8 The alpha particle scattering experiment led to a number of observations and conclusions.

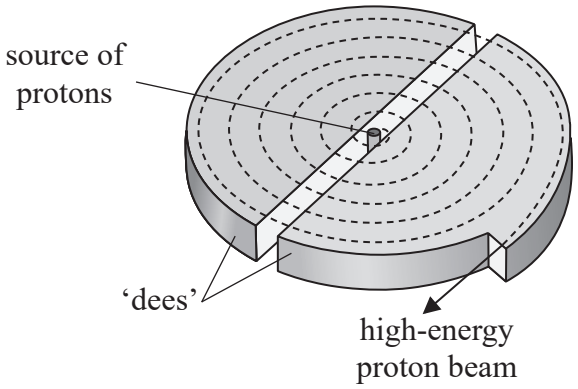
Which row in the table gives a correct observation and corresponding conclusion from the alpha particle scattering experiment?

	Observation	Conclusion
☒ **A**	Most alpha particles come straight back.	The nucleus is charged.
☒ **B**	Most alpha particles come straight back.	The atom is mainly empty space.
☒ **C**	Most alpha particles go straight through.	The atom is mainly empty space.
☒ **D**	Most alpha particles go straight through.	The nucleus is charged.

(Total for Question 8 = 1 mark)

13 Proton beam therapy is being introduced in the UK as a new cancer treatment.

A beam of protons is accelerated by a cyclotron to an energy of 23 MeV and is then focused onto a tumour.

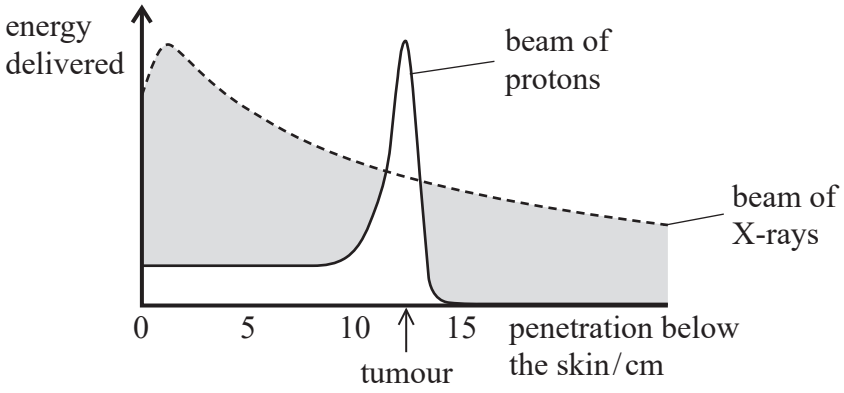


*(a) Explain how the cyclotron produces the high-energy proton beam.

(6)

(b) Conventional treatment may use X-rays to deliver energy to a tumour.

The graph shows the variation of energy delivered with penetration below the skin for a beam of protons and a beam of X-rays.



Deduce why the beam of protons could be a more effective treatment for tumours than a beam of X-rays.

(2)

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.....

(c) Developing new cancer treatments is expensive.

Give two possible reasons why money should be provided for the development of this new cancer treatment.

(2)

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(Total for Question 13 = 10 marks)

16 The neutral lambda Λ^0 particle is a baryon of mass 1116 MeV/c^2 and contains one strange quark.

(a) The table shows quarks and their relative charge.

Quark	Charge / *e*
u	+2/3
d	–1/3
s	–1/3

State, with justification, the quark content of a Λ^0 particle.

(2)

.....

.....

.....

(b) Calculate the mass of the Λ^0 particle in kg.

(3)

.....

.....

.....

.....

Mass of Λ^0 particle = ... kg

(c) A student suggests five ways a Λ^0 particle might decay. These are

$\Lambda^0 \rightarrow p + \pi^-$
$\Lambda^0 \rightarrow e^+ + e^-$
$\Lambda^0 \rightarrow n + \pi^0$
$\Lambda^0 \rightarrow n$
$\Lambda^0 \rightarrow p + \pi^0$

Deduce which of these decay processes are **not** possible.

(6)

(d) Lambda particles were first detected in experiments which made use of cosmic rays entering the atmosphere. Cosmic rays are mainly high-energy protons which have a mass less than that of a lambda particle.

Explain why a cosmic ray could lead to the creation of a lambda particle.

(2)

(e) The Λ^0 particle cannot be directly observed in particle experiments, however some of the decay products can.

Explain why the Λ^0 particle cannot be directly observed but information about it can be obtained by studying its decay particles.

