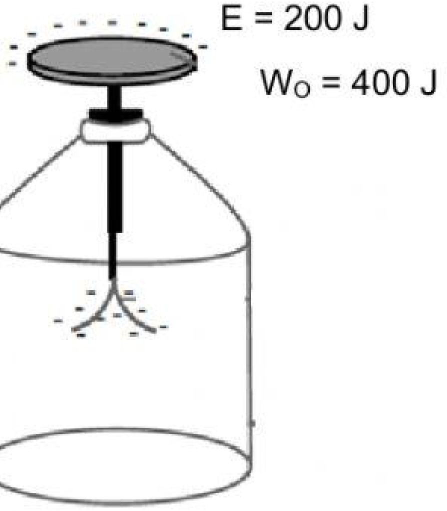
Photoelectric effect Worksheet 2

Examples:

1.



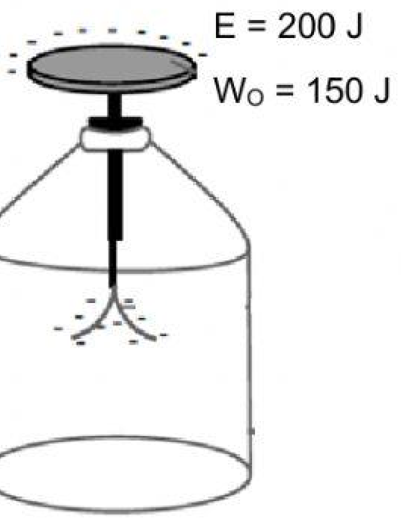
Determine

a) whether electrons will be emitted: yes no

b) If yes, the energy of the emitted photoelectrons

Ek = not applicable (if you tried to calculate the Ek here – you would get a negative value, and that is an indication that photoelectrons would **not** be emitted.)

2.



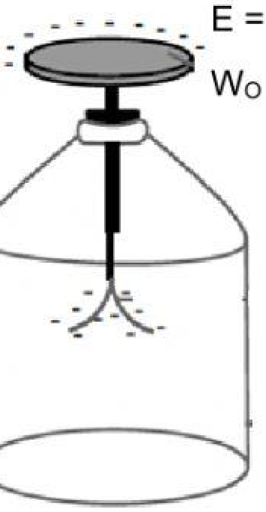
Determine

a) whether electrons will be emitted yes no

b) if yes, the energy (Ek_{max}) of the emitted electrons $Ek = E - W_O$

= (no spaces between values and units)

3.



Determine

a) whether electrons will be emitted yes no

b) if yes, the energy(Ek_{max}) of the emitted photoelectrons $Ek = E - W_O$

$=$

c) Calculate the speed of the emitted

For this we use the formula from gr 10

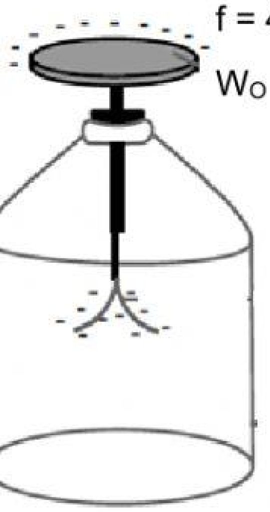
$\mathbf{Ek_{(max)} = \frac{1}{2} m.v^2}$

$150 = \frac{1}{2} (9{,}11 \times 10^{-31}) v^2$

You use the mass of an electron (which is always given on the data sheet). The mass of the photon is negligible and thus we only use the mass of the electron.

v = ______x 10___m.s^{-1}

4.



Determine

a) whether electrons will be emitted yes no

Firstly we cannot compare the 2 values, since one is energy and one is frequency.

