BLOOD GAS ANALYZERS

Blood gas analyser are mainly used to measure the partial measures of hydrogen, carbon dioxide and oxygen present in the human blood.

PH MEASUREMENT

The chemical balance in the body can be determined by the ph value of blood and other body fluids.ph is defined as the hydrogen ion concentration of a fluid. It is the logarithm of the reciprocal value of h+ concentration. The ph equation is given as,

$$Ph= - \log_{10} [H^+] = \log_{10} 1/[H^+]$$

pH is the measure of acid- base balance in a fluid, A neutral solution has the ph value as 7. Solutions with pH value less than 7 are acidic and above 7 are basic. Most of the body fluids are slightly basic in nature.

Construction and working

The ph meter is made up of a thin glass membrane and it allows only the hydrogen ions to pass through it. The glass electrode provides a membrane interface for H+ ions. The glass bulb at the lower end of the ph meter contains a highly acidic buffer solution. The glass tube consists of a sliver-sliver chloride (Ag/Agcl) electrode and the reference electrode which is made up of calomel sliver-sliver chloride (Ag/Agcl) is tan placed in the solution in which ph is being measured.

The potential is measured across the two electrodes. The electrochemical measurement, which should be obtained by each of the electrodes called half- cell. The electrode potential is called as half-cell potential. Here the glass electrode inside the tube constitutes one half –cell and the calomel or reference electrode is considered as the other half-cell. The figure shows the pH electrode.

For easier ph measurement combination electrodes are used. In this type both the active glass electrode and reference electrode are present in the same meter. The glass electrodes are suitable only to measure ph values around 7. Since this type of glass electrodes produce considerable errors during the measurement of high Ph values, special type of Ph electrodes is used. After every measurement the pH meter is washed with 20% ammonium difluoride solution, for accurate results. The Ph meter with hydroscopic glass absorbs water readily and provides best pH value.

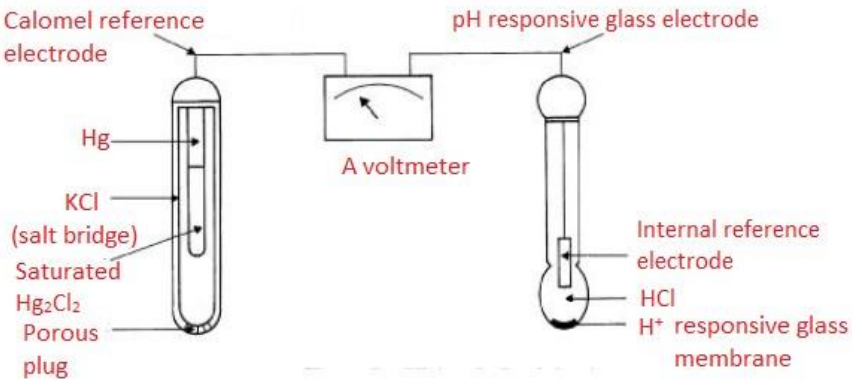


Fig: pH Electrode

PO_2 MEASUREMENT

The term PO_2 is defined as the partial pressure of oxygen respectively. The determination of PO_2 is one the most important physiological chemical measurement. The effective functioning of both respiratory and cardiovascular system can be by PO_2 measurement. The partial pressure of a gas is proportional to the quantity of that gas present in the blood.

The platinum wire, which is an active electrode, is embedded in glass for insulation and only its tip is exposed. It is kept in the electrolyte solution in which the oxygen is allowed to diffuse. The reference electrode is made up of silver-silver chloride (Ab/AgCl). A voltage of 0.7 is applied between the platinum wire and the reference electrode. The negative terminal is connected to the active electrode through a micro ammeter and the positive terminal is given to the reference electrode. The below figure shows PO_2 Electrode.

