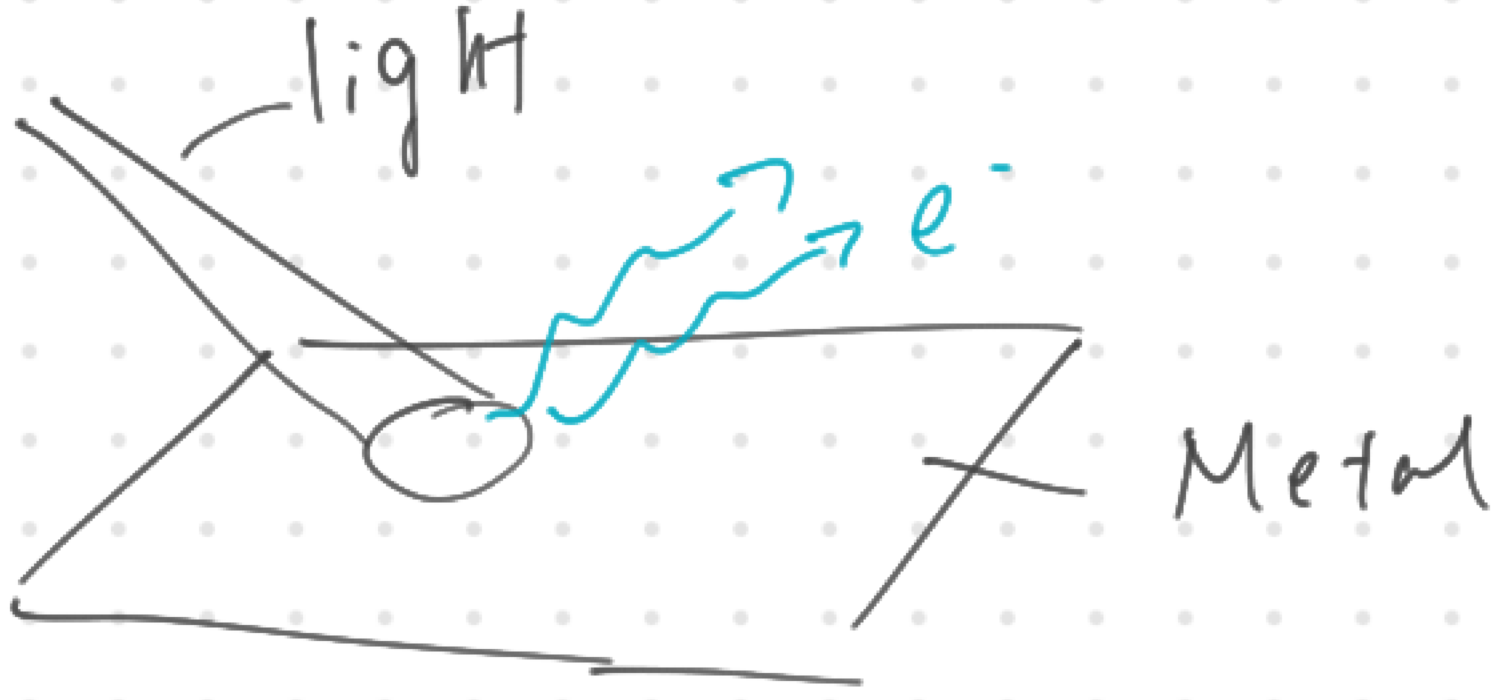
Photoelectric effect - work function, excitation, ionisation



e^- only ~~flie~~ fly out after a certain frequency of light/radiation on the metal

