Particles and radiation – 2022 AS Physics

1. June /2022/Paper_ 7407/1/No.1

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:

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

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 ☐

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

[3 marks]

2. June /2022/Paper_ 7407/1/No.2

0 2 A sample of bromine gas contains a mixture of two isotopes. An experiment is done to find the percentage of each isotope in this sample.

0 2 . 1 In the experiment, the gas is ionised by a beam of electrons.

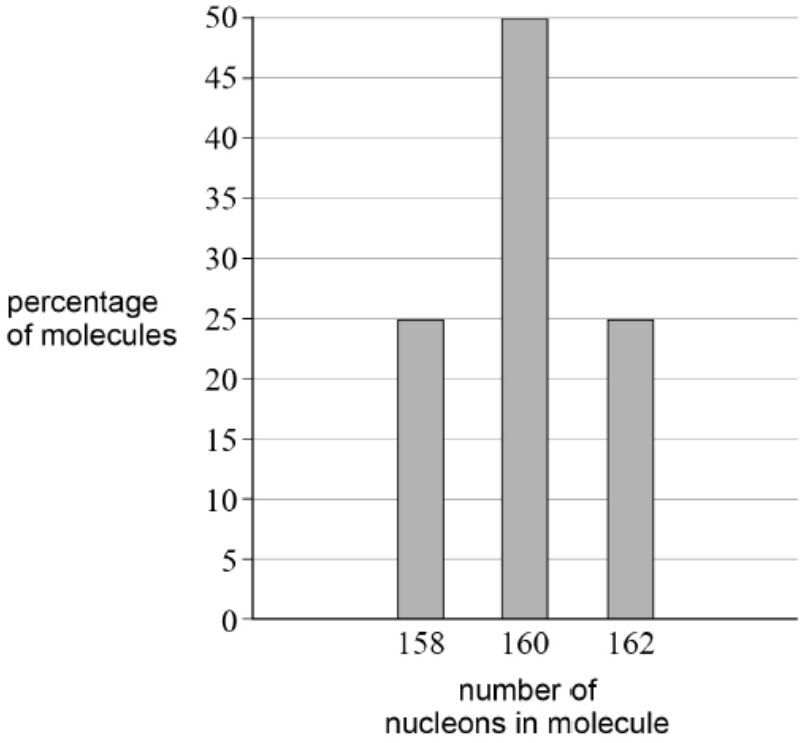
Explain how the beam of electrons causes a particle of the gas to have a charge of $+1e$.

[2 marks]

The gas consists of bromine molecules. Each molecule has two bromine atoms. The experiment finds that the bromine molecules contain 158, 160 or 162 nucleons.

Figure 1 shows the percentage of these different molecules in the sample.

Figure 1



0 2 . 2 Bromine has a proton number of 35
The two isotopes in the sample have different nucleon numbers.

Calculate the number of neutrons for the isotope that has the greater nucleon number.
[2 marks]

number of neutrons = _____

0 2 . 3 Deduce the percentage of each isotope in the gas.
Justify your conclusion.
[2 marks]

_____

_____

_____

_____

_____

_____

3. June /2022/Paper_ 7407/1/No.4

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]

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

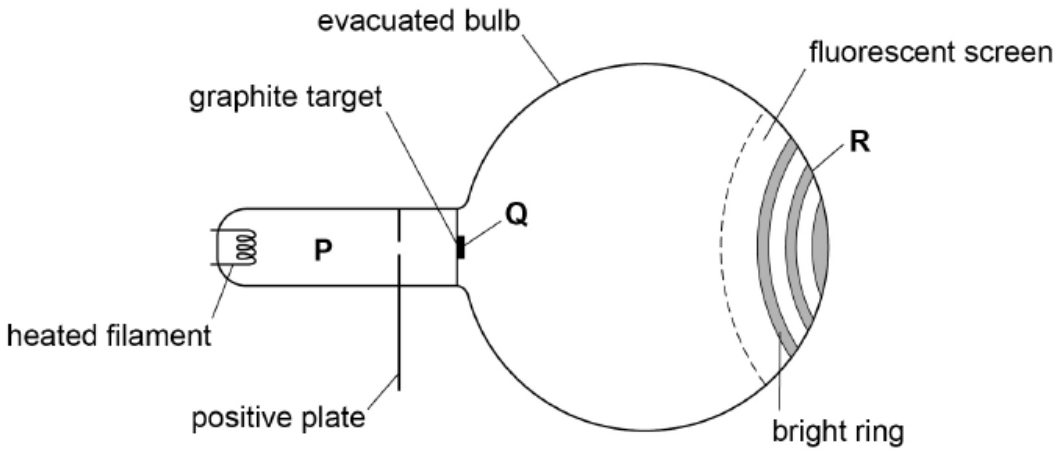
Calculate, in eV, the work function of the metal.

