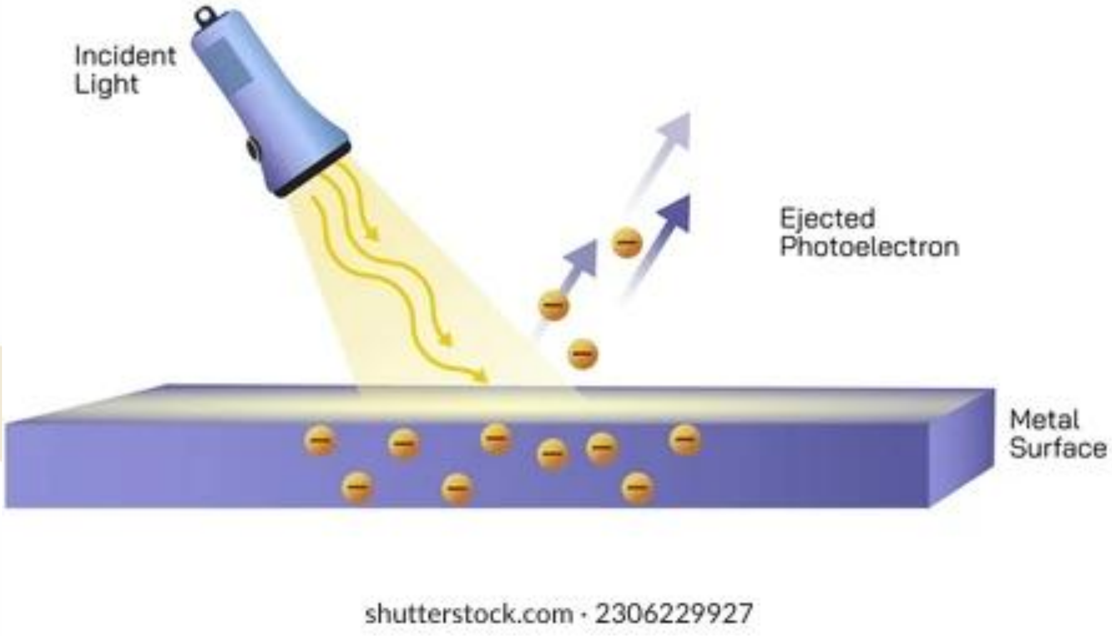

Chapter 16

Corpuscular Aspect of Light

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Quiz
Time

A metallic plate, covered with a layer of cesium, is illuminated with a monochromatic luminous beam of wavelength $\lambda = 0.45\mu m$ in vacuum.

The work function (extraction energy) of cesium is $W_0 = 1.88eV$

A convenient apparatus (D) is used to detect the electrons emitted by the illuminated plate.

Given: Planck's constant $h = 6.6 \times 10^{-34} J.s$; speed of light in vacuum $C = 3 \times 10^8 m/s$; $1eV = 1.6 \times 10^{-19} J$; elementary charge $e = 1.6 \times 10^{-19} C$.

Quiz **Photoelectric effect** **Duration: 20min**

$\lambda = 0.45\mu m$; $W_0 = 1.88 eV$; $h = 6.6 \times 10^{-34} J.s$; $C = 3 \times 10^{8} m/s$; $1eV = 1.6 \times 10^{-19} J$; $e = 1.6 \times 10^{-19} C$.

1) What aspect of light does the phenomenon of photoelectric effect show evidence of?

Photoelectric effect shows evidence of Corpuscular (particle) aspect of light

2) Define the term "work function" of a metal.

The work function (W_0) of a substance is the minimum energy needed to extract an electron from the substance.

Quiz **Photoelectric effect** **Duration: 20min**

$\lambda = 0.45\mu m$; $W_0 = 1.88eV$; $h = 6.6 \times 10^{-34} J.s$; $C = 3 \times 10^8 m/s$; $1eV = 1.6 \times 10^{-19} J$; $e = 1.6 \times 10^{-19} C$.

3) The luminous beam illuminating the metallic plate is formed of photons.

a) Write down the expression of the energy E of a photon in terms of h, c and λ.

$$E_{ph} = \frac{hc}{\lambda}$$

Quiz **Photoelectric effect** **Duration: 20min**

$\lambda = 0.45\mu m$; $W_0 = 1.88eV$; $h = 6.6 \times 10^{-34} J.s$; $C = 3 \times 10^8 m/s$; $1eV = 1.6 \times 10^{-19} J$; $e = 1.6 \times 10^{-19} C$.

b) Calculate, in eV, the energy of an incident photon.

$$E_{ph} = \frac{hc}{\lambda}$$

$$E_{ph} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{0.45 \times 10^{-6}}$$

$$E_{ph} = 44 \times 10^{-20} J = 2.75 eV$$

Quiz **Photoelectric effect** **Duration: 20min**

$\lambda = 0.45\mu m$; $W_0 = 1.88eV$; $h = 6.6 \times 10^{-34} J.s$; $C = 3 \times 10^8 m/s$; $1eV = 1.6 \times 10^{-19} J$; $e = 1.6 \times 10^{-19} C$.

c) (D) detects electrons emitted by the plate. Why do we have an emission of electrons by the plate?

