Physics Date:………………

Questions on Energy Levels and Diffraction Gratings

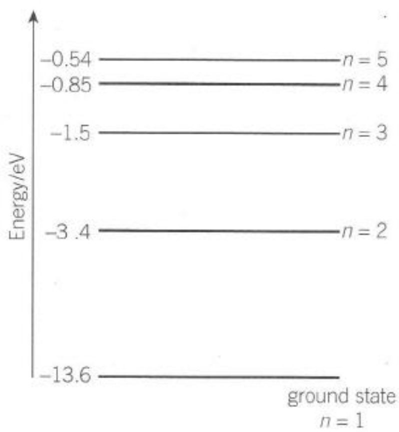
Exercise A

1 An atom emits a photon of frequency 4.5×10^{15} Hz. Calculate the difference in energy between the two energy levels in the gas atom. *(2 marks)*

2 Explain why the wavelength of the emitted photon is shorter when an electron in an atom moves into the ground state from $n = 3$ than when it drops to the ground state from $n = 2$. *(3 marks)*

3 An electron moves from an energy level of −4.0 eV to −6.7 eV. Calculate the wavelength of the photon it emits and state in which part of the electromagnetic spectrum this photon belongs. *(4 marks)*

4 Use the energy levels for hydrogen in Figure 3 to calculate the possible frequencies of the photons emitted when an electron moves into $n = 1$, $n = 2$, and $n = 3$ from a higher energy level (nine possible photons in total). *(9 marks)*



▲ **Figure 3** *The five lowest energy levels for electrons in hydrogen atoms, labelled with the principal quantum number, n*

5 A laser emits photons when electrons make transitions between energy levels. If a laser has a power output of 1.0 mW and emits 3.48×10^{15} photons per second, all of the same frequency, calculate the difference between the energy levels in eV. *(3 marks)*

Exercise B

1 Describe the differences between a continuous spectrum and an emission line spectrum. *(2 marks)*

2 Explain why the wavelengths of the emission lines for gas atoms of a particular element have the same wavelengths as the dark absorption lines for the same atoms. *(2 marks)*

3 An absorption line at a wavelength of 682 nm is observed in the spectrum from a star. Determine the difference between the energy levels for the atoms in the gas responsible for this absorption line. *(3 marks)*

4 An absorption line is observed in the spectrum of a particular gas when electrons absorb photons and move between energy levels at −10.4 eV and −4.6 eV. Calculate the wavelength of these photons and so identify the part of the electromagnetic spectrum to which this absorption line belongs. *(4 marks)*

5 The value of the energy level in eV for the hydrogen atom is given by the equation $E_n = -\frac{13.6}{n^2}$

where n is an integer 1, 2, 3 etc.

a Draw an energy level diagram (to scale) for the hydrogen atom showing the five lowest energy levels. *(2 marks)*

b Determine the wavelength of the emitted photon when an electron makes a transition between levels $n = 3$ and $n = 2$. *(3 marks)*

Exercise C

1 Suggest why the maxima produced from a diffraction grating are brighter than those produced via the double-slit experiment. *(2 marks)*

2 Explain why the highest order maxima visible through a diffraction grating is given by $\frac{d}{\lambda}$. *(2 marks)*

3 A diffraction grating with grating spacing of 3.3×10^{-6} m is used to observe light from a star. The spectral line produces a first-order image at a diffraction angle of 8.6°. Calculate the wavelength of this spectral line. *(3 marks)*

4 Calculate the angle of the third-order maximum when light of wavelength 450 nm is incident on a diffraction grating with 350 lines/mm. *(4 marks)*

5 Calculate the maximum number of orders that can be observed with the arrangement in question 4. *(2 marks)*

6 A spectral line from a distant star is analysed using a diffraction grating with a grating spacing of 2.5×10^{-6} m. An absorption line in the first-order spectrum is observed at an angle of 13.4°. Calculate the energy in eV of the photons responsible for this spectral line. *(4 marks)*