$$E_\gamma = hf$$

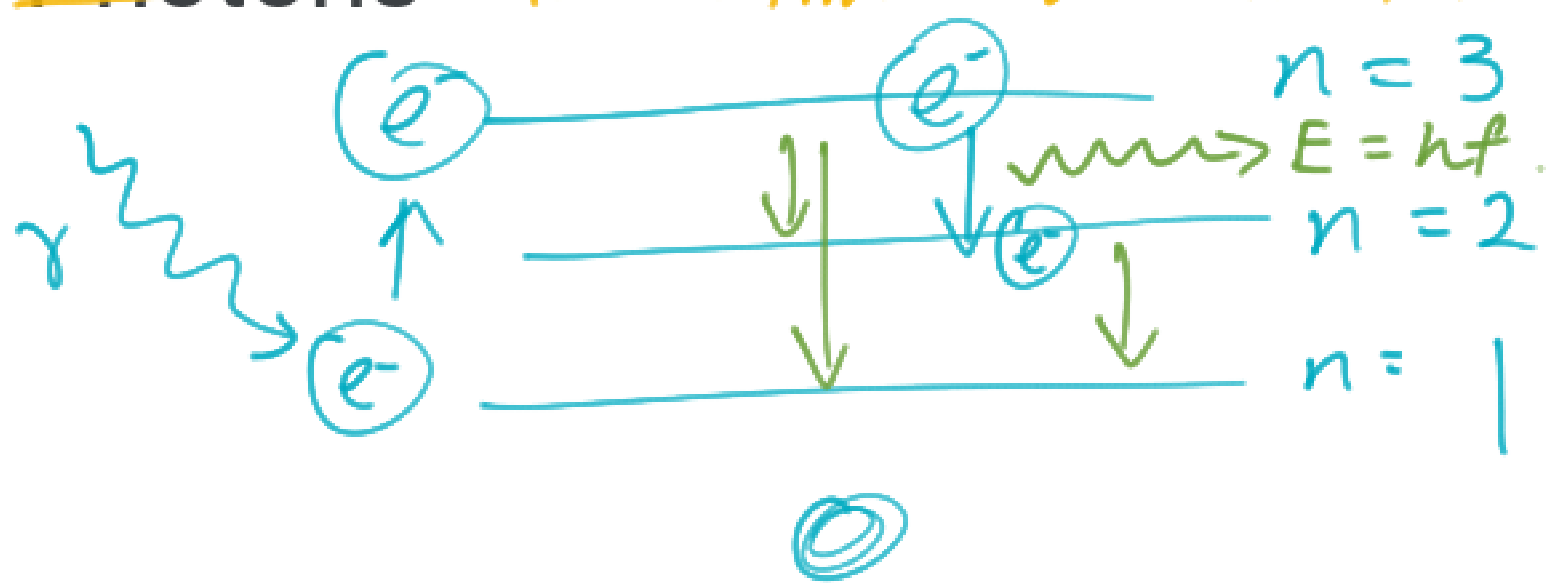
surface

γ transfer energy to e^-. $\rightarrow$ e^- is knocked out and emitted as photoelectron.

$$hf = E_\gamma = \overbrace{\underline{KE} + \phi}^{\text{energy of } e^-}$$

energy used to overcome binding energy of metal.

~~Photons~~ ionisation & excitation



Total no. of unique EM wave f produced.

$$\sum_{i}^{n-1} i$$

ionisation

$n \rightarrow \infty$.

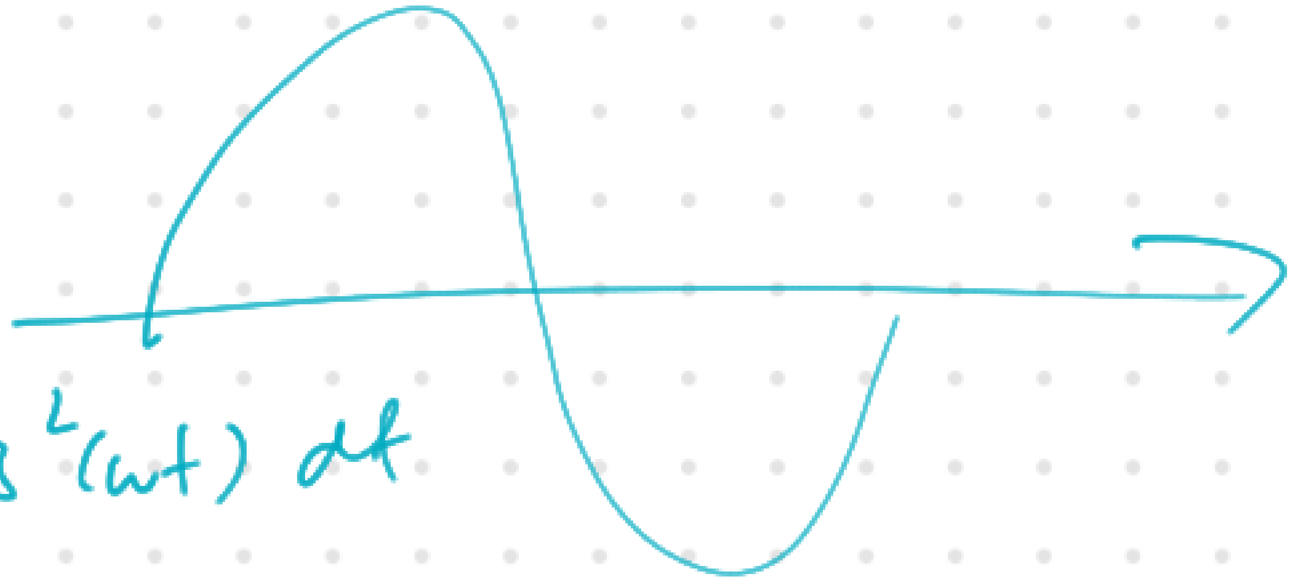
$$E_n = -\left(\frac{R_\infty}{n^2}\right)$$

Ionisation energy:

excite until $n \rightarrow \infty$

Energy required to ionise an electron in the ground state in its atom

$\psi = A\cos(\omega t)$



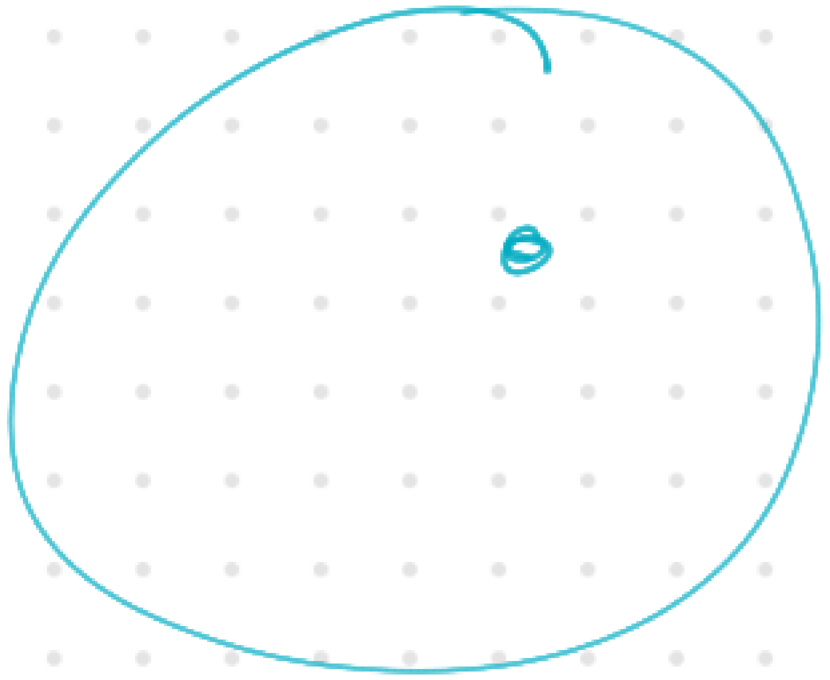
$\langle \psi \rangle_t = \frac{1}{T}\int_0^T A^2\cos^2(\omega t)\,dt$

$= \frac{A^2}{2} \rightarrow I_0$ (intensity)

$W m^{-2}$

$2.6 \cdot 10^{26}$ W.

