جامعة الانبار
كلية العلوم التطبيقية – هيت
قسم الفيزياء الحياتية

الاجهزة الطبية

Blood Gas Analyzer

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Definition

- **Blood gas analysis**
  - Also called Arterial Blood Gas (ABG) analyzer
  - It uses **3 electrodes** to test arterial blood

- **Used in**
  1. Respiratory (breathing) therapy departments
  2. Clinical and cardiopulmonary (**heart and the lungs**) labs
  3. Critical care units, surgical suites
  4. Physician offices, and hospital nurseries to monitor patients' acid-base balance and oxygen (O2)- carbon dioxide (CO2) exchange, providing the clinician with information to use in patient diagnosis and regulation of therapy.

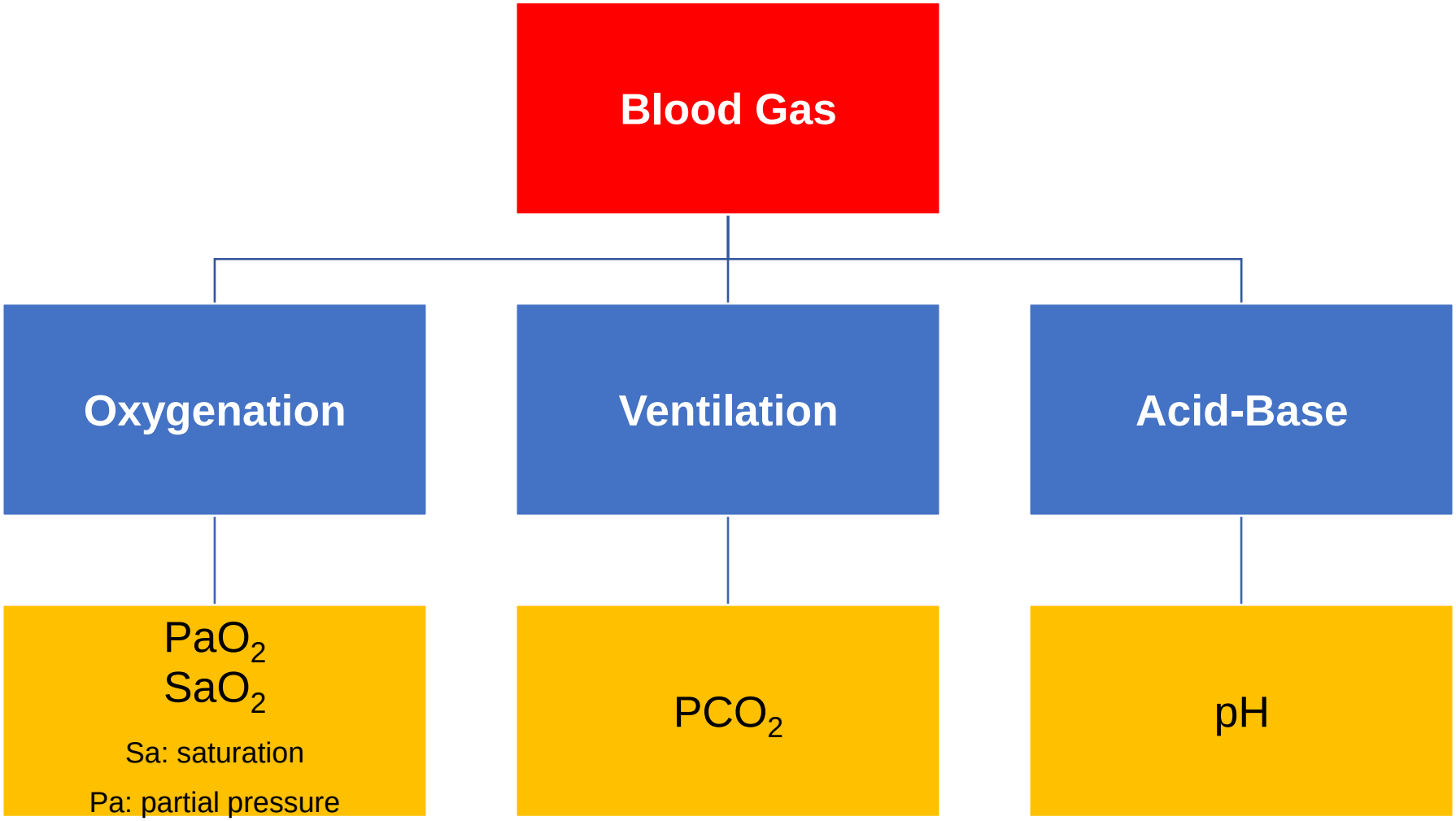
Purpose

Blood gas/pH analyzers measure:

