Important Instructions to examiners:

1) The answers should be examined by keywords 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. No.	Question & its Answer	Remark	Total Marks
1 A)	**Attempt any three:**		**12**
a)	**What is pH? List the types of electrodes used for pH measurement.**		**04**
Ans.	**pH:** Hydrogen ion concentration, as distinct from total acidities in a chemical solution is represented by a symbol pH. It is defined by following equation $pH = -\log_{10} C_H$ where C_H is the hydrogen ion concentration The lower case letter 'p' in pH stand for negative common (base ten) logarithm, while the upper case letter "H" stands for the element Hydrogen. Thus pH is a logarithmic measurement of the number of moles of hydrogen ion (H^+) per liter of solution. **Electrodes for pH measurement**: 1. Hydrogen electrode 2. Glass electrode 3. Calomel or reference electrode. 4. Silver silver chloride reference electrode .	**02 Marks for definition And formula** **02 Marks for list of electrodes**	
b)	**State the basic principle of NMR. Explain the resonance condition in NMR.**		**04**
Ans.	**Principle of NMR:** **Nuclear Spin:** Elementary particles such as electrons or a nucleus behaves as if they rotate about an axis possesses the property of spin known as nuclear spin. The angular momentum is associated with the spin of particle would be an integral or half integral multiple of $h/2\pi$ where, h is planck's	**02 Marks for principle**	

constant.
Since a nucleus possesses a charge, its spin gives rise to a magnetic field that is analogues to the field produced when an electric current is passed through a coil of wire. The resulting magnetic dipole or nuclear magnetic moment μ is oriented along the axis of spin and has a value that is characteristic for each kind of particle.
When spinning nucleus is placed in a strong uniform magnetic field (H), the field exerts a torque upon the nuclear magnet. This would make the nucleus to assume a definite orientation with respect to the external field. The torque is a vector with its direction at right angles to the plane of μ and H. This results in a rotation of the nuclear axis around the direction of the external field. This is called processional
motion.

Resonance Condition:

When an alternating RF field, superimposed over the stationary magnetic field, rotates at exactly the frequency of an energy level, the nuclei will be provided enough energy to undergo a transition from lower energy level to a higher energy level. In general Energy difference between states is given by,
$\Delta E = \mu\beta.Ho/I$
Where,
Ho = strength of external magnetic field in gauges
B = constant called the nuclear magneton, 5.049 × 10-24 ergs
μ = magnetic moment of the particle expressed in units of nuclear magnetons
The frequency, ν of radiation determine from Planck's equations
$\Delta E = h\nu = \mu\beta.Ho/I$
The frequency can be varied by applying magnetic field,
$\nu = \mu /h.\beta.$ Ho/I …. h = 6.626 × 10-27 ergs
= 2.797 × 5.05 × 10-24 × 23000
(6.6256 × 10-27) (1/2)
= 95 × 106 Hz
= 95 MHz
The proton will process 95 million terms per second in a field of 23000 gauss. The frequency 95 MHz lies in the radio frequency range of the electromagnetic spectrum.

OR

Any other relevant explanation should be considered.

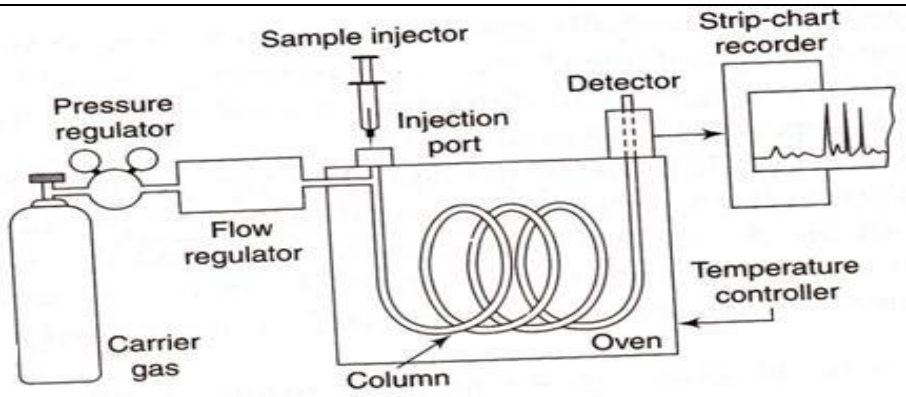
02 Marks for Explanation

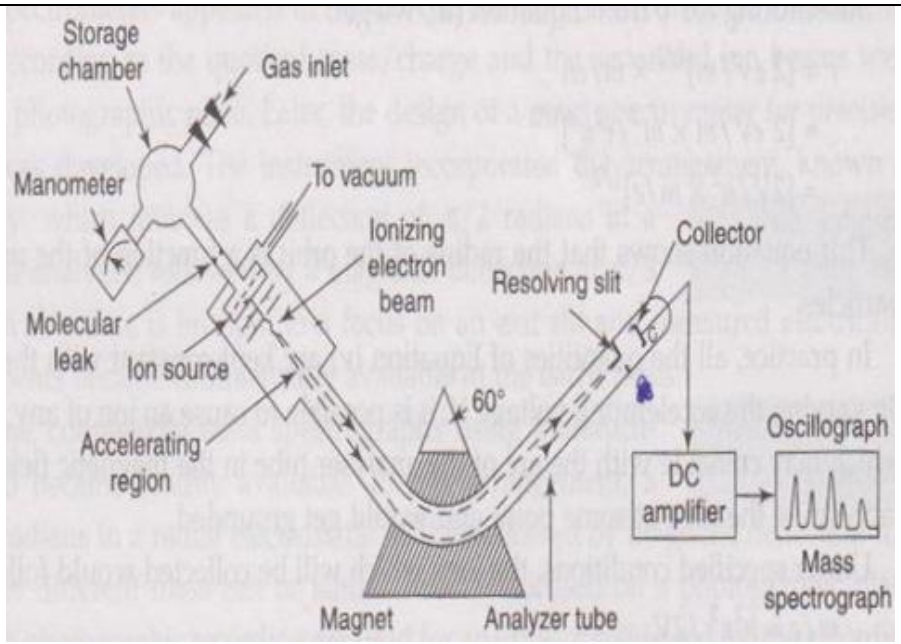
c) Name any four blood gas parameters. State their normal range. — **04**

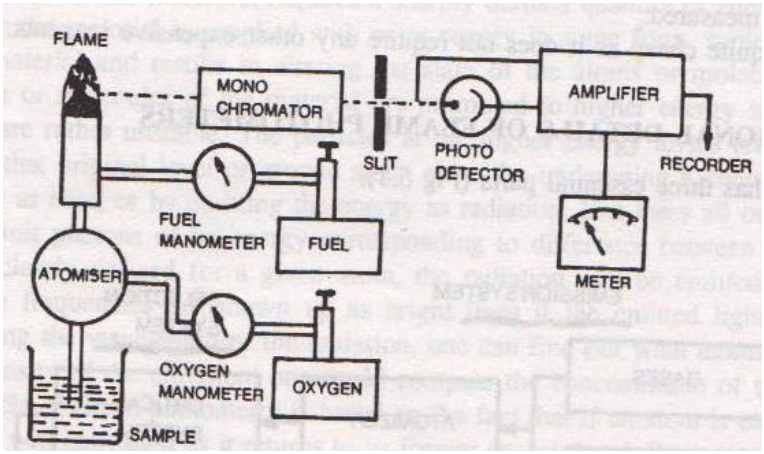
Ans. **Blood Gas Parameters: (Any four)** — **01 Mark for each parameter**

Serial Number	Plasma Parameter		Arterial Capillary Blood	Venous Plasma
1.	**pH**	-	7.37 to7.44	7.35 to 7.45