Since $E = 2.75\ eV > W_0 = 1.88eV$

d)Calculate, in eV, the maximum kinetic energy of an emitted electron.

$$E = W_0 + K.E$$

$$2.75 = 1.88 + K.E$$

$$K.E = 0.87eV$$

4) The luminous power P received by the plate is $10^{-3}W$, and the emitted electrons form a current $I = 5\,mA$.

a) Calculate the number n of photons received by the plate in one second.

$$P = n \times E \quad \Rightarrow \quad n = \frac{P}{E}$$

$$n = \frac{10^{-3}}{44 \times 10^{-20}}$$

$$n = 227 \times 10^{13} ele/s$$

b)Knowing that the current I is related to the number N of the electrons emitted per second and to the elementary charge e by the relation: $I = N \times e$. Calculate N.

$$I = \frac{N \times e}{t} \Rightarrow N = \frac{I \times t}{e} \Rightarrow N = \frac{5 \times 10^{-3} \times 1}{1.6 \times 10^{-19}}$$

$$N = 3.125 \times 10^{13} elec/sec$$

c) Calculate the quantum efficiency $r = \frac{N}{n}$.

$$r = \frac{3.125 \times 10^{13}}{227 \times 10^{13}}$$

$$r = 0.014 = 1.4\%$$

d) Deduce that the number of effective photons in one second is relatively small.

r is small, then the number of effective photons per second is small

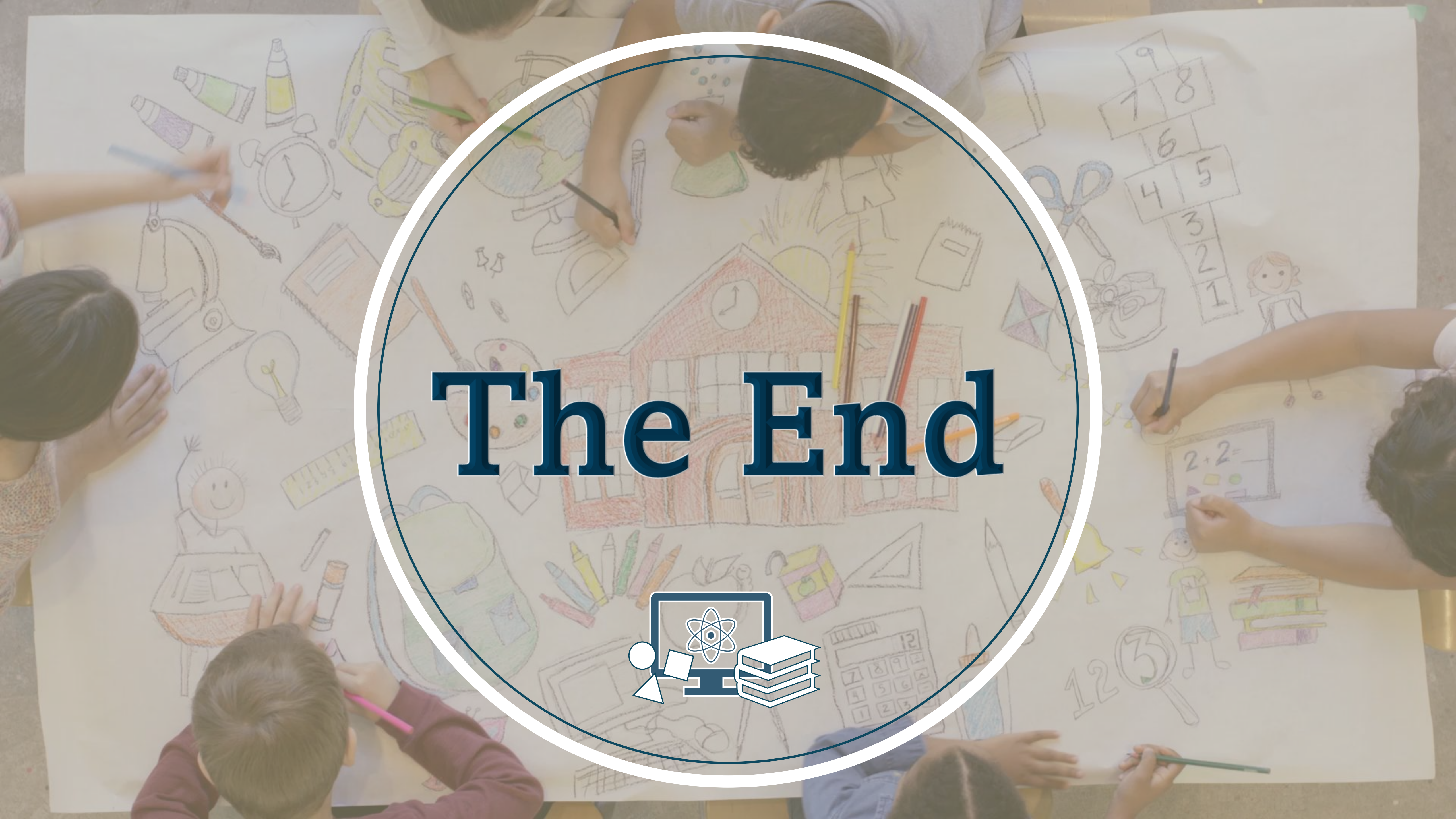
e) We increase the luminous power P received by the plate without changing the wavelength λ. Would the current increase or decrease? Why?

$$P = \frac{n \times E}{t} \Rightarrow P = n \times E \Rightarrow P = n\frac{hc}{\lambda}$$

If we increase P, and keep λ constant: then n increases. then $N_{eff} = N$ will increase:

But $I = N \times e$

Since the number N increases, then the current I will increase.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