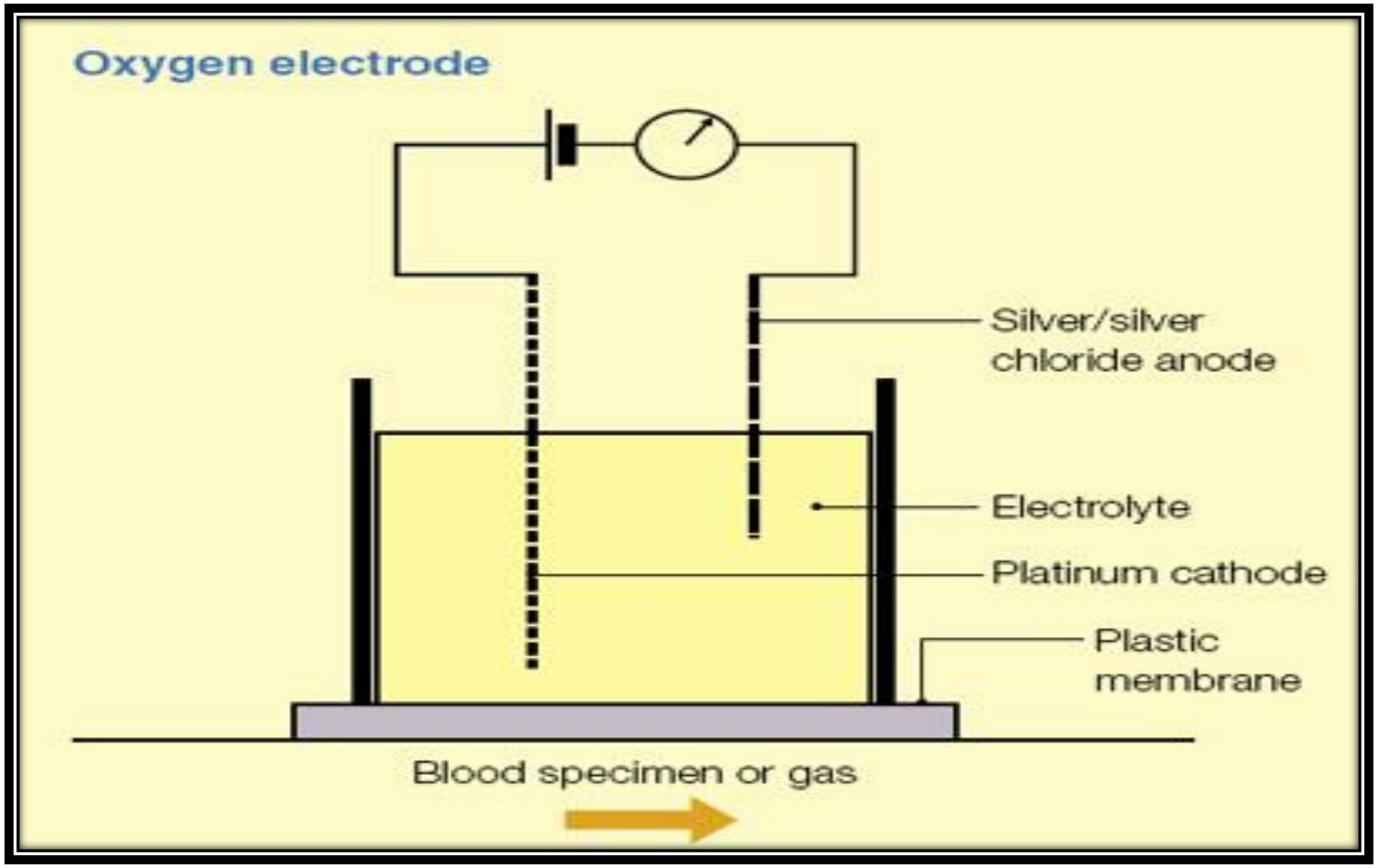
1. The partial pressure of oxygen (O_2) → po2
2. Carbon dioxide (CO_2) gases → pco2
3. The (hydrogen ion concentration) p(h+)
4. Sodium, potassium, and calcium concentrations

- Values for PO2, PCO2 and PH reflect the concentrations of these gases in arterial blood as well as the concentration of hydrogenions (H+)
- hence, the state of respiration, metabolism and body's acid production of a patient can be diagnosed

Components of Blood Gas



ABG Analyzer example



Calibration

- **Calibration**: with known concentrations of standard buffers and calibrated solutions.

