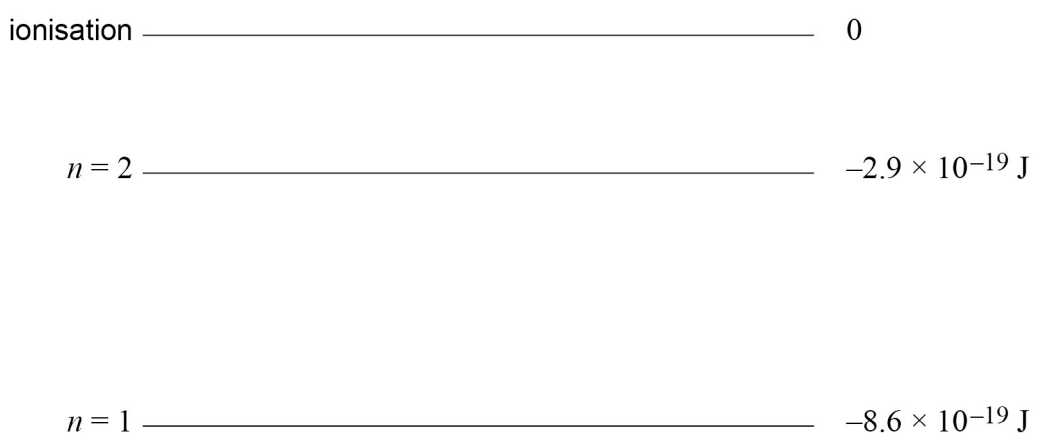
Do not write outside the box

1 3 Some energy levels of a lithium atom are shown below.



A free electron with kinetic energy 6.0×10^{-19} J collides with a stationary lithium atom in its $n = 1$ energy level. The lithium atom is excited to the $n = 2$ energy level.

What is the kinetic energy of the free electron after the collision?

[1 mark]

A 0.3×10^{-19} J ⬭

B 2.6×10^{-19} J ⬭

C 3.1×10^{-19} J ⬭

D 5.7×10^{-19} J ⬭

1 4 What are the products when a free neutron decays?

[1 mark]

A $p + e^- + \nu_e$ ⬭

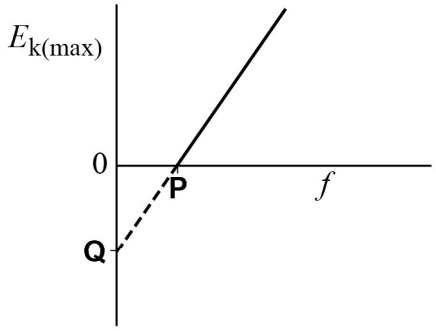
B $p + e^+ + \bar{\nu}_e$ ⬭

C $p + e^- + \bar{\nu}_e$ ⬭

D $p + e^+ + \nu_e$ ⬭

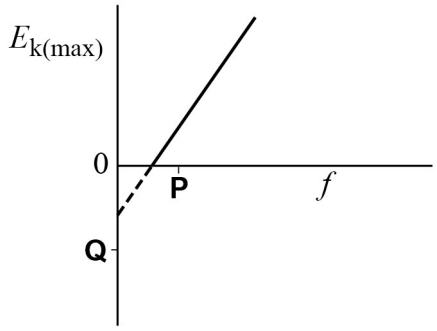
Do not write outside the box

2 1 The graph shows how the maximum kinetic energy $E_{k(max)}$ of photoelectrons emitted from a metal surface varies with the frequency f of the incident radiation.
P is the intercept on the f axis. **Q** is the intercept on the $E_{k(max)}$ axis.

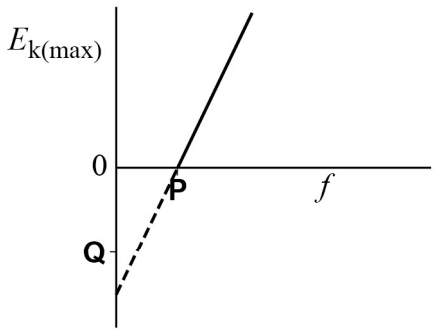


Which graph shows the variation of $E_{k(max)}$ with f for a metal with a greater work function?
[1 mark]