$I = \frac{P}{4\pi r^2} \leftarrow$



Brightness

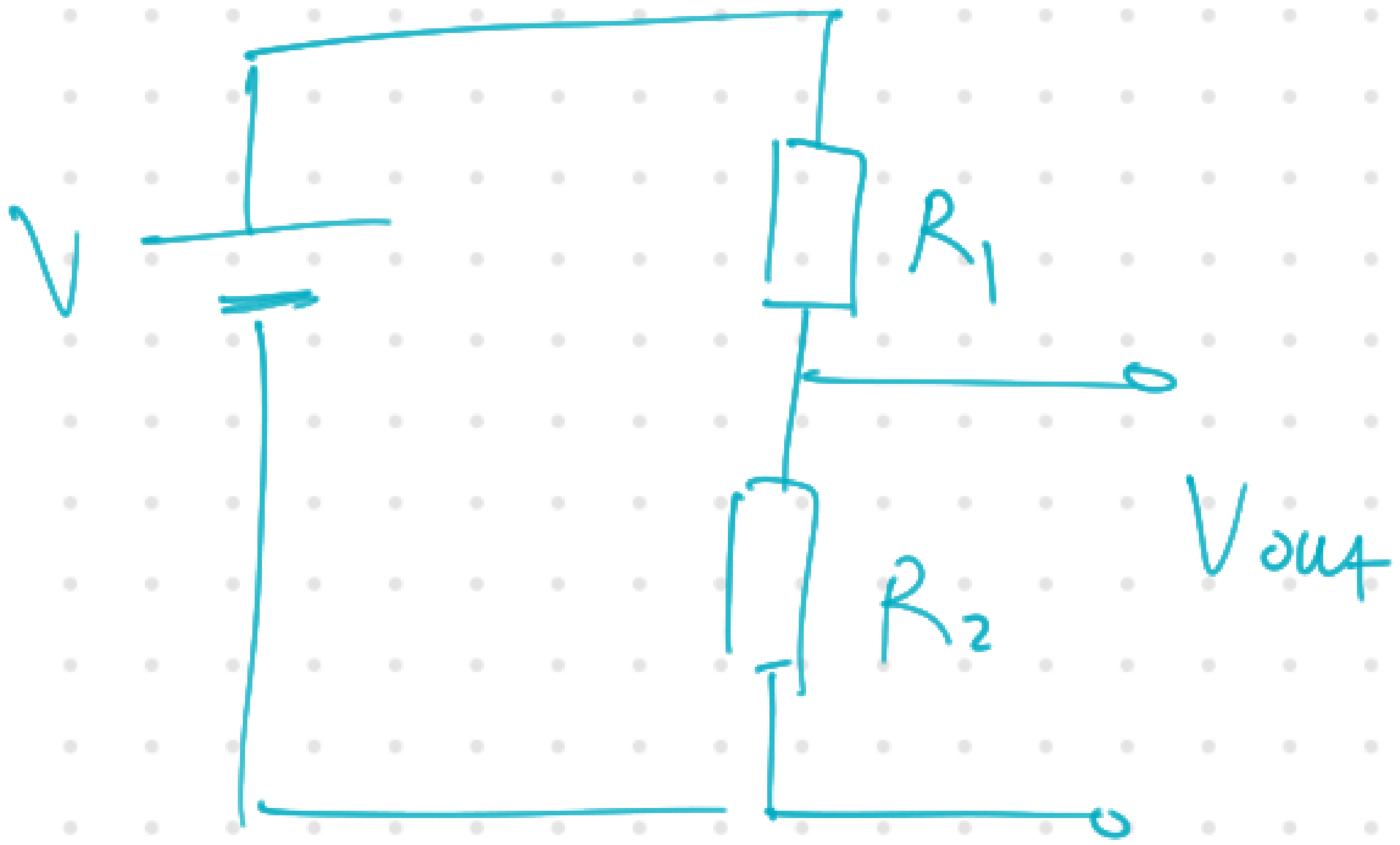
100 lm

$R = 10\,\Omega$

0 lm

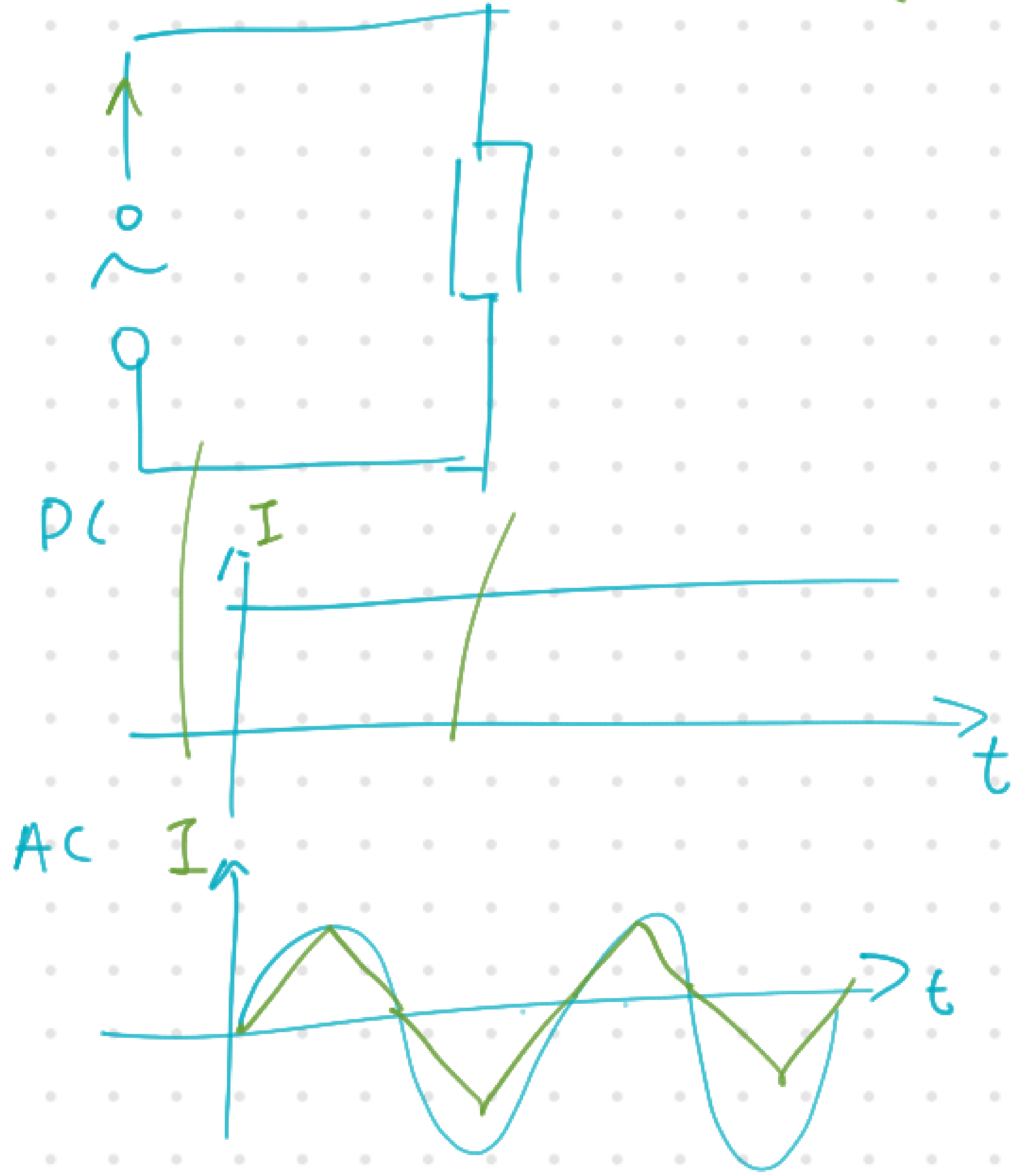
$\downarrow$