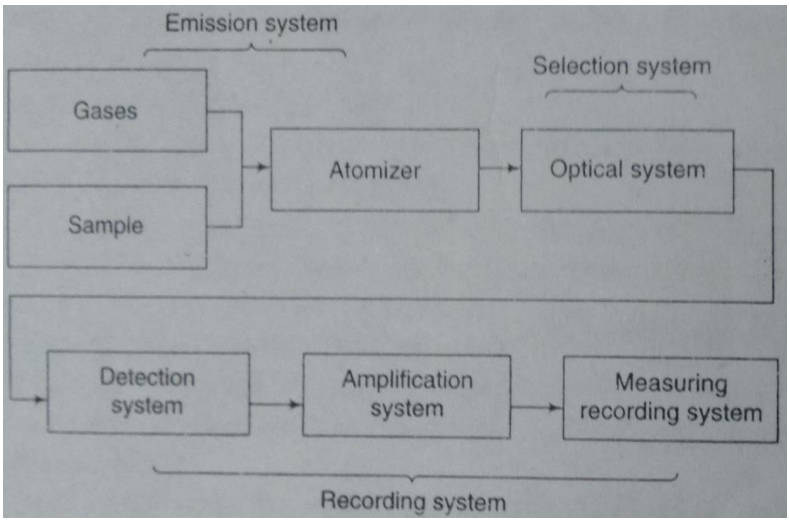
	2.	**pCO_2**	**Men**	34-35 mmHg	36-50 mmHg		
			Women	31-42 mmHg	34-50 mmHg		
	3.	**pO_2**	**Resting adult**	80-90 mmHg	25-40 mmHg		
			Resting adult over 65 years	75-85 mmHg	mmol/l		
	4.	**Biocarbonate**	**Men**	23-29 mmol/l	25-30 mmol/l		
			Women	20-29 mmol/l	23-28 mmol/l		
	5.	**Total CO2 (Plasma) Base Excess**	**Men**	24-30 mmol/l	26-31 mmol/l		
			Women	21-30 mmol/l	24-29 mmol/l		
			Men	-2.4- +2.3 mmol/l	0- 5 mmol/l		
			Women	-3.3- +1.2 mmol/l	-1- +3.5 mmol/l		
	NOTE: Any other relevant parameters range should be considered						
d)	**List the types and concentration of various gas pollutants.**						**04**
Ans.	The major gas pollutants are carbon monoxide, sulphur oxides, hydrocarbons, nitrogen oxides and particulates. **Carbon monoxide:** Its average concentration is below 200 ppm. **Hydrocarbon:** Its average concentration is below 80 ppm **Oxidants:** Its average concentration is below 500 ppb **Sulphur dioxide:** Its concentration in urban areas is 0.024 ppm. **Nitrogen oxides:** Its level ranges from 0.5 to 0.12 ppm.					**02 Marks for any four type** **02 Marks for any four concentration**	
B)	**Attempt any ONE :**						**06**
a)	**What is gas chromatography? Draw and explain labeled block diagram of gas chromatography.**						**06**

Ans.	 **Diagram of gas chromatography** **Working principle** Gas Chromatography is an analytical technique used for compound separation based primarily on their volatilities. It provides qualitative and quantitative information for individually present compounds. Compounds moves through column in gaseous phase and they are portioned between a stationary phases. The career gas (N2, Ar or He) is available in compressed form in a cylinder fitted with pressure regulator. The gas is conducted through flow regulator to sample injection port maintained at temperature T1. Gases and liquids samples are injected by syringe. The solute vapour mixes instantaneously with the flowing carrier gas and swept through chromatographic column. It is there the actual separation takes place. Column is maintained at temperature T2. At the end of the column, solutes emerging individually enter the detectors which produce an electrical signal corresponding to the quantity of solute leaving the column. The detector signal is supplied to recorder and plot of time – signal amplitude called chromatograph is obtained.	**03 Marks for diagram** **03 Marks for explanation**	
b)	**Draw and explain the construction of magnetic deflection mass spectrometer.**		**06**
Ans.	**Magnetic Deflection Mass Spectrometer :**		

	 **Principle of Working :** 1. The heated tungsten filament produces an electron beam, which passes between plates A & B. 2. A difference in electrical potential between A & B pulls ions out of beam, so that they pass through slit B into the region between B & C. 3. The potential difference between B & C is adjustable from 0 up to several thousand volts. 4. The ion beam then enters the space between two trapezoid shaped magnet poles, where it is deflected through an angle of 60, 90,120,180. 5. When ions of mass m & charge e pass through an accelerating electric field, they would attain velocity v which can be expressed in term of accelerating voltage V,as **½ mv2 =eV** Where ½ mv2 is kinetic energy of ion as it leaves in electric field 6. If the ions next enter a magnetic field of constant intensity h, which is applied at right angles to their direction of motion, the ions would be diverted into circular orbits. Therefore the magnetic sector follows an arc. 7. At the detector, voltage output is obtained, which is used to have mass spectrum of element.	**03 Marks for diagram** **03 Marks for explanation**	
2	**Attempt any four:**		**16**
a)	**Draw the block diagram of flame photometer and explain its working.**		**04**
Ans.	**Principle:** It is based on the fact that if an atom is excited in a flame to high energy level, it will emit light as it returns to its former energy level. By measuring the amount of light emitted we can measure the nos of atoms excited by the flame.	**02 Marks for diagram**	



OR



Explanation of each block is as follows:

The flame photometer consists of three essential parts

1) Emission system.
2) Optical system.
3) Recording system.

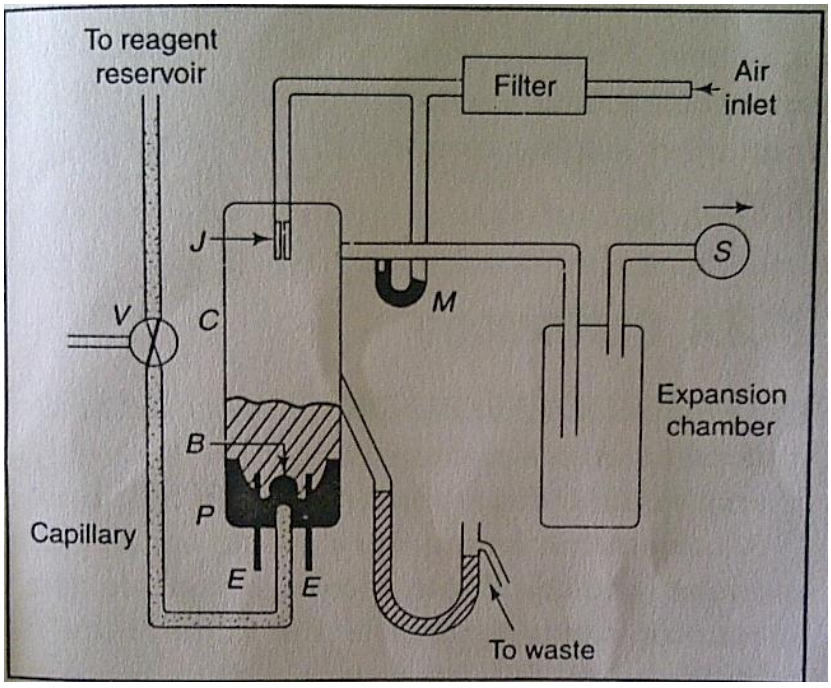
02 Marks for explanation

1) Emission system: It has other parts.
   a. Fuel Gases and Regulator.
   b. Automizer
   c. Burner
   d. Flame.

