KEY

First Name:_____ Last Name:_____

L13 – Worksheet – Photons

Diploma Questions – Photoelectric Effect (Basic Concepts)

Q673: The wave theory of light can account for all of the following EXCEPT

a. Reflection
b. Refraction
c. Polarization
(d.) Photoelectric effect

Q679: A metal surface has a threshold frequency of f_o. If the metal surface is illuminated with radiation of a frequency of $3.5hf_o$ then the maximum kinetic energy of emitted photoelectrons is

a. $4.5hf_o$
b. $3.5hf_o$
(c.) $2.5hf_o$
d. $1.0hf_o$

$E_{photon} \rightarrow W + E_K$
$3.5hf_o \rightarrow hf_o + E_K$
$-hf_o \quad -hf_o$
$2.5hf_o = E_K$

Q680: If a photoelectric device is illuminated by light with a frequency greater than threshold frequency, what will happen as the frequency of the light is increased?

a. The photoelectric current will increase.
b. More photoelectrons will be emitted.
c. The work function of the device will increase.
(d.) Photoelectrons will be emitted with greater energy.

$E_{photon} \rightarrow W + E_K$
$hf \uparrow \rightarrow W + E_K \uparrow$

Single photon still only causes emission of a single photoelectron.

Q682: In a photoelectric experiment, the maximum kinetic energy of photoelectrons does **not** depend on the

a. Work function of the emitted material
b. Wavelength of the incident light
(c.) Intensity of the incident light
d. Energy of an incident photon

$E_{photon} \rightarrow W + E_K$

KEY

Diploma Questions – Photoelectric Effect (Calculations)

Q685: Sodium used in a photoelectric cell is irradiated by EM radiation of frequency 6.2×10^{15} Hz. If the threshold frequency for sodium is 5.6×10^{14} Hz, then the maximum E_k of the photoelectrons produced is

a. 1.1×10^{-19} J
b. 4.1×10^{-18} J
c. 3.7×10^{-18} J
d. 5.6×10^{-15} J

$E_{photon} \rightarrow W + E_K$

$hf \rightarrow hf_o + E_K$

$(6.63\times10^{-34})(6.2\times10^{15}) = (6.63\times10^{-34})(5.6\times10^{14}) + E_K$

$E_K = 3.73932\times10^{-18}$ J

Q687: If light with a frequency of 1.0×10^{15} Hz causes a metal to emit electrons with kinetic energy of 1.0×10^{-19} J, the work function of the metal is

a. 1.0×10^{-4} J
b. 6.6×10^{-19} J
c. 5.6×10^{-19} J
d. 1.0×10^{-19} J

$E_{photon} \rightarrow W + E_K$

$hf \rightarrow W + E_K$

$(6.63\times10^{-34})(1.0\times10^{15}) = W + (1.0\times10^{-19})$

$W = 5.63\times10^{-19}$ J

Q697: Copper has a work function of 4.46 eV. What is the maximum kinetic energy of the ejected electrons if the metal is illuminated by light with a wavelength of 450 nm?

a. 2.72×10^{-19} J
b. 4.42×10^{-19} J
c. 7.14×10^{-19} J
d. 0 J, because no electrons are ejected

$E_{photon} \rightarrow W + E_K$

$\frac{hc}{\lambda} \rightarrow W + E_K$

$\frac{(6.63\times10^{-34})(3.0\times10^{8})}{(450\times10^{-9})} = 7.136\times10^{-19} + E_K$

$4.42\times10^{-19} = 7.136\times10^{-19} + E_K$

KEY

Diploma Questions – Photoelectric Effect (Order of EMR)

Use the following information to answer Q706 and Q707:

707	706		
	Observations in Photoelectric Experiments		
x	✓	I.	The magnitude of the current increases.
✓	x	II.	The magnitude of the current decreases.
x	x	III.	The magnitude of the current is constant.
✓	x	IV.	The energy of the photoelectrons increases.
x	x	V.	The energy of the photoelectrons decreases.
x	✓	VI.	The energy of the photoelectrons is constant.

