7 Particle X of mass m is moving with velocity v and has a de Broglie wavelength λ.

Particle Y has a de Broglie wavelength 0.25λ.

Which row of the table could give the mass and velocity of particle Y?

	Mass	Velocity
☒ **A**	$0.25m$	v
☒ **B**	$0.5m$	$8v$
☒ **C**	m	$2v$
☒ **D**	$2m$	$4v$

(Total for Question 7 = 1 mark)

3 An electron has a de Broglie wavelength of 3.5×10^{-10} m.

Which of the following expressions gives the velocity of the electron in $m\,s^{-1}$?

☒ **A** $\dfrac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 3.5 \times 10^{-10}}$

☒ **B** $\dfrac{6.63 \times 10^{-34}}{3.5 \times 10^{-10}}$

☒ **C** $\dfrac{9.11 \times 10^{-31} \times 3.5 \times 10^{-10}}{6.63 \times 10^{-34}}$

☒ **D** $\dfrac{3.5 \times 10^{-10}}{6.63 \times 10^{-34}}$

(Total for Question 3 = 1 mark)

5 An electron has a de Broglie wavelength of 1.55×10^{-9} m.

Which of the following gives the speed, in $m\,s^{-1}$, of this electron?

☒ **A** $\dfrac{9.11 \times 10^{-31}}{6.63 \times 10^{-34} \times 1.55 \times 10^{-9}}$

☒ **B** $\dfrac{1.55 \times 10^{-9} \times 9.11 \times 10^{-31}}{6.63 \times 10^{-34}}$

☒ **C** $\dfrac{6.63 \times 10^{-34} \times 1.55 \times 10^{-9}}{9.11 \times 10^{-31}}$

☒ **D** $\dfrac{6.63 \times 10^{-34}}{1.55 \times 10^{-9} \times 9.11 \times 10^{-31}}$

(Total for Question 5 = 1 mark)

6 When the photoelectric effect occurs, light incident on the surface of a metal releases electrons.

Which of the following is an experimental observation of the photoelectric effect?

☒ **A** Electrons are only released after light has been incident for a long time.

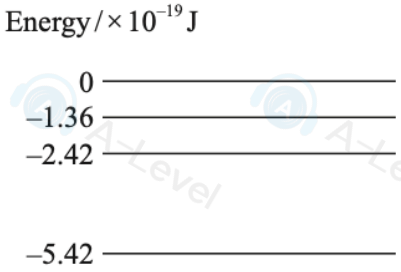
☒ **B** Increasing the frequency of the light increases the maximum kinetic energy of the released electrons.

☒ **C** Increasing the intensity of the light increases the maximum kinetic energy of the released electrons.

☒ **D** Only light with a wavelength above a threshold value releases electrons.

(Total for Question 6 = 1 mark)

9 The diagram shows some of the energy levels for a hydrogen atom.



Which of the following expressions is equal to the lowest frequency of light possible from a transition between these energy levels?

☒ **A** $\frac{5.42 \times 10^{-19}}{6.63 \times 10^{-34}}$

☒ **B** $\frac{1.36 \times 10^{-19}}{6.63 \times 10^{-34}}$

☒ **C** $\frac{2.42 \times 10^{-19} + 1.36 \times 10^{-19}}{6.63 \times 10^{-34}}$

☒ **D** $\frac{2.42 \times 10^{-19} - 1.36 \times 10^{-19}}{6.63 \times 10^{-34}}$

(Total for Question 9 = 1 mark)

4 Which of the following is evidence that electrons can behave like waves?

☒ **A** Electrons are attracted towards positively charged objects.

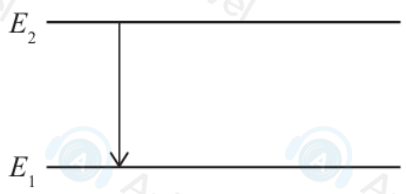
☒ **B** Electrons can absorb photons and move between energy levels in an atom.

☒ **C** Electrons can be diffracted when passing through a thin sheet of graphite.

☒ **D** Electrons can be released by photons in the photoelectric effect.

(Total for Question 4 = 1 mark)

10 In an atom, an electron drops from energy level E_2 to energy level E_1, as shown.



A photon of wavelength λ is emitted.

Which of the following expressions gives the energy E_2?