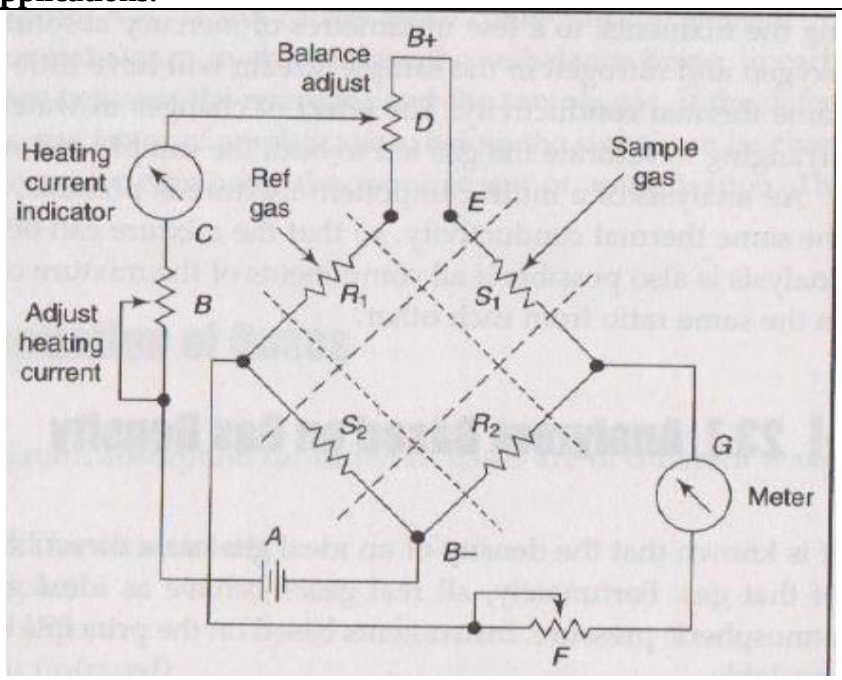
a) Fuel Gases and their Regulation

Pressure Regulators: In order to obtain a steady emission reading, it is

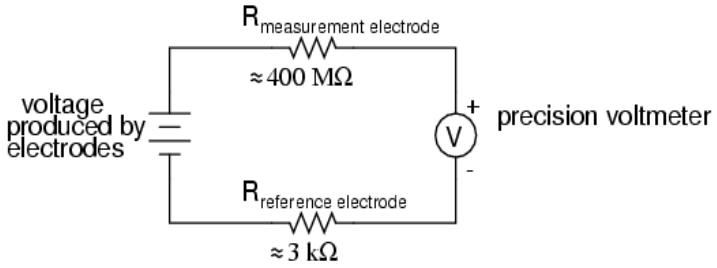
	needed to have steady flame. In order to achieve this, the air or oxygen and fuel pressure has to be maintained constant during the operation of the instrument. Suitable pressure gauges are therefore provided in the instrument to indicate the pressure that is actually present in the line. The fuel gas normally used in flame photometry is acetylene gas, which is commercially available in cylinders of various sizes. **b) Atomizer:** It is a system used to form aerosol (drop of liquid) by breaking atoms of liquid into small drops. This little device is responsible for introducing the liquid sample into the flame at a stable and reproducible rate. The atomizer must not be attacked by corrosive solutions. **c) Burner:** The burner brings the fuel, oxidant and sample aerosol together so that they may react safely and produce a good flame. **d) Flames:** It forms the source in which the light radiations characteristics of sample elements are produced. 2) **Optical system:** the emitted light by flame is passed through filters, monochromators and focused on photo detector. This detector converts light energy into electrical signal. 3) **Recording system:** electrical signals o/p of detector is recorded or indicated using suitable photometer recorders using amplifier.		
b)	**Classify liquid chromatography. State any 2 applications of liquid chromatography.**		**04**
Ans.	**Classification Liquid chromatography**: a. Paper chromatography b. Column chromatography i. Liquid/Liquid (partition) chromatography. ii. Liquid/Solid (adsorption) chromatography. iii. Gel permeation chromatography. iv. Ion exchange chromatography. c. Thin layer chromatography. **Applications of liquid chromatography (Any two)** 1. Biochemical Screening for Genetic Disorders, 2. Analysis of biological fluids, 3. Therapeutic Drug Monitoring and Toxicology, 4. R&D in pharmaceutical industries, 5. Vitamins and Related Metabolites, 6. Steroid Hormones	**02Marks for classification** **01 Mark for each application**	
c)	**Explain conductivity measurement techniques for gas pollutants.**		**04**
Ans.	**Conductivity method for measurement of SO2 in air :** When air sample containing SO2 (sulphur dioxide) is passed through a solution consisting of sulphuric acid and hydrogen peroxide, its electrical conductivity changes due to formation of sulphuric acid by oxidation of SO2.	**02 Marks Explanation**	

	$H_2O_2+SO_2 \rightarrow H_2SO_4 \rightarrow H^+ + (HSO4)^-$ Conductivity cell is used for continuous measurement of SO2 in the air. It is made of glass, consists of a jet **J**, and orifice near the jet. It consists of 2 electrodes **E**, made of stainless steel wire. It is inserted through a cap **P**. The cap is sealed to the base of the cell. Reagent enters the cell from a central feed tube inserted in the cap. A small glass bead **B** in the cell acts as a non return valve on the entry of the central feed tube and prevents sulphuric acid diffusing from the cell.The end of the jet is made from a piece of capillary tube. A filter is placed before the jet to prevent blocking due to solid material. Since the cell is of small size, its capacity to absorb SO2 is limited. Therefore electrolyte is discharged and replaced at regular intervals.5 V AC is applied to the cell to measure the conductivity. AC avoids polarization. The resulting output current is recorded as saw-tooth waveform. Concentration of SO2 at any instant is proportional to slope of saw-tooth at that instant  **OR** **Any other conductivity measurement techniques for gas pollutants with suitable diagram should be considered.**	**02 Marks diagram**	
d)	**What do the abbreviation GCMS and LCMS stands for? State two application of each.**		**04**
Ans.			

	GCMS: Gas Chromatography- mass spectrometry, GCMS is chemistry technique that combine the physical separation capabilities of gas chromatography with the mass analysis capabilities of mass spectrometry **LCMS:** Liquid chromatography–mass spectrometry, LCMS is a chemistry technique that combines the physical separation capabilities of liquid chromatography with the mass analysis capabilities of mass spectrometry. LC-MS is a powerful technique used for many applications which has very high sensitivity and selectivity. Generally its application is oriented towards the general detection and potential identification of chemicals in the presence of other chemicals (in a complex mixture). **Application**: **GCMS:** 1) In bio chemical analysis in medicine and other field. 2) In studying respiratory physiology in routine clinical investigation of patients breathing cycle. 3) Analysis of lighter hydrocarbon. **LCMS:** 1) Preparative LC-MS system can be used for fast and mass directed purification of natural-products extracts and new molecular entities important to food, pharmaceutical, agrochemical and other industries. 2) Detection and measurement of concentration of pollutant in air and water **3)** In refineries for analysis of lubricating oil.	**01 Mark** **01 Mark** **01 Mark for any one application** **01 Mark for any one application**	
e)	**Define Chemiluminescence. How is measurement of nitrogen oxides done using chemiluminescence?**		**04**
Ans.	**Definition:** The phenomenon of emission of radiation from chemi-excited species is known as Chemiluminescence. It results due to the formation of new chemical bonds. The species in the excited state possess higher energy levels than the ground state and usually have a very short life. **Nitrogen oxide measurement using Chemiluminescence:** 1. Chemiluminescence phenomenon is very useful for measurement of air pollutants, particularly NO and NO_2. 2. Instruments based on the measurement of chemiluminescent emission, based on the following reaction have been developed: $NO + O_3 \rightarrow NO_2 + O_2$ $NO_2 \rightarrow NO_2 + h\upsilon$ (λ max =6300 Å) 3. Since NO_2reacts only slowly with ozone and the reaction which produces NO_3 is not accompanied by Chemiluminescence, it is necessary to reduce to	**01 Mark for Definition** **03 Marks for explanation**	

