Contact voltage

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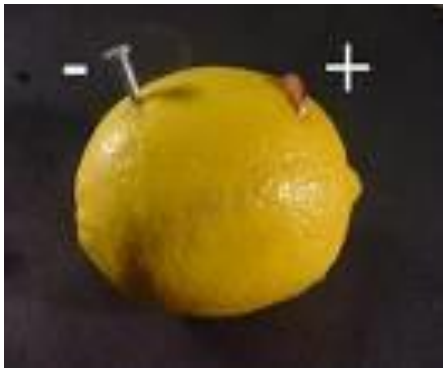
Reminder

- Power supply
- Electromotive force
- Electric current
- Conductors of electric current

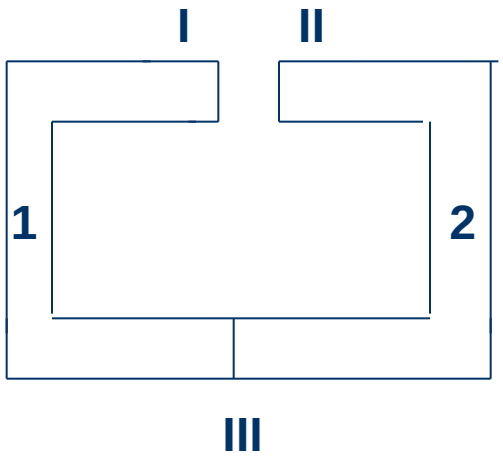


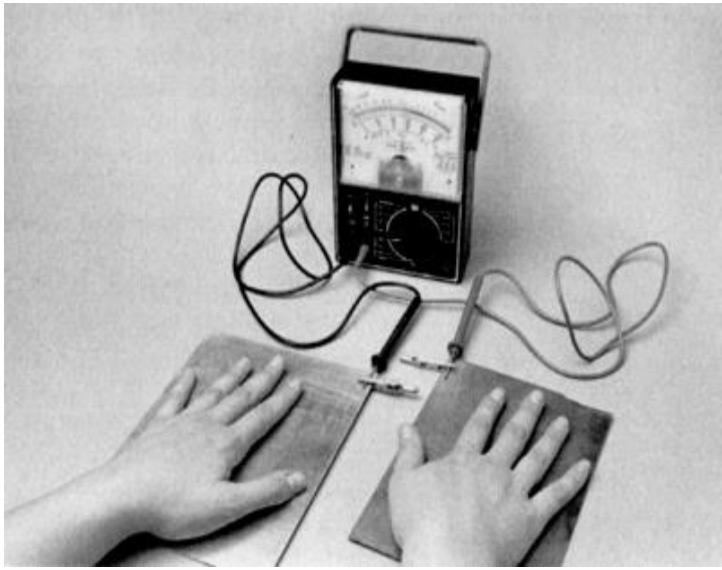
Reminder

- The atoms in the metal are placed in the crystal grid nodes.
- Free electrons are moving in the crystal lattice space.
- Work function or binding energy is the lowest energy needed to release electrons from the highest filled state.
- Electrons can come out of the metal surface if they have at least work function (Φ).

Contact voltage metal-metal

● Two different metals 1 and 2 are connected to at one end (connecting surface III).

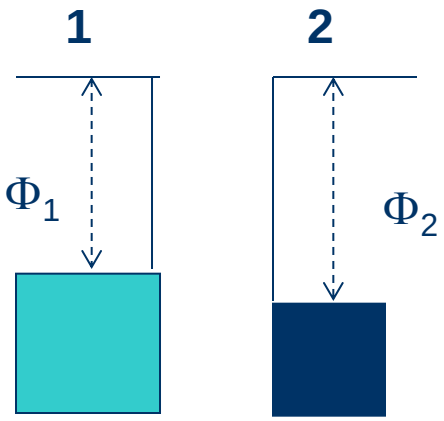




● Although both metals are electrially neutral, between the points I and II, there is a potential difference called the contact voltage.

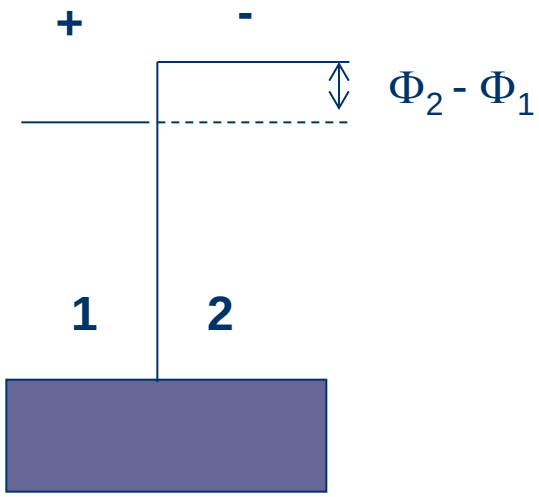
Contact voltage metal-metal

- Electrons in metal 1 have smaller work function



- The result: net flow of electrons from metal 1 to metal 2
  - Does the voltage change because of the change in temperature?

- Electric potential 1 becomes positive, el. potential of metal 2 becomes negative.