1. Gas mixtures with high and low concentrations of O2 and CO2 are alternately admitted to the sample chamber,
2. O2 and CO2 electrode responses are used to set high and low points of the PO2 and PCO2 curves.
3. Calibrations are done by adjusting the electrode response and are usually referred to:
   - **One level** (either high or low)
   - **Two levels** (both high and low)

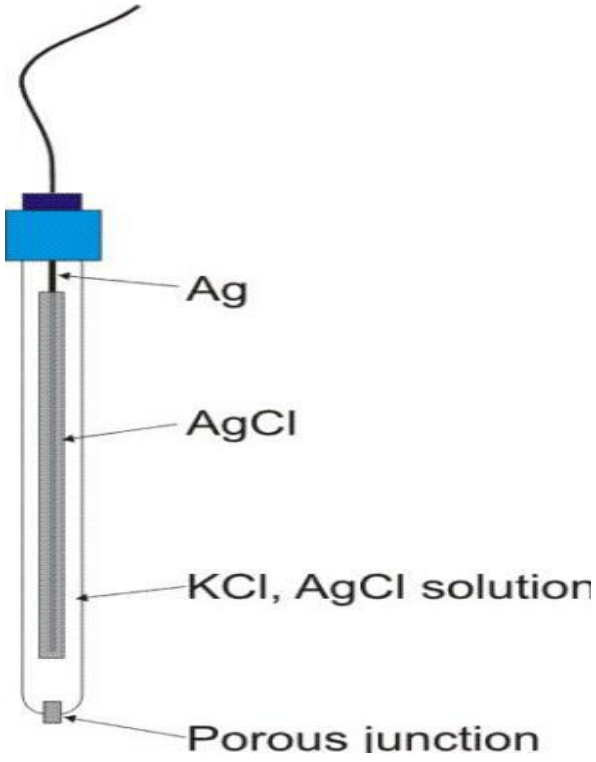
- The electrode systems and the sample chamber are located inside a temperature-controlled block maintained at **37°C**

Reference Electrode

- The reference electrode is used in the measurement of pH and electrolyte parameters, located in the pH/Blood Gas module.

