1 An excitation tube is filled with low pressure mercury vapour. The current at the anode is measured as the voltage across the cathode - anode is increased. A graph of the anode current is shown below.

The current drops rapidly at 4.9 V.

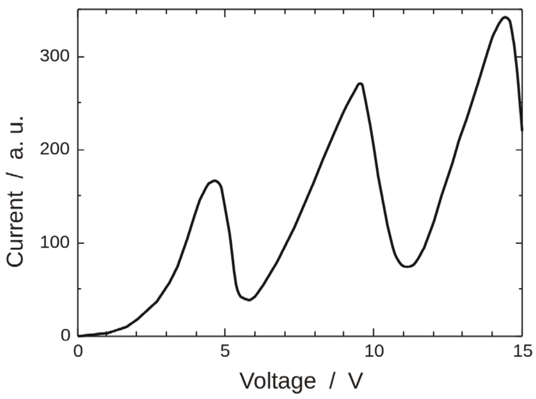
a Explain this using the idea of electron collisions with the mercury atoms

b What happens to the mercury atom when an electron with greater than 4.9 eV kinetic energy collides with the mercury atom?

c Why does this not happen with when electrons collide with mercury atoms with kinetic energy less than 4.9 eV?

d What is meant by the phrase the energy of atoms is quantised? Why is this very different to the macroscopic world - for instance when describing the energy of a rugby ball?

e Give a reason using the idea of electron collisions to explain why there is a second drop in current at 9.8 V?



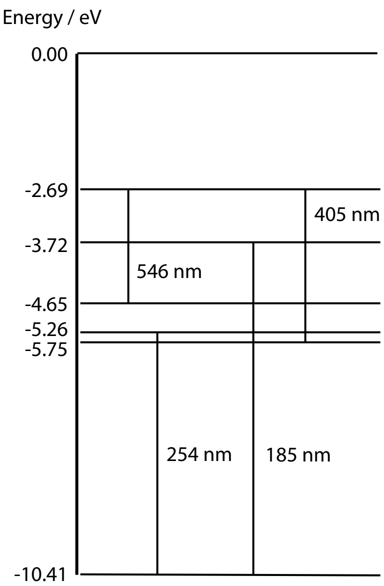
2 The energy levels of the mercury atom are show in the diagram below.

a Calculate the energy of a photon emitted by a transition from the energy level at -5.26 eV to the ground state of mercury.

b Explain how this can help explain how excitation of mercury atoms occurs once the kinetic energy of the electron exceeds 4.9 eV.

c Look at the wavelengths of the photons shown on the diagram. Which transition shown is responsible for one of the blue visible lines in the mercury emission spectrum?

d Calculate the wavelength of the emission line resulting from the transition -2.69 eV to -5.26 eV. What colour will this line be?



3 Fluorescent tubes using mercury vapour need a coating of phosphor powder to ensure that they emit predominantly white light.
Mercury atoms absorbs energy significantly when the colliding electrons are accelerated to a kinetic energy of at least 4.9 eV.

a Explain what happens inside the mercury atom when an electron with at least 4.9 eV collides with a mercury atom.

b What frequency is the photon emitted when the atom de-excites after such a collision?

c Why would this light not be suitable to use for lighting rooms?

d A powdered phosphor coating is placed around the inside the fluorescent tube. Explain how this ensures that the fluorescent tube produces white light.

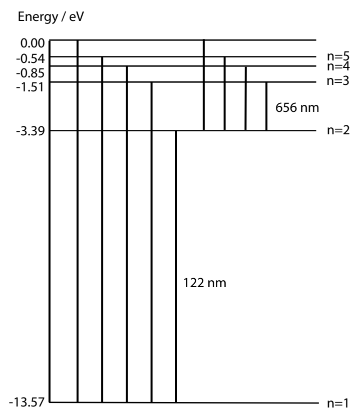
4 The diagram below shows the first 5 energy levels for an hydrogen atom.
The Hα line is caused by a transition from n=3 to n=2 in the hydrogen gas in a star's atmosphere.

a Calculate the energy of a photon of a Hα photon.

b Calculate the wavelength of any other visible photon emitted by hydrogen as it de-excites.

c Prove that any transition down to n=1 must be in the ultraviolet region of the spectrum

d Suggest without calculation any transition that would produce an infrared photon.



5 A beta particle is emitted with energy 0.156 MeV. Given the ionisation energy of nitrogen atoms is 14.53 eV,

a find the number of nitrogen atoms the beta particle can ionise before losing all of its kinetic energy

b If the range in air of this beta particle is 23 cm, how many ionisations must be occurring per metre as the beta particle travels through air?

c What does this information tell you about how to handle a beta source producing beta particles with maximum energy 0.156 MeV?