Particles and radiation – A2 Physics P1 2022

1. June /2022/Paper_ 7408/1/No.1

0 1 Two stable isotopes of helium are $^{4}_{2}\mathrm{He}$ and $^{3}_{2}\mathrm{He}$.

0 1 . 1 An atom of $^{4}_{2}\mathrm{He}$ is produced in a rock that contains uranium. It is produced following the radioactive decay of a $^{238}_{92}\mathrm{U}$ atom. The decay also creates an atom of thorium (Th).

Write an equation for the decay of $^{238}_{92}\mathrm{U}$.

[2 marks]

$^{238}_{92}\mathrm{U} \rightarrow$

0 1 . 2 A $^{3}_{2}\mathrm{He}$ nucleus can be produced by the decay of a tritium nucleus $^{3}_{1}\mathrm{H}$.

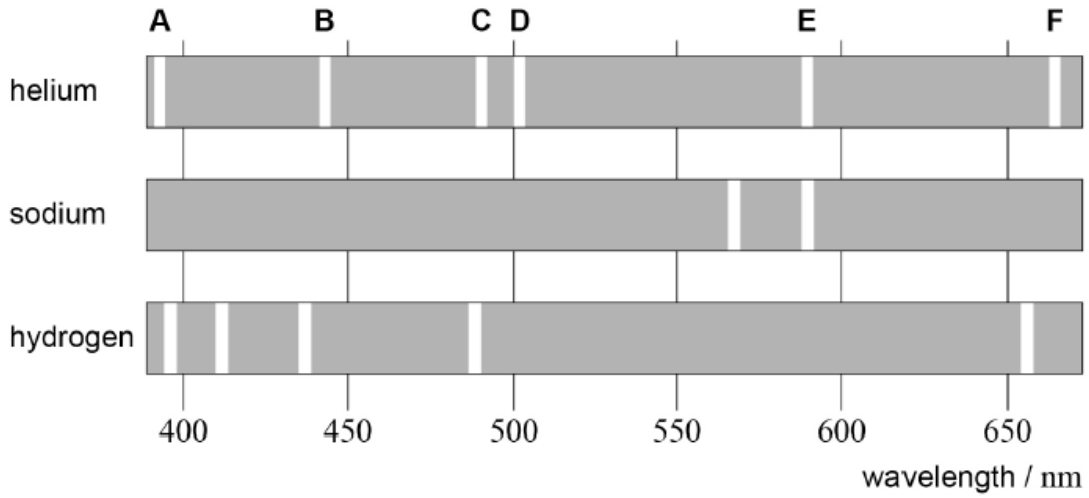
State and explain which exchange particle is responsible for this decay.

[2 marks]

Helium was discovered by analysing the light in the **absorption** spectrum of the Sun.

Figure 1 shows the positions of the brightest lines, labelled **A** to **F**, in the **emission** spectrum of helium. The brightest lines in the emission spectra of sodium and hydrogen are also shown.

Figure 1



0 1 . 3 Before helium was identified, some scientists suggested that the lines of the helium spectrum seen in the absorption spectrum of the Sun were due to the presence of sodium and hydrogen.

Discuss, with reference to the lines **A** to **F** in **Figure 1**, the evidence for and against this suggestion.

[2 marks]

0 1 . 4 Calculate, in eV, the change in energy level responsible for the spectral line labelled **E** in **Figure 1**.

[3 marks]

change in energy level = _____ eV

0 1 . 5 Explain, with reference to the processes within an atom, the difference between an emission spectrum and an absorption spectrum.

[3 marks]

2. June /2022/Paper_ 7408/1/No.2

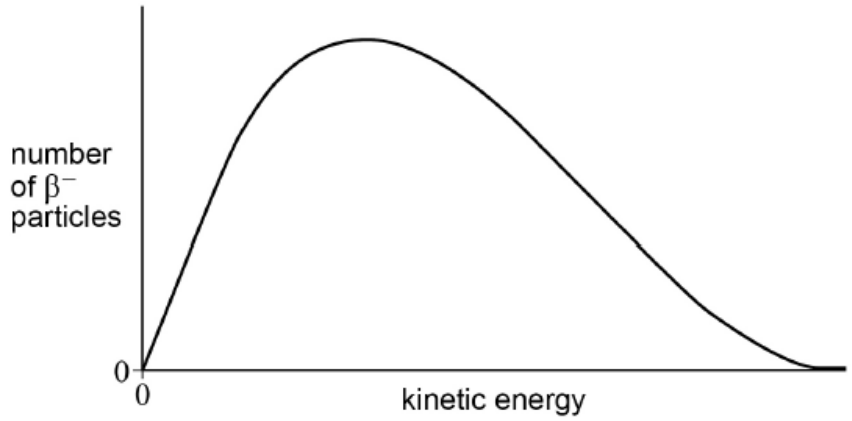
0 2 Carbon-14 decays into nitrogen-14 with the release of a beta (β^-) particle and an antineutrino ($\overline{\nu}_e$).

