GCE PHYSICS

S21-A420QS

Assessment Resource number 23

Light and Nuclei Resource E

1

(a) It is possible to distinguish between α, β and γ radiation by their different absorption properties. Explain briefly **one other method** of differentiating between α, β and γ radiation. [3]

Space for diagram

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(b) The half-life of beryllium-7 is 53.1 days. The initial count rate with a beryllium-7 source in position is measured as 3.50 counts per second (cps) and this dropped to 1.50 cps after 84 days.

(i) Show that this final count rate is approximately 0.33 cps higher than would be expected from beryllium alone (approximately 1.17 cps). [3]

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(ii) The discrepancy between the measured count of 1.50 cps and the expected count of 1.17 cps is due to background radiation. Given that the background count rate is a constant 0.50 cps, determine whether the final measured count rate of 1.50 cps is exactly as expected. [4]

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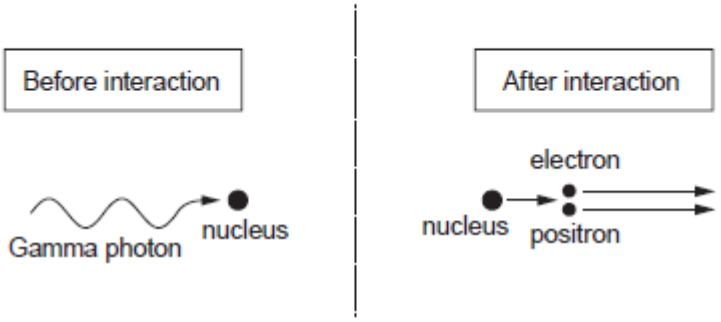
2

The following interaction can take place when a gamma photon encounters a stationary nucleus.



The energy of the gamma photon "creates" a positron-electron pair and the nucleus gains some momentum in the direction of the original gamma photon.

(a) Show that this interaction can only take place if the energy of the gamma photon is greater than 1.02 MeV. [3]

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(b) The actual energy of the incident gamma photon is 1.03 MeV. **Assuming that the kinetic energy of the nucleus after the interaction is negligible**, explain briefly why the kinetic energies of the positron and electron are approximately 0.005 MeV **each**. [2]

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(c) Use the kinetic energies of 0.005 MeV and conservation of momentum to show that the speeds of the positron and electron are $4.2 \times 10^{7}\,\text{m s}^{-1}$ and that the momentum of the nucleus after the collision is $4.7 \times 10^{-22}\,\text{kg m s}^{-1}$. [4]

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(d) The momentum of the nucleus (4.7×10^{-22} kg m s^{-1}) is essential otherwise conservation **of momentum would be impossible. Deduce whether or not the assumption in part** *(b)* is valid (the mass of the nucleus is 3.3×10^{-25} kg). [2]

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3

(a) The anti-Δ^{++} is an anti-baryon and a first-generation particle which has a charge of $-2e$. Explain why the only possible quark make-up of the anti-Δ^{++} is $\bar{u}\bar{u}\bar{u}$. [1]

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(b) The anti-Δ^{++} has a lifetime of approximately 6×10^{-24} s and decays into a π meson and another anti-baryon. Deduce the quark make-up of the π meson and the anti-baryon and name them. [2]

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(c) State which force is responsible for the decay of the anti-Δ^{++} into a π meson and anti-baryon, giving a reason for your answer. [2]

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(d) In 2011, a highly respected international research collaboration reported that they had measured neutrinos travelling at speeds greater than that of light. This report was met by caution from the scientific community and then the result was disproved. Explain briefly why the result was met with caution and how the results might have been disproved. [3]

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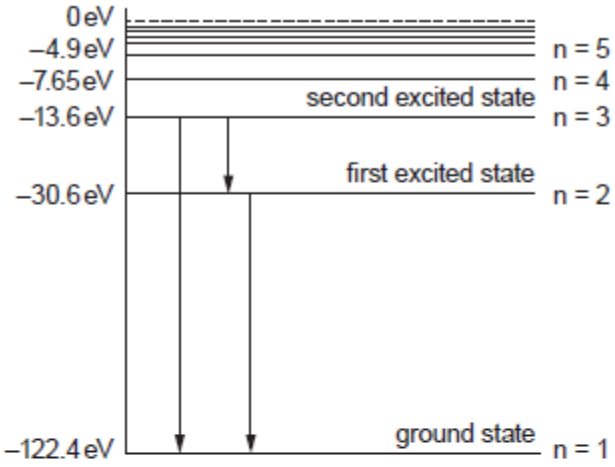
4

The energy levels of a lithium ion are shown.



(a) Calculate the ionisation energy of the lithium ion in joules. [2]

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(b) Calculate the wavelength of the electromagnetic radiation emitted when an electron drops from the second excited state (n = 3) to the first excited state (n = 2) and state the region of the electromagnetic spectrum to which it belongs. [3]

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(c) The emission and absorption spectra of another element are shown below.

