9 In 1924 de Broglie suggested that electrons have wave properties.
The de Broglie equation states:

$$\lambda = \frac{h}{p}$$

Which of the following is correct?

- ☒ **A** The de Broglie wavelength is independent of the mass of the particle.
- ☒ **B** The de Broglie equation can be used to calculate the momentum of a photon.
- ☒ **C** The term p represents the mass of an electron multiplied by the speed of light.
- ☒ **D** The value of h depends on the particle involved.

(Total for Question 9 = 1 mark)

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4 Which of the following has the largest de Broglie wavelength?

- ☒ **A** an electron travelling at $3.0 \times 10^5\,\mathrm{m\,s^{-1}}$
- ☒ **B** an electron travelling at $4.0 \times 10^5\,\mathrm{m\,s^{-1}}$
- ☒ **C** a neutron travelling at $3.0 \times 10^5\,\mathrm{m\,s^{-1}}$
- ☒ **D** a neutron travelling at $4.0 \times 10^5\,\mathrm{m\,s^{-1}}$

(Total for Question 4 = 1 mark)

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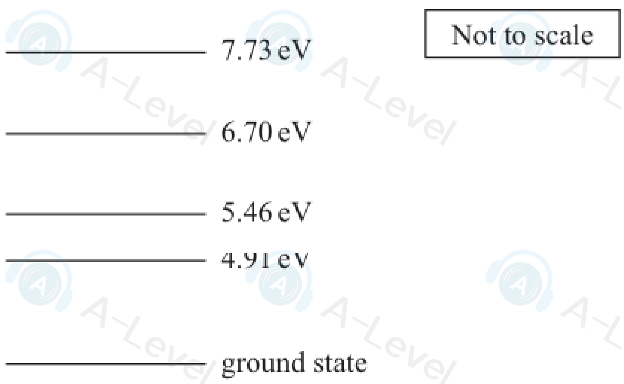
9 The diagram shows the energy needed for an electron in the ground state of a mercury atom to move to different energy levels.



Photons transfer 8.74×10^{-19} J to electrons in the ground state of mercury atoms.

Which of the following gives the number of different frequencies of light that could be emitted?

- ☒ **A** 1
- ☒ **B** 3
- ☒ **C** 6
- ☒ **D** 10

(Total for Question 9 = 1 mark)

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7 A fluorescent lamp has a power input of 14 W.

The rate of transfer to thermal energy by the lamp is 9.8 W, the remainder of the energy becoming light.

Which of the following is the efficiency of the lamp?

- ☒ **A** 0.30
- ☒ **B** 0.43
- ☒ **C** 0.70
- ☒ **D** 1.43

(Total for Question 7 = 1 mark)

P 5 5 4 4 3 A 0 4 2 4

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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)

4 An electron has a velocity of $2 \times 10^7\,\mathrm{m\,s^{-1}}$.

Which of the following expressions gives the de Broglie wavelength of the electron in metres?

☒ **A** $\dfrac{6.63 \times 10^{-34}}{1.67 \times 10^{-27} \times 2 \times 10^7}$

☒ **B** $\dfrac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 2 \times 10^7}$

☒ **C** $\dfrac{9.11 \times 10^{-31} \times 2 \times 10^7}{6.63 \times 10^{-34}}$

☒ **D** $\dfrac{1.67 \times 10^{-27} \times 2 \times 10^7}{6.63 \times 10^{-34}}$

(Total for Question 4 = 1 mark)

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)

4 Which of the following describes a change in energy of 1 eV?

☒ **A** A charge of 1 C is accelerated across a potential difference of 1 V.

☒ **B** A charge of 1 C passes a point in a time of 1 s.

☒ **C** An electron is accelerated across a potential difference of 1 V.

☒ **D** There is a current of 1 A for a time of 1 s.

(Total for Question 4 = 1 mark)

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12 Solar panels generate electricity when sunlight is incident on the surface of the panel.

(a) The total generation of electricity worldwide in the year 2014 was approximately 23 800 TWh (1 TWh = 3.6×10^{15} J).

Some scientists claim that if the Sahara Desert were covered with solar panels, sufficient electricity could be generated to supply the whole world.

(i) Calculate the maximum energy received by the solar panels in one hour.

maximum intensity of solar radiation at the Earth's surface = 1100 Wm^{-2}
area of Sahara Desert = 9.2×10^{12} m^2

(2)

Maximum energy received in one hour = ...

(ii) Determine whether covering the Sahara Desert with solar panels would be able to generate enough electricity for the whole world.

(2)

(b) Sand storms are common in the Sahara Desert.

Explain why sand storms reduce the power generated by the solar panels.

(2)

(Total for Question 12 = 6 marks)

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13 The orbits of planets around the Sun are elliptical.

The intensity of radiation received at the top of the Earth's atmosphere is monitored during one orbit of the Earth around the Sun.

The following data is recorded:

maximum intensity of radiation = $1.41\,\text{kW m}^{-2}$
minimum intensity of radiation = $1.32\,\text{kW m}^{-2}$

(a) Calculate the minimum distance between the Earth and the Sun.

power of the Sun = $3.83 \times 10^{26}\,\text{W}$

(3)

Minimum distance = ...

(b) As Mars orbits the Sun, the intensity of radiation received at the top of its atmosphere varies from $491\,\text{W m}^{-2}$ to $711\,\text{W m}^{-2}$.

Explain two differences between the orbits of Mars and Earth that can be deduced from this data.

(3)

(Total for Question 13 = 6 marks)

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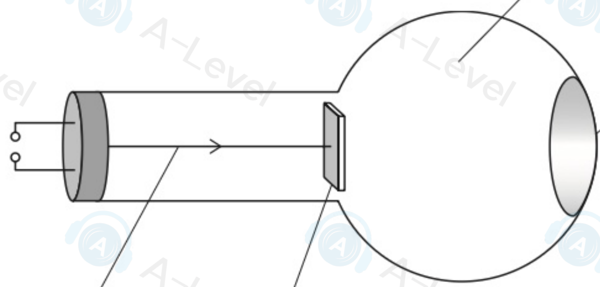
15 A teacher demonstrated the behaviour of electrons travelling through graphite.
An electron beam was directed through a thin piece of graphite towards a fluorescent screen, as shown.



The electrons produced a pattern on the fluorescent screen as shown below.

(Source: © ANDREW LAMBERT PHOTOGRAPHY/SCIENCE PHOTO LIBRARY)

(a) This demonstration can be used to make conclusions about the behaviour of the electrons and the structure of the graphite.

State these conclusions.

(4)

....

(b) The electrons were accelerated through a potential difference (p.d.) of 2400 V before interacting with the graphite.

(i) Show that the work done on each electron is about 4×10^{-16} J.

(2)

....

....

....

....

(ii) Calculate the maximum velocity of the electrons.

(2)

....

....

....

Maximum velocity = ...

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14 The diagram shows some of the energy levels for an atom of hydrogen.

When an electron with a kinetic energy of 12.3 eV interacts with this atom, an electron in the atom moves from the −13.6 eV level to the −1.5 eV level.

When a photon with a photon energy of 12.3 eV is incident on this atom, the electron in the atom at the −13.6 eV level remains at the −13.6 eV level.

Explain these observations.

(4)

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