Photoelectric Effect & Atomic Spectra

Question Paper

Level	International A Level
Subject	Physics
Exam Board	Edexcel
Topic	Nature of Light
Sub Topic	Photoelectric Effect & Atomic Spectra
Booklet	Question Paper

Time Allowed: **78 minutes**

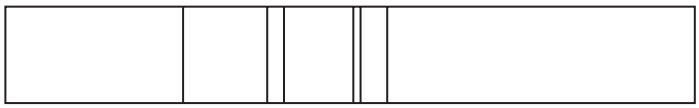
Score: **/65**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 The diagram shows the line spectrum produced by a particular element as viewed in a laboratory.

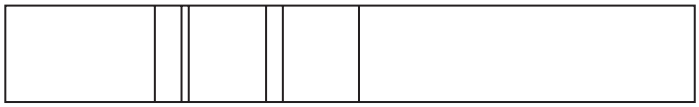


red violet

A star containing the element is moving away from the Earth.

Which of the following spectra could be obtained for light from the star?

☒ **A**



red violet

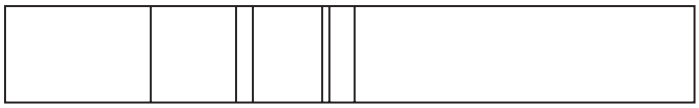
☒ **B**

red violet

☒ **C**

red violet

☒ **D**



red violet

(Total for Question 1 = 1 mark)

2 Which table correctly shows the wavelength and frequency of light at each end of the visible spectrum?

☒ **A**

	wavelength / 10^{-9} m	**frequency / 10^{12} Hz**
red	390	400
violet	750	770

☒ **B**

	wavelength / 10^{-9} m	**frequency / 10^{12} Hz**
red	750	400
violet	390	770

☒ **C**

	wavelength / 10^{-9} m	**frequency / 10^{12} Hz**
red	390	770
violet	750	400

☒ **D**

	wavelength / 10^{-9} m	**frequency / 10^{12} Hz**
red	750	770
violet	390	400

(Total for Question 2 = 1 mark)

***3** A hydrogen discharge tube contains hydrogen gas at a low pressure.

A high potential difference is applied across the tube and a spectrometer can be used to produce a visible line spectrum, as shown below.

Explain how line spectra are formed.

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(Total for Question 3 = 5 marks)

4 During a demonstration ultraviolet radiation is shone onto a zinc plate. When the frequency of the radiation is greater than a certain value f_0 the zinc plate becomes positively charged.

(a) Explain why the zinc plate becomes positively charged when the frequency of the radiation is greater than f_0.

(3)

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(b) Ultraviolet radiation of a frequency greater than f_0 is shone onto the zinc plate. The intensity of the radiation is increased and the magnitude of the positive charge on the plate increases at a greater rate.

Explain why.

(2)

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(c) Suggest a potential risk with performing this demonstration in a school laboratory.

(1)

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(Total for Question 4 = 6 marks)

5 *(a) A metal surface is illuminated with light of a single frequency. This frequency is above the threshold frequency of the metal and so electrons are emitted. The rate of electron emission is measured.

The intensity of the incident light is then decreased but its frequency remains unchanged.

Describe the change in electron emission that would be observed and how this change would be explained by the wave theory and by the particle theory of light.

(3)

(b) Light of frequency 7.3×10^{14} Hz is incident on the surface of the metal. The maximum kinetic energy observed for emitted electrons is 1.8×10^{-19} J.

Calculate the work function energy for the metal in J.

(2)

Work function energy = ... J

(Total for Question 5 = 5 marks)

6 A student carries out an experiment to investigate the photoelectric effect by shining light of different frequencies onto a particular metal.

(a) Describe how the photoelectric effect takes place.

(2)

