BTG Winter School '10

Physical Sciences

Session 3 - Optical phenomena and properties of materials (Transmission & scattering of light, Photoelectric effect, Emission Spectra)

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Optical Properties

Transmission & Scattering

When light shines on an object it may be *reflected, transmitted or absorbed*.

Reflection of light

This is a phenomenon that leads to scattering. It will be discussed in more detail later.
HW Assignment: Find out how scattering relates to the colour of the sky; more specifically why the sky is blue.

Transmission of light

Transparent materials allow all the light which falls on the surface to pass through.

Translucent materials allow some light to pass through.

Opaque materials do not allow any light to pass through.

Absorption of light

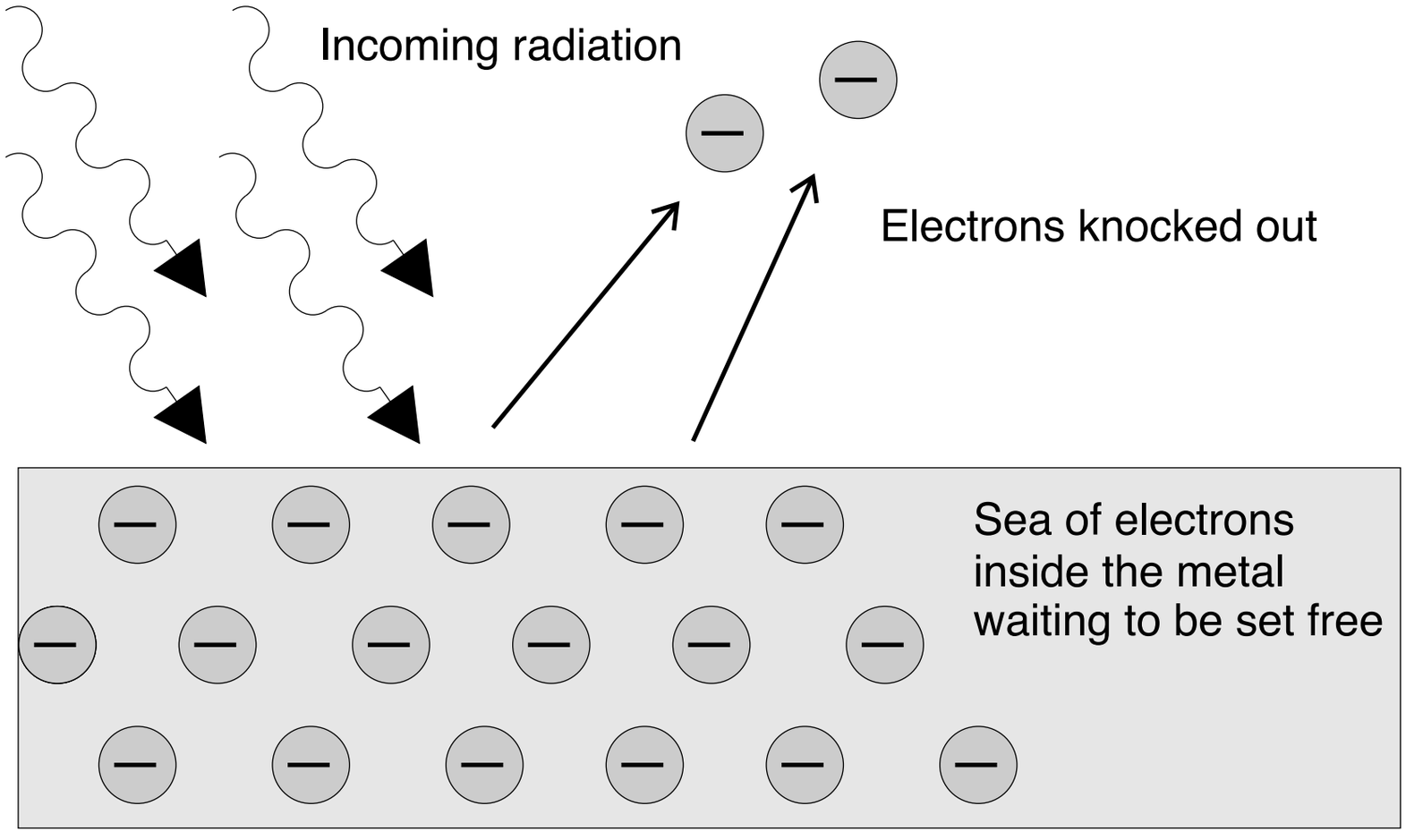
When light is absorbed by an object, the object gains internal energy which may appear as an increase in temperature, or an increase in chemical energy.

Photoelectric Effect

Photoelectric Effect

Definition: The photoelectric effect

The photoelectric effect is the process whereby an electron is emitted by a metal when light of a particular frequency shines on it.



The significance of the photoelectric effect

It establishes the quantum theory.

It illustrates the particle nature of light.