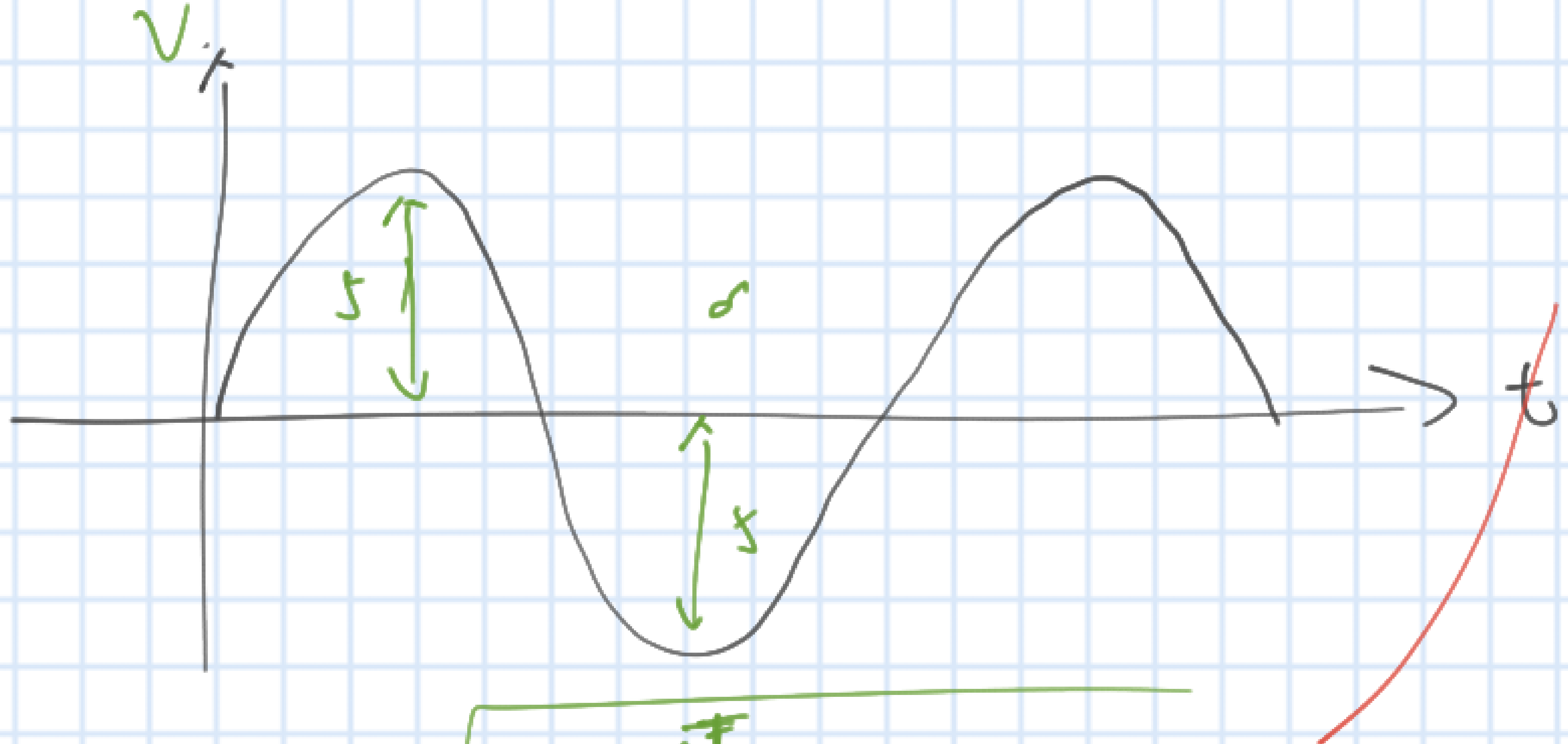
$R = 1000\,\Omega$



$V_{out} =$

$I = \frac{V}{R_1+R_2}$ $\quad V_{out} = IR_2 = \frac{R_2}{R_1+R_2}$



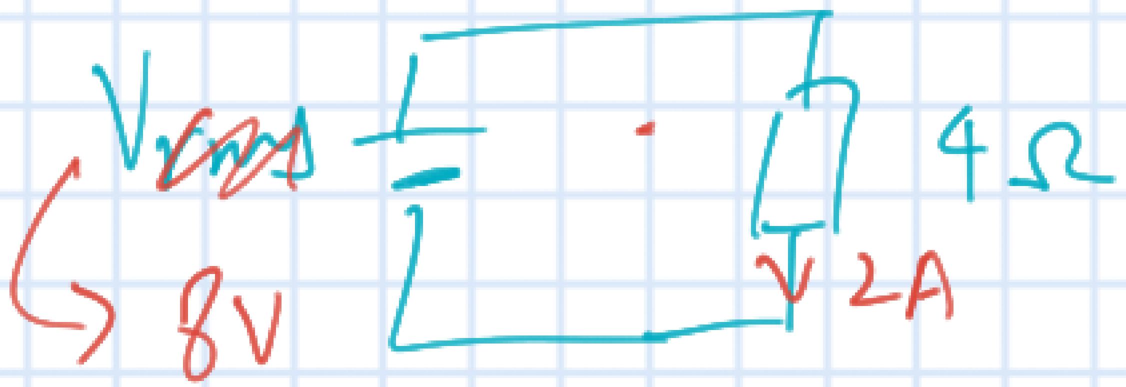