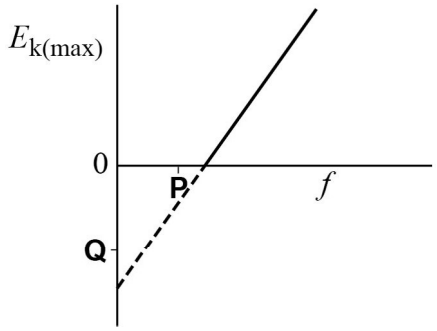
A



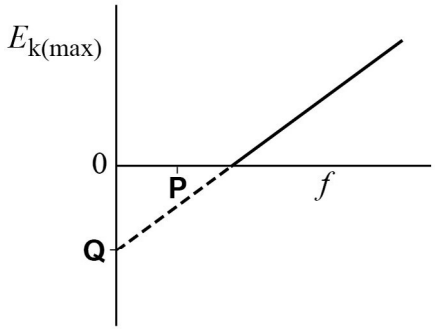
B



C



D



A ⬭

B ⬭

C ⬭

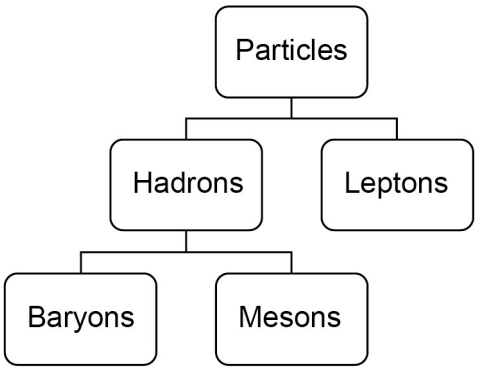
D ⬭

Do not write outside the box

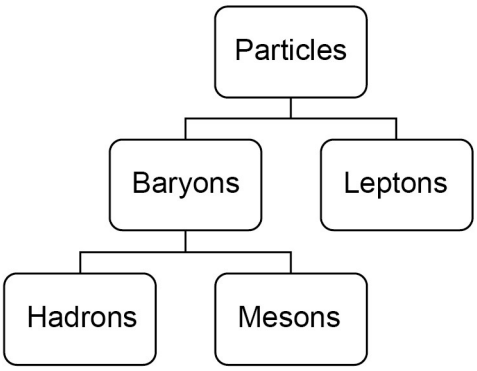
3 5 Which shows the classification of particles?

[1 mark]

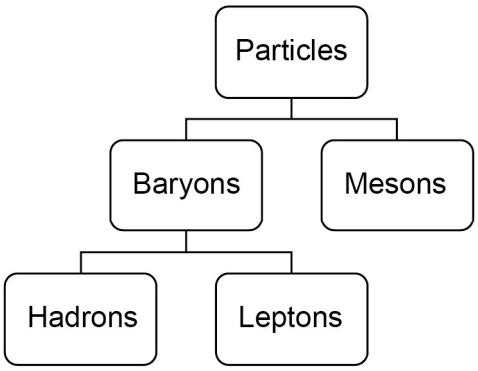
A



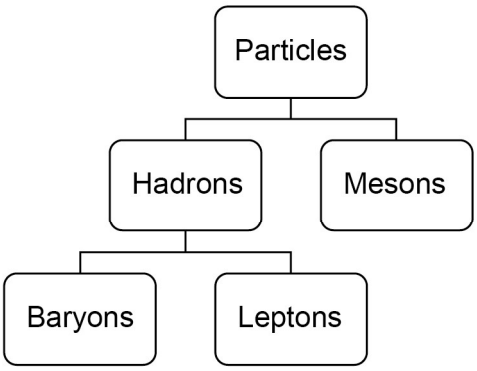
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

30

END OF QUESTIONS

Do not write outside the box

Answer **all** questions in the spaces provided.

0 1 A sigma-plus (Σ^+) particle and an unidentified particle **Y** are produced by the strong interaction between a positive pion (π^+) and a proton (p).

This interaction is represented by the equation:

$$\pi^+ + p \rightarrow \Sigma^+ + \mathbf{Y}$$

0 1 . 1 Complete **Table 1** to show the baryon number B, charge Q and strangeness S for the particles in this interaction.

[2 marks]

Table 1

	π^+	p	Σ^+	Y
B				0
Q	+1	+1	+1	
S				+1

0 1 . 2 Which particle in **Table 1** has the quark structure uus?