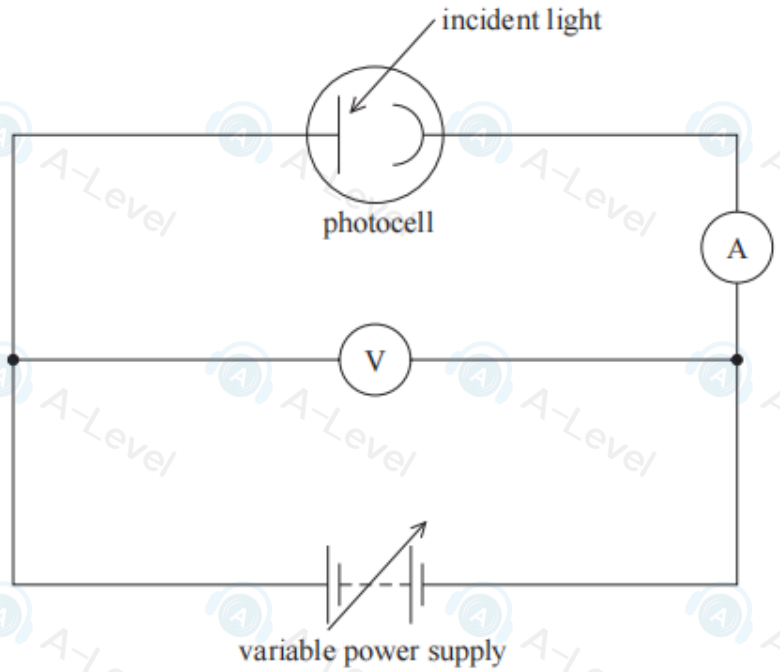
- ☒ **A** $\frac{hc}{\lambda} - E_1$
- ☒ **B** $\frac{hc}{\lambda} + E_1$
- ☒ **C** $\frac{h\lambda}{c} - E_1$

6 Which of the following describes threshold frequency?

- ☒ **A** The frequency of light that causes photoelectrons to have maximum kinetic energy.
- ☒ **B** The frequency of light emitted when excited electrons fall to the ground state.
- ☒ **C** The minimum frequency of light that can cause an electron to leave a surface.
- ☒ **D** The maximum frequency of light which excites an electron in the ground state.

(Total for Question 6 = 1 mark)

14 Photocells make use of the photoelectric effect. The following circuit can be used to determine the work function of a metal used in a photocell.



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

(1)

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(b) This photocell works with ultraviolet light but does not work with visible light.

Explain why.

(2)

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(c) An experiment was carried out using this circuit. The potential difference applied to the photocell opposes the movement of the electrons through the photocell, reducing the current.

(i) The variable power supply was initially set at 0 V and the reading on the ammeter was 2.4 μA.

The intensity of the ultraviolet light was then increased without changing the frequency.

Explain what happened to the reading on the ammeter.

(3)

(ii) The variable power supply was adjusted until the reading on the ammeter became 0 μA. The reading on the voltmeter was 3.59 V.

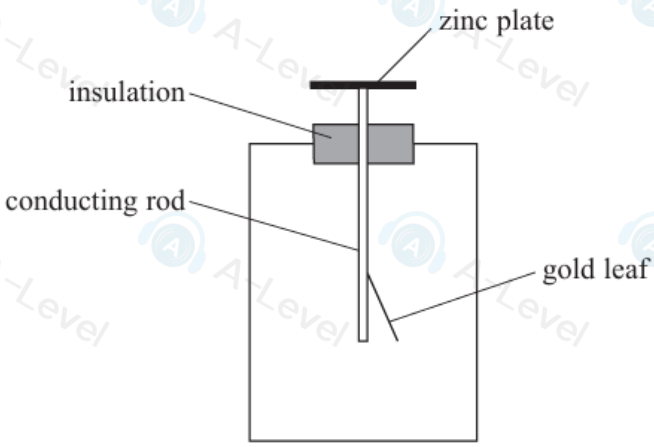
Calculate the work function, in joules, of the metal used in the photocell.

frequency of ultraviolet used = 2.00×10^{15} Hz

(4)

Work function = ... J

14 A gold leaf electroscope is used to demonstrate the photoelectric effect. When the zinc plate of the electroscope is given a negative charge, the conducting rod and gold leaf also become negatively charged. The gold leaf deflects away from the metal stem as shown. The deflection of the gold leaf depends on the amount of charge on the zinc plate and the conducting rod.



A beam of ultraviolet radiation is incident on the zinc plate. The gold leaf immediately begins to fall back to the conducting rod.

