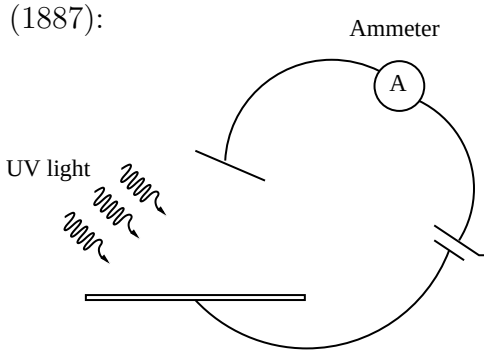
**Phys. 2b 2023, Classical failure for Photoelectric Effect**

**Classical Failure III. Photoelectric Effect**

Experiment of Hertz (1887):




Polished metal plates emit electrons when irradiated by UV light.
Energy of EM wave apparently liberates electrons.

Recall that Classical EM theory says that energy density in EM wave $E/V \propto |\vec{E}|^2$
and the UV EM wave intensity hitting the plate is $I_{UV}$ = energy/per unit area/per sec.
But classical theory FAILS (see below). Enter Einstein ...

Einstein explained this effect in 1905, by using $E = nh\nu$ for the EM field (i.e. photons)

| **Detailed Exp. Results** | **Classical Theory** | **Einstein Theory** |
|---|---|---|
| 1. Time of $e^-$ emission is "instantaneous"; *independent* of light intensity. | Should take *hours* to emit $e^-$ at low light intensity | Current starts as soon as first photon hits plate (can be instantaneous) |
| 2. There is a frequency (or $\lambda$) threshold that varies in metals (i.e., get $e^-$ only if $\nu > \nu_{thresh}$) | Unexplained | $h\nu_{thresh} = W_0 =$ Work Function ($W_0$ = energy to remove single $e^-$ from given metal) |
| 3. Kinetic energy of $e^-$ ($E_{e^-}$) is independent of UV intensity but obeys $E_{e^-} \propto \nu$. | $E_{e^-} \propto I_{UV}(maybe?)$ ($\nu$ is irrelevent) | $E_{e^-} = h\nu - W_0$ |
| **Final Grade:** | $\mathbf{F^-}$ | $\mathbf{A^+}$ |