Tick (✓) **one** box.

[1 mark]

π^+ ☐

p ☐

Σ^+ ☐

Y ☐

Do not write outside the box

0 1 . 3 Deduce which particle, π^+ or **Y**, has the greater charge-to-mass ratio. Justify your conclusion.

[3 marks]

6

Turn over for the next question

Do not write outside the box

0 4 An isolated metal plate is given a negative charge. Electromagnetic radiation is incident on the plate. The plate loses its charge due to the photoelectric effect.

0 4 . 1 Discuss how the rate of loss of charge from the plate depends on the frequency and intensity of the incident radiation.

In your answer you should explain why:

- the plate loses its charge
- the photoelectric effect occurs only for frequencies greater than a particular value
- the rate of loss of charge increases with intensity for radiation above that particular value of frequency.

[6 marks]

Do not write outside the box

0 4 . 2 Charged particles are emitted from the metal plate with a maximum kinetic energy of $1.1\ \text{eV}$ when radiation of frequency $1.2 \times 10^{15}\ \text{Hz}$ is incident on the plate.

Calculate, in eV, the work function of the metal.

[3 marks]

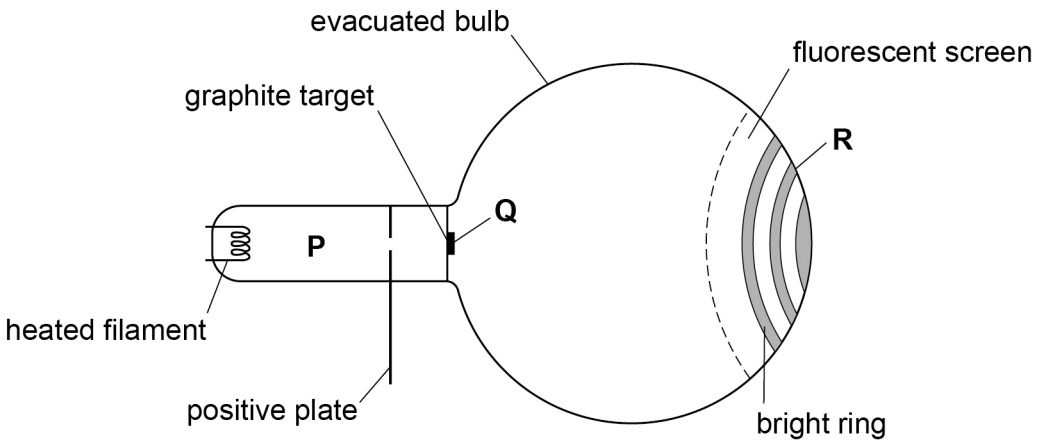
work function = _____ eV

9

Do not write outside the box

0 5 **Figure 4** shows apparatus used to demonstrate the wave–particle duality of electrons.

Figure 4



The heated filament emits slow-moving electrons.

In region **P**, the electrons are accelerated to a high speed.
At **Q**, the fast-moving electrons are incident on the graphite target.
R is a point on one of the bright rings that are formed where the electrons strike the fluorescent screen.

0 5 . 1 The electrons demonstrate wave-like and particle-like behaviour as they travel from the filament to the screen.

State and explain at which of **P**, **Q** or **R** the electrons are demonstrating wave-like behaviour.

[2 marks]

Do not write outside the box

0 5 . 2 The apparatus is adjusted so that the electrons are incident on the graphite target with a greater speed.

Explain why the bright rings formed on the screen now have a smaller diameter.

[3 marks]

5

Turn over for the next question

Do not write outside the box

Section C

Each of Questions **05** to **34** is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.
For each question, completely fill in the circle alongside the appropriate answer.

CORRECT METHOD 

WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

You may do your working in the blank space around each question but this will not be marked. Do **not** use additional sheets for this working.

0 5 Which row has the largest value for

$$\frac{\text{specific charge of the particle in column } \mathbf{X}}{\text{specific charge of the particle in column } \mathbf{Y}} ?$$

[1 mark]

	X	**Y**	
A	electron	alpha particle	⬭
B	alpha particle	electron	⬭
C	electron	proton	⬭
D	proton	alpha particle	⬭