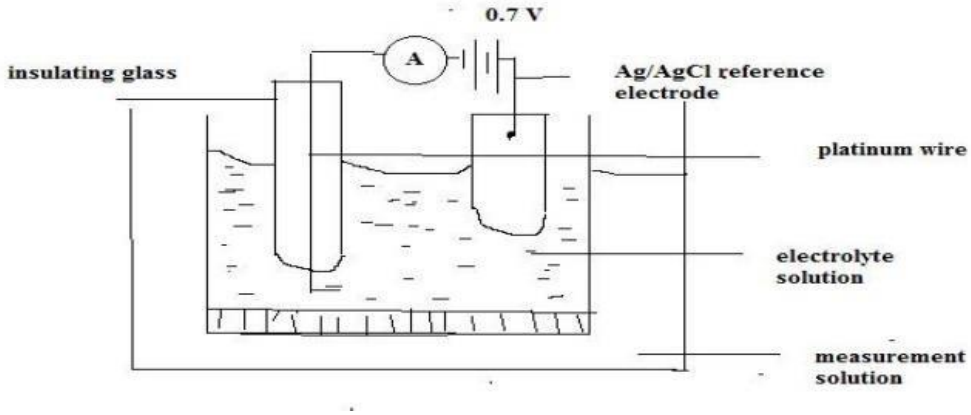


Fig: PO_2 Electrode

Due to the negative terminal, the oxygen reduction takes place at the platinum cathode. Finally, the oxidation reduction current proportional to the partial pressure of oxygen diffused into the electrolyte can be measured in the micro ammeter.

The electrolyte is generally scaled in the electrode chamber by means of a membrane through which the oxygen can diffuse from the blood or sample solution. There are two types of PO_2 measurement. They are

- Vitro Measurement
- Vivo Measurement

In case of dark electrode, the platinum cathode and the reference electrode are present in a single unit. This electrode is used for vitro and vivo measurements.

In Vitro Measurements:

In this method the blood sample is taken and the measurement for oxygen saturation is made in the laboratory. The electrode is placed in the sample blood solution and the PO_2 value is determined.

In Vivo Measurements:

In this method the oxygen saturation is determined while the blood is flowing in the circulatory system. A micro version of the pO_2 electrode is placed at the tip of the catheter so that it can be inserted into various parts of the heart or circulatory system.

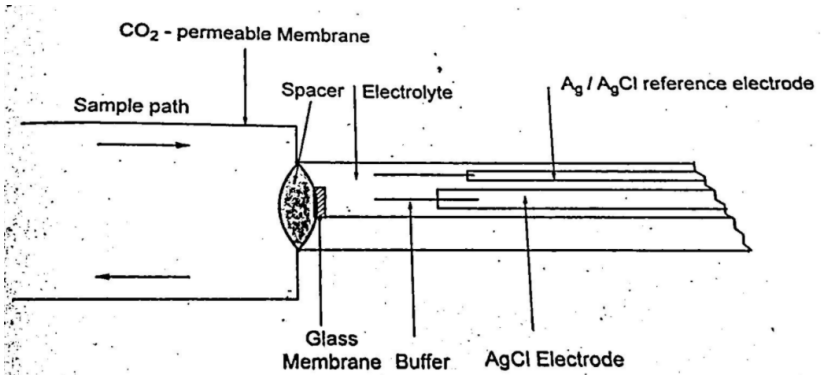
The PO_2 measurement also has some disadvantages in it. The reduction process in the platinum cathode removes a finite amount of the oxygen from the cathode. And there is a gradual reduction of current with respect to time. However careful design and proper procedures in modern PO_2 electrodes reduce the errors.

PCO_2 MEASUREMENT

This value is measured directly by the CO_2 electrode. An increased PCO_2 is often the result of acute, chronic or impending respiratory failure. An decreased PCO_2 is the result of hyperventilation stimulated by a metabolic acidosis or hysteria and severe anxiety reactions. The normal arterial PCO_2 is 40 mmHg and the above process is expressed as

$$PCO_2 = \text{Barometric pressure} - \text{water vapour pressure} \times \frac{\%\ CO_2}{100}$$

All modern blood gas analysers use a PCO_2 electrode.