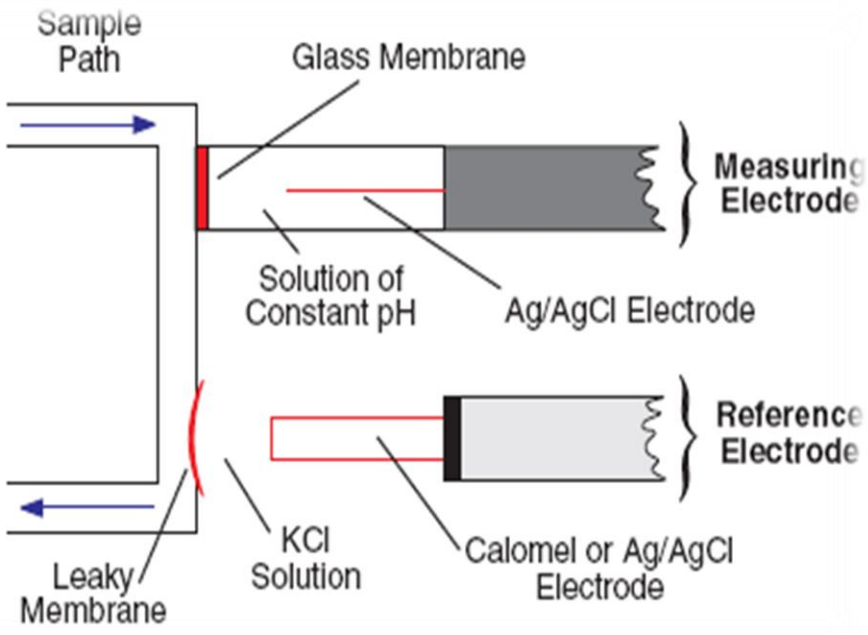
Components

1. Pole: AgCl
2. Electrolyte: KCl
3. Permeable seal



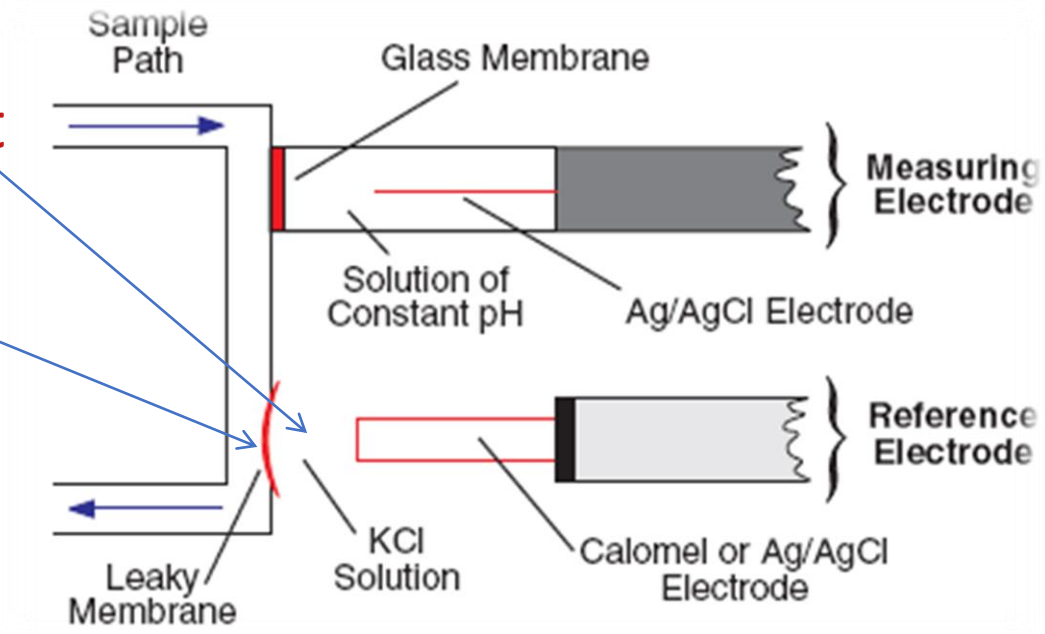
pH electrode

- The pH measurement is performed using two separate electrodes:
  1. Ph-measuring Electrode
  2. Reference Electrode
- The pH-sensitive glass membrane is located at the tip and seals the inner buffer solution with a constant and known pH.



pH electrode

- A saturated electrolyte solution (**Potassium Chloride**) in the reference electrode and a **leaky membrane** permit current flow from the reference electrode through the sample in the measurement chamber to the measuring electrode.



