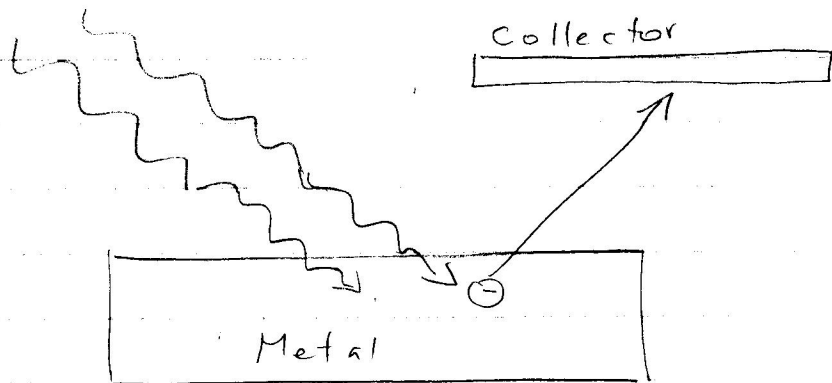


# Photoelectric Effect

Hertz 1887

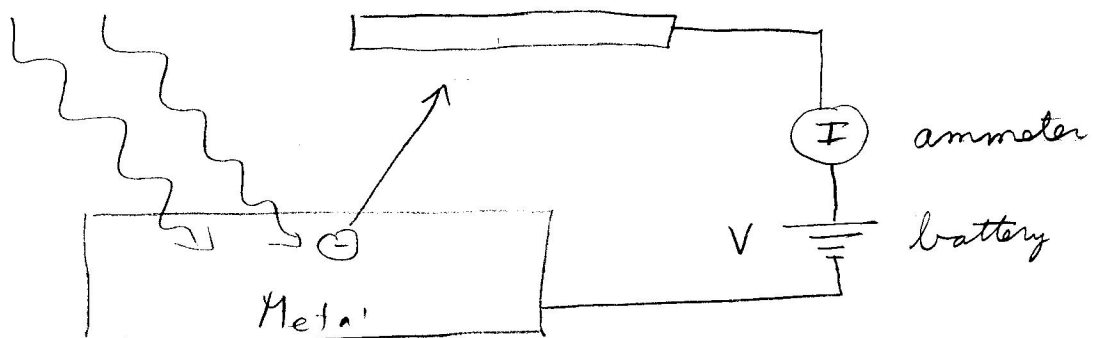
ultraviolet light shining on a metal surface  
ejects particles with negative electric charge



Thompson 1899: charged particles are electrons

Leonard 1902

connect collector to metal by a wire  
study current  $I$  as function of voltage  $V$



- There is a minimum voltage  $V_{\text{stop}}$  above which electrons are completely stopped.
- $V_{\text{stop}}$  does not depend on intensity of light
- For  $V < V_{\text{stop}}$ , the current  $I$  is proportional to the intensity of light
- $V_{\text{stop}}$  is larger for light of higher frequency



- electrons in metal have energy distribution with a sharp maximum (Fermi energy  $E_F$ )
- intensity of light determines number of electrons that absorb energy
- frequency of light determines the maximum energy they can absorb