	NO_2 to NO before admission into the reactor $NO_2 \rightarrow NO + ½ O_2$ 4. Nitric oxide and ozone containing gas steam are mixed in a vessel at a sub atmospheric pressure of about 2 mm of Hg. 5. Light emission is measured with a photomultiplier. 6. With the use of high gain, low dark current photomultiplier tubes, extremely low levels of radiation can be measured. 7. The response of the instruments based on Chemiluminescence is linear from 1 ppb to 1000ppm of NO. 8. This technique is extremely useful for measurement of NO in automotive exhaust gases.		
f)	**Explain the working principle of thermal conductivity analyzer. List any two applications.**		**04**
Ans.	 **Working:** In a typical hot-wire cell thermal conductivity analyzer; four platinum filaments are employed as heat sensing elements. They are arranged in a constant current bridge circuit and each of them is placed in a separate cavity in a brass or stainless steel block. The block acts as a heat sink. The material used for construction of filaments must have a high temperature-coefficient of resistance. The materials generally used for the purpose include tungsten, Kovar (alloy of co,Ni and Fe) or platinum. Two filaments connected in opposite arms of the Wheatstone bridge act as reference arms, whereas the other two filaments are connected in the gas stream, which act as measuring arms. The use of a four-cell arrangement	**03 Marks for Diagram and Explanation**	

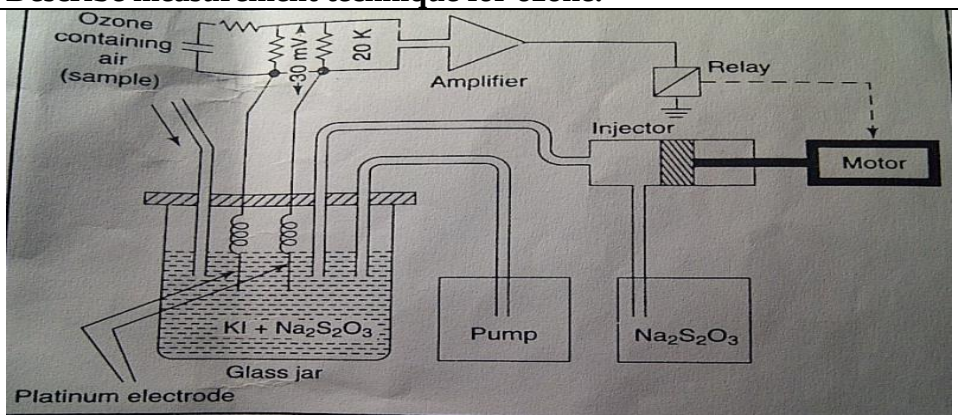
	serves to compensate for temperature and power supply variations. Initially, reference gas is made to flow through all the cells and the bridge is balanced precisely with the help of potentiometer D. When the gas stream passes through the measuring pair of filaments, the wires are cooled and there is a corresponding change in the resistance of the filaments. The higher the thermal conductivity of the gas, the lower would be the resistance of the wire and vice versa. Consequently, the greater the difference in thermal conductivities of the reference and sample gas, the greater would be the unbalance of the Wheatstone bridge. **(NOTE: thermal conductivity analyzer using thermistor can be considered)** **Applications of Thermal Conductivity analyser:** 1. In oil industry for detection of hydrocarbon. 2. In medical field for lung function testing equipment. 3. In gas chromatography 4. For monitoring of hydrogen purity in hydrogen cooled turbo generator 5. Detection of helium loss from helium vessel of an MRI superconducting magnet	**01 Mark for any two applications**	
3	**Attempt any FOUR :**		**16**
a)	**State Beer Lambert's law. Give its mathematical expression.**		**04**
Ans.	**Statement:** Beer Lambert Law, states the relationship between absorbance (A) and transmittance (T). It states that the concentration of a substance in solution is directly proportional to the 'absorbance', A, of the solution. Absorbance A = εcb Where, A = absorbance (ε = molar absorptivity c = molar concentration b = path length Mathematically, absorbance is related to percentage transmittance T by the expression: $A=\log10(I0I) = \log10(100T) = \varepsilon bc$	**02 Marks for statement** **02 Marks for expression**	
b)	**List any four applications of NMR.**		**04**
Ans.	**Applications of NMR:(any four)** 1) NMR is used in magnetic resonance imaging in medical diagnosis 2) By studying peak of nuclear magnetic spectra, chemist can determine structure of chemical compound. 3) NMR is extremely used for analysis of sample nondestructively. 4) NMR is used for data acquisition in petroleum industry and natural gas exploration and recovery.	**01 mark for each application**	

	5) NMR is used in process control and process optimization in oil refineries and petrochemical plant. 6) It is a complex system integrating several technologies. 7)In medical field 8)Structural determination of flavors 9) fragrance in gradient Food industry 10) Chemical research & development of organic product. 11) Pharmaceutical production. 12) Analysis of Polymers. **Note: any other relevant four applications should be considered.)**		
c)	**Explain the working of null detector type pH meter.**		**04**
Ans.	**Diagram of null-detector type pH meter:**  **OR** **Other relevant diagram shall be considered.** **Working of null-detector type pH meter:** 1) The null-detector type pH meter is uses a potentiometric 'null-balance' method. 2) Fig shows the principle of this method in which the voltage output between a pair of pH electrodes is measured without drawing any current from the circuit under test. 3) In the circuit, the emf developed on the pH electrodes is shown along with series resistors of both the glass electrode and reference electrode. 4) The Precision voltage can be adjusted until the null detector shows zero. 5) The reading on the voltmeter connected in parallel with the precision voltage would show the electrode potential representing pH of the solution. 6) At the 'null' condition, there would be zero current in the pH electrode circuit and therefore no voltage drop across the resistances of either electrode, giving the real electrode voltage at the voltmeter terminals. 7) The pH value is read from the calibrated precision voltage source dial marked in pH units	**02 Marks for Diagram** **02 Marks for explanation**	
d)	**Compare Gas chromatography and Liquid chromatography (four**		**04**

	points).		
Ans.		**01 Mark for each comparison**	

Gas chromatography	**Liquid chromatography**
In this mobile phase gas is used.	In this mobile phase liquid is used.
Types are gas / liquid & gas / solid	Types are paper , column and thin layer.
Detectors used are as thermal conductivity detector , flame ionized detector,flame photometric detector etc.	Detectors used are UV spectrophotometric detector , florescence detector , RI detector
He, Ar, Ne gases may be Used as carrier.	Volatile solvents, Eluent solution are used as carrier.
Accuracy is more.	Accuracy is less.
Technique is simple	Technique is complicated.
Takes less time.	Takes more time

(NOTE: Any other relevant four points should be considered.)