0 2 . 1 State the change of quark character in β^- decay.

[1 mark]

0 2 . 2 **Figure 2** shows the distribution of kinetic energies of β^- particles from the decay of carbon-14.

Figure 2



Explain how **Figure 2** supports the existence of the antineutrino.

[2 marks]

The existence of the antineutrino was confirmed by experiments in which antineutrinos interact with protons. The equation for this interaction is:

$$\overline{\nu_e} + p \rightarrow e^+ + \mathbf{X}$$

0 2 . 3 Identify particle **X**.

[1 mark]

0 2 . 4 The positron released in this interaction is annihilated when it encounters an electron. A pair of gamma photons is then produced.
Particle **X** can be absorbed by a nucleus. This produces another gamma ray.
Table 1 contains data for three gamma photons detected during an antineutrino–proton interaction experiment.

Table 1

Gamma photon	Photon energy / J
G1	5.0×10^{-14}
G2	6.6×10^{-14}
G3	1.0×10^{-13}

Deduce which of the three gamma photons could have been produced by positron annihilation.

[3 marks]

3. June /2022/Paper_ 7408/1/No.10

What is the specific charge of a $^{13}_{6}C$ nucleus?

[1 mark]

A 4.4×10^7 C kg^{-1} ⬭

B 5.2×10^7 C kg^{-1} ⬭

C 8.3×10^7 C kg^{-1} ⬭

D 2.1×10^8 C kg^{-1} ⬭

4. June /2022/Paper_ 7408/1/No.11

Which row describes the variation with distance of the strong nuclear force?

[1 mark]

	Attractive	Repulsive	
A	beyond 3 fm	from 0.5 fm to 3 fm	⬭
B	from 0.5 fm to 3 fm	beyond 3 fm	⬭
C	from 0.5 fm to 3 fm	up to 0.5 fm	⬭
D	up to 0.5 fm	from 0.5 fm to 3 fm	⬭

5. June /2022/Paper_ 7408/1/No.12

Which statement is correct?

[1 mark]

A All strange particles are mesons. ⬭

B Strange particles are always created in pairs. ⬭

C Strangeness can only change in strong interactions. ⬭

D Strangeness can only have a value of 0 or -1 ⬭

6. June /2022/Paper_ 7408/1/No.13

Which combination of quarks is possible?

[1 mark]

A sd ⬭

B sū ⬭

C sūd ⬭

D ud ⬭

7. June /2022/Paper_ 7408/1/No.14

In photoelectricity, V_s is the stopping potential.

What quantity is eV_s?

[1 mark]

A energy of an incident photon ⬭

B maximum kinetic energy of a photoelectron ⬭

C threshold frequency × the Planck constant ⬭

D work function ⬭

8. June /2022/Paper_ 7408/1/No.15

A fluorescent tube contains a gas.

The coating of the tube

[1 mark]

A becomes ionised by the gas and emits photons of ultraviolet light. ⬭

B absorbs photons of ultraviolet light from the gas and emits visible light. ⬭

C absorbs photons of ultraviolet light from the gas and emits photoelectrons. ⬭

D absorbs several photons of visible light from the gas and then emits one photon of ultraviolet light. ⬭

9. June /2022/Paper_ 7408/1/No.16

Which row gives evidence for the wave nature of electrons and evidence for the particulate nature of light?

[1 mark]

	Wave nature of electrons	Particulate nature of light	
A	electron diffraction	photoelectric effect	⬭
B	electron diffraction	single-slit diffraction	⬭
C	photoelectric effect	single-slit diffraction	⬭
D	photoelectric effect	electron diffraction	⬭

10. June /2022/Paper_ 7408/1/No.17

Which particle has the smallest de Broglie wavelength?

[1 mark]

A an electron moving at 4×10^3 m s^{-1} ⬭

B a proton moving at 4×10^3 m s^{-1} ⬭

C an electron moving at 8×10^5 m s^{-1} ⬭

D a proton moving at 8×10^5 m s^{-1} ⬭