$$E_{\text{max}} = eV_{\text{stop}}$$

## Einstein 1905

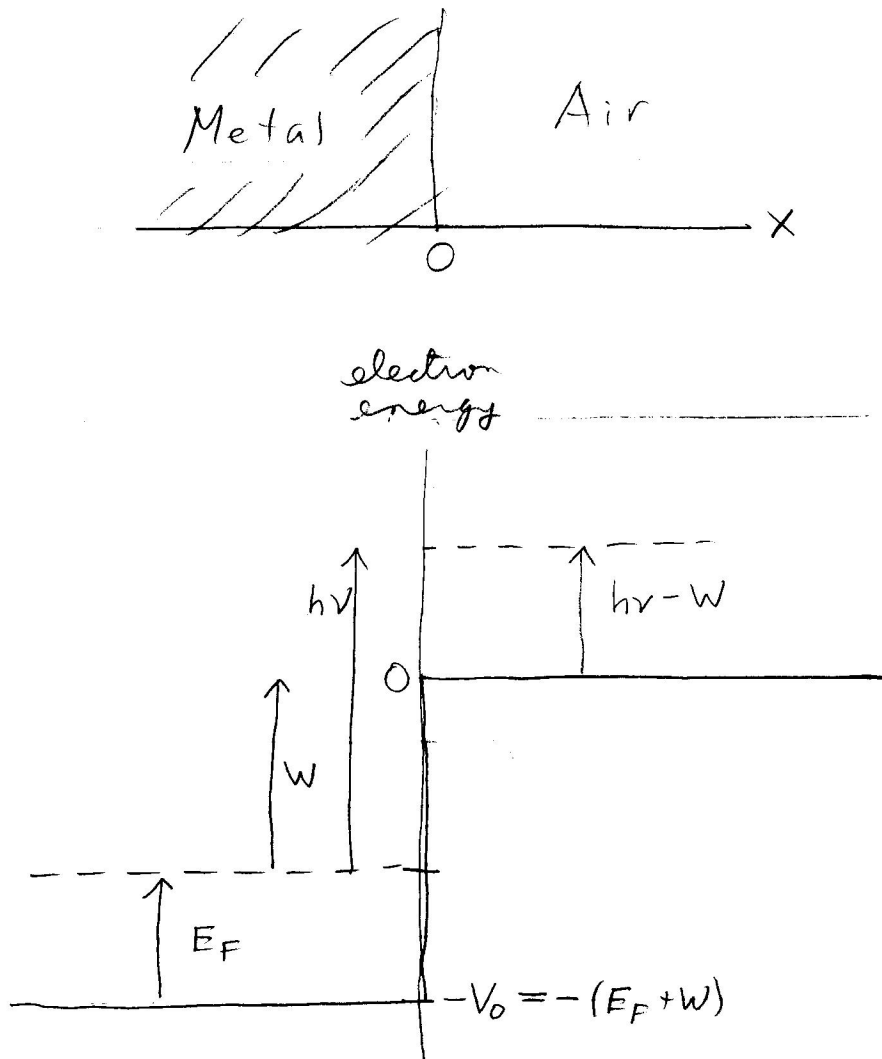
Light of frequency  $\nu$   
is absorbed by an electron  
in lumps of energy  $h\nu$  (quantum)

If an electron of energy  $E$  absorbs light,  
its energy becomes

$$E' = E + h\nu$$

- electron inside metal  
has energy distribution with sharp maximum
- additional energy required to escape metal:  $W$  ( $= E_B$ ?)  
"work function" ("binding energy"?)
- electron absorbs quantum of energy  $h\nu$  from light
- electrons that escape from metal  
have kinetic energy distribution  
with sharp maximum  $E_{\max}$

metal-air interface



electron energy  $E$

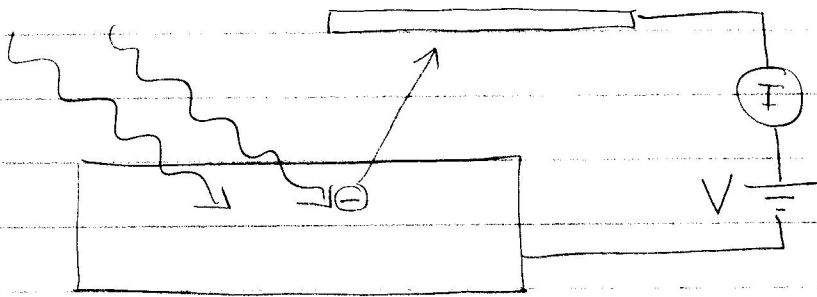
before absorbing quantum:  $E < -V_0 + E_F$

after absorbing quantum:  $E < -V_0 + E_F + h\nu = -W + h\nu$

after escaping metal:  $E < -W + h\nu$

maximum kinetic energy:  $E_{\max} = h\nu - W$

## Photoelectric experiments



electron inside metal  
absorbs quantum of light  
escapes from metal

initial kinetic energy:  $E < E_{\max} = h\nu - W$

electron can reach collector only if  $E > eV$

photoelectric current stops flowing  
when  $V$  is increased to  $V_{\text{stop}}$

$$eV_{\text{stop}} = h\nu - W$$

prediction (Einstein)

$V_{\text{stop}}$  increases linearly with  $\nu$   
with same slope  $h/e$  for all metals

confirmation: Millikan 1916

Nobel prizes: Einstein 1921, Millikan 1923