- Contact voltage: $U = \frac{1}{e}(\Phi_2 - \Phi_1)$

Galvanic series

- The contact voltage was discovered by Volta (1793), and based on the research, he ordered the metals of the value and the polarity of the voltage in the series – galvanic series.
- The contact voltage is the order of magnitude mV.
- If any two different metals of the galvanic series are touched, the metal closer to the left end is positive, and the other is negative.

Galvanic series

Seebeck effect

- The **thermoelectric effect** – inducing the voltage (difference in electric potentials) because of the temperature difference - thermocouple.
- A thermoelectric device creates voltage when there is a different temperature on each side.

- The term "thermoelectric effect" encompasses three separately identified effects: the **Seebeck effect**, **Peltier effect**, and **Thomson effect**.

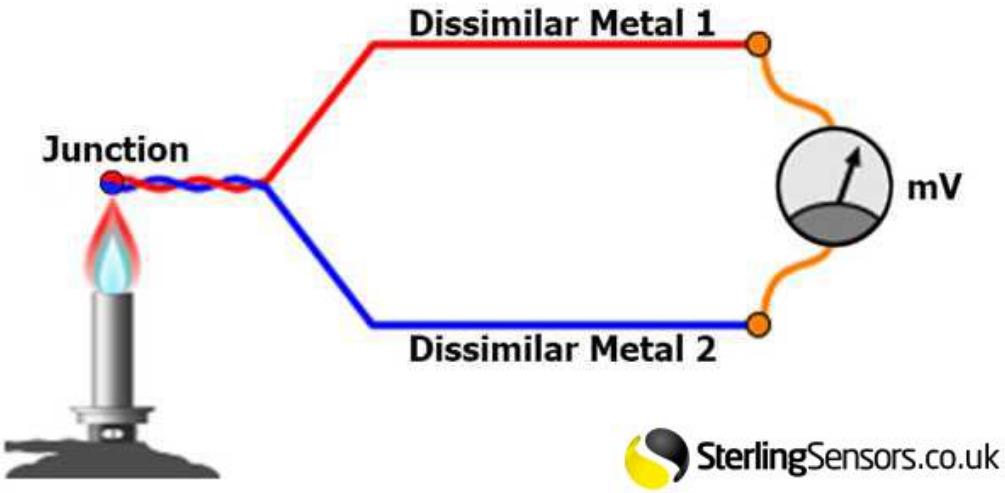
Thermocouple

- A **thermocouple** is an electrical device consisting of two dissimilar electrical conductors forming electrical junctions at differing temperatures.

- A thermocouple produces a temperature-dependent voltage as a result of the thermoelectric effect, and this voltage can be interpreted to measure temperature.
- Thermocouples are a widely used type of temperature sensor, for measuring a certain dotted structure in the oral cavity.

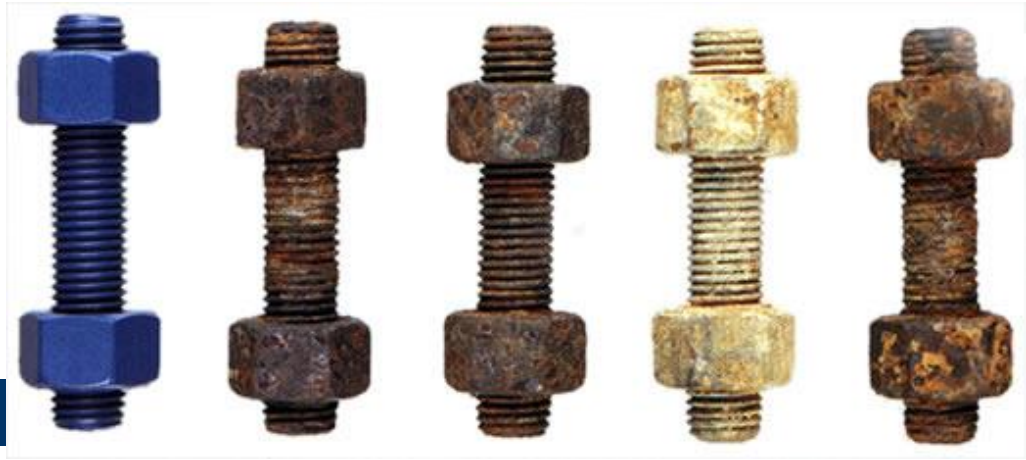
- Thermocouples consist of two wire legs made from dissimilar metals which are fixed together at one end, creating a junction.

