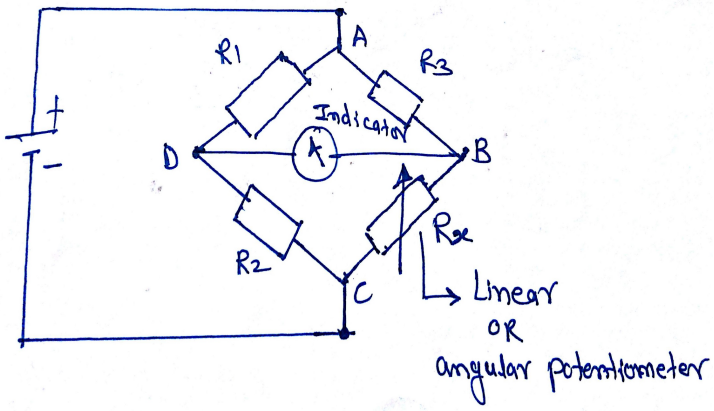
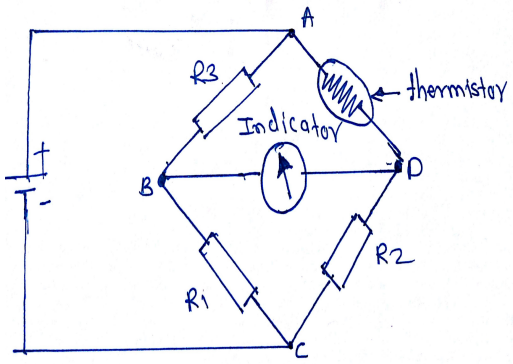
= (-1mV) (1+20)

= (-1mV) (21)

Vo = - 21mV

2 marks

	e)	**Classify transducer based on:** **i) Process used** **ii) Physical or chemical principle used** **iii) Application** **Ans :** The transducer can be classified in many ways, such as i) By the process used to convert the signal energy into an electrical signal. For this , transducer categorized as: Active Transducer- A transducer that converts one form of energy directly into another. For example: Photovoltaic cell in which light energy is converted into electrical energy. Passive Transducer- A transducer that requires energy to be put into it in order to translate changes due to the measurrand. For example: Thermistor , RTD ii) By the physical or chemical principle used. example for physical principle – variable resistance devices, Hall effect and optical fiber transducer. example for Chemical principle – $p0_2$, Pco_2 electrodes. iii) By application for measuring a specific physiological variable. For example: flow transducer, pressure transducer, temperature transducer.	**4 marks**
	f)	**Describe any four factors that should be considered while designing any Man Instrumentation System.** **Ans :** 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. **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	**1 mark each**

		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 <u>FOUR</u> of the following:**	**16 Marks**
	a)	**Describe how Wheatstone bridge can be used for the measurement of linear and angular displacement with suitable diagram.** **Ans :** 	**Diagram = 2 marks**
		Potentiometer converts rotary motion or displacement into a change of resistance. Generally potentiometer is placed as one leg of Wheatstone bridge at a balanced condition, When there is no change in the displacement using shaft or movable contact of potentiometer, the galvanometer indicates zero. As shaft or movable contact changes their position, the resistance of potentiometer increases or decreases. Due to which the Wheatstone bridge circuit becomes unbalanced. Thus deflection of the galvanometer calibrated as displacement scale in terms of voltage.	**Explanation = 2 marks**
	b)	**Describe how Whetstone's bridge can be used for temperature measurement with suitable diagram.** **Ans :** 	**Diagram = 2 marks**
		To measure temperature with thermistor measured. As the temperature of substance increases the resistance of thermistor decreases and vice versa. Generally thermistor is placed as one leg of Wheatstone bridge at a balanced condition, when there is no change in the temperature, the galvanometer indicates zero. As temperature increases or decreases the resistance of thermistor increases or decreases. Due to which the Wheatstone bridge circuit becomes unbalanced. Thus deflection of the galvanometer can be calibrated as temperature scale.	**Explanation = 2 marks**

	c)	**Describe Indicator dilution method of flow measurement.** **Ans :** Indicator dilution principle states that if we introduce into or remove from a stream of fluid a known amount of indicator & measure the concentration difference upstream & downstream of the injection site, we can estimate the volume flow of the fluid. Two methods are generally employed for introducing the indicator in the blood stream; it may be injected at a constant rate or as a bolus. The method of continuous infusion suffers from the disadvantage that most indicators recirculate , & this prevents a maxima from being achieved. In the bolus injection method, a small but known quantity of an indicator such as a dye or radioisotope is administered into the circulation. It is injected into a large vein or preferably into the right heart itself. After passing through the right heart, lungs& the left heart. The indicator appears in the arterial circulation. The presence of an indicator in the peripheral artery is detected by a suitable (photoelectric) transducer & is displayed on a chart recorder. This way we get the cardiac output curve. This is also called dilution curve.	**4 marks**
	d)	**Describe construction and working of ISFET.** **Ans :** **Construction:** 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-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 SiO2, Si3N4, Al2O3 and Ta2O5.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 SiO2 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: $—Si–OH + H_2O \leftrightarrow —Si–O^- + H_3O^+$ $—Si–OH + H_3O^+ \leftrightarrow —Si–OH_2^+ + H_2O$	**2 marks** **2 marks**
	e)	**What are motion artifacts? How it can be reduced?** **Ans :** The term artifact refers to any component of a signal i.e. extraneous to the variable represented by the signal. Thus random noise generated within the measuring instrument, cross talk and unwanted variations in the signal are considered as artifacts. The movement of the subject often produces variations in the output signal these are called as artifacts generated due to motion. Motion artifacts must be as less as possible. Avoid the motion of the patient body. Also take precautions for no movement of the electrodes.	**4 marks**
	f)	**A platinum RTD has a resistance of 100Ω at 25 ℃** **(i) Find its resistance at 50℃. The resistance temperature coefficient of platinum is 0.00392Ω/Ω℃.** **(ii) If the RTD has resistance of 150Ω, calculate the temperature.**	

		Ans : (i) using the linear approximation , the resistance at any temperature Θ°C is Rt=Ro(1+ α Δ t) Given , Resistance at 50°C is , R_{50} =100 [1 + 0.00392 (50-25)] R_{50} = 109.8 Ω (ii) 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 59.8 = 0.392t **t = 152.55°c**	**02 marks** **02 marks**