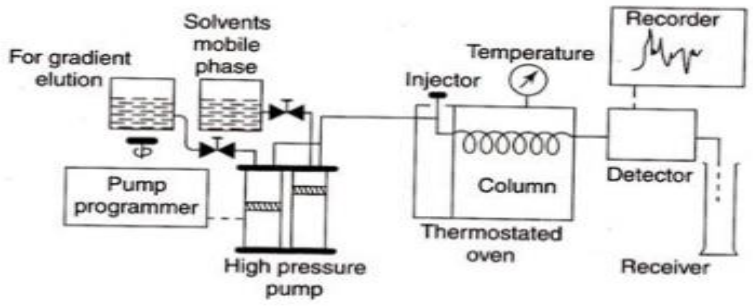
e)	**Describe measurement technique for ozone.**		**04**
Ans.		**02 Marks for Diagram**	

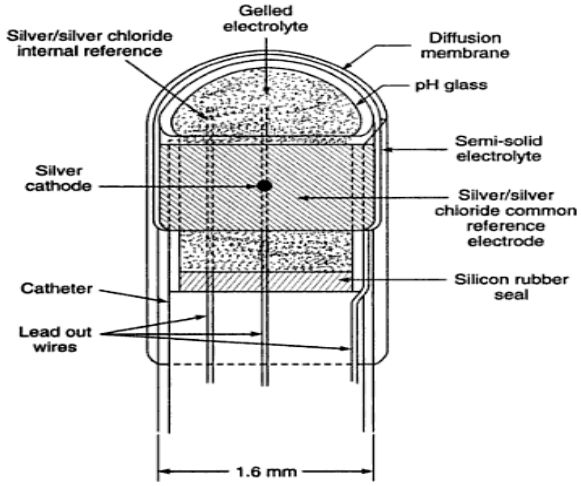
A wet chemical method which uses the oxidizing properties of O3 is employed to sensitive meter for continuous sampling of contaminating oxidants in atmosphere. The ozone containing air is bubbled into potassium iodide solution and resulting iodine determined by measuring current through the cell. The current is related to ambient O3 levels by previous calibration with known ozone source. Thus construct air-ozone meter which measures and records instantaneous ozone concentrations.

02 Marks for Explanation

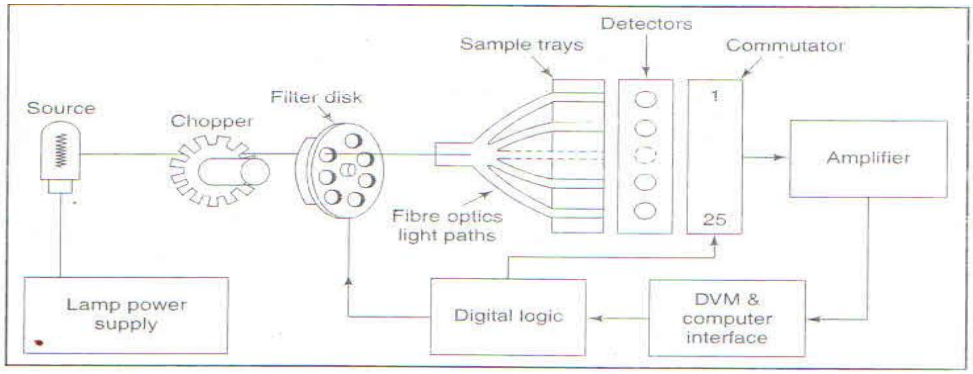
The arrangement is as shown in figure.

- It consist of an hermetically sealed glass jar containing 150 cm3 of buffered 10 % KI solution and 0.5 cm3 sodium thiosulphate of known concentration.
- Two spiral platinum electrodes dip into the solution and bias voltage of 30mV is applied across them. The air above the solution is evacuated.

	• When ozone enters the solution the following reaction takes place • $O_3+2I+H_2O \rightarrow I_2+O_2+2OH^-$ iodine then reacts with thiosulphate $I_2+2(S_2O_3)^- \rightarrow 2(I^-)+S_4O_6^{--}$ • Reaction continues so long as there is thiosulphate in the solution. When all the thiosulphate has been reacted, free iodine appears and reacts at the electrodes. • The electrical resistance is high as long as there is an excess of thiosulphate. The resistance decreases when it is used up. This change is used to control the operation of instrument. • The voltage drop across 20kohm resistance which is in series with the electrode is used to operate the recorder as well as relay which controls a motorized injector which injects $0.5cm^3$ thiosulphate in each operation. • The recorder serves mainly to indicate as to when the injection was made and thus the average ozone concentration between any two injections can be calculated. Since the pumping rate is known, knowledge of the time intervals gives the total volumes of air sample.		
4 (A)	**Attempt any THREE:**		**12**
(a)	**Draw a neat block diagram of liquid chromatography. What is the role of high pressure pump in it?**		**04**
Ans.	**Diagram of Liquid chromatography:**  **OR** **Any Other relevant diagram shall be considered.** **Role of high pressure pump in Liquid chromatography** • Liquid Chromatography uses smaller diameter columns filled with fine mesh particles which need high pressure solvent delivery system. Constant flow pumps and constant pressure pumps are commonly used. • High pressure is required to yield the desired flow rate, So LC need high pressure pumps. • The pressure of carrier in LC is typically 1000psig at flow rate of 1 ml /min. This is done by high pressure pump either air driven pump	**02 Marks for Diagram** **02 Marks for explanation**	

	or motor driven pump.		
(b)	**State any four drawbacks of IR analyzer**		**04**
Ans.	Drawbacks of IR analyzer :**(Any four relevant points)** • With IR analyzer, it is not possible to know molecular weight of substance. • It is not frequently non-adherence to Beer's law of complexity spectra. • The narrowness of spectra and effect of stray radiations make the measurements of absorbance upon slit width and wavelength setting. • Generally, IR analyzer does not provide information of relative positions of different functional groups on molecule. • From spectrum of unknown substance, it is not possible to know whether it is pure compound mixture of compound.	**01 Mark for each drawback**	
(c)	**Draw a labeled diagram of electrode which can measure PO_2 and PCO_2 of blood. Explain its working.**		**04**
Ans.	**Diagram of electrode which can measure PO_2 and PCO_2 of blood.**  **OR** **Any other relevant diagram & explanation should be considered.** • These are the miniature electrodes for in vivo transcutaneous measurement of blood PCO_2 & PO_2. The electrodes are small enough to be mounted on the catheter tip and able to perform more than one parameter i.e measurement of blood PCO_2 & PO_2. • The electrode consists of pH sensitive glass bulb at the tip of catheter for measurement of blood PO_2 and silver cathode electrode for measurement of blood PCO_2. Silver/ silver chloride is the common electrode. A semisolid electrolyte is common for both PCO_2 & PO_2 electrodes. • The electrodes are dip-coated with a thin polystyrene diffusion	**02 Marks for Diagram** **02 Marks for Explanation**	

	membrane. When the device is placed in blood, water vapours diffuse through the membrane. • This, together with NaHCO3 & NaCl crystals deposited in the hydgrogel film, constitute the electrolyte for PCO_2 electrode. Under these conditions, the output signal from both PCO_2 & PO_2 electrodes is thus obtained.		
(d)	**Define i)Nuclear spin ii)Resonance level iii)Chemical shift iv)spectrometer**		**04**
Ans.	**Nuclear Spin:** Elementary particles such as electrons or a nucleus behaves as if they rotate about an axis possesses the property of spin known as nuclear spin. The angular momentum is associated with the spin of particle would be an integral or half integral multiple of h/2π where, h is planck's constant. **Resonance level:** When an alternating RF field, superimposed over the stationary magnetic field, rotates at exactly the frequency of an energy level, the nuclei will be provided enough energy to undergo a transition from lower energy level to a higher energy level. In general Energy difference between states is given by, $\Delta E = \mu\beta.Ho/I$ Where, Ho = strength of external magnetic field in gauges B = constant called the nuclear magneton, 5.049 × 10-24 ergs μ = magnetic moment of the particle expressed in units of nuclear magnetons The frequency, ν of radiation determine from Planck's equations $\Delta E = h\nu = \mu\beta.Ho/I$ **Chemical shift:** This is the phenomenon that occurs in some atoms like Carbon or hydrogen in a given molecule which resonate at slightly different frequency based on its local chemical environment so this difference in resonance frequency is called as chemical shift. Chemical shift is expressed as $\delta = \frac{Frequency\ of\ sample - Frequency\ of\ reference}{Spectrometer\ frequency} * 10^6$ $\delta = \frac{H\ sample - H\ TMSi}{H1} * 10^6$ **Spectrometer:** It is an analytical instrument that helps to identify the amount and type of chemical present in a sample of measuring the mass to charge ratio and abundance of gas –phase ions.	**01 mark for each definition** **(equations are not compulsory)**	