- The potential difference is displayed on a voltmeter calibrated in pH units.

pO2 electrode

- **Oxygen electrode** measures the oxygen partial pressure in a blood or gas sample.

1. **Cathode**: platinum
2. **Anode**: a silver/silver chloride
3. **Electrolyte Solution:** sodium chloride, Cathode and anode are placed in the electrolyte
4. **Applied voltage**: 700 mV
5. **Permeable membrane:** (Plastic) designed to allow only O2 to leak

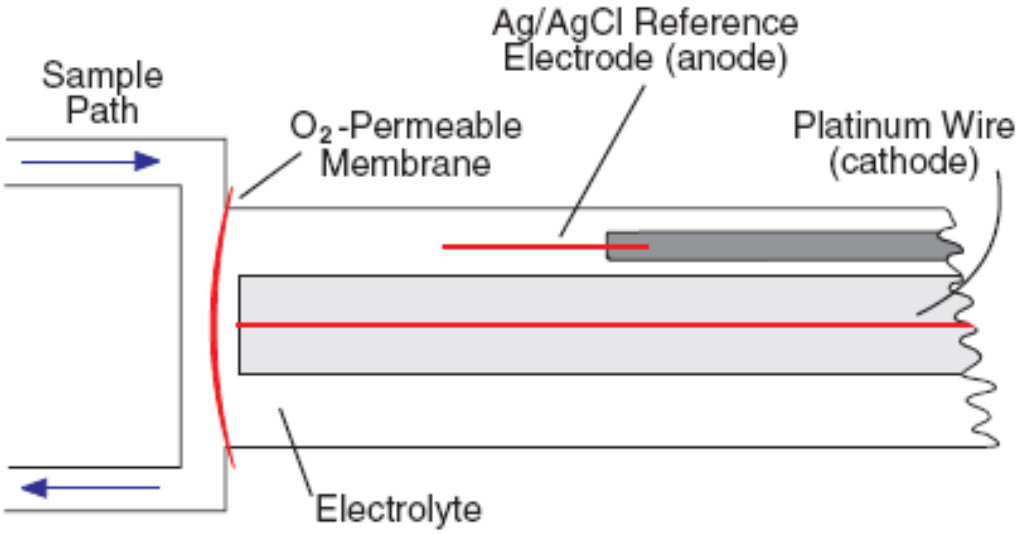
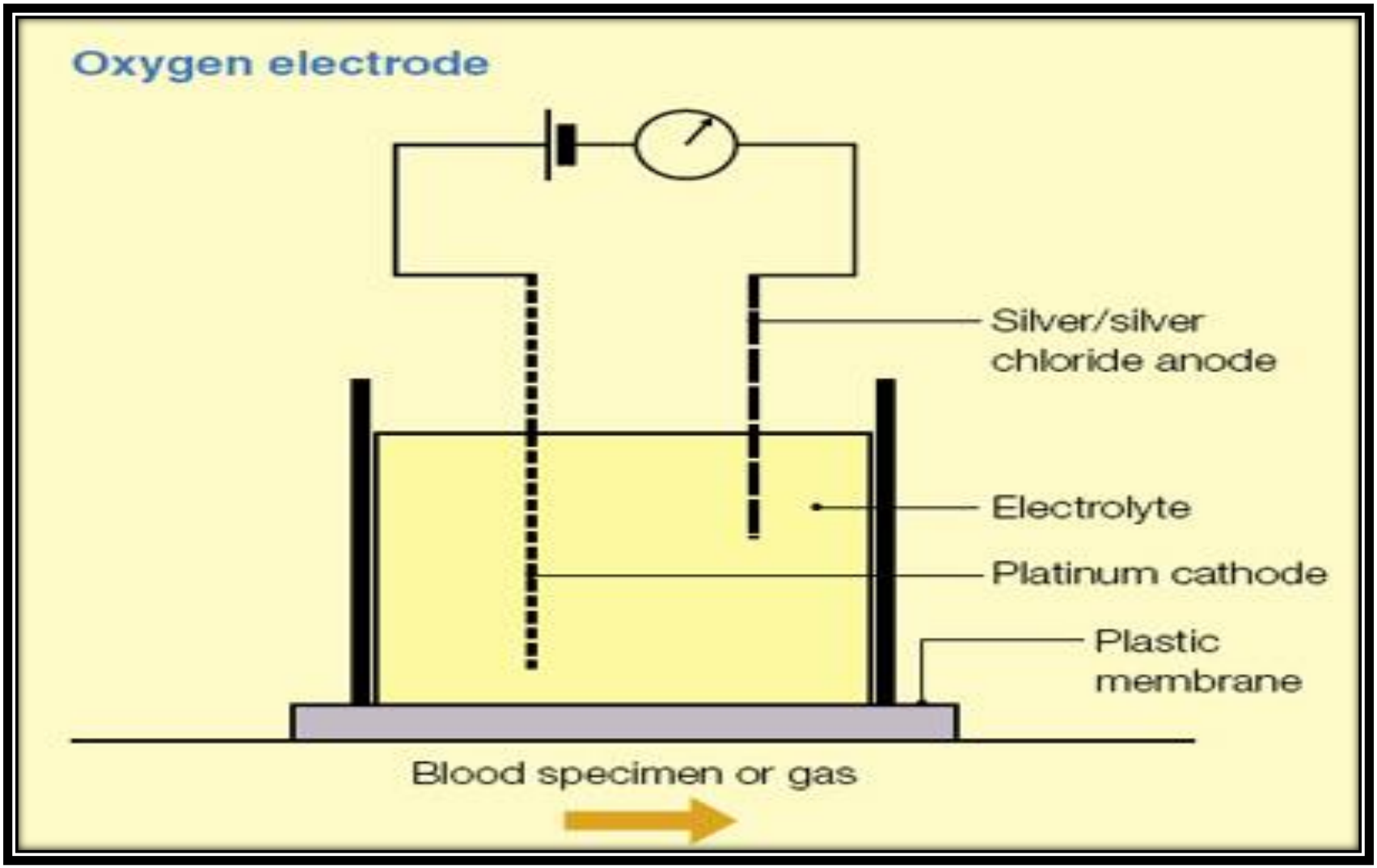


