Photoelectric Effect QP2

1 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

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

(2)

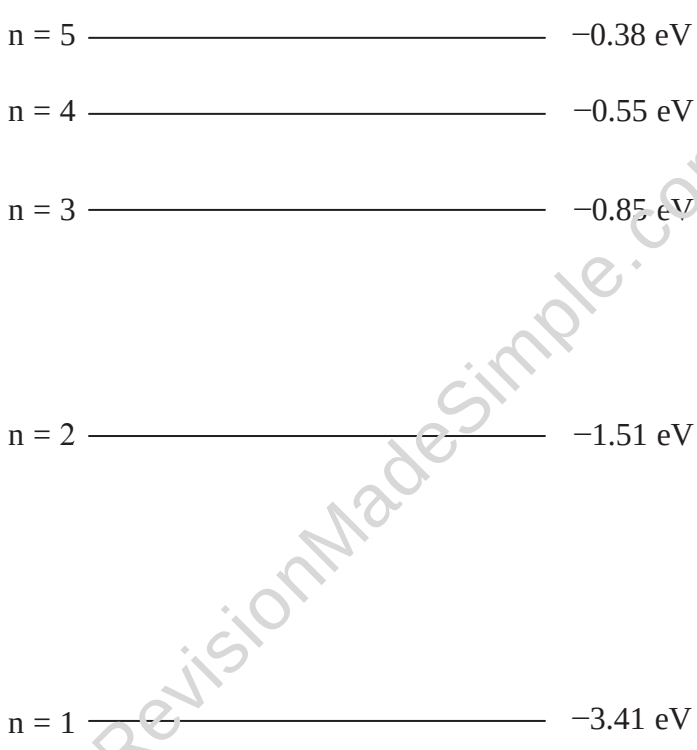
.....

.....

.....

.....

(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 = ...

***3** 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)

4 (a) Explain what is meant by the work function of a metal.

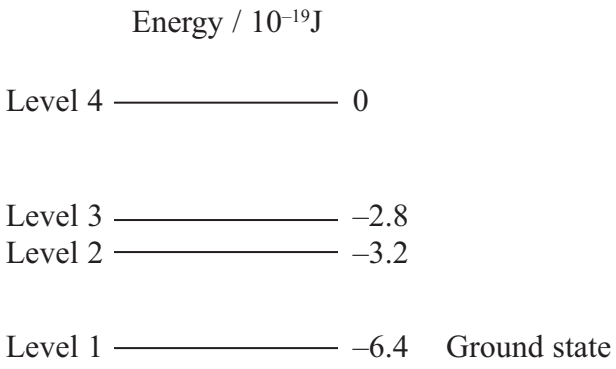
(1)

*(b) Observations of the photoelectric effect support the particle theory of light.

State **one** such observation and explain how it supports the particle theory of light.

(3)

5 The diagram shows four energy levels for an electron in a particular atom.



Not to scale

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

(1)

.....

.....

(b) Draw on the diagram **two** arrows to indicate two different transitions that would result in emitted radiation of the same frequency.

(2)

(c) A gas consisting of these atoms can emit a line spectrum.

Explain how this happens.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(d) One of these atoms in its ground state absorbs 3.6×10^{-19} J of energy from a collision with an electron.

Calculate the smallest frequency of radiation that the atom may subsequently emit.

(3)

Smallest frequency = ...

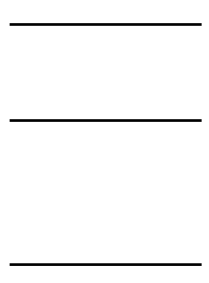
(e) Calculate how much energy in eV would be required to ionise the atom in its ground state.

(2)

Energy = ...

(Total for Question 16 = 11 marks)

6 The energy level diagram shows the ground state and two excited states E_1 and E_2 of a neon atom.



In a helium neon laser, collisions occur between helium atoms and neon atoms. This results in the helium neon atoms being excited from the ground state to level E_2. They then emit photons and move to level E_1.

(a) What is meant by 'energy level'?

(1)

.....

.....

(b) What is a photon?

(1)

.....

.....

(c) Write a formula in terms of E_1 and E_2 for the energy of an emitted photon.

(1)

.....

.....

(d) The wavelength of an emitted photon is 6.33×10^{-7}m.

Calculate the energy of this photon.

(3)

.....

.....

Energy = ...

7 The following passage describes some important aspects of the photoelectric effect. Insert the missing words.

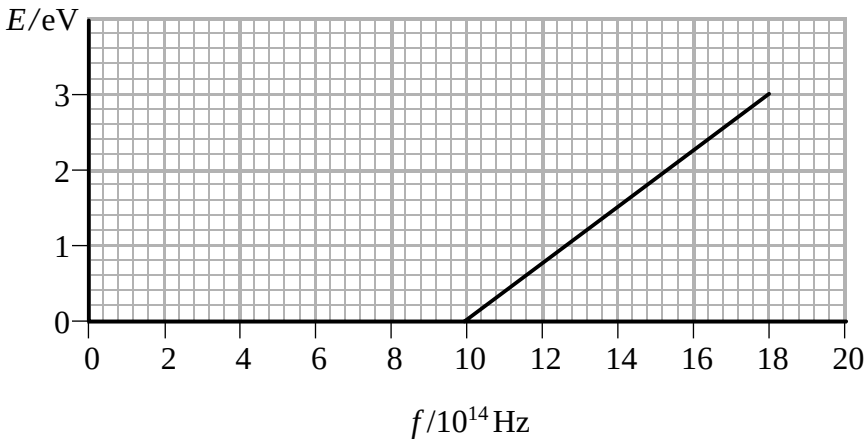
In the photoelectric effect, a single ..... interacts with a single electron at the surface of a ..... In this interaction ..... is conserved. This was summarised by Albert Einstein in the following equation

$$hf = \Phi + \tfrac{1}{2}mv^2$$

where $\tfrac{1}{2}mv^2$ is the maximum kinetic energy of the .....

and Φ is the .....

8 The graph shows how the maximum kinetic energy E of photoelectrons emitted from the surface of aluminium varies with the frequency f of the incident radiation.



(a) Explain why no photoelectrons are emitted below a frequency of 10×10^{14} Hz.

(1)

.....

.....

(b) Calculate the work function of aluminium in electron volts.

(3)

.....

.....

.....

.....

Work function = ...

(c) State the quantity represented by the gradient of the graph.

(1)

.....

(d) Add a second line to the graph to show how E varies with f for a metal which has a work function less than aluminium.

(2)