$$\sqrt{\frac{1}{T}\int_0^T \sin^2 \omega t \, dt}$$

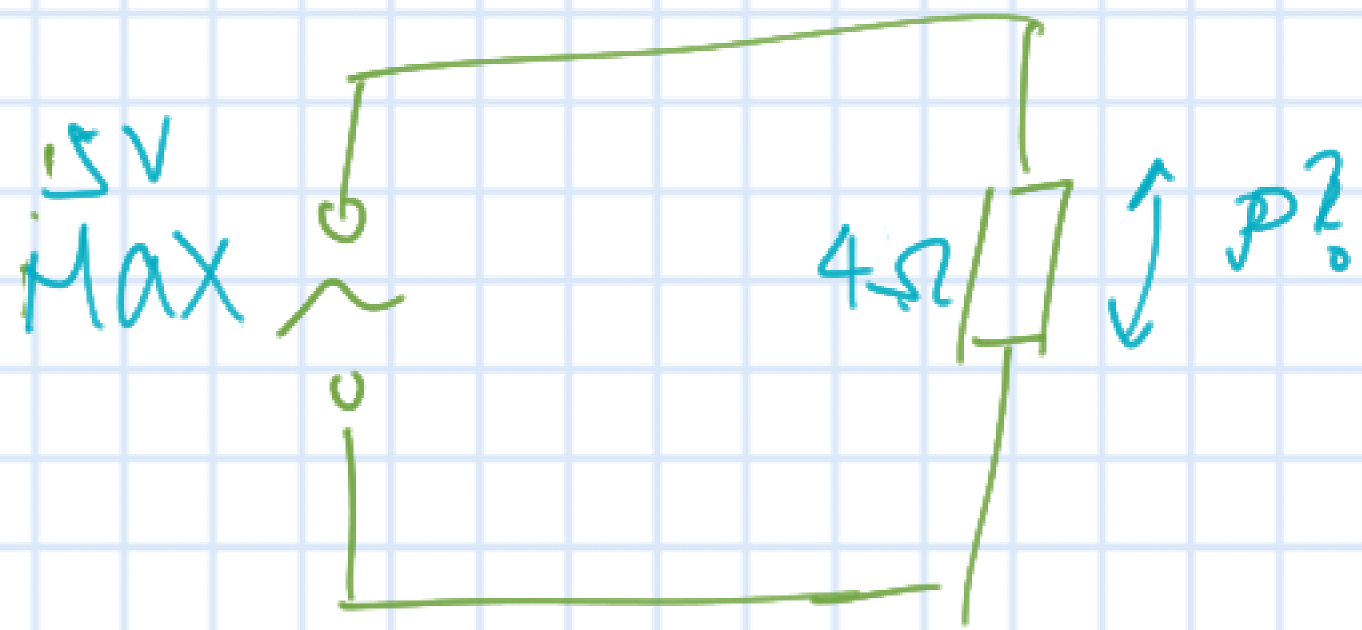
V_0^2

$$\sqrt{\frac{1}{2} V_0^2}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}.$$



