**Nuclear HW 2 Name:**

Assessor’s use only

A

M

A

M

E

A

Light, of wavelength 4.87×10−7 m, is incident on a photoelectric cell.

(a) Show that the energy of a photon of the light is 4.08×10-19 J.

(b) Explain, in full, how light causes electric current in a photoelectric cell like the one shown in the diagram.

collector

Metal

emitter

Light

(c) One of the materials considered for the emitter plate has a work function of   
3.04×10-19 J. Explain whether this material would produce a current with light of wavelength 4.87×10−7 m.

(d) The light source is changed for a *brighter* light of the same wavelength. Explain the effect of this new light source on the current generated in the photoelectric cell.

Assessor’s use only

A

M

A

M

E

An unknown metal is placed in the photoelectric cell and an adjustable battery is added with its polarity opposing the flow of current. The voltage of the battery is adjusted until the current stops. Using the original light of wavelength 4.87×10−7 m, the stopping potential for this circuit is 0.5066 V.

collector

Emitter with

Unknown metal

Light

V

(e) Calculate the work function for the new metal.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **N0** | **N1** | **N2** | **A3** | **A4** | **M5** | **M6** | **E7** | **E8** |
| No correct relevant physics | A | 2A | 3A | 4A | 2M | 3M  Or E+M | E +2M | 2E |

**Scholarship Level Score /8**

1. The rest mass of the sun decreases by 4000 tonnes every second. Assuming the sun only emits radiation, and the average wavelength of the photons is 550 nm.

(a) Calculate the number of photons the sun emits in one second. [1]

The radius of the earth is 6300 km. The earth’s orbital radius is 1.5 x 1011 m

1. Estimate the number of photons reaching earth from the sun. [1]

1. A key concept in modern physics is “wave particle duality”. Explain clearly what this means in terms of light, giving examples of both aspects. [3]

1. The graph below shows the results of a photoelectric experiment using lithium.

E

6 x 1014

F (Hz)

Calculate the velocity of electrons emitted when light of wavelength 3.0 x 10-7 nm is shone on the metal, (you will need the electron mass and Planck’s constant). [2]

1. When a gamma ray collides with a massive nucleus it disappears and its energy is used to create an electron/positron pair.

Derive the following equation for the velocity of the two particles. [1]



|  |  |  |  |  |
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|  | **Evidence** | **Ach** | **Merit** | **Exc** |
| (a) | *E = hf, c = fλ*, ⇒ *E* =  =  = 4.0817×10−19 = 4.08×10−19 m | 2 *Correct frequency (6.16×1014 Hz)*. | 2 Correct working (show question) |  |
| (b) | Light is quantised / made of photons / photons are tiny quanta / particles of light.  Each photon has a certain amount of energy.  The energy of a photon is proportional to its frequency / each frequency/wavelength of light has its own energy photon.  The energy of one photon can be absorbed by only one electron.  When an electron absorbs a photon’s energy, the electron is moved up in energy level.  If the energy is sufficient the electron will be removed from the nucleus/metallic energy band it is attached to/the electron can move to the surface of the metal and leave the surface.  Electrons that have left the nucleus move to the anode and current is made. | *1* Electron absorbs enough energy from a photon to leave metal*.* | 1  Light is quantised energy.  1 photon – 1 electron  Electron moves/leaves surface. | 1 Full answer. |
| (c) | Yes since work function is less than the energy of the photon so the electron will have some kinetic energy as it leaves the surface of the metal. | 1 Correctly compare E and φ and conclude ‘Yes’ |  |  |
| (d) | A brighter source will release more electrons, since brighter light means a greater rate of photons incident on the photocell and each photon is capable of releasing one electron.  This will result in a higher current as I = q/t (cs-1) | *1* Higher current reading due to more Photons | Higher current reading due to more Photons and 1 photon releases1 electron. |  |
| (e) | *EK = eV* = 1.602×10−19 × 0.5066  = 8.11573×10-20 J  φ = 4.0817×10−19 − 8.11573×10-20 J  φ = 3.2701×10-19 = 3.27×10-19 J | Recongines that stopping voltage is kinetic energy of e in eVs | 2 *Correct EK*. | 2 Correct answer. |

1a) [1]

1b)

The fraction of photons reaching earth is the area of the earth’s cross section divided by the area of the sphere of light from the sun at a distance of 1.5 x 1011 m [2]

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1. Prior to 1900, it was accepted that light was a wave. It undergoes diffraction, interference polarization etc. Only waves do this. [1]

In the photoelectric experiment it was shown that when light interacts with matter is behaves as if it was a tiny particle or bundle of energy. [1]

Light is neither a wave or a particle, depending on how you observe it, it will sometimes behave like a wave and sometimes like a particle. This is known as particle wave duality*.* [1]



3)

[2]



4) [1]