- When this junction experiences a change in temperature a voltage is induced, this voltage can then be measured and referenced back to the temperature.




protective
hood
thermocouple
read-out
thermocouple
probe

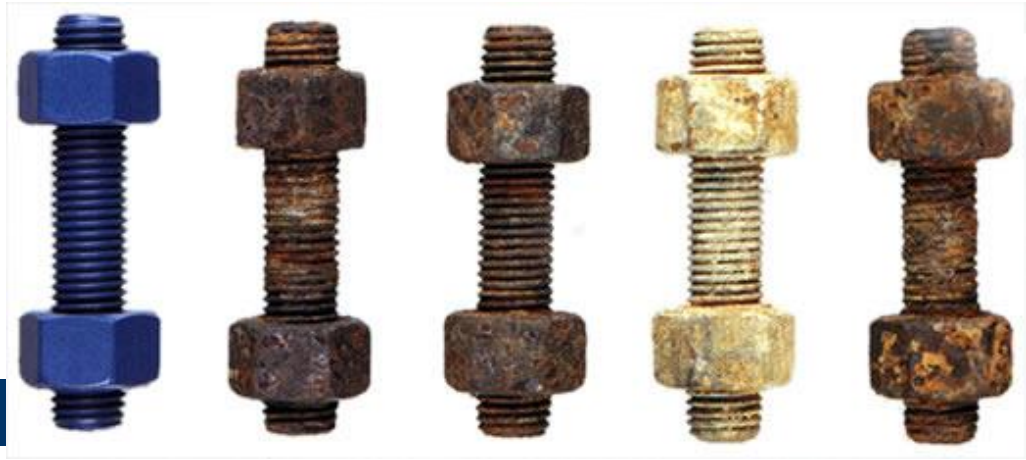
Corrosion



- Galvanic corrosion occurs when two different metals have physical or electrical contact with each other and are immersed in a common electrolyte, or when the same metal is exposed to electrolyte with different concentrations.

- In a galvanic couple, the more active metal (the anode) corrodes at an accelerated rate and the more noble metal (the cathode) corrodes at a slower rate.

Corrosion



- When immersed separately, each metal corrodes at its own rate. What type of metal(s) to use is readily determined by following the galvanic series. For example, zinc is often used as a sacrificial anode for steel structures. Galvanic corrosion is of major interest to the marine industry and also anywhere water (containing salts) contacts pipes or metal structures.

- Factors such as relative size of anode, types of metal, and operating conditions (temperature, humidity, salinity, etc.) affect galvanic corrosion. The surface area ratio of the anode and cathode directly affects the corrosion rates of the materials.

Electrode potential, *E* is the electromotive force of a cell built of two electrodes:

- on the left-hand side of the cell diagram is the standard hydrogen electrode and
- on the right-hand side is the electrode in question.

$$E_{cell} = E_{right} - E_{left} = E_{electrode} - 0\ V = E_{electrode}$$

Electrode reaction	E°	Electrode reaction	E°
$Li = Li^+ + e^-$	-3.05	$Fe = Fe^{2+} + 2e^-$	-0.440
$K = K^+ + e^-$	-2.92	$Cd = Cd^{2+} + 2e^-$	-0.403
$Ca = Ca^{2+} + 2e^-$	-2.87	$In = In^{3+} + 3e^-$	-0.342
$Na = Na^+ + e^-$	-2.71	$Co = Co^{2+} + 2e^-$	-0.277
$Mg = Mg^{2+} + 2e^-$	-2.36	$Ni = Ni^{2+} + 2e^-$	-0.250
$Be = Be^{2+} + 2e^-$	-1.85	$Mo = Mo^{3+} + 3e^-$	-0.200
$Hf = Hf^{4+} + 4e^-$	-1.70	$Sn = Sn^{2+} + 2e^-$	-0.136
$Al = Al^{3+} + 3e^-$	-1.66	$Pb = Pb^{2+} + 2e^-$	-0.126
$Ti = Ti^{2+} + 2e^-$	-1.63	$H_2 = 2H^+ + 2e^-$	±0.000
$Zr = Zr^{4+} + 4e^-$	-1.54	$Cu = Cu^{2+} + 2e^-$	0.337
$Mn = Mn^{2+} + 2e^-$	-1.18	$2Hg = Hg_2^{2+} + 2e^-$	0.778
$V = V^{2+} + 2e^-$	-1.175	$Ag = Ag^+ + e^-$	0.798
$Nb = Nb^{3+} + 3e^-$	-1.1	$Pd = Pd^{2+} + 2e^-$	0.987
$Zn = Zn^{2+} + 2e^-$	-0.763	$Pt = Pt^{2+} + 2e^-$	1.188
$Cr = Cr^{3+} + 3e^-$	-0.744	$Au = Au^{3+} + 3e^-$	1.498

Oral galvanism

- **Oral galvanism** is a phenomenon that can occur when two or more dissimilar metals in dental restorations which are bathed in saliva, or a single metal in contact with two electrolytes such as saliva and pulp fluid tissue, produce an electric current.

- When associated with pain, the term **galvanic pain** has been used.

- While there seems to be little dispute that the presence of dissimilar metals can cause an electric current and can, in some cases, cause a metallic taste in the mouth, some discomfort, and also possibly lead to premature corrosion of the metallic restorations.

Oral galvanism

- Oral galvanism is sometimes treated by replacing metallic amalgam restorations with ceramic or polymer restorations.

- Dental **amalgam** is a liquid mercury and metal alloy mixture used in dentistry to fill cavities caused by tooth decay. Low-copper amalgam commonly consists of mercury (50%), silver (~22–32%), tin (~14%), copper (~8%) and other trace metals.