Emission spectrum

Absorption spectrum

Explain briefly the processes that give rise to these spectra and why the lines appear at the same wavelengths in the two spectra. [3]

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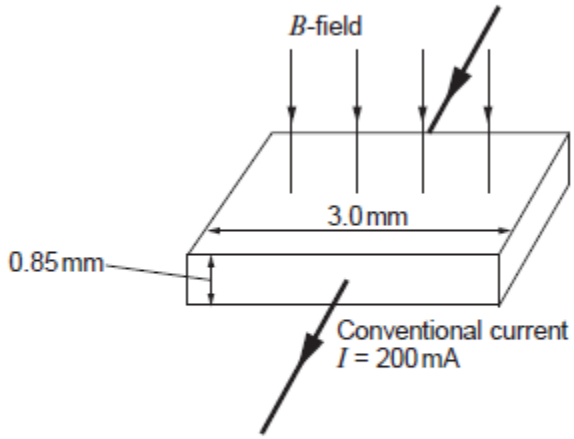
5

(a) The silicon chip shown in the diagram is used as a Hall probe with electrons as the charge carriers. Explain how the Hall voltage arises and which face of the chip becomes positively charged. [4]



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(b) The concentration of conduction electrons is $2.4 \times 10^{24}\,\text{m}^{-3}$. Calculate the mean drift velocity of the electrons. [2]

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(c) The Hall voltage, V_H, for this chip can be expressed as:

$$V_H = kB$$

where k is a constant and B is the magnetic flux density. Calculate a value for k and **state its unit**. [3]

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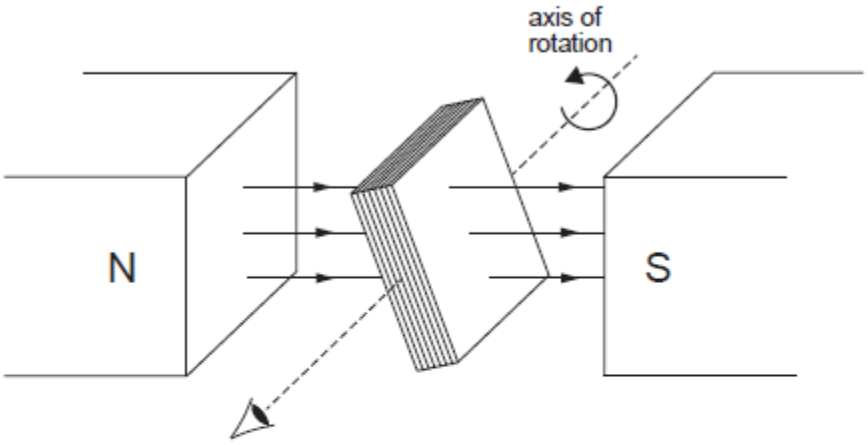
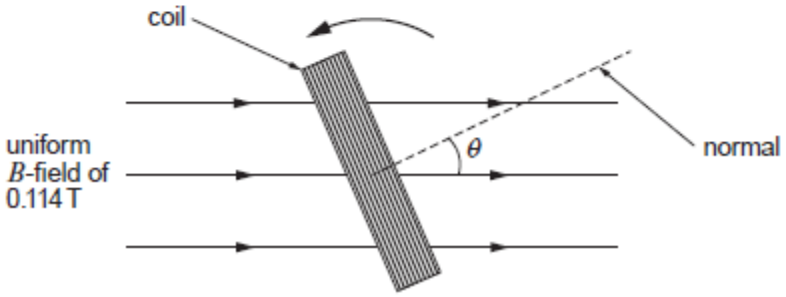
6

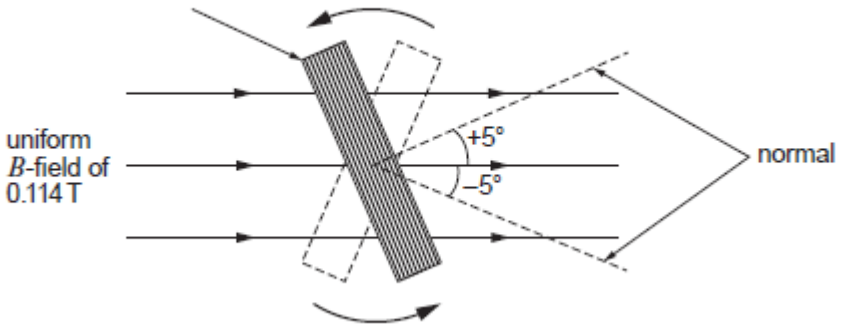
A rectangular coil rotates at a constant angular velocity within a uniform magnetic field of 0.114 T. The coil has 270 turns and cross-sectional area 420 cm^2. The diagram below is a simplified 3D diagram of the coil.



This second diagram is a 2D representation of the coil looking along the axis of rotation.



The flux **linkage** of the coil for the angles $\theta = -5°$ and $\theta = +5°$ is 1.29 Wb turn in each case.



(a) Show clearly how this value for the flux linkage is obtained. [2]

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(b) Explain why the induced emf is zero when $\theta = 0$. [1]

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(c) The flux **linkage** of the coil for the angles $\theta = 85°$ and $\theta = 95°$ are 0.11 Wb turn and –0.11 Wb turn respectively. The coil rotates 10° in a time of 5.8 ms. Calculate the mean induced emf when rotating between $\theta = 85°$ and $\theta = 95°$. [2]

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