A2 Level Physics

Chapter 5 – Waves and Particle Nature of Light

5.10.2 Energy Levels in Atoms

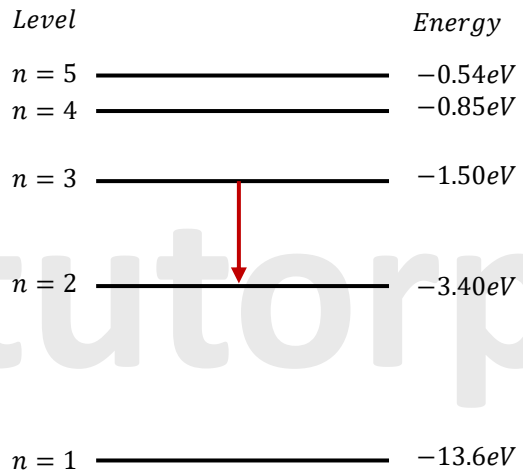
Worked Examples

Energy Levels of Electrons

Exam Style Question 1

The diagram below shows some of the energy levels in a hydrogen atom.

Calculate the wavelength of the photon produced by an electron transition from $n = 3$ to $n = 2$.



Energy Levels of Electrons

Exam Style Question 1

1) Find the difference in energy between the two energy levels. This will be the photon energy.

$$\Delta E = E_1 - E_2 = 3.40 - 1.50 = 1.90\ eV$$

Because all of the energies are negative, you can just subtract their magnitudes and ignore the minuses.

2) Convert the energy from eV to joules. This will help you find the wavelength later.

$$1\ eV = 1.60 \times 10^{-19}\ J$$
$$\therefore 1.90\ eV \times 1.60 \times 10^{-19} = 3.04 \times 10^{-19}\ J$$

3) Substitute this energy, the speed of light and the Planck constant into the equation and find the wavelength:

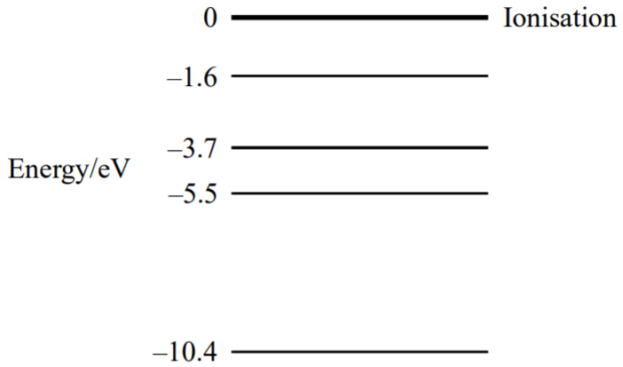
$$E = \frac{hc}{\lambda}$$

$$3.04 \times 10^{-19} = \frac{(6.63 \times 10^{-34}) \times (3.00 \times 10^{8})}{\lambda}$$
$$\therefore \lambda = \frac{(6.63 \times 10^{-34}) \times (3.00 \times 10^{8})}{3.04 \times 10^{-19}}$$
$$\lambda = 6.54 \times 10^{-7}\ m\ (3\ s.f.)$$

Energy Levels of Electrons

Exam Style Question 2

The diagram shows some of the outer energy levels of the mercury atom.



a) Calculate the ionisation energy in joules for an electron in the $-10.4\ eV$ level.

b) An electron has been excited to the $-1.6\ eV$ energy level. Show on the diagram all the possible ways it can return to the $-10.4\ eV$ level.

c) Which change in energy levels will give rise to a yellowish line ($\lambda = 600\ nm$) in the mercury spectrum?

Energy Levels of Electrons

Exam Style Question 2

a) Calculate the ionisation energy in joules for an electron in the $-10.4\ eV$ level.

To go from eV to Joules you just need to times by $1.6 \times 10^{-19}\ J$

$$10.4\ eV \times 1.6 \times 10^{-19}\ J = 1.66 \times 10^{-18}\ J$$

b) An electron has been excited to the $-1.6\ eV$ energy level. Show on the diagram all the possible ways it can return to the $-10.4\ eV$ level.

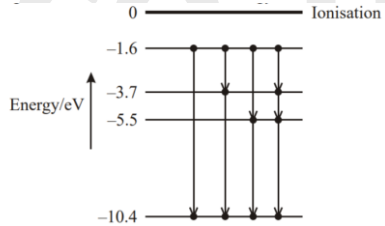
There are 4 routes the electron can take to go from $-1.6\ eV$ to $-10.4\ eV$ e.g.:

1) $-1.6\ eV \rightarrow -10.4\ eV$

2) $-1.6\ eV \rightarrow -3.7\ eV \rightarrow -10.4\ eV$

3) $-1.6\ eV \rightarrow -5.5\ eV \rightarrow -10.4\ eV$

4) $-1.6\ eV \rightarrow -3.7\ eV \rightarrow -5.5\ eV \rightarrow -10.4\ eV$



c) Which change in energy levels will give rise to a yellowish line ($\lambda = 600\ nm$) in the mercury spectrum?

Use $E = \frac{hc}{\lambda}$

$$E = \frac{(6.63 \times 10^{-34}\ J\ s)(3 \times 10^{8}\ m\ s^{-1})}{(600 \times 10^{-9}\ m)}$$

$$E = \frac{(3.315 \times 10^{-19} J)}{1.6 \times 10^{-19}} = 2.07\ eV \approx 2.1\ eV$$

Therefore the change in energy levels is from -1.6 to -3.7 (as $3.7 - 1.6 = 2.1$).

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Energy Levels of Electrons

Exam Style Question 3

(a) What is a line spectrum?

(b) Describe an absorption spectrum.

(c) Calcium has a line spectrum, which includes the spectral line at a wavelength of $393\ nm$. Calculate the frequency of this line.

(d) What information about a star can be deduced from its spectrum?

Energy Levels of Electrons

Exam Style Question 3

(a) What is a line spectrum?

A series of lines on a dark/white background.

(b) Describe an absorption spectrum.

Dark lines against a background of continuous spectrum.

(c) Calcium has a line spectrum, which includes the spectral line at a wavelength of $393\ nm$. Calculate the frequency of this line.

Use $v = f\lambda$ and rearrange for f:

$$f = \frac{v}{\lambda} = \frac{3 \times 10^{8}\ m\ s^{-1}}{393 \times 10^{-9}\ m}$$

$$f = 7.63 \times 10^{14}\ Hz$$

(d) What information about a star can be deduced from its spectrum?

Its chemical composition and surface temperature.

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Please see '5.10.1 Energy Levels in Atoms notes' pack for exam style questions.

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