# 5. Sensors, Types of Sensors

17 November 2023 08:59

## SENSORS

- Detects and responds to some certain types of inputs from the environment

Input examples: Moisture, molecules, light, heat, gas etc.

## TYPES OF SENSORS

| | | |
|---|---|---|
| S: | Semiconductor sensor | Eg: Solar cells |
| O: | Optical sensor | Eg: Ga-As, Ge-Si, photodetective sensor |
| M: | Mass-sensitive sensor | Eg: Piezo device |
| E: | Electrochemical sensor | Eg: $O_2$ sensor [voltage], glucose sensor [current] |
| C: | Conductivity sensor | Eg: Pt electrode |
| C: | Capacitive sensor | Eg: Touch screens, polycarbonate, polyethylene |
| C: | Calorific sensor | Eg: Microcalorimeter, Differential Scanning Calorimetry |
| T: | Thermosensitive sensor | Eg: Thermostat |

## ELECTROCHEMICAL SENSORS

→ electrode used as transducer; electrode-analyte interaction generates electrical signal

- Potentiometric (measures voltage)
  - Ion selective
    - Glass electrode ($H^+$, $Na^+$)
    - Solid electrode ($AgX$)
    - Liquid electrode ($Ca^{2+}$)
  - Gas
    - Eg: $O_2$ sensor (or) λ-sensor
- Amperometric (measures current)
  - Biosensor (glucose sensor)

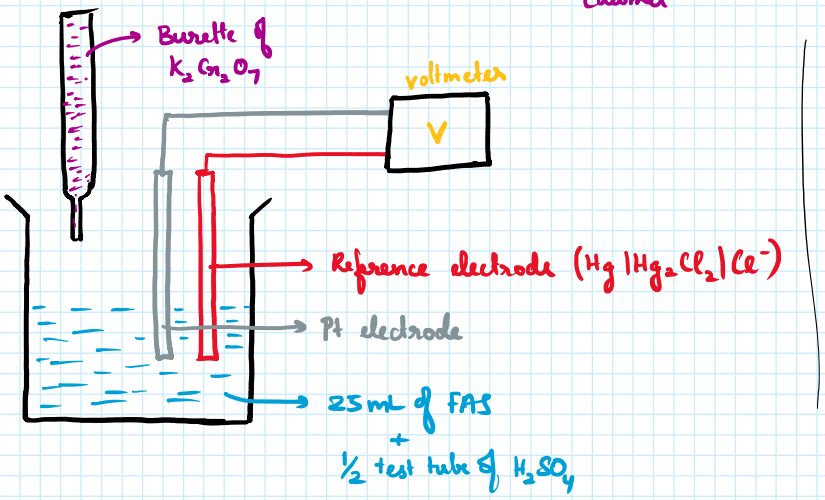
## POTENTIOMETRIC SENSOR

- Determines analyte concentration by measuring variation of potential b/w working & reference electrodes
- 2 electrode system

Analyte → Receptor → Transducer → Signal → Computer

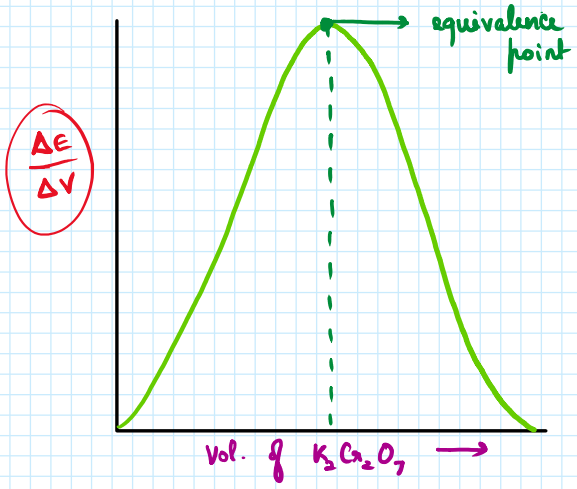
- Pt electrode
- Reference electrode
  - Eg: Ag-AgCl

↳ Reference electrode
Eg: Ag-AgCl
Calomel




Oxid.

