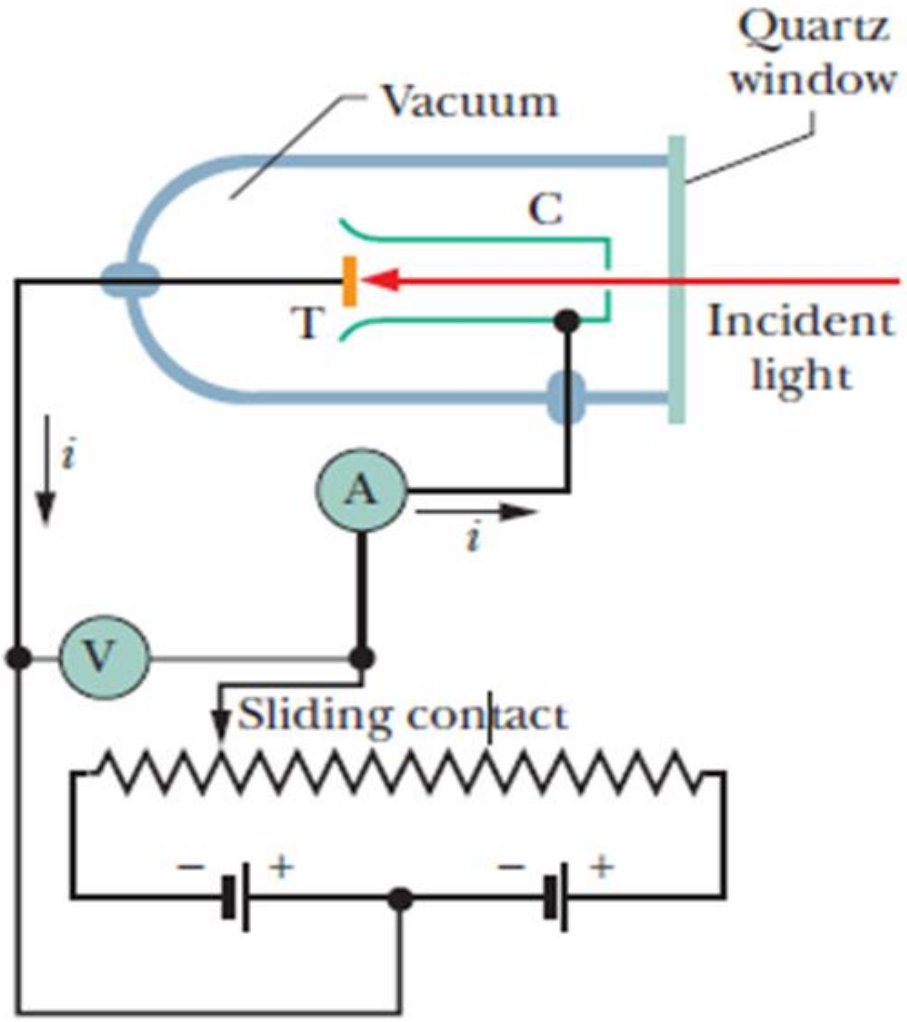
Lecture (8)

Photoelectric and photovoltaic effect

❑The Photoelectric Effect

If you direct a beam of light of short enough wavelength onto a clean metal surface, the light will cause electrons to leave that surface



We adjust the potential difference V by moving the sliding contact in Figure , so that collector C is slightly negative with respect to target T. This potential difference acts to slow down the ejected electrons. We then vary V until it reaches a certain value, called the stopping potential V stop, at which point the reading of meter A has just dropped to zero

$$K_{max} = eV_{stop},$$

- **Measurements show that for light of a given frequency, K_{max} does not depend on the intensity of the light source.**

