9 **(a)** State the name of a phenomenon that gives evidence that light behaves like

(i) a wave

.....

..... [1]

(ii) a stream of particles (photons)

.....

..... [1]

(b) A hydrogen lamp is found to produce red light and blue light. The wavelengths of the lights are 6.56×10^{-7} m and 4.86×10^{-7} m.

(i) Explain why the lamp produces lights of specific wavelengths.

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.....

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.....

.....

..... [3]

(ii) The blue light from the hydrogen lamp is incident normally on a metal surface with work function energy of 2.00 eV.

Show, by appropriate calculations, that photoelectric emission will be observed.

[3]

(iii) The intensity of the blue light is 6.80×10^3 W m^{-2}. The area of the metal surface is 3.00 cm^2.

1. Show that the power of the blue light that is incident on the metal surface is 2.04 W.

[1]

2. Calculate the force exerted by the photons of the blue light on the metal surface, assuming that all the photons are absorbed.

force = ... N [4]

(c) The red and blue lights of **(b)** are part of the Balmer series of light emitted by the hydrogen atom. The wavelengths λ_n of the Balmer series are given by:

$$\frac{1}{\lambda_n} = R\left(\frac{1}{4} - \frac{1}{n^2}\right)$$

where R is a constant and has the value of 1.097×10^7 m^{-1} and n is an integer greater than 2. That is, n = 3, 4, 5, …., etc.

(i) Determine:

1. the value of n that gives the red light

n for red light = ... [1]

2. the value of *n* that gives the blue light.

n for blue light = ... [1]

(ii) Calculate the shortest wavelength in the Balmer series.

wavelength = ... m [2]

(iii) Use your answers in **(c)(i)** and **(c)(ii)**, sketch a partial energy level diagram for the Balmer series. Label the energy levels with their respective values of energy.

[3]

[Total: 20]