Red.




**Advantages**

- Accurately measure voltage
- Simple
- Qualitative and quantitative measurements

**Disadvantages**

- Calibration
- Variation in temperature causes change in value of voltage measured

**$O_2$ SENSOR** (solid oxide sensor) (potentiometric sensor) → measures proportion of $O_2$ in analyte

**Applications**

- I.C. engines
- Medical applications → respiration, anaesthesia
- Deep sea divers

- Medical applications → anaesthesia
- Deep sea divers

Anode: Pt

Cathode: Pt

Electrolyte: Ceramic material : YSZ → releases $O^{2-}$ ions

Yttria Stabilised Zirconia

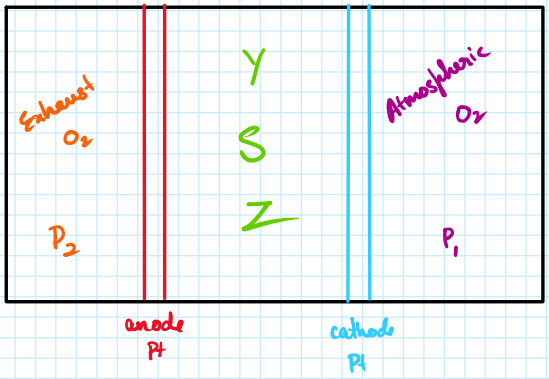
$ZrO_2$ doped with $Y_2O_3$

Operating temp.: 360°C (minimum)

- Air : fuel = 14.7 : 1
- Ideal voltage = 0.45 V

→ For ideal combustion

- Must use lead-free gasoline as lead poisons Pt electrodes




$$E_{cell} = \frac{2.303RT}{nF} \log \frac{P_1}{P_2}$$

$P_1$ → atmospheric $O_2$; $P_2$ → exhaust $O_2$

At 25°C,

$$E_{cell} = \frac{0.0591}{n} \log \frac{P_1}{P_2}$$

$P_1$ → atmospheric $O_2$; $P_2$ → exhaust $O_2$

Equations

Anode: $2O^{2-} \longrightarrow O_2 + 4e^-$

Cathode: $O_2 + 4e^- \longrightarrow 2O^{2-}$

Rich mixture (less $O_2$) → 0.8 V (emission of $CO_2$, unburnt C)

Lean mixture (more $O_2$) → 0.2 V (emission of $NO_x$ gases)

## Signs of failure

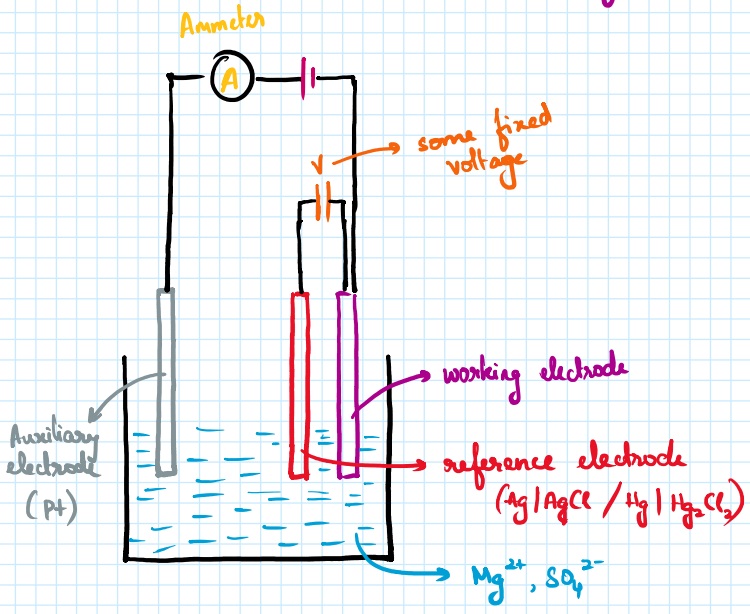
- Tailpipe emission
- Hesitation on acceleration
- Increased fuel consumption