Q706: In a photoelectric experiment, a student increases the intensity of the incident light while maintaining a constant frequency. What are the effects on the magnitude of the photoelectric current and on the energy of the photoelectrons?

a. I and IV
b. I and VI
c. III and IV
d. III and IV

↑ Intensity, ↑ Current
Same Freq, Same E_K

Q707: In a photoelectric experiment, a student decreases the intensity of the incident light while increasing its frequency. What are the effects on the magnitude of the photoelectric current and on the energy of the photoelectrons?

a. II and IV
b. II and V
c. III and IV
d. III and VI

↓ Intensity, ↓ Current
↑ Freq, ↑ E_K

Q709: When a blue laser beam is incident upon the surface of the metal of a photoelectric cell, there is no photoemission. A second beam of radiation causes photoelectrons to be emitted. The second beam may consist of

Low f High f

a. Ultraviolet radiation
b. Infrared radiation
c. Red laser radiation
d. Microwave radiation

ROYGBIV
RMI V U X G

KEY

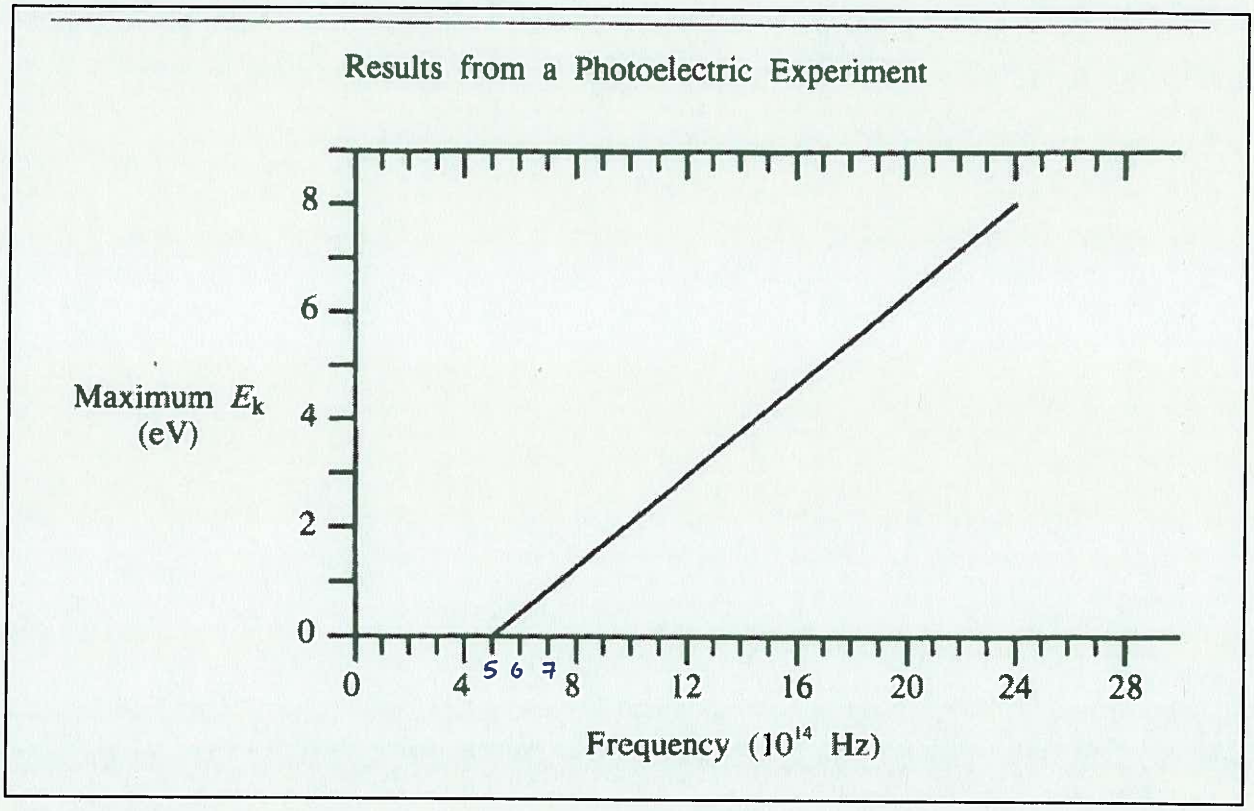
Q710: Violet light striking the negative electrode in a phototube causes a current to flow in the tube. Under the same conditions, another form of light that will always cause a current to flow is