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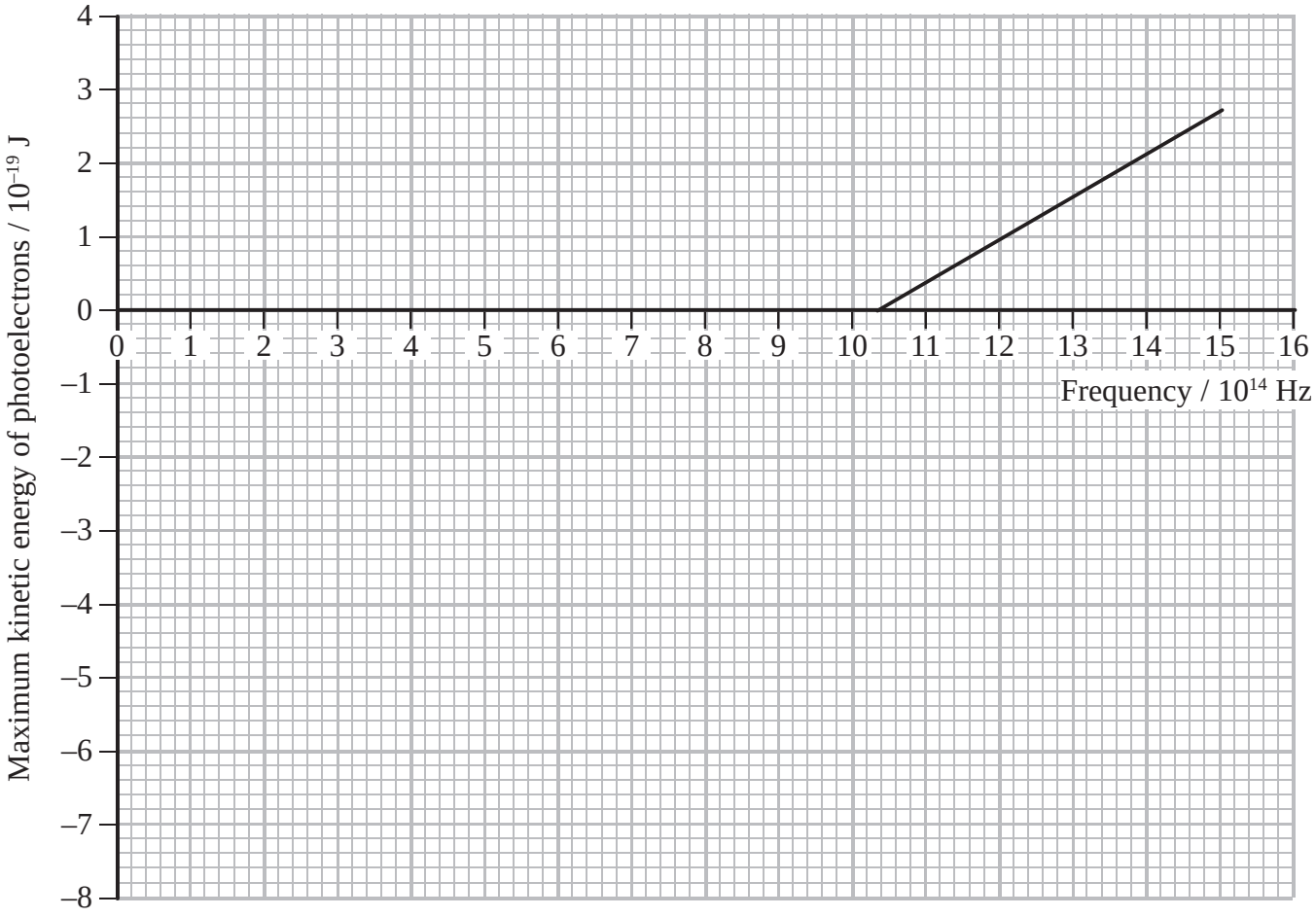
(b) The maximum kinetic energy of the photoelectrons is determined for a range of frequencies of incident light. The results are shown on the graph below.



(i) The list of formulae on this paper gives the expression

$$hf = \phi + \tfrac{1}{2} mv^2_{max}$$

Use this expression and the graph to determine the value of the Planck constant and the work function for the metal in this experiment.

(4)

Planck constant = ...

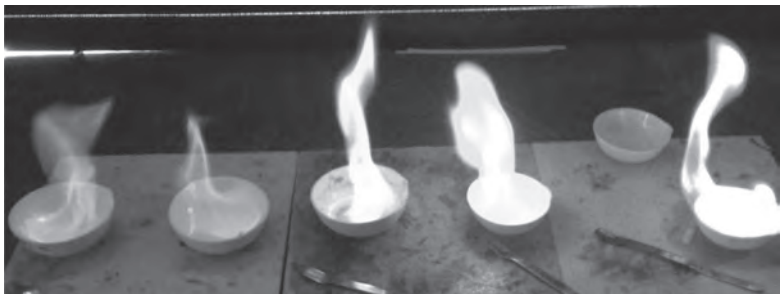
Work function = ...

(ii) Explain why the results of the experiment cannot be explained using the wave theory of light.

(2)

(Total for Question 6 = 8 marks)

7 The photograph shows flame tests being carried out on some chemical compounds.



Flame tests are used to identify the elements present in some chemical compounds. The compounds produce different coloured flames when vaporised. This is because different elements produce spectra containing light with different wavelengths.

Sodium compounds produce a yellow flame because the spectrum of sodium includes light with frequency 5.1×10^{14} Hz.

Before the sodium compound is vaporised the electrons involved in producing the yellow light are in the energy level −5.14 eV.

(a) State what is meant by an energy level.

(1)

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(b) (i) Explain why light is emitted when the sodium compound is vaporised.