[3 marks]

4. June /2022/Paper_ 7407/1/No.5

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]

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. June /2022/Paper_ 7407/2/No.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]

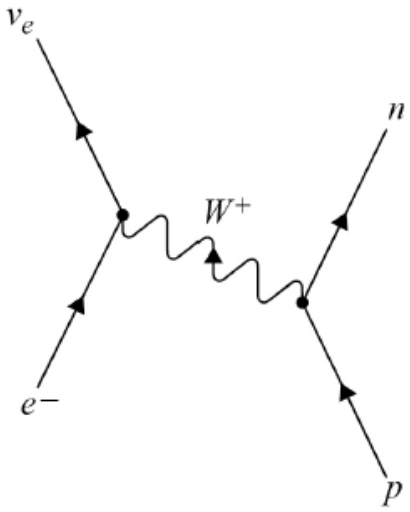
	X	Y	
A	electron	alpha particle	⬭
B	alpha particle	electron	⬭
C	electron	proton	⬭
D	proton	alpha particle	⬭

6. June /2022/Paper_ 7407/2/No.8

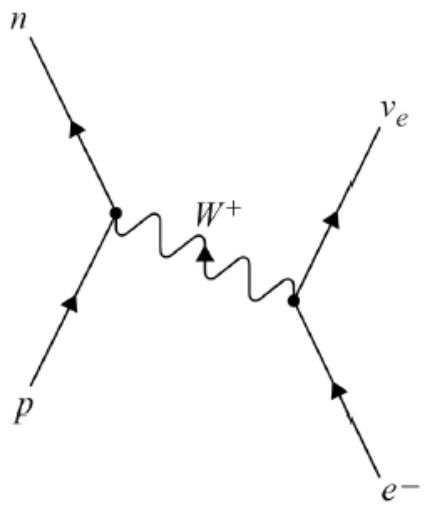
Which diagram represents the process of electron capture?

[1 mark]

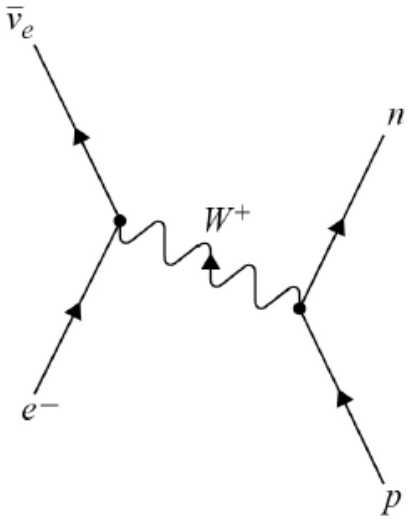
A



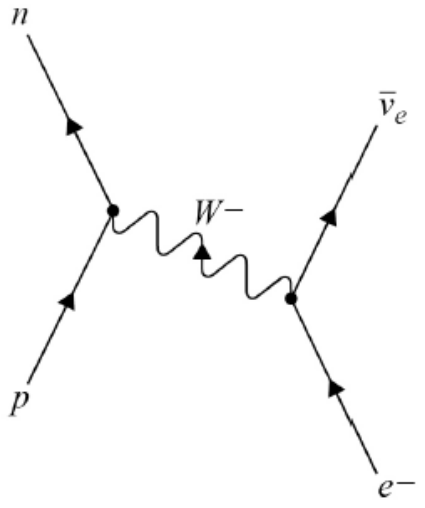
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

7. June /2022/Paper_ 7407/2/No.9

Which row is correct?

[1 mark]

	Name of particle	Classification	Quark structure	
A	antineutron	meson	$\bar{u}\bar{u}\bar{d}$	⬭
B	positive kaon	baryon	$\bar{u}s$	⬭
C	antiproton	baryon	$\bar{u}\bar{u}\bar{d}$	⬭
D	positive pion	meson	$\bar{u}d$	⬭

8. June /2022/Paper_ 7407/2/No.10

An alpha particle and a nucleus of boron ${}^{10}_{5}\mathrm{B}$ interact to form an unstable nucleus and a free neutron.

The unstable nucleus decays by positron emission to form a nucleus of nuclide **X**.

What is **X**?

[1 mark]

A ${}^{13}_{5}\mathrm{B}$ ⬭

B ${}^{13}_{6}\mathrm{C}$ ⬭

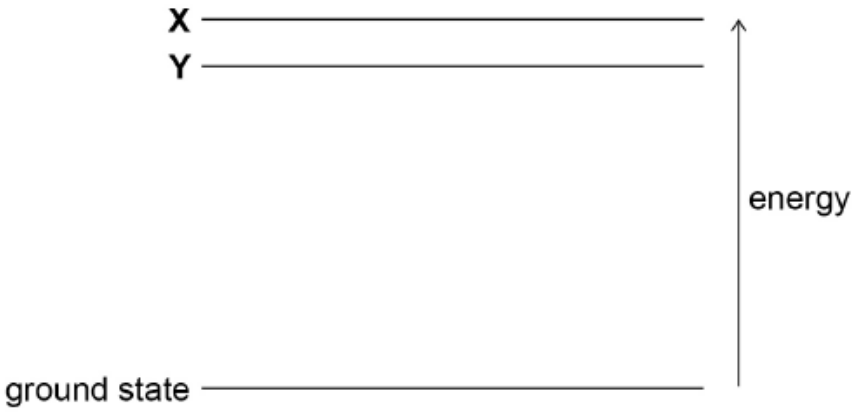
C ${}^{13}_{7}\mathrm{N}$ ⬭

D ${}^{13}_{8}\mathrm{O}$ ⬭

9. June /2022/Paper_ 7407/2/No.12

The diagram shows the ground state and two higher-energy states **X** and **Y** of an atom.

A transition from **X** to the ground state produces a photon of wavelength 147 nm.
A transition from **Y** to the ground state produces a photon of wavelength 160 nm.



What is the energy difference between **X** and **Y**?

[1 mark]

A 1.5×10^{-17} J ⬭

B 1.4×10^{-18} J ⬭

C 1.2×10^{-18} J ⬭

D 1.1×10^{-19} J ⬭

10. June /2022/Paper_ 7407/2/No.13

Which provides evidence for discrete atomic energy levels?

[1 mark]

A β^+ decay ⬭

B electron diffraction ⬭

C line spectra ⬭

D the photoelectric effect ⬭