(a) Explain why this observation cannot be explained by the wave model of electromagnetic radiation.

(2)

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(b) Photons of ultraviolet radiation with an energy of 9.3×10^{-19} J are directed towards

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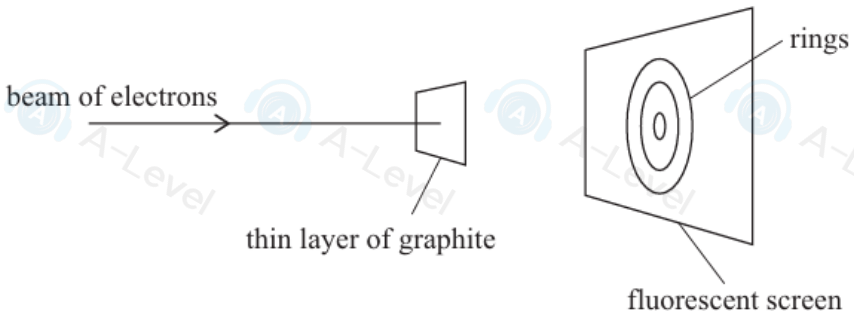
11 A beam of electrons passes through a thin layer of graphite. The electrons are then incident on a fluorescent screen, causing a series of rings to form, as shown.



Explain what the rings show about the nature of electrons.

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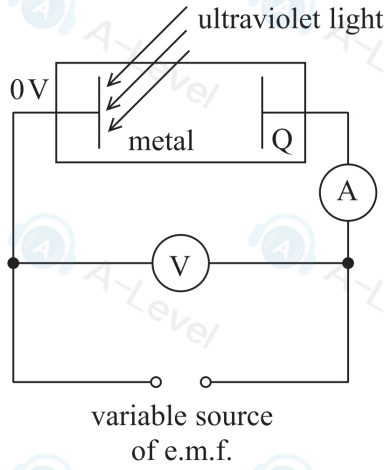
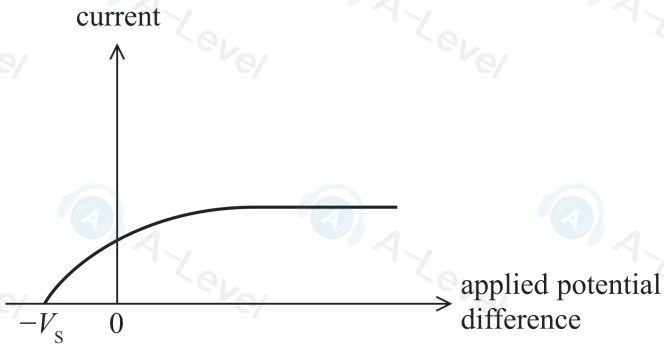
(Total for Question 11 = 2 marks)

17 The diagram shows apparatus used to investigate the photoelectric effect.



When ultraviolet light of a particular frequency is shone on the metal a current is produced.
Current is produced for all values of potential difference when Q is positive.
If Q is negative there is a p.d. beyond which there is no current. The magnitude of this p.d. is called the stopping potential V_S.

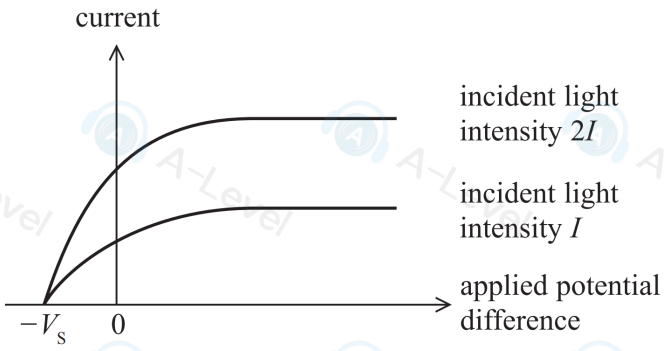
The graph shows the results for a particular investigation with light intensity I.



*(a) (i) Explain why there is a current for positive p.d.s, but none for reverse p.d.s greater than the stopping potential.

(5)

(ii) The investigation is repeated with light intensity $2I$. The results are as shown below.



Explain the difference between the results for incident light intensity I and incident light intensity $2I$ for positive values of the applied potential difference.

(2)

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(b) Calculate the value of V_S.

frequency of ultraviolet light = 1.20×10^{15} Hz
work function of metal = 4.26 eV

(3)

V_S = ...

(Total for Question 17 = 10 marks)

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