Low f — High f
ROYGBIV

a. Blue
b. Green
c. Infrared
d. Ultraviolet

Diploma Questions – Photoelectric Effect (Graphs)

Use the following information to answer Q711:



Q711: The maximum kinetic energy of the photoelectrons that are emitted by light of wavelength 1.7×10^{-7} m is

a. 1.1 eV
b. 5.2 eV
c. 6.2 eV
d. 7.3 eV

$f_o = 5 \times 10^{14}$ Hz

$E_{photon} \rightarrow W + E_K$

$\frac{hc}{\lambda} \rightarrow hf_o + E_K$

$\frac{(4.14 \times 10^{-15})(3.0 \times 10^{8})}{(1.7 \times 10^{-7})} = (4.14 \times 10^{-15})(5 \times 10^{14}) + E_K$

$E_K = 5.23588\ldots$ eV

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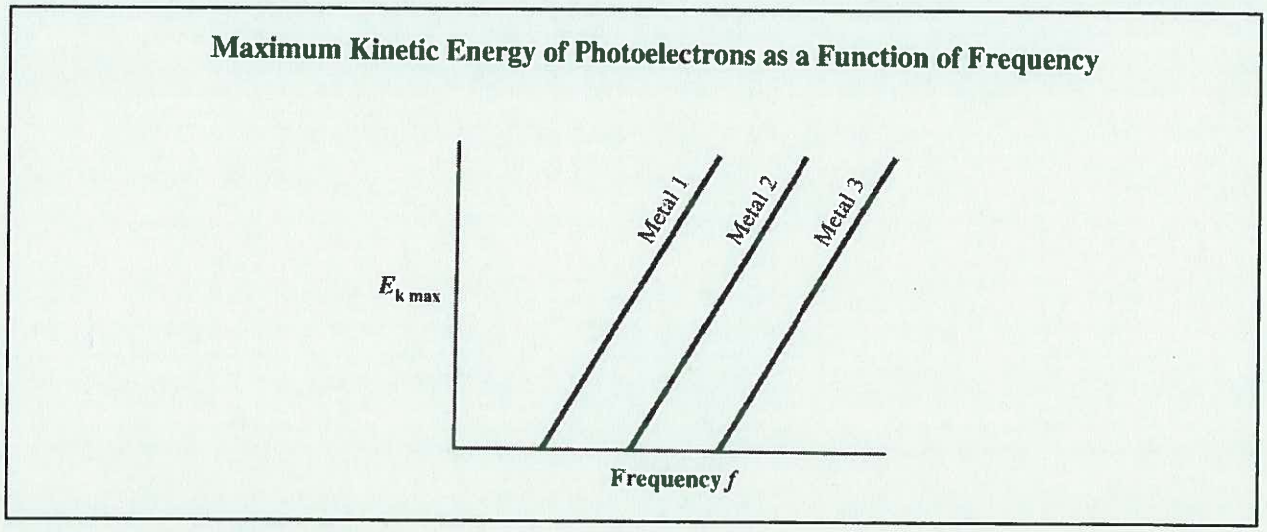
Use the following information to answer Q712:



Q712: The graph illustrates that

- ✗ a. For a given frequency of incident light, photoelectrons emitted from metal 2 have more kinetic energy than those emitted from metal 1
- ✗ b. The maximum kinetic energy of emitted photoelectrons is dependent upon the intensity of the incident light
- ✗ c. Metals will emit photoelectrons only if the intensity of the incident light is greater than some critical value
- (d) Metals will emit photoelectrons only if the frequency of incident light is greater than some critical value