PCO_2 Electrode system

- The PCO_2 electrode is a modified pH electrode. There are two major differences between this electrode and the pH electrode.
- The first difference is that in this electrode, the blood sample comes in contact with a CO_2 permeable membrane such as Teflon, silicon rubber, rather than a pH sensitive glass as in pH electrode.
- The CO_2 from the blood sample diffuses via the CO_2 permeable membrane into a bicarbonate solution.

NON-INVASIVE MONITORING

Blood gas determination can provide valuable information about the efficiency of pulmonary gas exchange, the adequacy of alveolar ventilation, blood gas transport and tissue oxygenation. Although invasive techniques to determine arterial blood gases are widely practiced in many clinical situations it is becoming apparent that simple, real time, continuous and non-invasive techniques offer many advantages.

Advantages:

- Intermittent blood sampling provides historical data valid only at the time the sample was drawn.
- Delay between when the blood samples is drawn.
- When the blood gas values are reported average about 30 min.

Disadvantages:

- These limitations are particularly serious in critically in patients for close monitoring of arterial blood gases.

- Painful and have associated risks.
- Irreversible cell damage occurs.

Skin characteristics:

In order to appreciate the challenges of non-invasive measurement of the blood chemistry, it is important to understand the structure of the human skin. The human skin has three principal layers,

- Stratum corneum
- Epidermis
- Dermis

These layers from a cohesive structure that typically varies in thickness from 0.2 to 2mm, depending on the position on the body. The stratum corneum is the non-living, out layer of the skin. It is composed of a supple, protective layer of dehydrated cells. The non-vascular epidermis layer is a living tissue underneath the stratum corneum. It consists of proteins, lipids and the melanin forming cells that gives skin its color. The average thickness of the epidermis is 0.1 to 0.2mm.

Pulse oximetry:

A two-wavelength transmission non-invasive pulse oximeter was introduced yoshiya in 1980. This instrument determines SO_2 by analyzing the time varying, or ac, components of the light transmitted through the skin during the systolic phase of the blood flow in the tissue.

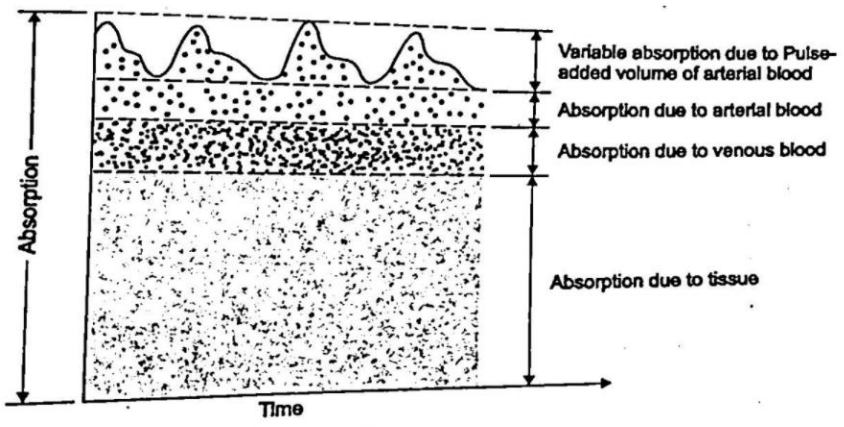


Fig: The pulse oximeter analyses the light absorption at two wavelengths of only the pulse-added volume of oxygenated arterial blood

This approach achieves measurements of the arterial oxygen with only two wavelengths. The dc component of the transmitted light, which represents light absorption by the skin pigments and other tissues, is used to normalize the ac signals. A transcutaneous reflectance oximeter based on a similar photoplethysmographic technique has been developed.

The advantage of the reflectance oximeter is that it can monitor SO_2 transcutaneously at various locations on the body surface, including more central locations that are not accessible via conventional transmission oximetry.