Photoelectric Effect

Define: Threshold Frequency

This is the minimum frequency a light ray must have in order to emit electrons from a metal. (Every metal has its own threshold frequency)

If a light ray with a higher frequency than that of the threshold frequency strikes a metal, electrons are emitted with a certain amount of kinetic energy.

Definition: Work Function

The minimum amount of energy required to emit electrons from a metal without any kinetic energy.

Intensity of light

The greater the intensity of the light ray the more electrons that will be emitted, provided the light ray meets the threshold frequency.
NB: It does NOT affect the energy of the photoelectrons.

Photoelectric Effect

Equations for calculations

The energy of a photon/photoelectron (E) is given by the following formula where h is planck's constant ($6{,}63\text{x}10^{-34}$) and f is the frequency of the incident ray.

$$E = hf$$

This energy is made up of the work function (W_o) and kinetic energy (K).

$$E = W_o + K$$

Derivations and substitutions of the above formulae.

$$W_o = hf_o$$

$$hf = W_o + (\tfrac{1}{2})mv^2$$

PE intro questions

Question 1: Ultraviolet radiation with a wavelength of 250 nm is incident on a silver foil (work function $\varphi = 6{,}9\times10^{-19}$ J). What is the maximum kinetic energy of the emitted electrons?

Question 2: If we were to shine the same ultraviolet radiation ($f = 1{,}2\times10^{15}$ Hz), on a gold foil (work function = $8{,}2\times10^{-19}$ J), would any electrons be emitted from the surface of the gold foil?

Question 3: List two reasons why the observation of the photoelectric effect was significant.

Question 4: I shine a light of an unknown wavelength onto some silver foil. The light has only enough energy to eject electrons from the silver foil but not enough to give them kinetic energy. (Refer to the Table when answering the questions below:)

(a) If I shine the same light onto some copper foil, would electrons be ejected?

(b) If I shine the same light onto some silicon, would electrons be ejected?

(c) If I increase the intensity of the light shining on the silver foil, what happens?

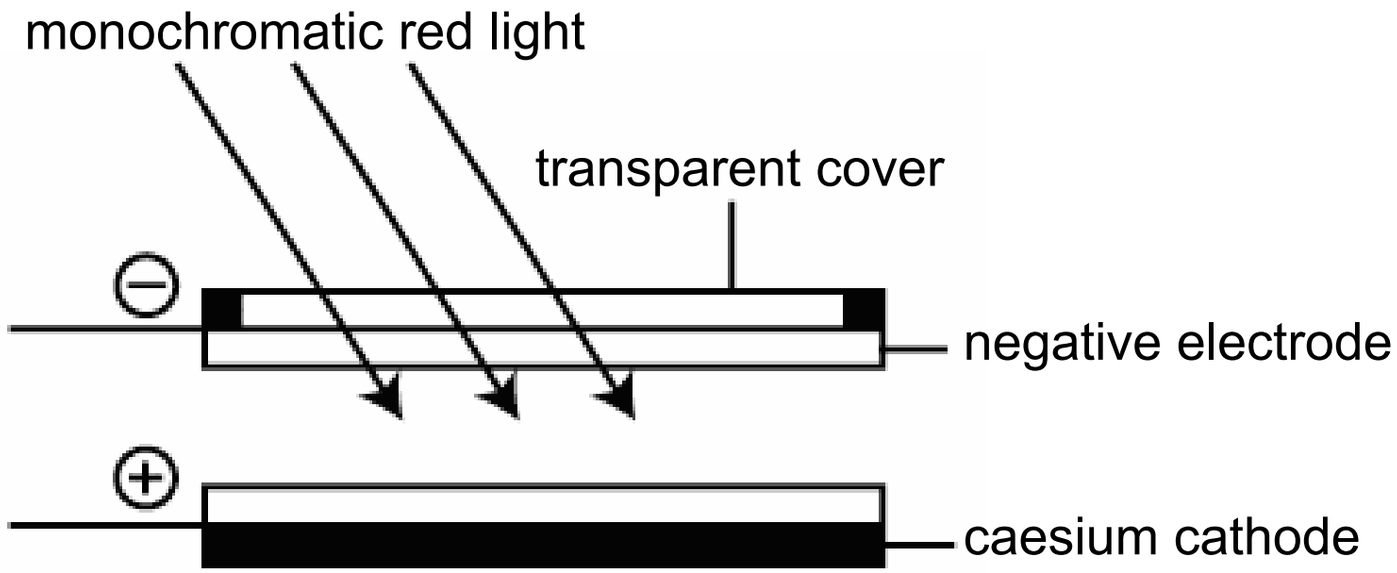
(d) If I increase the frequency of the light shining on the silver foil, what happens?