Figure 3. PO_2 electrode system

pO2 electrode



Pco2 Electrode

- The pCO2 electrode is a combined pH and Ag/AgCl reference electrode mounted in a plastic jacket, which is filled with a **bicarbonate electrolyte**.
- The PCO2 electrode also contains a spacer (usually a porous membrane of nylon) that acts as a support.

→ As CO2 diffuses through the membrane and into the support, **The pH of the electrolyte changes**

→ The output of this modified pH electrode is proportional to the PCO2 present in the sample.

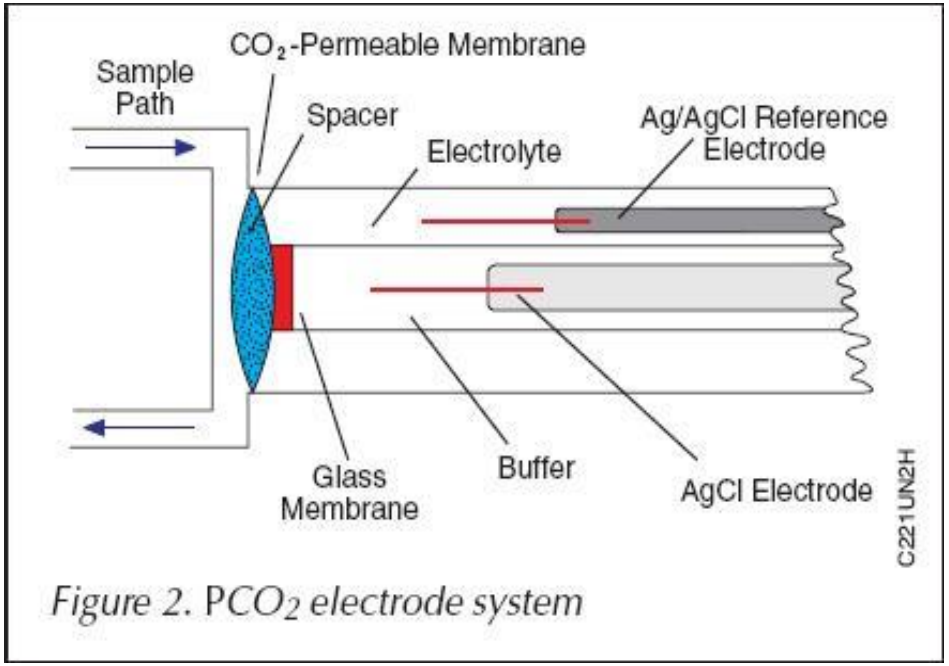
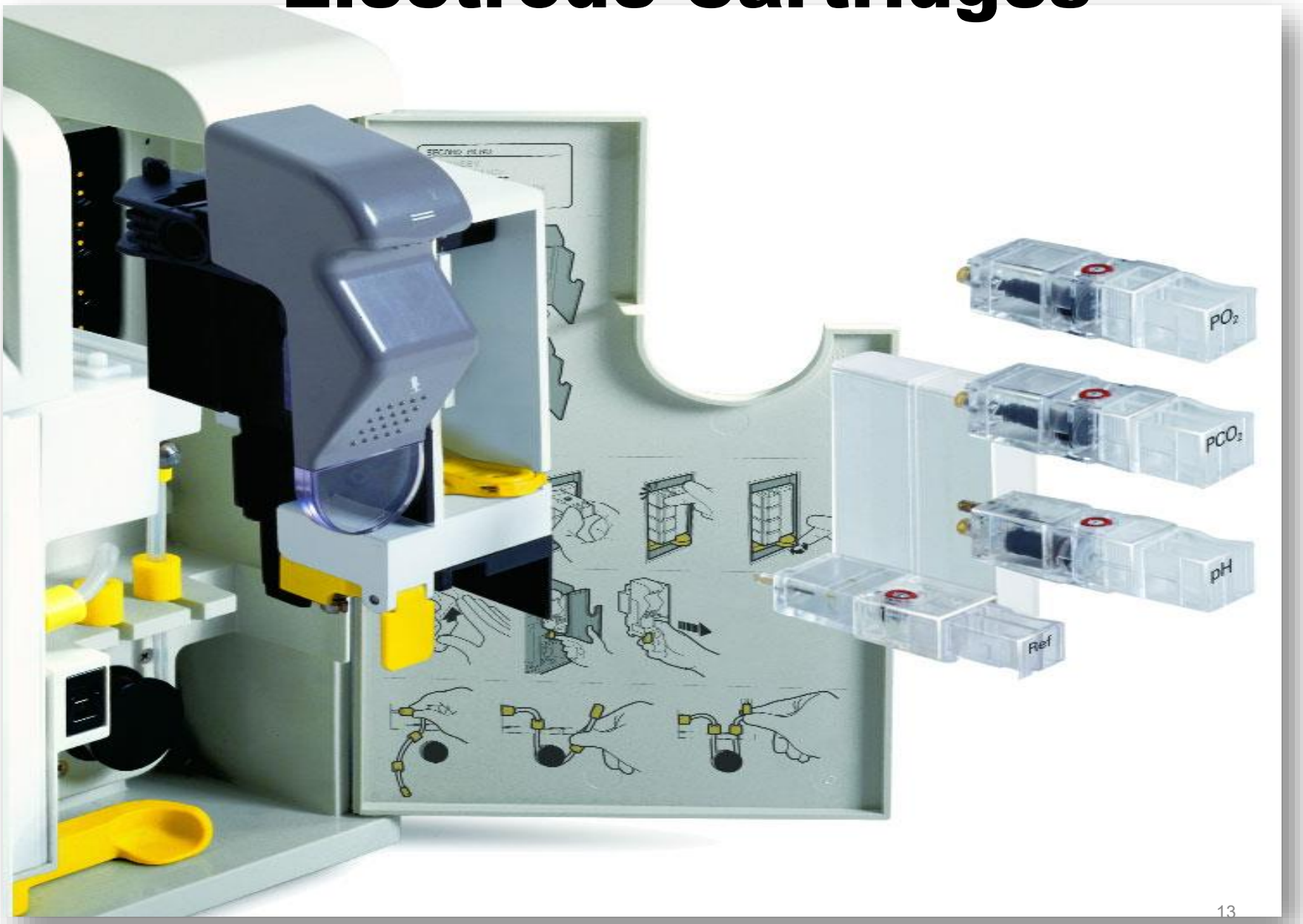