So we calculate the energy of the light first (E) using one of the formulae below

$E = h.f$

$E = \frac{h.c}{\lambda}$

$E = hf$

$= 6{,}63 \times 10^{-34} (4 \times 10^{4})$

$= 2{,}652 \times 10^{-29}$ J {don't round off yet}

So you can compare the two values

$E > W_O$

$2{,}652 \times 10^{-29} > 2 \times 10^{-29}$

Thus photoelectrons will be emitted

b) Calculate the energy of the emitted photoelectrons

$E = W_O + E_k$

$2{,}652 \times 10^{-29} = 2 \times 10^{-29} + Ek$

Ek = ______x 10___ _____

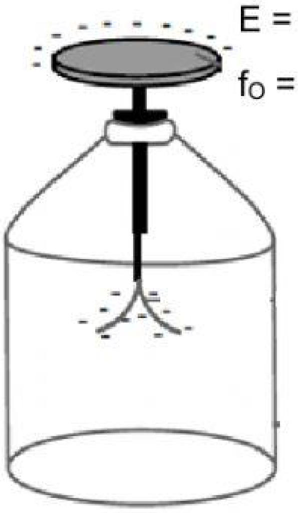
c) Calculate the speed of the emitted

$Ek_{(max)} = \frac{1}{2} m.v^2$

$6{,}52 \times 10^{-30} = \frac{1}{2} (9{,}11 \times 10^{-31}) v^2$

v = _________$m.s^{-1}$

5.



Determine

a) whether electrons will be emitted yes no

Firstly we cannot compare the 2 values, since one is energy and one is frequency.

So calculate the energy that the metal plate needs to emit electrons first (Wo) using the formulae below

$W_o = h.f_O$

$= 6{,}63 \times 10^{-34} (3{,}5 \times 10^6)$

$= 2{,}32 \times 10^{-27}$ J

Careful, this is in fact a bigger value, since -20 is a bigger exponent value then -27

$2 \times 10^{-20} > 2{,}32 \times 10^{-27}$

E > Wo

Thus, yes photoelectrons will be emitted

b) Calculate the energy of the emitted photoelectrons

$E = W_O + E_k$

$2 \times 10^{-20} = 2{,}32 \times 10^{-27} + Ek$

Ek = ______x 10___m.s^{-1}

c) Calculate the speed of the emitted

$Ek_{(max)} = ½ m.v^2$

$2 \times 10^{-20} = ½ (9{,}11 \times 10^{-31}) v^2$

v = ______x 10___m.s^{-1}

6. The threshold frequency of a metal is the **same as the frequency of green** light.

Would the following colours of light emit photoelectrons:

a) blue: yes no

because (pick the correct option/s):

f of blue light > f of green light | f of blue light < f of green light

E of blue > E of green light | E of blue < E of green light

b) red: yes no

f of red light > f of green light | f of red light < f of green light

E of red > E of green light | E of red < E of green light

c) yellow: yes no

f of yellow light > f of green light | f of yellow light < f of green light

E of yellow light > E of green light | E of yellow light < E of green light

notice you don't actually need to know the actual frequency values of each colour, but rather just the order

ROYGBIV

Red Orange Yellow Green Blue Indigo Violet

Frequency increases

Wavelength decreases $f \propto \frac{1}{\lambda}$

Energy increases $E \propto f$

Just take a quick look at what everything on the formula sheet represents in this section:

WAVES, SOUND AND LIGHT/*GOLWE, KLANK EN LIG*

(1) $T = \frac{1}{f}$

(2) $E = hf$

(3) $E = h\frac{c}{\lambda}$

(4) $E = W_o + E_{k(max)}$

where/*waar*

$E = hf$ and/*en* $W_0 = hf_0$ and $E_{k(max)} = \frac{1}{2}mv^2_{max}$

(5) (6)

1. T – period of the wave (s)

   f – frequency of the photon of light (Hz)

2. E – energy of the photon(J)

   h- planck's constant: 6.63×10^{-34}

   f – frequency of the photon (Hz)

3. E- energy of the emitted photon(J)

   c- speed of light 3×10^8 m.s^{-1}

λ - wavelength of light (m)

4. E - energy of the photon (J)

   W_0 – work function of the metal – the min energy needed to shine on the metal remove an electron from the metal plate (J)

   $Ek_{(max)}$ – Kinetic energy of the emitted photo-electron (J)

5. W_o - work function of the metal – the min energy needed to remove an electron from the metal plate

   f_o – threshold frequency of the metal- the min frequency of the light shone onto the metal in order to remove an electron from the metal plate

6. $E_{k(max)}$ – Kinetic energy of the emitted photo-electron (J)

   m – mass of an electron: 9,11 x 10^{-31}kg (given on the data sheet)

   $v_{(max)}$– speed of emitted photo-electron ($m.s^{-1}$)