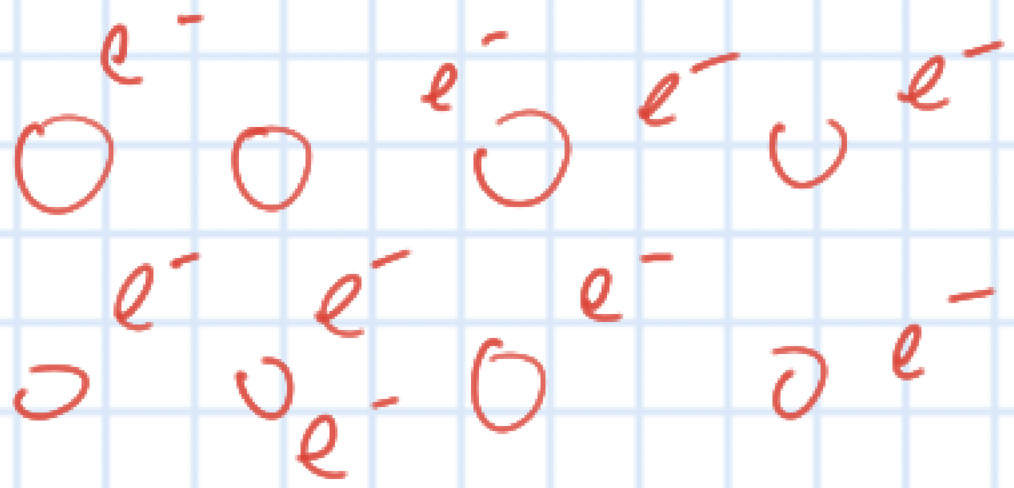
$AC = 8\sqrt{2} \sin \omega t$



$$P = \frac{V_{rms}^2}{R}$$

$$= \frac{V_{max}^2}{2R}$$

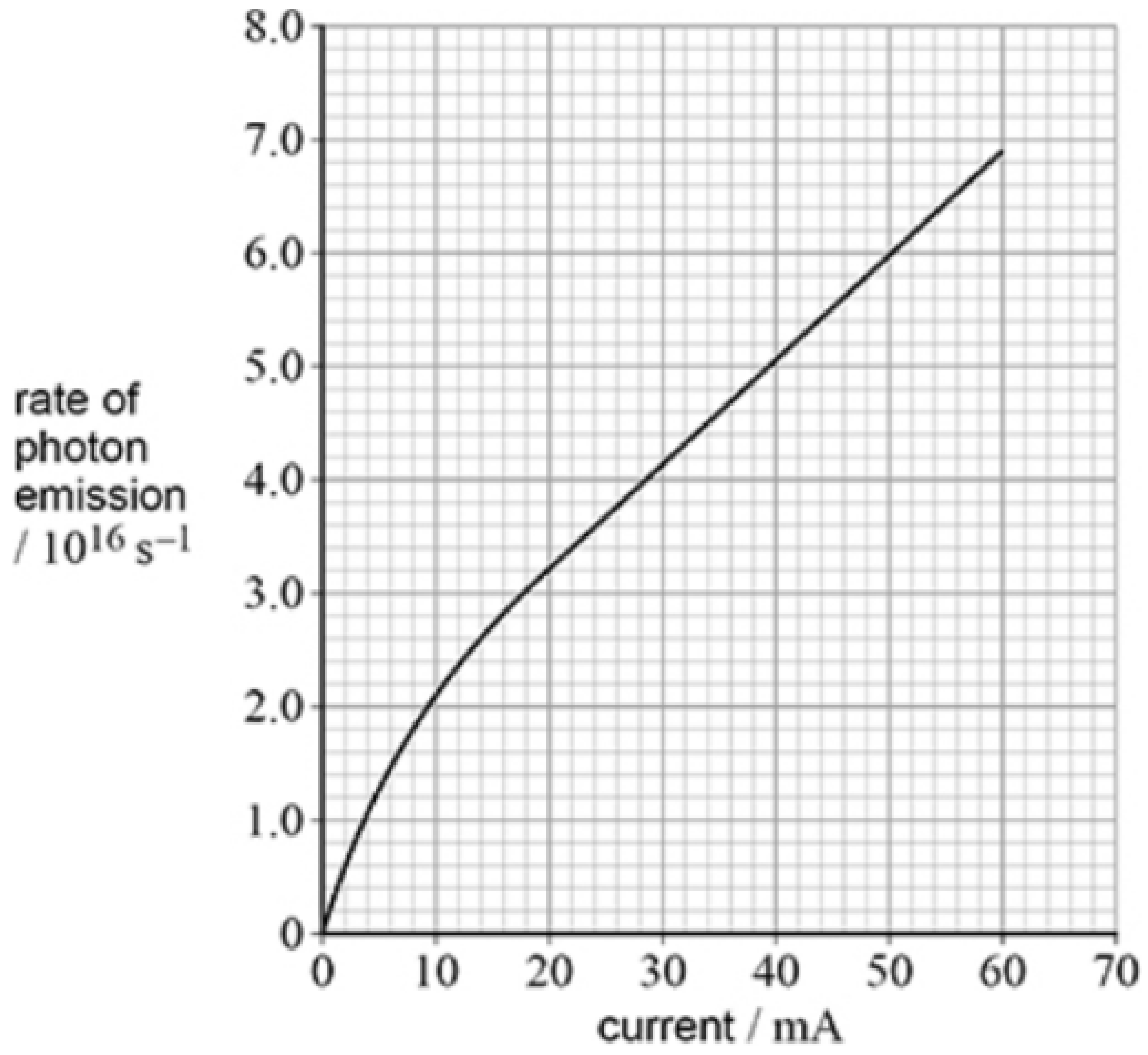
$$= \frac{25}{8}$$



1. (a) A light emitting diode (LED) emits blue light with a wavelength of 440 nm. The rate of photon emission is $3.0 \times 10^{16}\ s^{-1}$.

Show that the power output of the LED is approximately 0.014 W.

(b) A different LED emits red light with a wavelength of 660 nm.
The graph below shows how the rate of photon emission varies with current up to the maximum operating current of this LED.



A student claims that the red LED can have twice the power output of the blue LED.