(2)

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(ii) The diagram represents the −5.14 eV energy level in a sodium atom.

–5.14 eV _____

Calculate the energy of the other energy level involved in the emission of the yellow light.
Add this energy level to the diagram and label it with the correct value.

(4)

(c) Explain why different elements produce different spectra.

(2)

(Total for Question 7 = 9 marks)

8 (a) State what is meant by the ground state of an atom.

(1)

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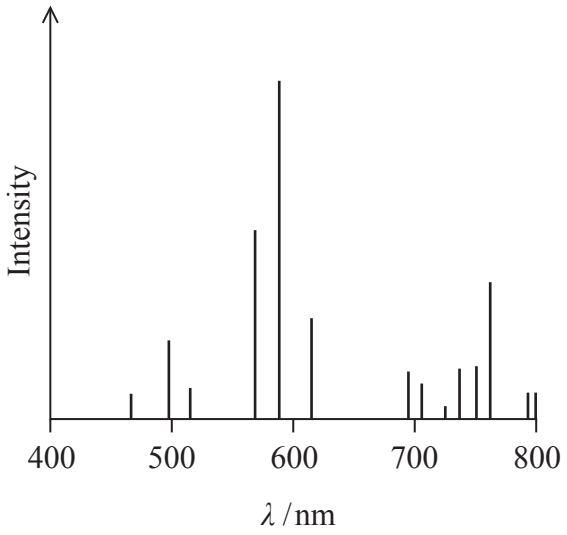
*(b) Some street lamps produce a bright light which appears yellow. This light is produced by sodium vapour in the lamp.

The graph shows the relative intensity of different wavelengths of light in the visible spectrum produced by this type of street lamp.



Explain why only certain wavelengths of light are emitted.

(6)

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(Total for Question 8 = 7 marks)

9 A metal surface is illuminated with ultraviolet light of a single frequency. Electrons are emitted from the metal surface.

*(a) It can be observed that the electrons have a range of kinetic energies up to a specific maximum.

Explain how this observation provides evidence to support the particle nature of light rather than the wave nature of light.

(4)

(b) Calculate the maximum kinetic energy, in joule, of the emitted electrons when the frequency of the ultraviolet light is 2.5×10^{15} Hz.

work function = 2.3 eV

(4)

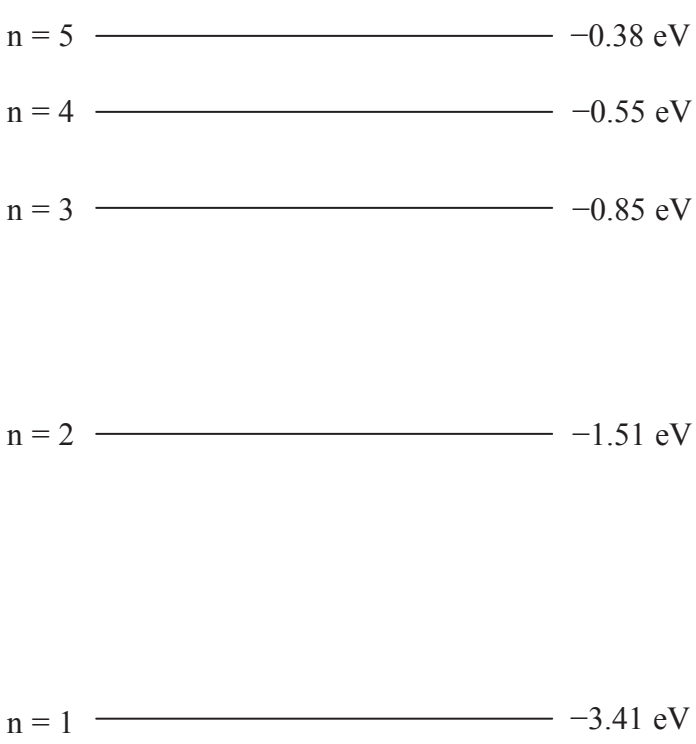
Maximum kinetic energy = ... J

(Total for Question 9 = 8 marks)

10 (a) State what is meant by a photon.

(2)

(b) The diagram shows some energy levels of an atom.



Not to scale

(i) State what is meant by an energy level.

(1)

(ii) Transitions between energy levels are associated with the emission or absorption of photons.

Describe the emission of the lowest frequency photon possible for an excited atom with these energy levels and calculate its frequency.

(6)

Frequency = ...

(Total for Question 10 = 9 marks)

***11** The list of data, formulae and relationships for this paper states the following:

Einstein's photoelectric equation $hf = \phi + \frac{1}{2}mv^2_{max}$

Describe the photoelectric effect, including an explanation of each of the terms, hf, ϕ and $\frac{1}{2}mv^2_{max}$, in the equation.

(6)

(Total for Question 11 = 6 marks)