RSPT 2305: Section 6

PHYSICAL PRINCIPLES IN BLOOD GAS ANALYZATION

I. pH Electrode - Sanz e.

A. Theory
   1. if two solutions of different pH are separated by a special glass membrane, an electrical potential will exist across the "pH-sensitive" glass
   2. chemical half-cells are used to measure small potential differences as seen in changes of blood pH
      a. reference electrode -
      b. measuring electrode -
      c. contact bridge -

B. Calibration
   1. calibration is possible because of the Nernst equation (modified)

$$pH\mu = pH\kappa \left(\frac{E\mu - E\kappa}{2.3026\ T} \right) x \left(\frac{F}{R} \right)$$

      a. if pH of known (κ) = pH of unknown (μ) the potential difference is = 0
      b. potential of 61.5 millivolts (mv) exists for every pH unit of difference at 37°C
   2. potentiometers are used to adjust voltage to calibrate analyzer
      a. 6.840 buffer solution - 0 voltage, reading is adjusted to 0 by potentiometer **CAL**
      b. 7.384 buffer solution - difference is 0.544 pH units or 33.5 mv, adjusting potentiometer to 7.384 after cal is called **SLOPE**
   3. potential difference is nearly linear, two point calibration sets the range of the analyzer

C. Sanz electrode - must meet several demands
   1. blood sample must remain anaerobic
   2. measurement must use minimal amount of blood -
   3. constant temperature must be maintained

II. PCO_2 Electrode - Severinghaus e.

A. Theory
   1. **Henry's law** - the amount of gas diffusing across a permeable membrane is directly proportional to the pressure gradient of the gas
   2. a reaction occurs as CO_2 diffuses into an aqueous bicarbonate solution
      a. H+ ions are formed and change the pH
      b. the change of CO_2 alters pH and therefore a potential is produced
      c. CO_2 is measured indirectly
   3. silicon membrane separates blood from the electrode half cell
   4. a nylon spacer separates the pH sensitive glass from the silicon membrane, the electrolyte is -
   5. the measuring half-cell is silver-silver chloride
   6. the reference electrode is also silver-silver chloride

B. Calibration
   1. pre-analyzed gases at precisely measured concentrations are used to calibrate the analyzer
   2. **CAL** gas is around 5% CO_2 -
   3. **SLOPE** gas is normally 10% CO_2 -

C. Severinghaus electrode
   1. introduced by Stowe
   2. modified in 1958 by Severinghaus

III. PO2 Electrode - Clarke (polarographic electrode)

A. Theory
1. reduction - chemical reaction where electrons are gained, occurs at the cathode
2. oxidation - chemical reaction with the loss of electrons, occurs at the anode
3. oxygen dissolved in water and exposed to a polarizing voltage will under go the following reaction
   a. $O_2 + 2H_2O + 4$ electrons -----> $4OH^-$
   b. this is the chemical reduction of oxygen
4. polarographic electrode-
   a. silver anode immersed in KCl will attract Cl^- to form silver chloride
   b. oxidation reaction produces a constant flow of electrons -
   c. a platinum cathode will react chemically with oxygen to form OH^-
   d. the amount of oxygen reduced is proportionate to the number of e- used in the cathode reaction
   e. the flow of current (e- exchange) is directly proportional to the amount of oxygen in solution; the greater the conc. of oxygen the greater the current used
   f. a small polarizing voltage (-0.6 v) is required to min. the interference of other gases

B. Calibration
1. the balance point is determined by using a gas mixture without oxygen (0%)
   a. usually referred to as the **CAL**
2. the slope point is set using 12% oxygen (sometimes 20%)

C. Clark electrode
1. electrode is covered by a polypropylene membrane -
2. without the membrane, oxygen would be consumed from the mixture
3. first developed in 1930's, the modern electrode was developed in 1950's and attributed to Clark

IV. Spectrophotometry

A. Theory
1. light is an electromagnetic form of energy characterized by specific wavelengths and frequencies
2. energy properties of light are described as quanta
   a. intensity is determined by the number of quanta produced per second
3. atoms are in random, vibrating motion; these vibrations are similar to the ones produced by light
4. light passing through a substance that has the same frequency as the vibration between the atoms of that substance will be absorbed
5. a molecule's vibrational characteristics can be drawn as a spectrum (molecules absorb energy a various wavelengths)
6. **Beer's law** - the intensity of light that is absorbed while passing through the solution will be proportional to the concentration of that molecule within the solution

B. Oximeter
1. Hb exists in various forms -
   a. each form has its own light spectrum
2. oximeter - is a spectrophotometer with specific wavelengths for the oxyhemogblobin spectrum -

C. CO-Oximeter
1. spectrophotometer capable of measuring three spectra -
2. units of measurement
   a. sum of Hb concentration - grams per 100 ml of blood
   b. oxy Hb and carboxy Hb - % of Hb concentration