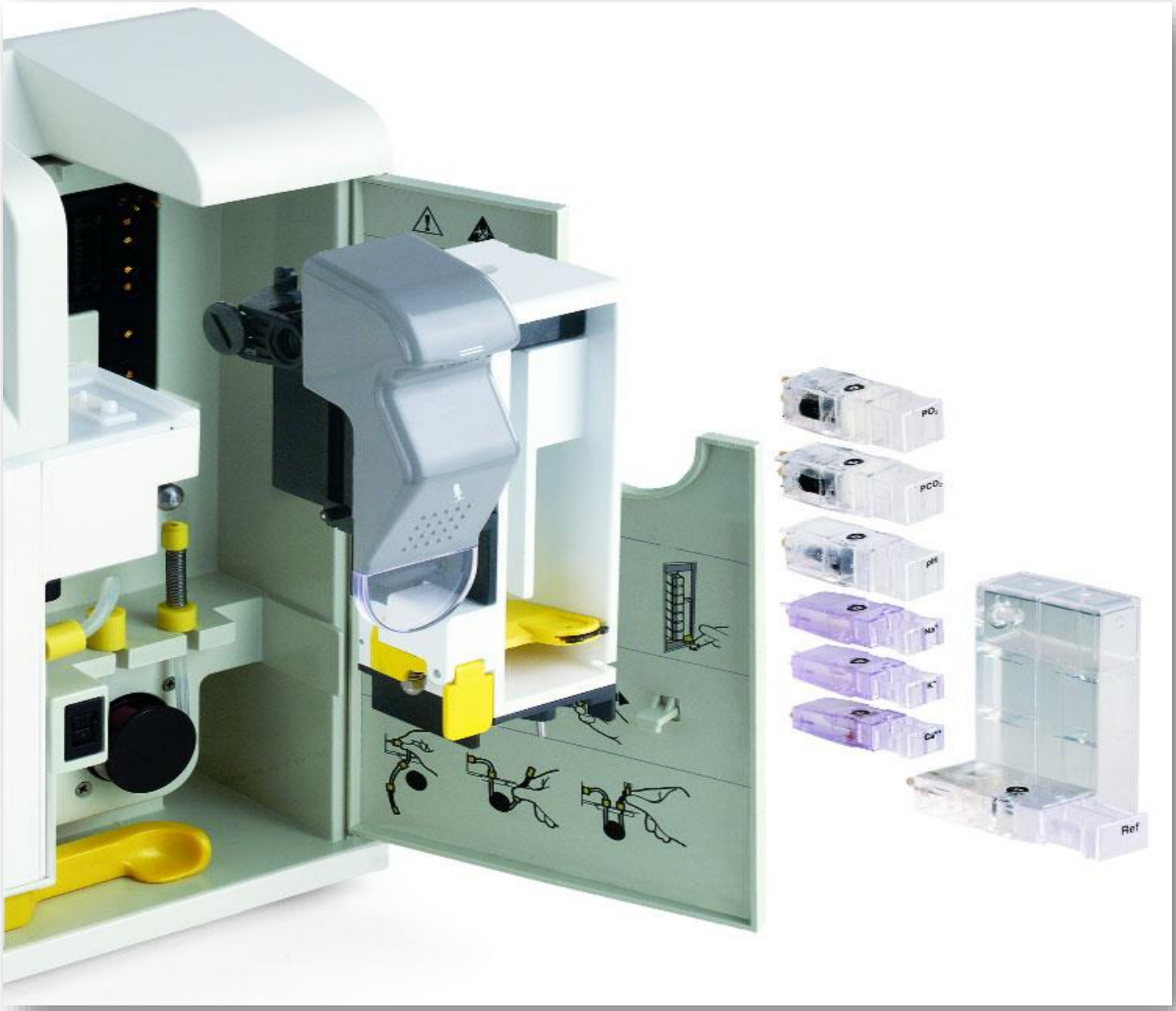
Figure 2. PCO_2 electrode system

Electrode Cartridges



Other Electrodes

- The **K+ electrode** is an ion-selective electrode
  - **Sensing Element** is a PVC membrane containing a potassium-neutral ion carrier.
- The **Na+ electrode** is an ion-selective electrode
  - **Sensing Element** is a Na+-sensitive ceramic pin contained in the tip of the jacket.
- The **Ca++ electrode** is an ion-selective electrode
  - **Sensing Element** is a PVC membrane containing a calcium-neutral ion carrier.


PO_2
PCO_2
pH
Na^+
K^+
Ca^{++}
Ref

Sensor and valve modules slide in for easy replacement.


Ready
Processing time for new sample: 00:01:10
RADIOMETER
ABL800

In-line (extracorporeal) monitors

- Connected to the patient's existing arterial line
- These devices consist of a sensor, an arterial blood gas (ABG) module, and a monitor.

Operation:

Blood is drawn into the sensor

→ Fluorescent dyes in the sensor detect the pH, *PO2, and PCO2 levels and* transmit light of a specific wavelength