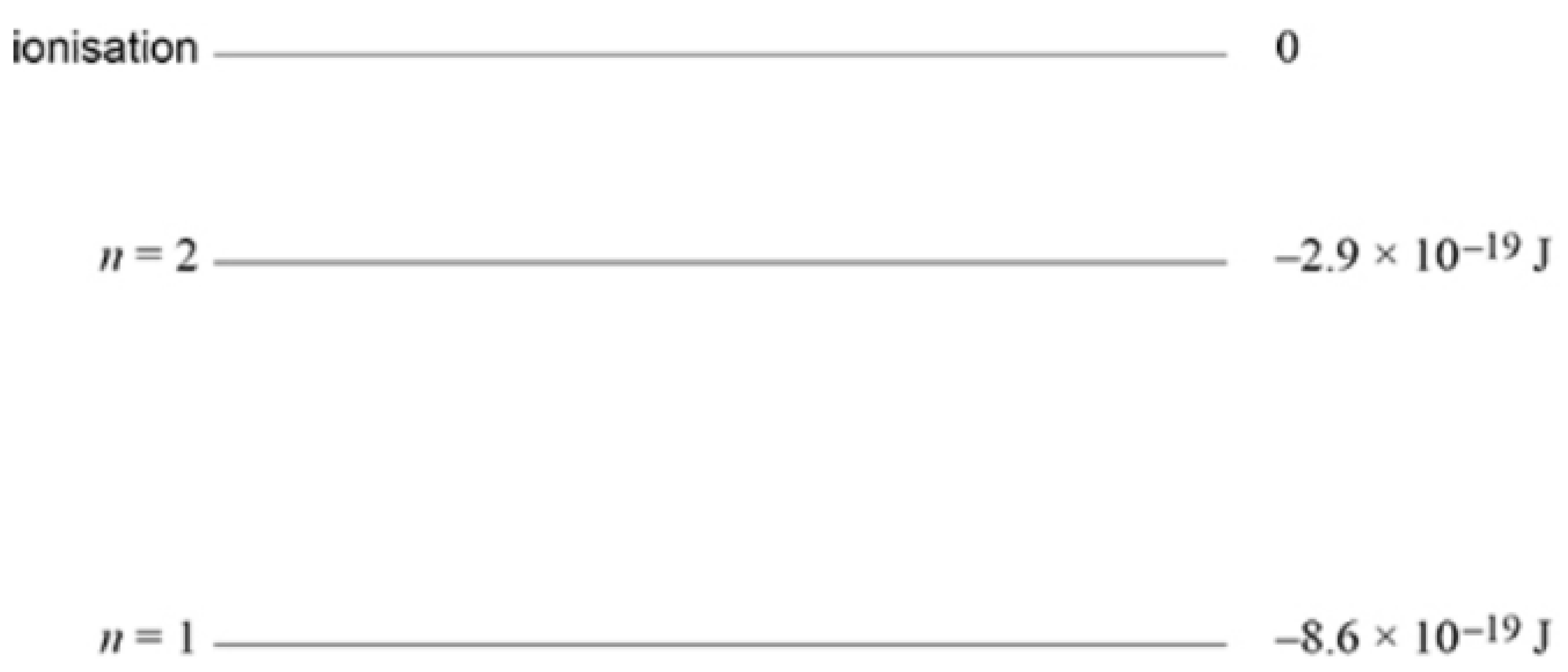
Deduce whether the student's claim is correct.

(c) The student has paint that fluoresces when light of any wavelength is incident on it. She coats the blue LED and the red LED with the paint.

Compare the wavelengths of light emitted by the paint on each LED.

In your answer you should also explain the processes that cause the paint to fluoresce.

2. Some energy levels of a lithium atom are shown below.



A free electron with kinetic energy 6.0×10^{-19} J collides with a stationary lithium atom in its $n = 1$ energy level. The lithium atom is excited to the $n = 2$ energy level.

What is the kinetic energy of the free electron after the collision?