B)	**Attempt any ONE:**		**06**
(a)	**Describe how measurement of carbon monoxide is done using gas chromatography.**		**06**
Ans.	• When an air sample containing CO is passed through a stripper column, the heavy hydrocarbons are retained and CO and methane are passed into chromatographic column and then into a catalytic reducing chamber. • The methane would pass through the reducing chamber unaffected while CO is reduced to methane. • By using flame ionization detector both methane peaks can be detected. • The first peak is due to methane. • The second peak would correspond to CO. • The accuracy is about +-2%.peak heights of CO and CH4 would gives sensitivity of 50 ppb.	**06 Marks for explanation**	
(b)	**Explain the working principle and construction of multichannel photometer with a neat diagram.**		**06**
Ans.	**Diagram of multichannel photometer:**  **Working Principle:** • The light source of 50Wtungsten halogen lamp is controlled by a voltage source. • The light is chopped by a mechanical rotating chopper. • The colour filter selects a suitable wavelength, the filter is used to block the higher ordered wavelength. • A lens focuses the light on the end of a bundle of fiber optic elements. • The sample is kept at the end of this. At a time 24 samples are analyzed. • Therefore 24 samples covets are arranged in a rack of 3*8 matrix. • The 25th channel serves as a reference beam and eliminates possible source and detector drifts. • The output of detector is amplified and displayed on DVM. The	**03Marks for Diagram** **03Marks for Explanation**	

digital logic circuit is used to synchronize the whole operation.

5 Attempt any FOUR : **16**

a) Differentiate between colorimeter and spectrometer. **04**

Ans.

Sr no	Colorimeter	Spectrometer
1	It is a device used for measurement of absorption of particular wavelengths of light by a specific solution. In its simplest form, it uses only human eye as the measuring instrument.	It is an instrument that provides information about the intensity of radiation as a function of wavelength or frequency.
2	Here comparison is made by obtaining a match between the colour of the unknown solution and that of a particular standard solution by visual method.	Here photoelectric measurement methods are used.
3	It is simple in construction and operation	More complex than colorimeter.
4	It works with only light in the visible part of electromagnetic spectrum.	It works with infrared, ultra violet and visible light.
5	It is used for analytical work where high accuracy is not required.	As it provides spectral analysis of a given sample it is suitable for applications in research and development phase.
6	less costly	More expensive as it performs many complex functions.

01 mark for each comparison

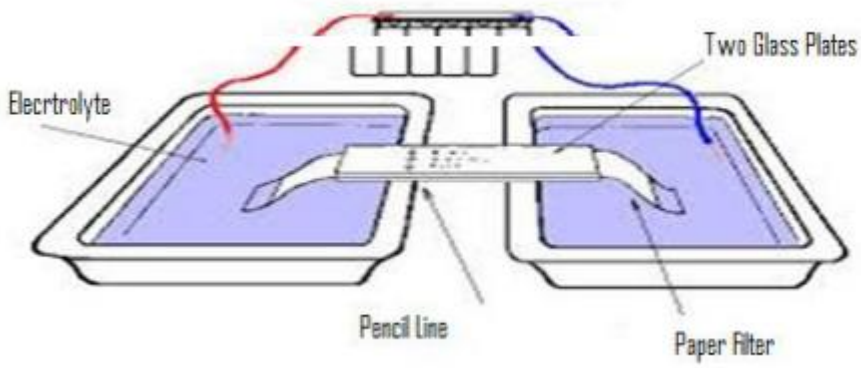
(Any four points)

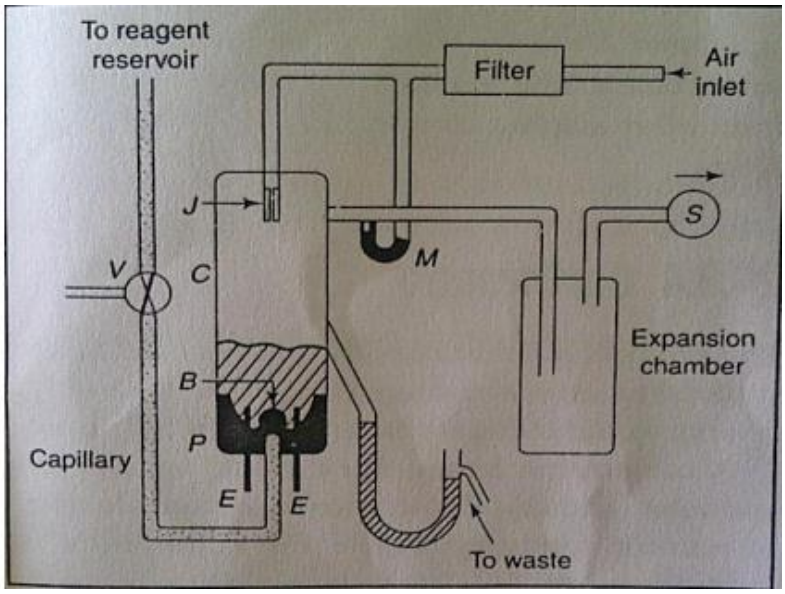
OR

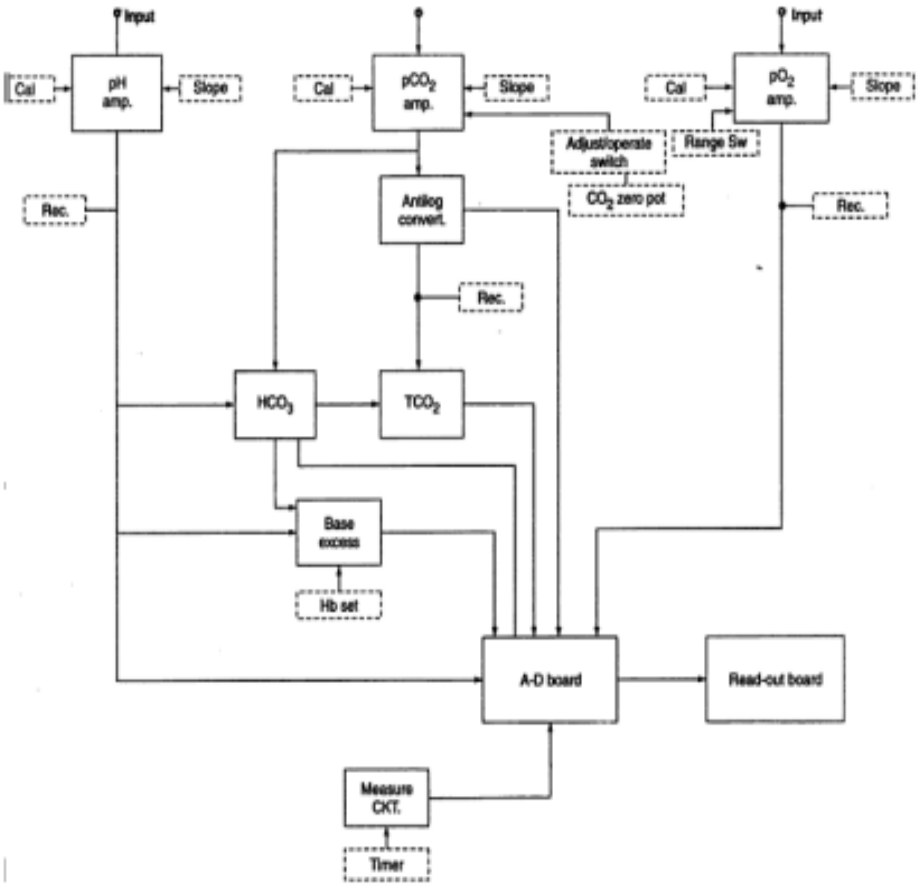
Any other relevant four points should be considered

