1 In an experiment to demonstrate the photoelectric effect, a charged metal plate is illuminated with light from different sources. The plate loses its charge when an ultraviolet light source is used but not when a red light source is used.

What is the reason for this?

A The intensity of the red light is too low. ⬭

B The wavelength of the red light is too short. ⬭

C The frequency of the red light is too high. ⬭

D The energy of red light photons is too small. ⬭

(Total 1 mark)

2 Which of the following classes of electromagnetic waves will **not** ionise neutral atoms?

What is the reason for this?

A ultraviolet ⬭

B X radiation ⬭

C gamma radiation ⬭

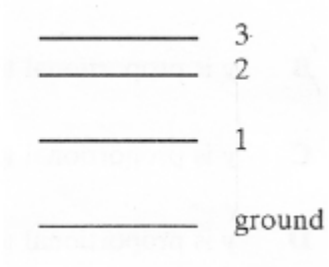
D microwave ⬭

(Total 1 mark)

3 The values of the lowest three energy levels in a particular atom are shown in the table.

The diagram shows these levels together with the ground state of the atom.

Level	Energy/eV
3	–0.85
2	–1.51
1	–3.39



When an electron moves from level 3 to level 1, radiation of frequency 6.2×10^{14} Hz is emitted.

What is the frequency of the radiation emitted when an electron moves from level 2 to level 1?

A 2.3×10^{14} Hz ⬭

B 3.5×10^{14} Hz ⬭

C 4.6×10^{14} Hz ⬭

D 8.3×10^{14} Hz ⬭

(Total 1 mark)

4 Experiments on which of the following suggested the wave nature of electrons?

A electron diffraction by a crystalline material ⬭

B β^- decay ⬭

C line spectra of atoms ⬭

D the photoelectric effect ⬭

(Total 1 mark)

5 Which of the following statements about the behaviour of waves is **incorrect**?

A All waves can be diffracted. ⬭

B All waves can be made to undergo superposition. ⬭

C All waves can be refracted. ⬭

D All waves can be polarised. ⬭

(Total 1 mark)

6 Electrons and protons in two beams are travelling at the same speed. The beams are diffracted by objects of the same size.

Which correctly compares the de Broglie wavelength λ_e of the electrons with the de Broglie wavelength λ_p of the protons and the width of the diffraction patterns that are produced by these beams?

	comparison of de Broglie wavelength	diffraction pattern	
A	$\lambda_e > \lambda_p$	electron beam width > proton beam width	⬭
B	$\lambda_e < \lambda_p$	electron beam width > proton beam width	⬭
C	$\lambda_e > \lambda_p$	electron beam width < proton beam width	⬭
D	$\lambda_e < \lambda_p$	electron beam width < proton beam width	⬭

(Total 1 mark)

7 The intensity of a monochromatic light source is increased. Which of the following is correct?

	Energy of an emitted photon	**Number of photons emitted per second**	
A	increases	increases	⬭
B	increases	unchanged	⬭
C	unchanged	increases	⬭
D	unchanged	unchanged	⬭

(Total 1 mark)

8 A diffraction pattern is formed by passing monochromatic light through a single slit. If the width of the single slit is reduced, which of the following is true?

	Width of central maximum	Intensity of central maximum	
A	unchanged	decreases	⬭
B	increases	increases	⬭
C	increases	decreases	⬭
D	decreases	decreases	⬭

(Total 1 mark)

9 When comparing X-rays with UV radiation, which statement is correct?

A X-rays have a lower frequency. ⬭

B X-rays travel faster in a vacuum. ⬭

C X-rays do not show diffraction and interference effects. ⬭

D Using the same element, photoelectrons emitted using X-rays have the greater maximum kinetic energy. ⬭

(Total 1 mark)

10 Monochromatic radiation from a source of light (source A) is shone on to a metallic surface and electrons are emitted from the surface. When a second source (source B) is used no electrons are emitted from the metallic surface. Which property of the radiation from source A must be greater than that from source B?