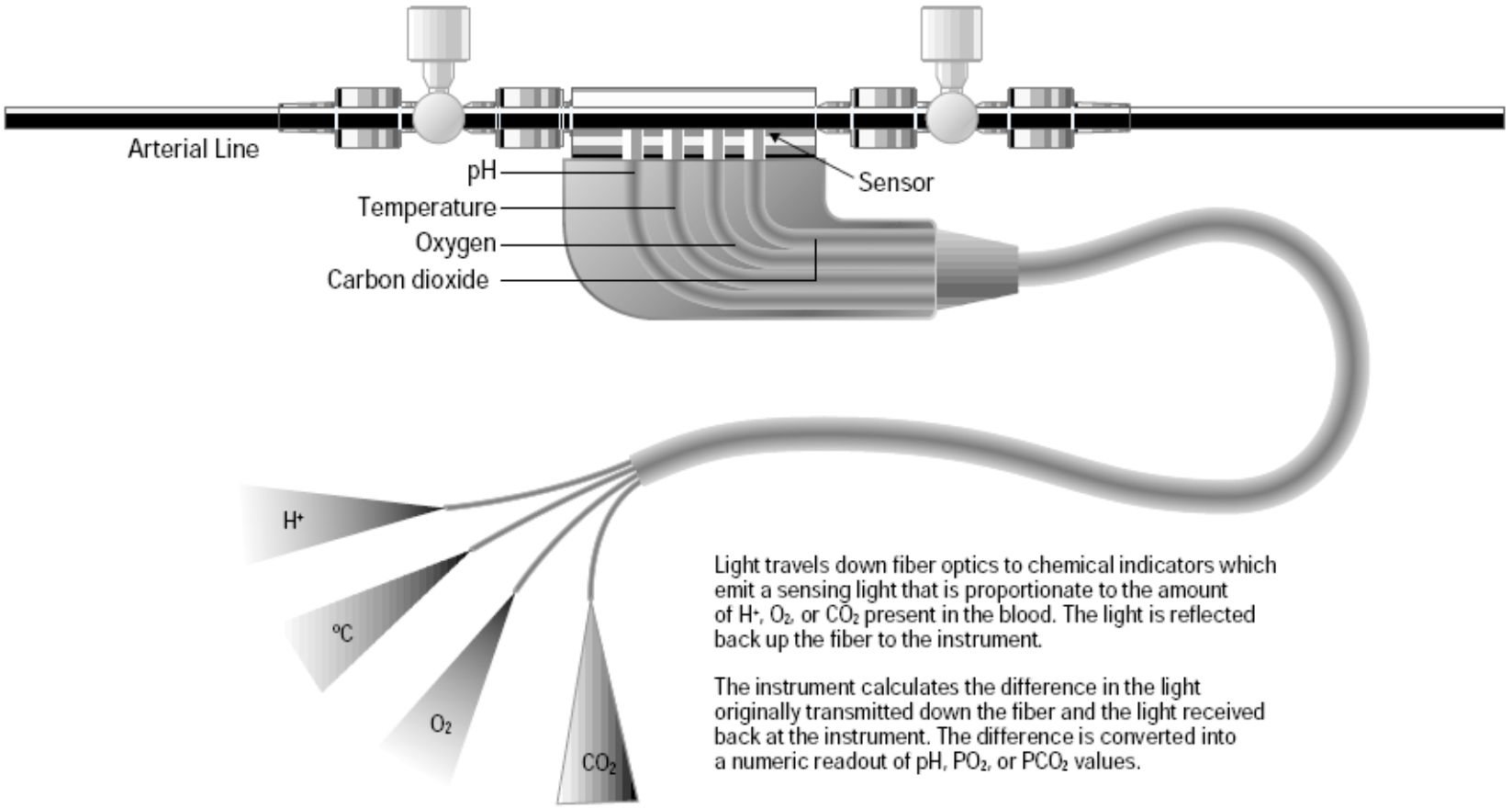
The ABG module emits excitation energy

→ *dyes* transmit light of a specific wavelength (λ1) through a fiber-optic cable to the instrument.

→ The dyes then emit light of a longer wavelength (λ2) and transmit it to the instrument through the cable.

→The parameters are then determined by the difference in the two wavelengths

In-line (extracorporeal) monitors



SensicathTM system consists of patented fiber optic technology in a sensor which attaches directly to the patient's arterial line

- **Continuous intravascular blood gas monitoring**
  - This technique uses electrochemical and optical detection methods; however, the measurements are taken in vivo

Modern blood gas analyzers features

- Measure/time:
  - pH (15 Seconds)
  - Po_2 (50 Seconds)
  - Pco_2 (30 Seconds)
- Have Monitor
- Analog Amplifier and digital control and storage circuits
- Easy calibration

Basic Safety Consideration

When analysis is complete, the blood specimen is disposed of in one of two ways:-

1. Most analyzers pump the specimen into a **waste container**, and the system is flushed with a rinse or wash solution.

2. Some newer units retain the specimen in the disposable **sealed reaction cartridge** which is then discarded.

Important Terminologies

1. **Analysis time, sec:** The time from sample insertion to a displayed or printed result.

2. **Calibration:** The operator can initiate random calibrations and calibrations during standby mode.

3. **Standby mode:** Unit calibrates only when the unit is in standby mode, otherwise it will calibrate according to programmed intervals

Basic Work Specifications

1. The equipment should possess electrodes with long life at least 2 years
2. Assessment of the instrument should be provided by the company.
3. All results should be available within 3 min.
4. The results should be microprocessor controlled and of latest technology version

Basic Work Specifications, cont.

5. The instrument should have facilities like monitor screen, external keyboard, mouse, and barcode reader
6. The instrument should have the capability to interface a computer and a computer should be supplied for data acquisition and patient record with recommended software. The system should have RS232 serial port.
7. Display language should have English