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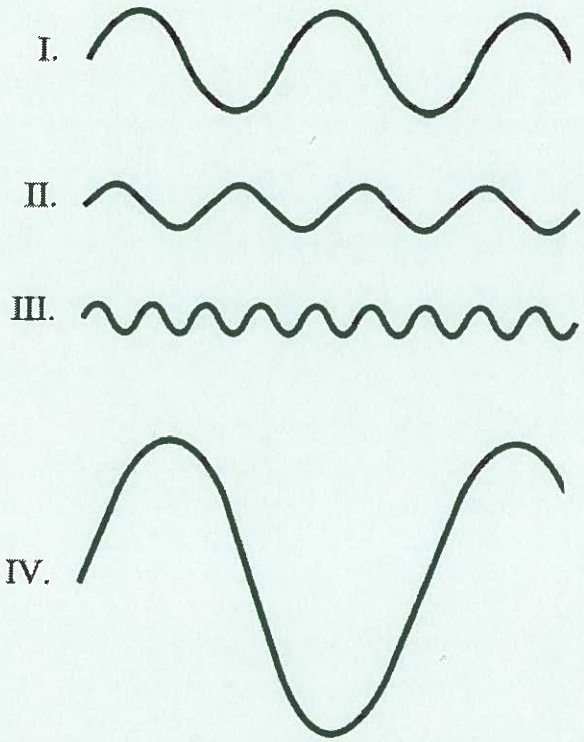
Use the following information to answer Q713:

These diagrams represent four electromagnetic waves incident upon the same metal surface.



← Highest frequency, $E = hf$

Amplitude is plotted vertically and time is plotted horizontally. All diagrams are drawn to the same scale.

Q713: Photoelectrons with the greatest kinetic energy would be emitted as the result of wave

a. I
b. II
c. III
d. IV

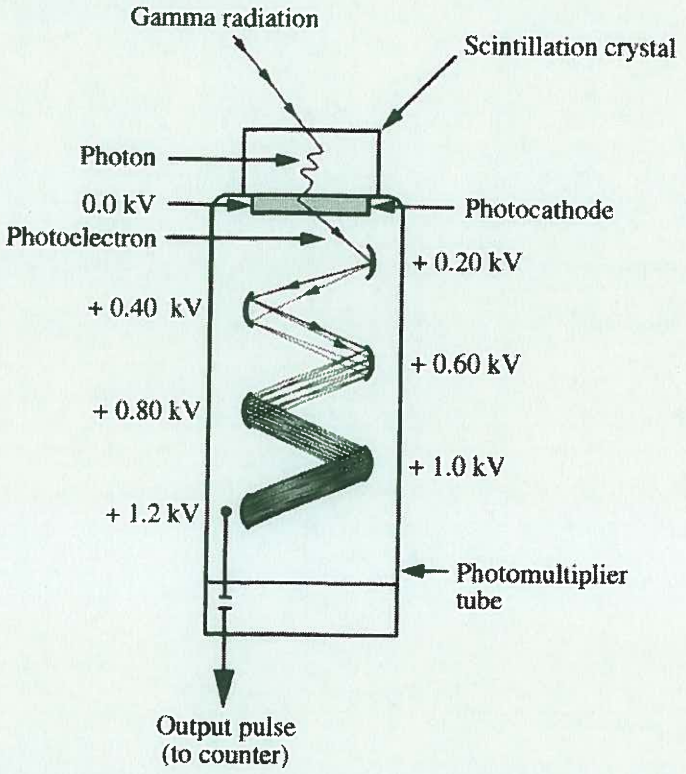
KEY

Diploma Questions – Photoelectric Effect (In Technology)

Use the following information to answer Q725 – Q726:

Photomultiplier Tube

When the scintillation crystal is struck by gamma radiation, it emits photons with a wavelength of 4.93×10^{-7} m. Some of these photons strike the photocathode. As a result, electrons are ejected from the bottom surface of the photocathode. The work function of the photocathode is 2.10 eV.