A amplitude ⬭

B frequency ⬭

C intensity ⬭

D wavelength ⬭

(Total 1 mark)

11 An electron has a kinetic energy E and a de Broglie wavelength λ. The kinetic energy is increased to $4E$. What is the new de Broglie wavelength?

A $\frac{\lambda}{4}$ ⬭

B $\frac{\lambda}{2}$ ⬭

C λ ⬭

D 4λ ⬭

(Total 1 mark)

12 In a photoelectric experiment, light is incident on the metal surface of a photocell. Increasing the intensity of the illumination at the surface leads to an increase in the

A work function ⬭

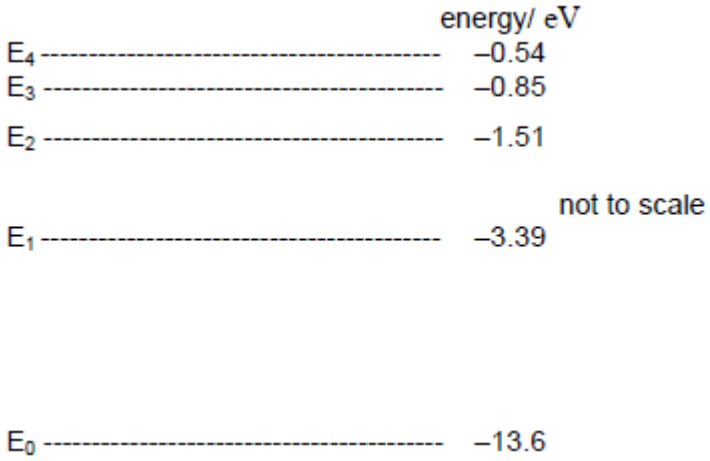
B minimum frequency at which electrons are emitted ⬭

C current through the photocell ⬭

D speed of the electrons ⬭

(Total 1 mark)

13 The diagram gives some of the energy levels of a hydrogen atom.



The transition of an excited hydrogen atom from E_3 to E_1 causes a photon of visible light to be emitted.

Which transition causes a photon of ultraviolet light to be emitted?

A E_4 to E_3 ⬭

B E_3 to E_2 ⬭

C E_2 to E_1 ⬭

D E_1 to E_0 ⬭

(Total 1 mark)

14 A proton moving with a speed v has a de Broglie wavelength λ.

What is the de Broglie wavelength of an alpha particle moving at the same speed v?

A $\frac{\lambda}{4}$ ⬭

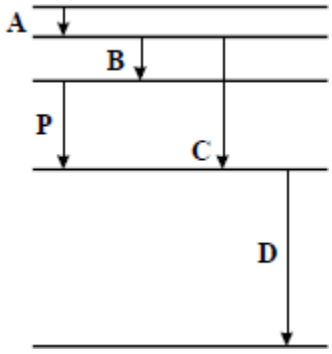
B λ ⬭

C 2λ ⬭

D 4λ ⬭

(Total 1 mark)

15 The diagram **drawn to scale** shows some of the energy levels of an atom. Transition **P** results in the emission of a photon of wavelength 4×10^{-7} m.



Which one of the transitions **A**, **B**, **C**, or **D** could result in the emission of a photon of wavelength 8×10^{-7} m?

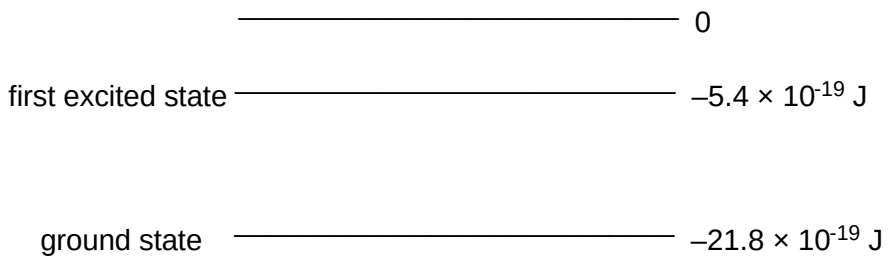
(Total 1 mark)