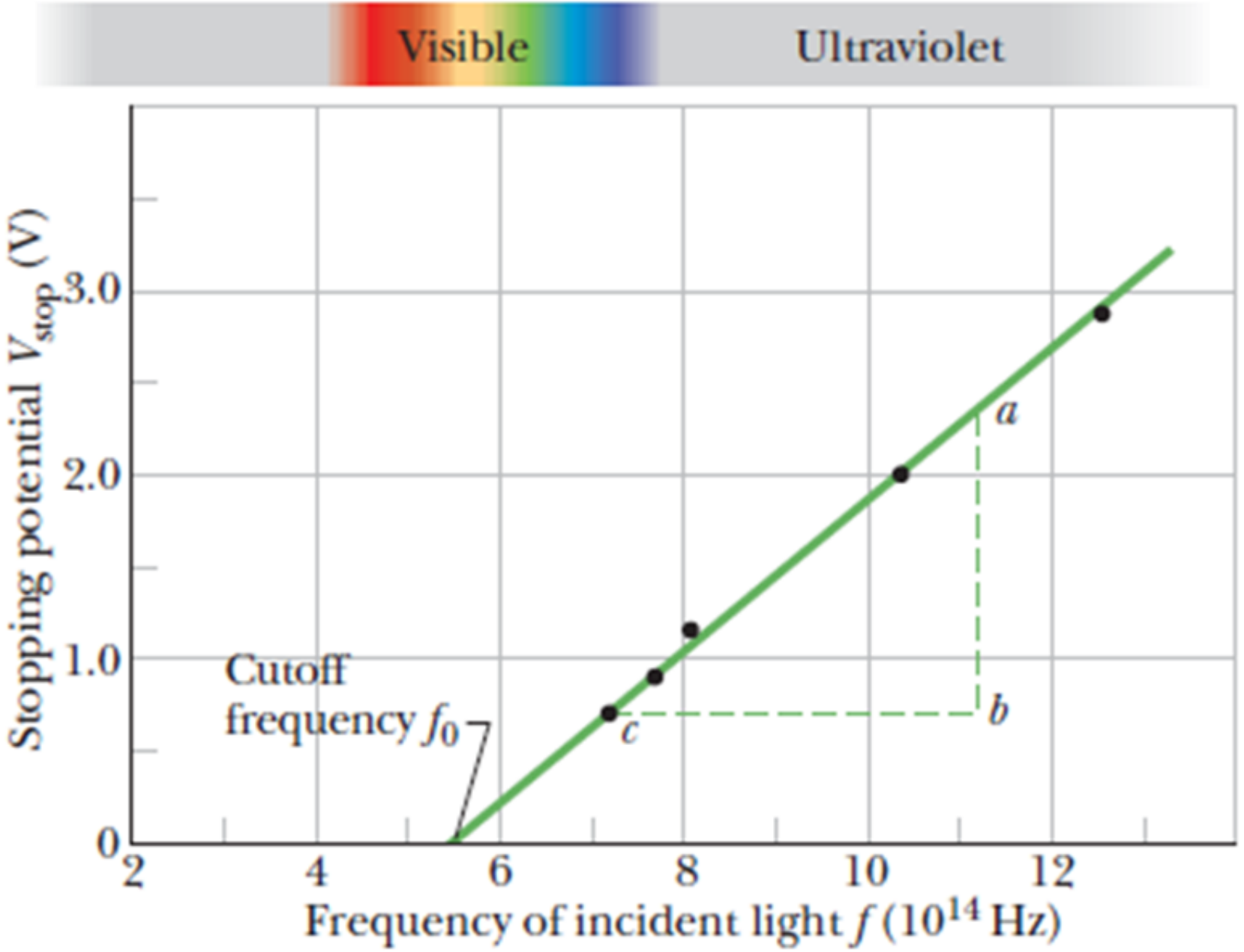
Classically

- **if we increase the amplitude of the wave (increase intensity of light), the electron should get a more energetic.**

❑ The actual result (modern physics)

- Increasing the light intensity increases the number of photons in the light, but the photon energy, given by Eq. (E = hf), is unchanged because the frequency is unchanged. Thus, the energy transferred to the kinetic energy of an electron is also unchanged.