Element	Work Function (J)
Aluminium	$6{,}9 \times 10^{-19}$
Beryllium	$8{,}0 \times 10^{-19}$
Calcium	$4{,}6 \times 10^{-19}$
Copper	$7{,}5 \times 10^{-19}$
Gold	$8{,}2 \times 10^{-19}$
Lead	$6{,}9 \times 10^{-19}$
Silicon	$1{,}8 \times 10^{-19}$
Silver	$6{,}9 \times 10^{-19}$
Sodium	$3{,}7 \times 10^{-19}$

PE NSC practice questions - Q14 Prep Examination 2008

QUESTION 14

14.1 The sketch below shows the components of a photocell used in a camera light meter.



The photocell consists of a caesium cathode with a small work function. When monochromatic red light from a 50 W light bulb strikes the cathode in the photocell, the light meter registers a small current.

14.1.1 What name is given to the effect described above? (1)

14.1.2 What will the effect on the current be when the 50 W bulb is replaced by a 100 W bulb? Give a reason for your answer. (2)

14.1.3 What will be the effect on the kinetic energy of the emitted photo electrons when the 50 W red light is replaced with a 50 W blue light bulb. Give a reason for your answer. (3)

14.2 Ultraviolet lamps are often used in butcheries, even though they are potentially harmful.

14.2.1 Which property of UV light makes it harmful? (1)

14.2.2 Explain why UV light is used in butcheries. (1)

14.2.3 A photon of ultraviolet light carrying 2,95 x 10^{-20} J of energy is shone onto a metal with a work function of 1 x 10^{-20} J. Calculate the speed of the ejected photo electron. (5)

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PE NSC practice questions - Q14 Additional Exemplar 2008

QUESTION 14

A learner wants to demonstrate the photoelectric effect. He uses a disk of zinc placed on an electroscope. The work function of zinc is $6,9 \times 10^{-19}$ J.

14.1 Define the concept work function. (2)

14.2 Calculate the maximum wavelength of light that will eject electrons from the zinc. (4)

14.3 The electroscope is negatively charged and then exposed to ultraviolet light from a mercury discharge lamp. One of the wavelengths of the light is 260 nm.

Calculate the kinetic energy of an electron emitted from the zinc disk by a photon of this light. (4)

14.4 When the student attempts the experiment with a positively charged electroscope, he finds that the ultraviolet light has no apparent effect. Explain this observation. (2)

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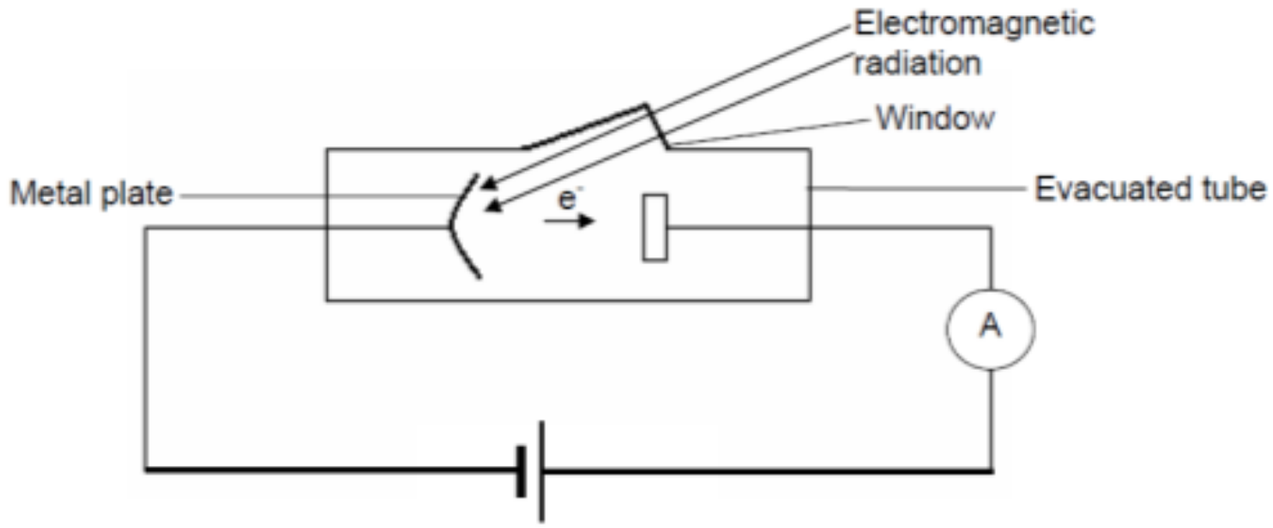
PE NSC practice questions - Q3 Learn Xtra June 2011

Question 3

The diagram shows a metal plate that emits electrons when a certain frequency of electromagnetic radiation is incident on it. The plate is connected to a source of potential difference and an ammeter as shown in the circuit below.



3.1 Name the phenomenon described above. (1)

When radiation of wavelength 555 nm is incident on the metal plate, electrons are released with zero kinetic energy.

3.2 Define the term *work function* of a metal. (2)

3.3 Calculate the work function of this metal. (6)

3.4 How will the reading on the ammeter change if the intensity of the electromagnetic radiation is increased? Write down only INCREASES, DECREASES or REMAINS THE SAME. Give a reason for your answer. (3)

3.5 Incident radiation with a longer wavelength is now used. How will the reading on the ammeter change? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)