A 0.3×10^{-19} J ☐

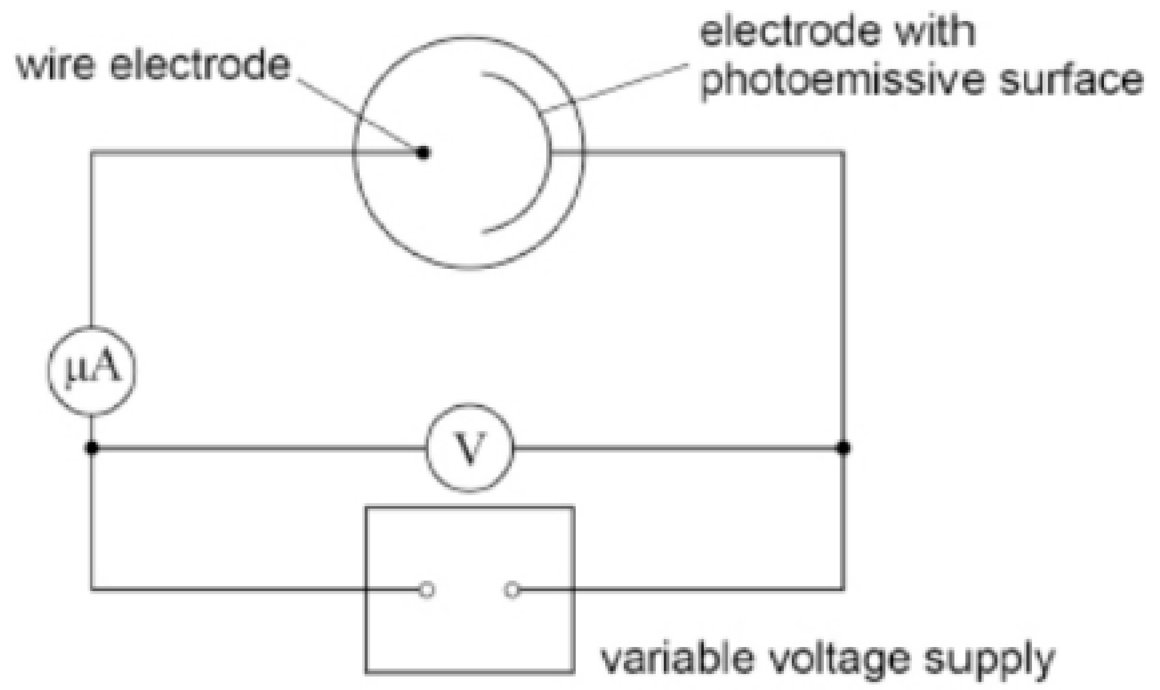
B 2.6×10^{-19} J ☐

C 3.1×10^{-19} J ☐

D 5.7×10^{-19} J ☐

11. **Figure 1** shows an arrangement used to investigate the photoelectric effect.

Figure 1



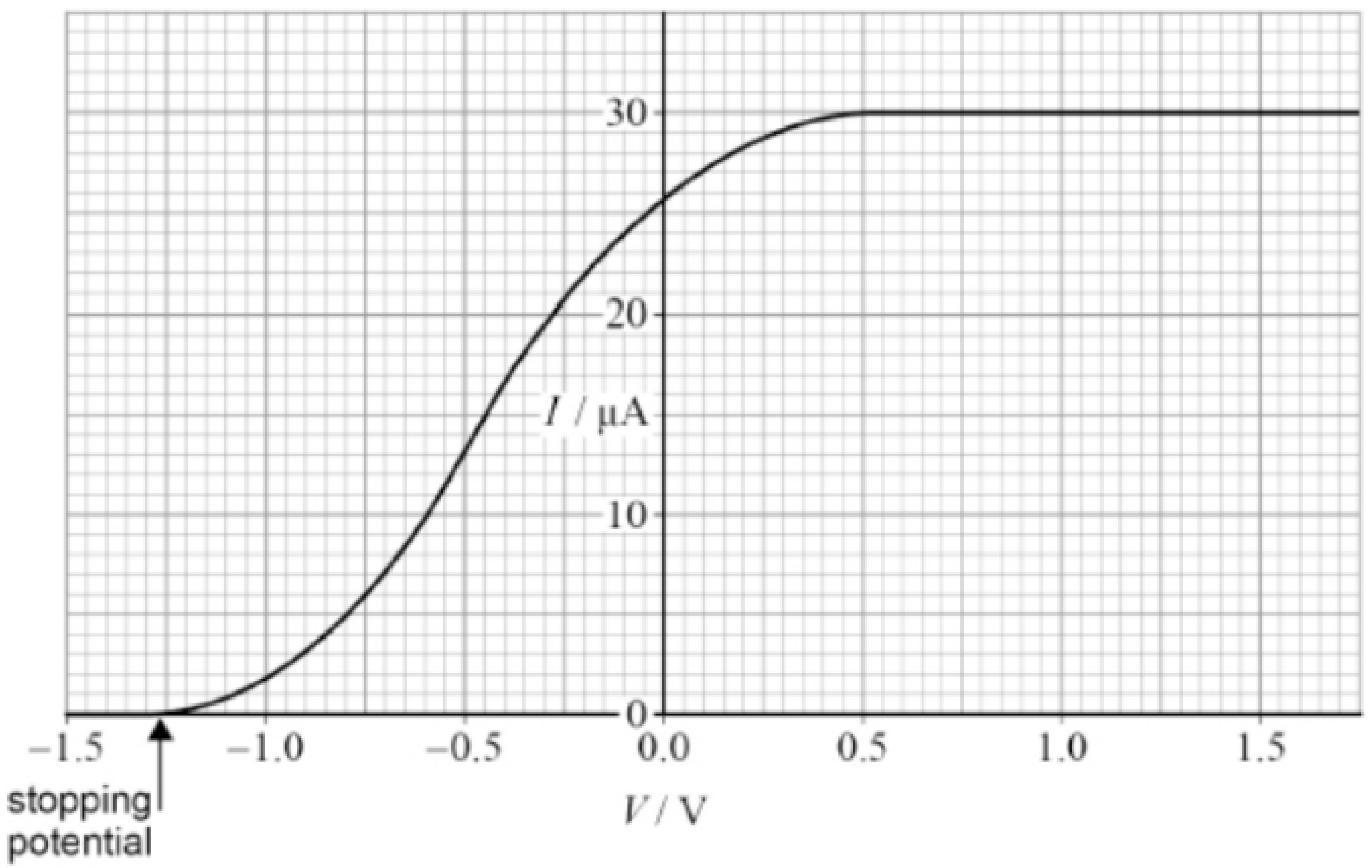
A current is measured on the microammeter only when electromagnetic radiation with a frequency greater than a certain value is incident on the photoemissive surface.

(a) Explain why the frequency of the electromagnetic radiation must be greater than a certain value.

The apparatus in **Figure 1** is used with a monochromatic light source of constant intensity. Measurements are made to investigate how the current I in the microammeter varies with positive and negative values of the potential difference V of the variable voltage supply.

The **Figure 2** shows how the results of the investigation can be used to find the stopping potential.

Figure 2



(b) Determine the number of photoelectrons per second leaving the photoemissive surface when the current is a maximum.

(c) Explain why I reaches a constant value for positive values of V.

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(2)

(d) Explain why I decreases as the value of V becomes more negative.

(e) The investigation is repeated with a different photoemissive surface that has a smaller value of the work function. The source of electromagnetic radiation is unchanged.

Discuss the effect that this change in surface has on the value of the stopping potential.