(3)

(Total for Question 16 = 16 marks)

(Total for Question 5 = 1 mark)

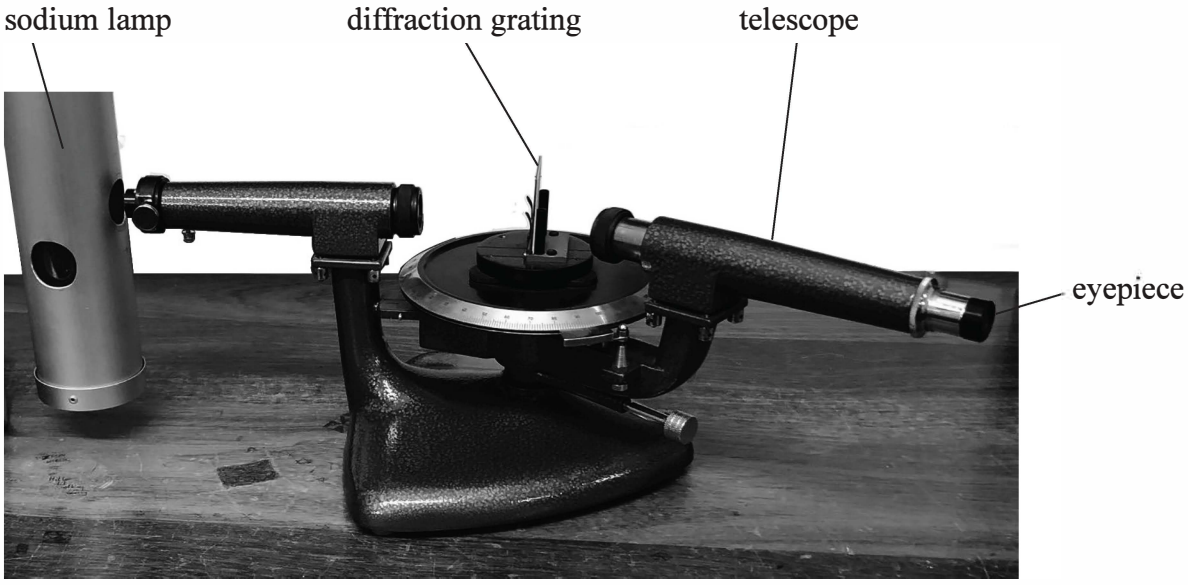
6 When light is incident on the surface of a metal, electrons may be emitted by the photoelectric effect. Observations of the photoelectric effect helped to establish that light can exhibit particle behaviour.

Which of the following observations of the photoelectric effect could also be explained by light behaving as a wave?

- ☐ **A** Emission of photoelectrons occurs immediately the surface is illuminated.
- ☐ **B** Photoelectrons are only emitted when the frequency of the light is more than a certain minimum value.
- ☐ **C** The maximum kinetic energy of the photoelectrons is independent of the intensity of the incident light.
- ☐ **D** When the intensity of the incident light increases, photoelectrons are emitted at a greater rate.

(Total for Question 6 = 1 mark)

17 The photograph shows a school spectrometer.



The spectrometer allows parallel rays of light to be passed through a diffraction grating and the resulting angles of diffraction to be measured.

(a) In the telescope, light from the grating is focused to make a real image 16.7 mm in front of the eyepiece lens. The eyepiece lens then uses this real image as an object to produce a magnified virtual image for the observer.

Calculate the magnification produced by the eyepiece lens.

focal length of eyepiece lens = 17.9 mm

(3)

Magnification = ...

(b) The spectrometer and diffraction grating are used to analyse the light from a sodium lamp. In the sodium lamp, sodium is heated until it becomes a vapour and an electric current is passed through it. The vapour then emits light.

After the light passes through the diffraction grating a line spectrum is observed.

(i) Explain why only certain wavelengths are observed.

(6)

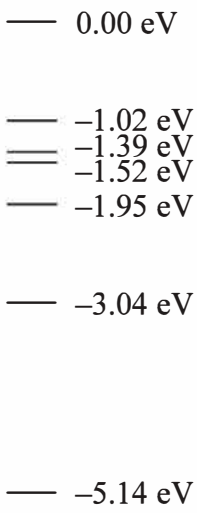
(ii) Diffraction gratings with the following spacings are available:

$d/10^{-6}$ m	1.0	1.7	2.0	3.3

Explain which would be the best spacing to use to measure the diffraction angle for the third order maximum for yellow light of wavelength 589 nm.

(3)

(c) The diagram shows some of the energy levels in a sodium atom.



Add an arrow to the diagram to show the transition involved in the emission of yellow light of wavelength 589 nm.

Show your working below.

(4)

(Total for Question 17 = 16 marks)