## AMPEROMETRIC SENSOR

- Measures current
- 3 electrode system

Analyte → Receptor → Transducer → Signal → Electronic display

- Working electrode
- Reference electrode [Ag|AgCl, calomel]
- Auxiliary electrode




## Advantages

- Simple to construct
- Qualitatively and quantitatively measure

## Disadvantages

- -ve voltage leads to errors due to liberation of $H_2$

**BIOSENSOR** → determines presence, concentration of specific substance in biological analyte

Analyte → Bioreceptor → Transducer → Signals → Electronic display

Blood

→ electrodes

Blood
RNA
DNA
cells

→ electrodes
→ pH
→ piezo electric device

## GLUCOSE SENSOR

- Amperometric sensor

Analyte (Blood) → Biosensor → Transducer → Signals → Electronic display

Transducer:
→ membrane
→ enzyme
→ electrode

Blood → HIGH glucose → hyperglycemia
Blood → LOW glucose → hypoglycemia

Glucose —GOX, oxidation→ Gluconolactone + $H_2O_2$

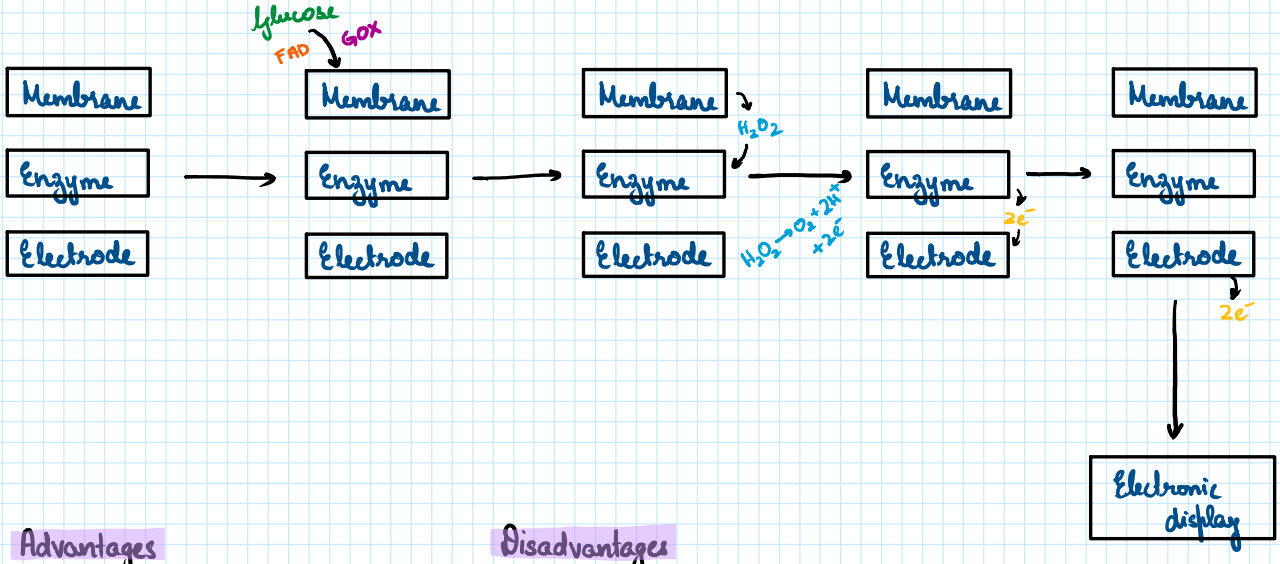
FAD → Flavin Adenine Dinucleotide

GOX → Glucose Oxidase Enzyme

$H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$

- More electrons: 250
- less electrons: 100

No of electron transfers at electrode surface → directly proportional to no of glucose molecules




### Advantages

- Simple method

### Disadvantages

- Treatment errors

Advantages

- Simple method
- Checking blood sugar

Disadvantages

- Treatment errors (glucose levels)