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Physics review

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Answers

Practice exam questions

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The historical development of quantum theory

1 **a** 0.48 eV

b The number of photons per second increases. More electrons are emitted per second because each emitted electron absorbs a single photon. The maximum kinetic energy of the electrons is unchanged because the energy of each photon is also unchanged as it depends only on the frequency of the light, not on its intensity.

2 **a** $B = \lambda.\frac{n^2-2^2}{n^2}$

b B = 364.6 nm

c The values for *B* are the same, to 4 significant figures.

d 410.2 nm. This is in the visible part of the electromagnetic spectrum.

e The wavelengths correspond to specific energy differences between quantised energy levels. Only certain values of *n* produce valid lines, implying that electrons transition between fixed energy levels characterised by an integer greater than 2.

3 **a** $\lambda \approx 3.64 \times 10^{-10}$ m

b $\lambda \approx 3.81 \times 10^{-34}$ m

c The electron's de Broglie wavelength is of the same order as the atomic spacing in crystals so that the waves are appreciably diffracted. Only wavelengths comparable to the structure being imaged will diffract and produce the interference patterns needed to reveal the crystal structure.

The tennis ball's wavelength is extremely small, much smaller than the size of the tennis ball itself and of any objects with which it will interact. Any diffraction effects will be too small to be measured.

Einstein: a man ahead of his time

1 **a i** 236

ii 92

b ${}^{144}_{56}Ba$; ${}^{89}_{36}Kr$

c Neutron; its role is to initiate the fission by being absorbed into the uranium-235 nucleus, making it unstable and causing it to split.

d Each fission event releases multiple neutrons (in this case, 3). These neutrons can be absorbed by other uranium-235 nuclei, causing further fission, leading to a chain reaction.

e Gamma radiation is electromagnetic radiation emitted from the nucleus when it falls from one energy level to another. The fact that the frequencies of gamma radiation are characteristic of a particular nucleus tells us that the nucleus, like the atom, has particular allowed energy levels and that gamma radiation is emitted when an excited nucleus transitions from one allowed energy level to another. This is analogous to the transitions from one allowed energy level to another by electrons in atoms. As in atoms, the energy levels of the nucleus are quantised.

Spintronics: two kinds of electron

1 **a** $\mu_z = 9.22 \times 10^{-24}\ \mathrm{J\ T^{-1}}$

b $\frac{\mathrm{d}\boldsymbol{B}}{\mathrm{d}z} = 20\ \mathrm{T\ m^{-1}}$

c $F = 1.84 \times 10^{-22}\ \mathrm{N}$

d The electron has an intrinsic magnetic moment due to its spin. In a non-uniform magnetic field, this magnetic moment interacts with the field gradient, resulting in a force that deflects the electron. Because electrons can have their spin orientated along the *z*-axis in either direction (spin up and spin down), the forces on spin up and spin down electrons are in opposite directions.

e The experiment shows that rather than the electron spin taking a continuous range of values, as might be expected in classical physics, the spin is quantised and can only take one of two allowed values.