- the photoelectric effect does not occur if the frequency is below a certain cutoff frequency f_0


Visible
Ultraviolet
Stopping potential V_{stop} (V)
3.0
2.0
1.0
0
Cutoff frequency f_0
a
b
c
2
4
6
8
10
12
Frequency of incident light f (10^{14} Hz)

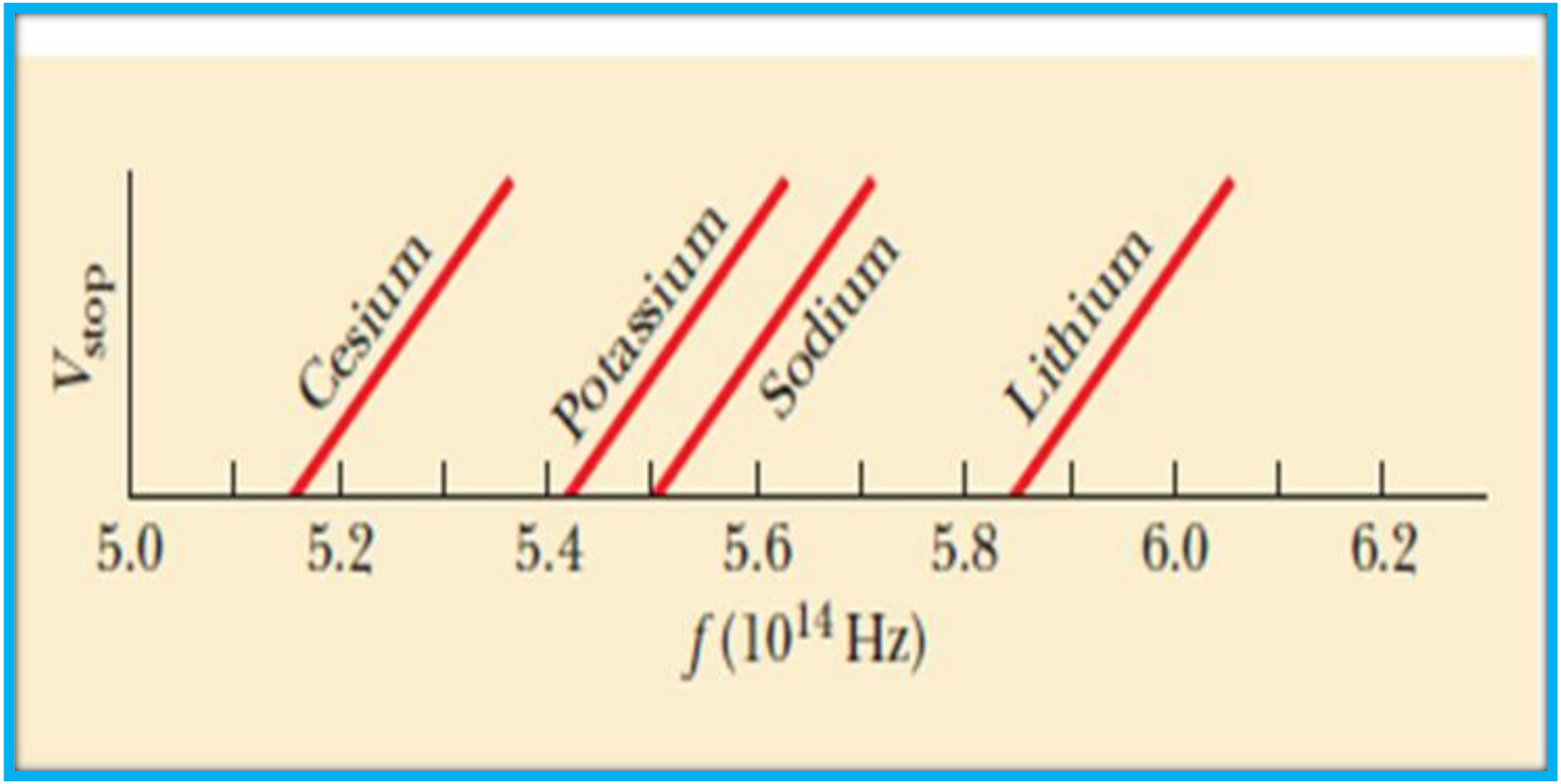
- To just escape from the target, an electron must pick up a certain minimum energy ,where ϕ is a property of the target material called its work function

- If the energy hf transferred to an electron by a photon exceeds the work function of the material (if $hf > \phi$), the electron can escape the target. If the energy transferred does not exceed the work function (that is, if $hf < \phi$), the electron cannot escape.