Q725: The maximum kinetic energy of the electrons ejected from the photocathode is

a. 6.7×10^{-20} J
b. 3.4×10^{-19} J
c. 4.0×10^{-19} J
d. 7.4×10^{-19} J

$E_{photon} \rightarrow W + E_K$

$\frac{hc}{\lambda} \rightarrow W + E_K$

$\frac{(6.63\times10^{-34})(3.0\times10^{8})}{(4.93\times10^{-7})} = 3.36\times10^{-19} + E_K$

$E_K = 6.744827\,5862 \times 10^{-20}$ J

Q726: The electrons leaving the photocathode are attracted by the 0.20 kV electrode. The maximum speed they attain is

a. 8.6×10^{5} m/s
b. 8.4×10^{6} m/s
c. 7.0×10^{13} m/s
d. 2.1×10^{15} m/s

$E_{K_i} + E_p \rightarrow E_{K_f}$

$6.744827\,5862\times10^{-20} + qV \rightarrow \frac{1}{2}mv^2$

$6.74482758\ldots\times10^{-20} + (1.60\times10^{-19})(0.2\times10^{3}) = \frac{1}{2}(9.11\times10^{-31})v^2$

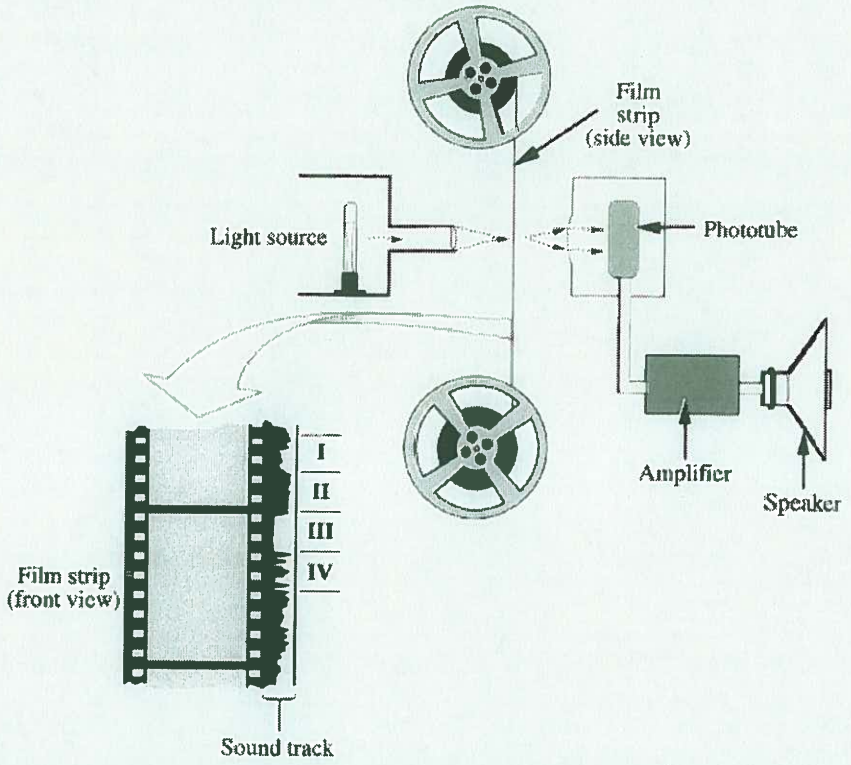
$v_f = 8.390503 \times 10^{6}$ m/s

KEY

Use the following information to answer Q734:

An Application of the Photoelectric Effect

On movie film, the sound track is located along the side of the film strip and consists of light and dark regions. Light from the projector is directed through the sound track and onto a phototube. Variations in the transparency of the regions on the sound track allow varying intensities of light to reach the phototube.



Q734: The region of the sound track that will allow the most electrical current to be produced in the phototube is labelled

a. I
b. II
c. III
d. IV

More intensity (number of photons) is region III.
Each photon can generate one photoelectron.