b) Draw the block diagram of paper electrophoresis. Explain its working. **04**

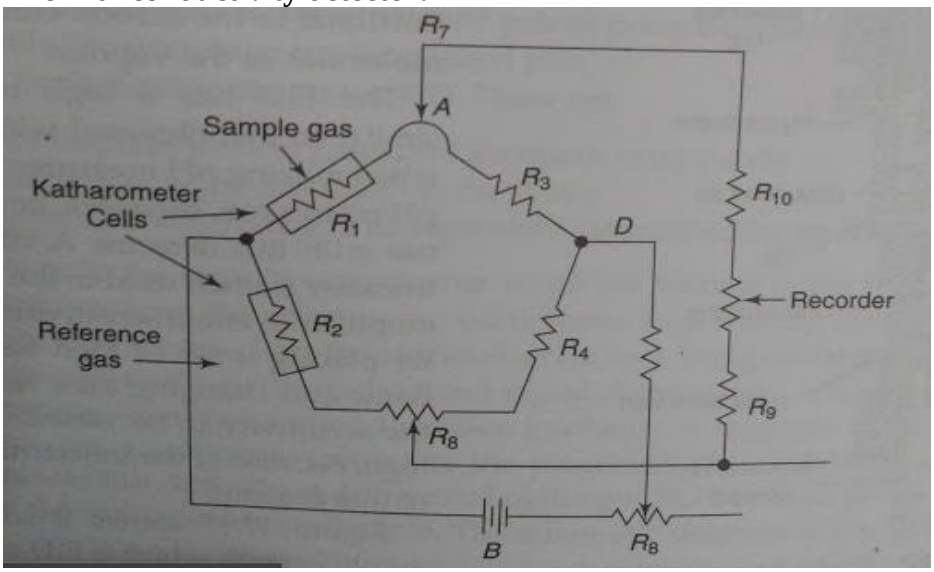
Ans.

	 Paper electrophoresis is a separation technique in which the separation of different particles occur on a piece of filter paper that is saturated with an electrolyte. The equipment used for electrophoresis basically consists of a power pack and an electrophoretic cell. The power pack provides a stabilized DC current and has controls for both voltage and current output which have an output of 0-500V and 0 – 150 mA available. The electrophoretic cell contains electrodes, buffer reservoirs, a support for paper and a supporting transparent insulating cover. The electrodes are usually made of platinum. The filter strips can be arranged horizontally or vertically depending upon the need. The filter paper used should be of good quality and have very slight adsorption capacity. **Procedure:** A strip of filter paper is moistened with buffer and the ends of the strip are immersed into the buffer reservoirs containing the electrodes. The samples are spotted in the center of the paper. When high voltage is applied, the spots migrate according to their charges. After the process of electrophoresis is over, the separated components can be detected by a variety of staining techniques depending upon their chemical identity. **OR** **Any other relevant block diagram & Explanation should be considered**	**02 Marks** **For diagram** **02 Marks for explanation**	
c)	**Explain any one technique for measurement of SO_2 concentration in air.**		**04**

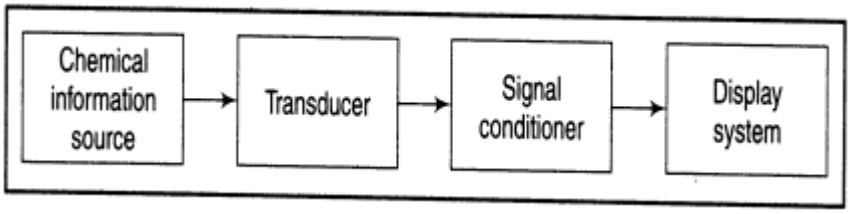
Ans.	Conductivity method for measurement of SO_2 concentration in air.  Principle: When an air sample containing SO_2 is passed through a solution containing sulphuric acid and hydrogen peroxide, its electrical conductivity changes due to formation of sulphuric acid by oxidation of SO_2. $H_2O_2+SO_2 \rightarrow H_2SO_4 \rightarrow H^+ + (HSO4)^-$ The diagram above represents a conductivity cell used for continuous measurement of SO_2in the air. It is made of glass, consists of a jet J, and orifice near the jet. It consists of 2 electrodes E, made of stainless steel wire inserted through a Perspex cap P. The cap is sealed to the base of the cell. Reagent enters the cell from a central tube inserted in the cap. A small glass bead B in the cell acts as a non return valve on the entry of the central feed tube and prevents sulphuric acid diffusing from the cell. The end of the jet is made from a piece of capillary tube. A filter is placed before the jet to prevent blocking due to solid materials. The cell is of small size, so its capacity to absorb $SO_2$is limited. Therefore it is operated intermittently and the electrolyte is discharged and replaced at regular intervals of 15 minutes.5 V AC is applied across the electrodes to measure the conductivity of the cell. AC current avoids polarization. The resulting output current is recorded as saw-tooth waveform. As the current is recorded every 15 minutes, the concentration of SO_2at any instant is proportional to slope of saw-tooth at that instant.	**02 Marks for diagram** **02 Marks for explanation**	

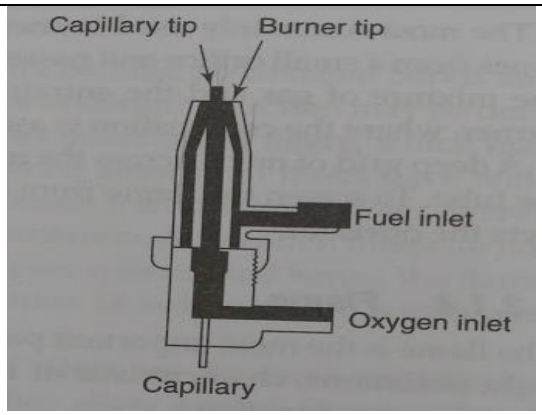
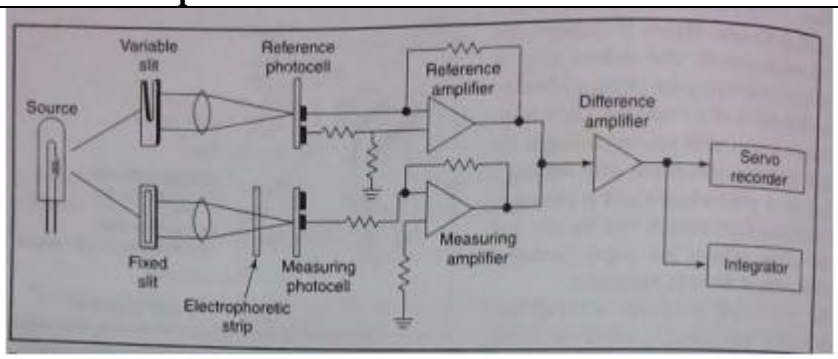
d)	**Draw a neat block diagram of complete blood gas analyzer and explain it.**		**04**
Ans.	 Blood gas analyzers are designed to measure pH, pCO_2 and pO_2 from a single sample of whole blood. With built in calculators they also calculate total CO_2 , (HCO_3^{-}) and base excess. In the block diagram there are separate sensors for pH, PCO_2 and PO_2 measurement. There are three separate high input impedance amplifiers designed to operate in the specific range of each measuring electrode. A separate module houses and thermostatically controls the three electrodes. Two gases of accurately known $O_2$and CO_2 percentage are used to calibrate the analyser in PO_2 and PCO_2 mode. Two standard buffer solutions of known pH are used to calibrate the analyser in the pH mode. The input signal to (HCO_3^{-}) calculator comes from the outputs of pH and PCO_2 amplifiers.	**02Marks for diagram** **02 Marks for explanation**	