Formula not on the formula sheet:

$c = f. \lambda$ (since it is given as $v = f. \lambda$)

Watch this quick video covering a photoelectric calculation

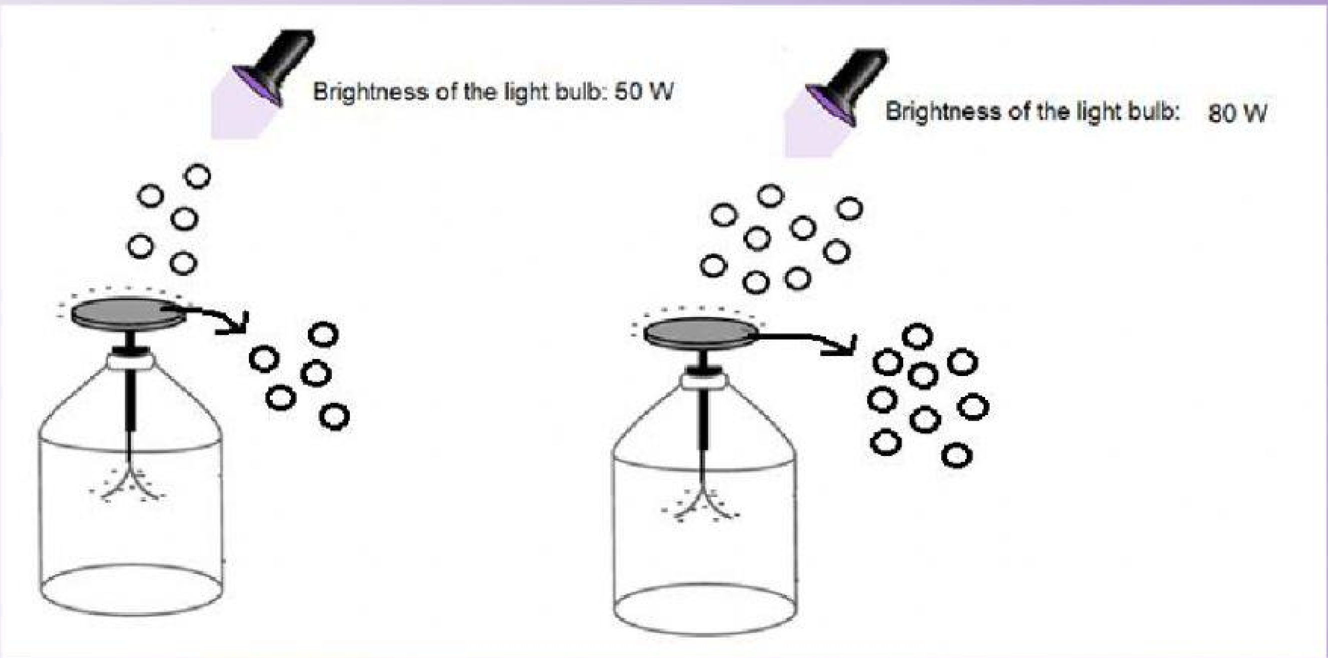
Brightness of the light and emitted photoelectrons

Increasing the brightness of the light causes

-more photons to be emitted,

-thus more photons hit the metal plate and

-more photoelectrons will be emitted. (But only if the energy of the light is greater than the work function of the metal.)



If the light's energy is lower than the work function then photoelectrons will **not** be emitted. Increasing the brightness of the light will then have no effect on photoelectrons. Photoelectrons will not suddenly be emitted if the brightness increases. $\mathbf{E < W_O}$

If the light's energy is higher than the work function then photoelectrons will be emitted. $\mathbf{E > W_O}$

Increasing the brightness of the light will then cause more photoelectrons to be emitted.

Frequency of the light and emitted photoelectrons

Increasing the frequency causes the

-energy of the photons to increase. (f is directly proportional to energy.)

-The number of photoelectrons is **not** affected.

Thus the photons travelling towards the metal have more energy and are moving faster.

-This causes the photoelectrons emitted to gain more energy (Ek_{max}) and also to have a higher speed when emitted. {However there are still the same number of electrons emitted per second, they are just moving faster). Since there are the same number of emitted photoelectrons, but they move faster, there just ends up being larger spaces between each emitted photoelectron.}