16 For which of the following relationships is the quantity y related to the quantity x by the relationship $x \propto \frac{1}{y}$?

	x	y
A	energy stored in a spring	extension of the spring
B	gravitational field strength	distance from a point mass
C	de Broglie wavelength of an electron	momentum of the electron
D	period of a mass-spring system	spring constant (stiffness) of the spring

(Total 1 mark)

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



A free electron of kinetic energy 20.0×10^{-19} J collides with a hydrogen atom in its ground state. The hydrogen atom is excited from its ground state to the first excited state. The kinetic energy of the free electron after the collision is

A 1.8×10^{-19} J

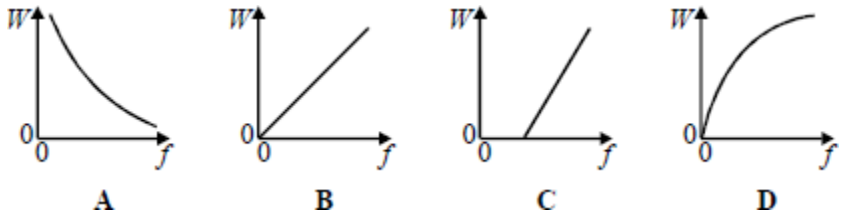
B 3.6×10^{-19} J

C 5.4×10^{-19} J

D 16.4×10^{-19} J

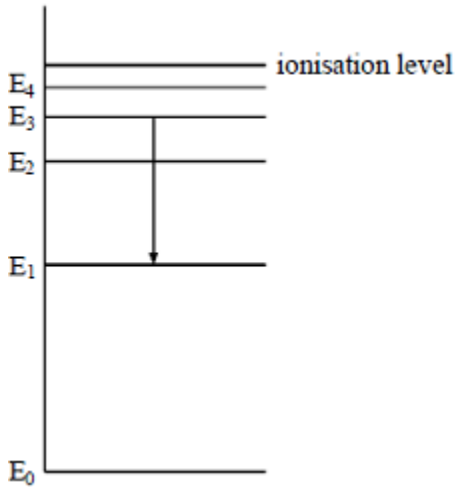
(Total 1 mark)

18 Which one of the graphs best represents the relationship between the energy W of a photon and the frequency f of the radiation?



(Total 1 mark)

19 The diagram shows some energy levels of an atom.



The transition E_3 to E_1 corresponds to the emission of visible light.

A transition corresponding to the emission of infrared radiation could be

A E_1 to E_0

B E_4 to E_1

C E_1 to E_2

D E_3 to E_2

(Total 1 mark)

Mark schemes

1 D **[1]**

2 D **[1]**

3 C **[1]**

4 A **[1]**

5 D **[1]**

6 A **[1]**

7 C **[1]**

8 C **[1]**

9 D **[1]**

10 B **[1]**

11 B **[1]**

12 C **[1]**

13 D **[1]**

14 A **[1]**

15 B **[1]**

16 C **[1]**

17 B **[1]**

18 B

[1]

19 D

[1]

Examiner reports

13 Approximately two thirds of students spotted that a bigger energy jump was needed to produce a photon of UV, and therefore chose D. Distractors A (the smallest energy jump) and C (the next smallest) were chosen by a similar number of students who failed to make the link between energy and frequency perhaps.

14 Multiple choice questions involving the algebraic manipulation of an equation, rather than the use of data, are fairly common. 62% of students were able to see that the alpha particle would have four times the mass, therefore four times the momentum, and one quarter of the wavelength. The most popular distractor, D, was chosen by students who missed out the last step, perhaps. C was also a common incorrect answer, perhaps chosen by students who thought that the fact alpha particles contain two protons was significant.