	The outputs are adjusted by multiplying each signal by a constant and given to an adder. The next stage is an antilog-generator and output of this circuit is given toA-D converter for display. Total CO_2 is calculated by summing the outputs of (HCO_3^-) calculator and output of PCO_2 amplifier. The base excess calculator consists of 3 stages. In the first stage, the output of the pH amplifier is inverted in an operational amplifier whose gain is controlled with a potentiometer (Hemoglobin value) placed in the front panel. The output of the (HCO_3^-)calculator is inverted in the second stage . The third stage is assuming amplifier A_3 whose output is given to A-D converter. This o/p is given to display unit for read out the measurement		
e)	**Define (i)Environment (ii) Pollutant (iii)Air pollution (iv)Acid rain**		**04**
Ans.	**(i)Environment:** The sum total of all surroundings of a living organism, including natural forces and other living things, which provide conditions for development and growth as well as of danger and damage is called environment. **OR** The surroundings or conditions in which a person, animal, or plant lives or operates is called environment. **(ii) Pollutant:** A pollutant is a substance or energy introduced into the environment that has undesired effects, or adversely affects the usefulness of a resource. It may cause long- or short-term damage by changing the growth rate of plant or animal species, or by interfering with human amenities, comfort, health, or property values. **(iii)Air pollution:** Air pollution is the introduction of particulates, biological molecules, and many harmful substances into Earth's atmosphere, causing diseases, allergies, death to humans, damage to other living organisms such as animals and food crops, or the natural or built environment. **OR** Air pollution is the contamination of air by smoke and harmful gases, mainly oxides of carbon, sulphur, and nitrogen. **(iv)Acid rain** **Acid rain** is a rain or any other form of precipitation that is unusually acidic,	**01 Mark for each definition**	

	meaning that it possesses elevated levels of hydrogen ions (low pH). It can have harmful effects on plants, aquatic animals and infrastructure. Acid rain is caused by emissions of sulfur dioxide and nitrogen oxide, which react with the water molecules in the atmosphere to produce acids. **OR** **Acid rain** is a rainfall made so acidic by atmospheric pollution that it causes environmental harm, chiefly to forests and lakes. The main cause is the industrial burning of coal and other fossil fuels, the waste gases from which contain sulphur and nitrogen oxides which combine with atmospheric water to form acids.		
f)	**Name the detectors used in gas chromatography. Explain any one in detail.**		**04**
Ans.	The various detectors used in gas chromatography are: (Any two) • The katharometer or thermal conductivity detector • Flame ionization detector • Flame photometric detector • Photoionization detector • Electron capture detector • Argon ionization detector • Cross section ionization detector • Atomic emission detector • Chemiluminiscence spectroscopy-based detector • Nitrogen-phosphorus detector **Thermal conductivity detector:**  	**01 Mark for naming the types** **03 Marks for any one type with diagram and explanation**	

	It is a simple and widely used detector. It is based on the principle that all gases have the ability to conduct heat in varying degrees. The difference in heat conduction is used to determine quantitatively the composition of a mixture of gases. It consists of two temperature sensing elements, one in the reference and another in the reference arm of a Wheatstone's bridge. In the circuit shown R_1 and R_2 are the Katharometer wires, R_3 and R_4 are the ratio arms of the bridge, R_7 and R_8 are used for base-line adjustments. Under balanced conditions, when carrier gas is flowing through the two cells, no current flows between A and C, and $R_1/R_2 = R_3/R_4$ WhenR_1 changes due to the components of sample gas, unbalance current flows through A&C. The magnitude of current helps to detect and measure the magnitude of gas component vapour passing over the measuring cell. **OR** **Any other relevant one type of detector diagram & explanation should be considered**		
6	**Attempt any FOUR :**		**16**
a)	**State the basic principle time of flight mass spectrometer.**		**04**
Ans.	Ions of different mass/charge ratio are separated by the time taken by them to travel over an identical path from ion source to the collector. When ions are accelerated by electric field of known strength, they traverse through an evacuated tube called drift tube and arrive at the detector which is sensitized for a brief instant to register their arrival. Velocity of the ions depends on the mass to charge ratio. Heavier ions of the same charge will travel at lower speeds. So, ions of different masses arrive at the detector at different times. The accurate measurement of the time between activating the source and sensitizing the detector gives the information about the mass of ions. **(NOTE: Diagram is optional)**	**04 marks**	
b)	**Explain the elements of analytical instruments with the help of a block diagram.**		**04**

Ans.	 Analytical instruments are used to provide information about the composition of a sample of matter. They are made up of the following basic blocks: **1.Chemical information source:** It generates a set of signals containing necessary information. The source may be in the sample itself. For example, yellow radiation emitted by heated sodium atoms constitutes the source of the signal in a flame photometer. **2. Transducer:** Transducer converts signal from one form to another. Because of the advantages of electric and electronic methods of measurement, it is the usual practice to convert all non-electrical quantities associated with the analysis of a sample into electrical form. **3. Signal conditioner:** Signal conditioner converts the output of the transducer into electrical quantity suitable for operation of display system. Signal conditioner may be varying in complexity from a simple resistance network or impedance matching device to multi-stage amplifiers and other electronic circuit. **Display system:** It provides a visible representation of the quantity as a displacement on a scale or on the chart of a recorder or on the screen of a CRT or in numerical form.	**02 Marks for block diagram** **02 Marks for explanation**	
c)	**Explain the working of integral burner type atomizer with a neat diagram.**		**04**

Ans.	 In this type of atomizer, the sample solution is directly introduced into the flame. The unit is made of glass or metal and comprises of two concentric tubes. The sample solution is drawn through the innermost tube by the passage of oxygen through the orifice of the inner annulus. At the tip of the inner sample capillary, the liquid is sheared off and dispersed into droplets. The outer annulus supplies the combustible gas to the flame. All droplets both small and large are directly introduced into the flame. Sample consumption is about0.8 to2 mi/min.	**02 Marks for diagram** **02 Marks for explanation**	
d)	**Draw and explain double beam densitometer.**		**04**
Ans.	 The main problem with densitometer using single photocell is its instability against line fluctuations. This is overcome by using a double beam densitometer with facilities for automatic recording. Here any fluctuation in lamp intensity is received simultaneously by both photocells, so the effect is automatically nullified. The figure above represents a double beam densitometer. It has two photo cells. One of the photocells acts as a reference photo cell. It receives light directly from the source lamp through a variable slit. The second photocell called the measuring photocell receives light through the	**02 Marks for diagram** **02 Marks for explanation**	

	fixed slit after passing through the stained electrophoretic paper strip. The stained electrophoretic paper strip is made translucent by prolonged immersion in a mixture of paraffin oil and bromonaphthalene. Initially the zero optical density is set on the recorder or meter by allowing light to pass through the translucent portion of the stained paper placed in front of the measuring photocell. Then the stained paper is made to move across the light source and the recorder will trace curves on the graph paper according to the concentration of the protein samples. The photocells are connected electrically such that the net output from them is the difference between the photo voltages of the two cells. Electronic integrators are used for measuring peak heights and results are available directly in concentration.		
e)	**What is the significance of column length in GC ?**		**04**
Ans.	A chromatographic column is the heart of a chromatograph where the fundamental process of separation takes place. When a sample of gas or vapour is introduced into the column, it spreads by molecular diffusion to yield a concentration profile. As the sample moves up the shape of the band is detected and recorded as chromatographic peak. A longer column length improves the process of separation. The column efficiency is a function of column length. Longer the column, greater is the efficiency. Doubling the length increases the resolution by 40%.	**04 Marks**	