❑ The Photoelectric Equation

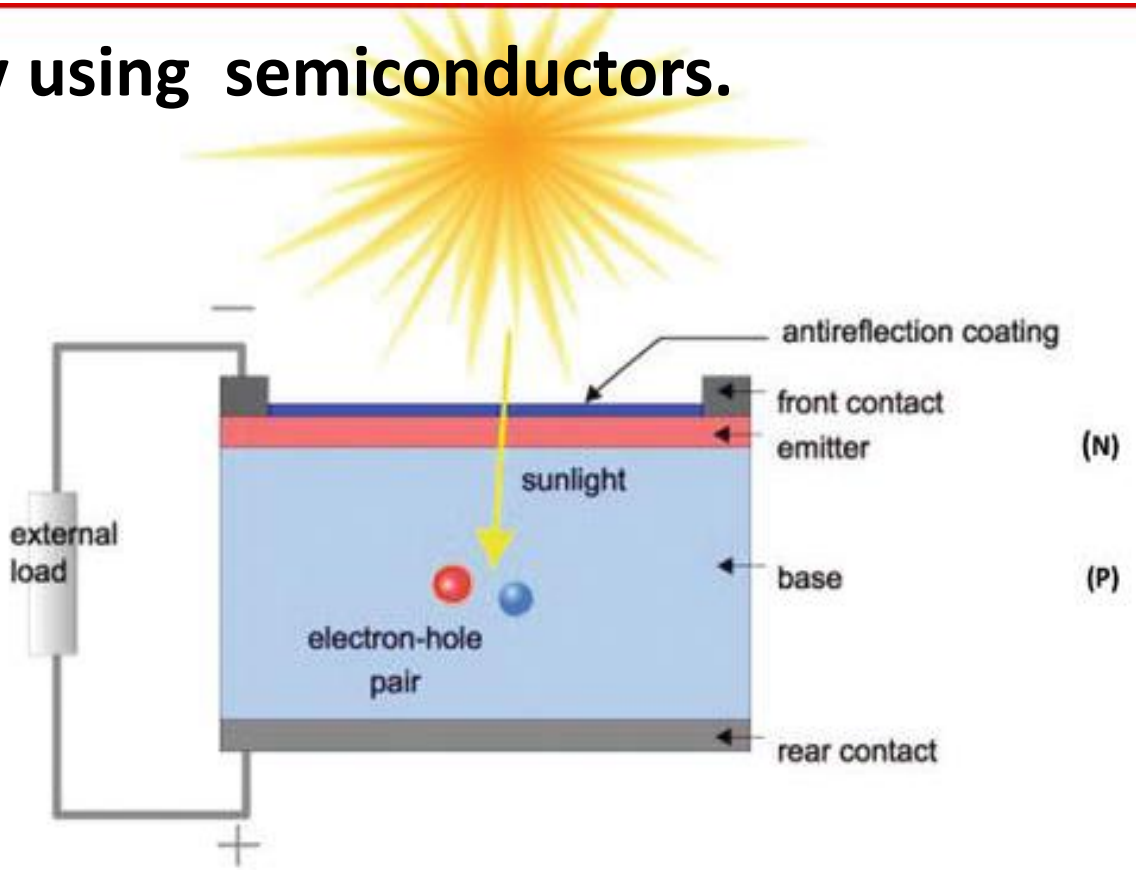
$$hf = K_{max} + \Phi$$

$$V_{stop} = \left(\frac{h}{e}\right) f - \frac{\Phi}{e}.$$


V_{stop}
Cesium
Potassium
Sodium
Lithium
5.0
5.2
5.4
5.6
5.8
6.0
6.2
$f\,(10^{14}\,\mathrm{Hz})$

❑ Photovoltaic effect

Photovoltaics (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors.



❑ Solar cell structure

An emitter that absorbs the incoming photons and transports their energies to the excited state of charge carries. Pentavalent-doped silicon (n-type) has a higher surface quality than trivalent doped silicon (p-type), so it is placed at the front of the cell, where majority of the light is absorbed.

❑ How solar cell work ?

Incident light causes electron–hole pairs to be generated in the semiconductor, and there is an increase in the concentration of electrons in the p-type region and holes in the n-type region. These photo-generated carriers cause the flow of photo-generated current.

Dr. Ali samir Awad