Name: ____ Date: ______________________ Period: _________

IB Physics SL Y2 – Option B (Quantum Physics) – Lesson 1 – The quantum nature of radiation (Classwork)

Objectives:

1. Describe the photoelectric effect. (B.1.1)
2. Describe the concept of the photon and use it to explain the photoelectric effect. (B.1.2)
3. Describe and explain an experiment to test the Einstein model. (B.1.3)
4. Solve problem involving the photoelectric effect. (B.1.4)

I. Calculate the energy of a photon in light of wavelength 120 nm.

II. The photoelectric work function of potassium is 2.0 eV.

   a. Calculate the threshold frequency of potassium.

   b. Calculate the maximum kinetic energy in electron-volts of electrons emitted from the surface of potassium when illuminated with light of wavelength 120 nm.

III. State and explain two observations associated with the photoelectric effect that cannot be explained by the Classical theory of electromagnetic radiation.

IV. In an experiment to measure the Planck constant, light of different frequencies f was shone on to the surface of silver and the stopping potential V_s for the emitted electrons was measured. The results are shown below. Uncertainties in the data are not shown.

V.

V_s / V	f / 10^{15} Hz
1.2	0.25
1.6	1.7
2.0	3.3
2.5	5.6
3.0	7.7
3.2	8.4

Plot a graph to show the variation of Vs with f.
Draw a line of best-it for the data points.

Use the graph to determine

   a. a value of the Planck constant
   b. the work function of silver in electron-volt.

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IB Physics SL Y2 – Option B (Quantum Physics) – Lesson 1 – The quantum nature of radiation (Homework)

1 A sample of sodium is illuminated by light of wavelength 422 nm in a photoelectric tube. The potential across the tube is increased to 0.6 V. At this potential no current flows across the tube. Calculate:

- **(a)** the maximum KE of the photoelectrons
- **(b)** the frequency of the incident photons
- **(c)** the work function of sodium
- **(d)** the lowest frequency of light that would cause photoelectric emission in sodium.

2 A sample of zinc is illuminated by UV light of wavelength 144 nm. If the work function of zinc is 4.3 eV, calculate

- **(a)** the photon energy in eV
- **(b)** the maximum KE of photoelectrons
- **(c)** the stopping potential
- **(d)** the threshold frequency.

3 If the zinc in Question 2 is illuminated by the light in Question 1, will any electrons be emitted?

4 The maximum KE of electrons emitted from a nickel sample is 1.4 eV. If the work function of nickel is 5.0 eV, what frequency of light must have been used?

Use the energy level diagram of Figure 7.16 to answer the following questions.

5 How many possible energy transitions are there in this atom?

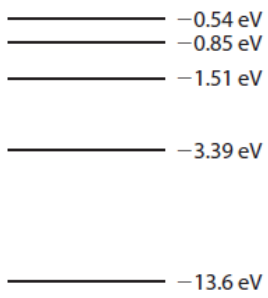


Figure 7.16

6 Calculate the maximum energy (in eV) that could be released and the frequency of the photon emitted.

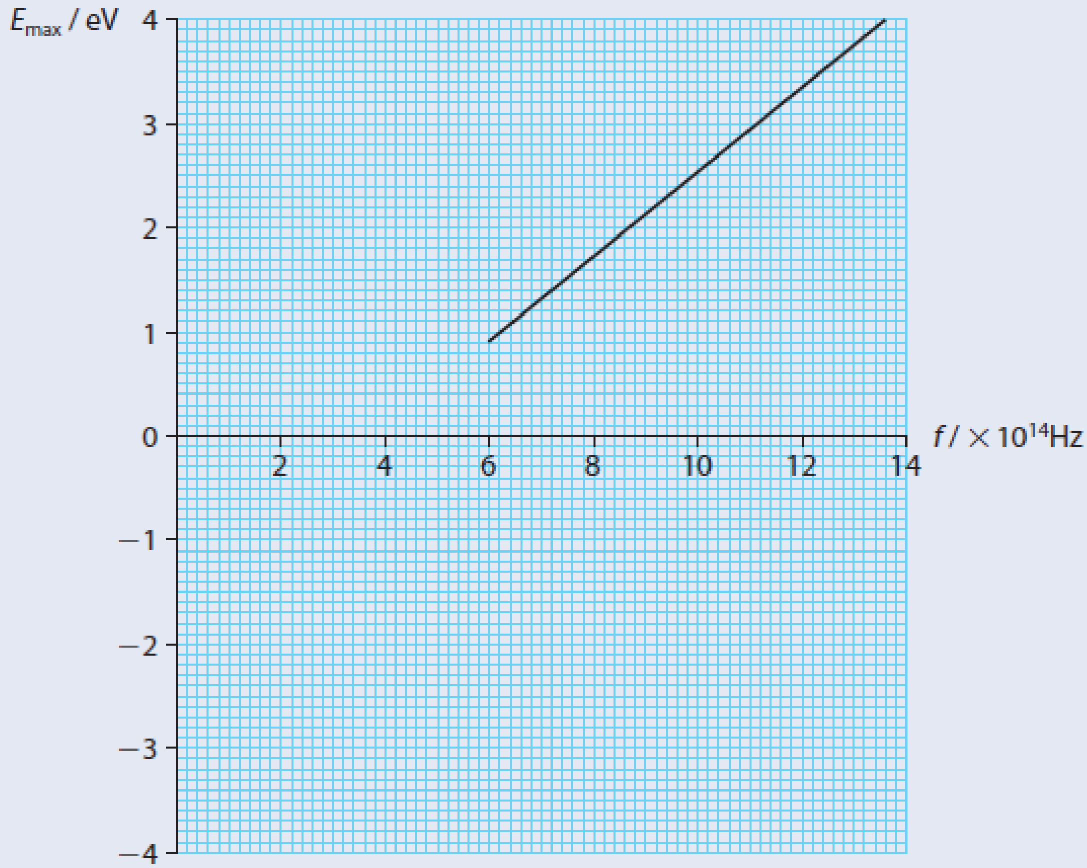
7 Calculate the minimum energy that could be released and the frequency of the associated photon.

8 How much energy would be required to completely remove an electron that was in the lowest energy level? Calculate the frequency of the photon that would have enough energy to do this.

This question is about the photoelectric effect.

(a) State **one** aspect of the photoelectric effect that **cannot** be explained by the wave model of light. Describe how the photon model provides an explanation for this aspect. (2)

Light is incident on a metal surface in a vacuum. The graph below shows the variation of the maximum kinetic energy E_{max} of the electrons emitted from the surface with the frequency f of the incident light.



(b) Use data from the graph to determine

(i) the threshold frequency. (2)

(ii) a value of the Planck constant. (2)

(iii) the work function of the surface. (2)

The threshold frequency of a different surface is 8.0×10^{14} Hz.

(c) On the axes opposite, draw a line to show the variation with frequency f of the maximum kinetic energy E_{max} of the electrons emitted. (2)

(Total 10 marks)