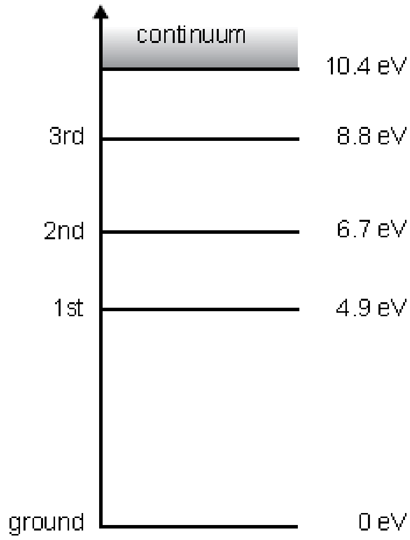
Quantised Energy Levels in Atoms

Questions

The figure shows the energy levels of a mercury atom. The atom is initially in the **2nd** excited state.



Example 1 2004 Question 5, 2 marks

Which **one or more** of the following photon energies can be emitted by a mercury atom which is initially in its **2nd excited** state?

A. 8.8 eV

B. 4.9 eV

C. 2.1 eV

D. 1.8 eV

Example 2 2004 Question 6, 2 marks

A mercury atom is initially in the 2nd excited state.
Which one of the following photon energies could be absorbed by this atom and hence excite it into the **3rd excited** state?

A. 8.8 eV

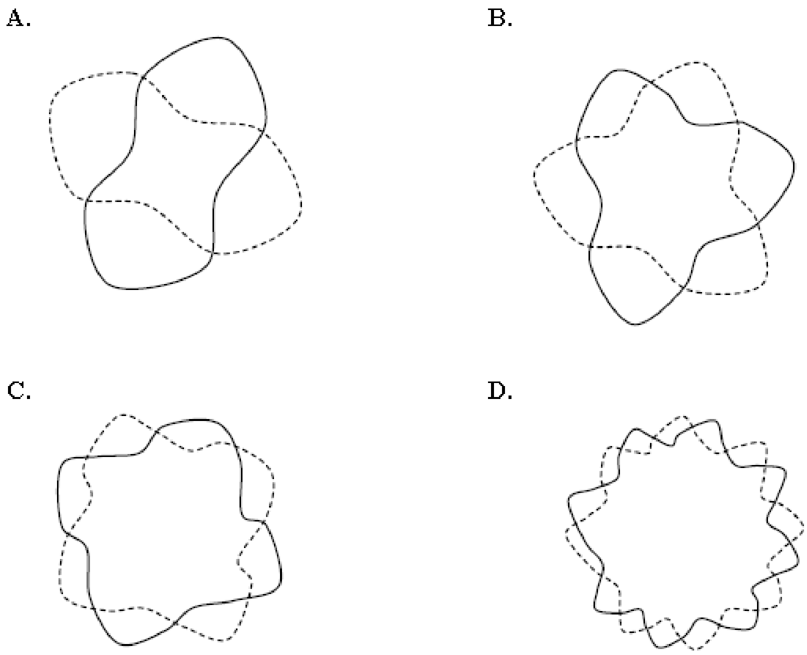
B. 4.9 eV

C. 2.1 eV

D. 1.8 eV

Example 3 2004 Question 11, 2 marks

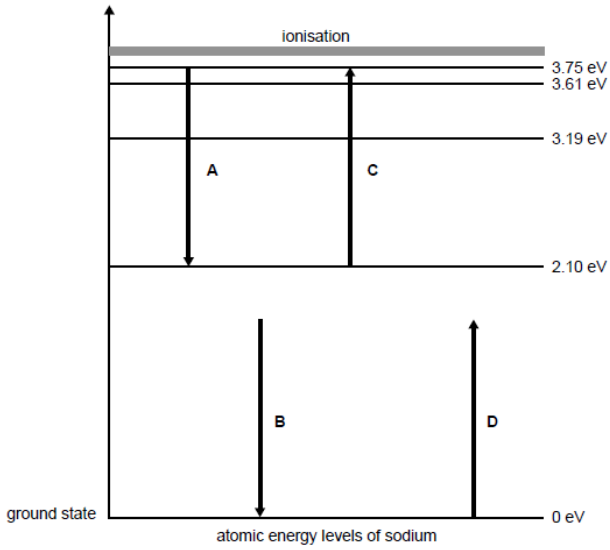
Which one of the following best represents the 'standing wave' state of an electron in a hydrogen atom where the circumference is equal to four wavelengths?



Part of the emission spectrum of sodium vapour produces a photon of energy 1.65 eV.

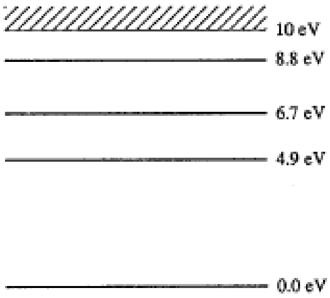
Example 4 2003 Question 1, 2 marks

Which **one** of the following transitions (**A – D**) on the energy level diagram demonstrates the change in atomic energy levels for the emission of a photon of energy 1.65 eV?

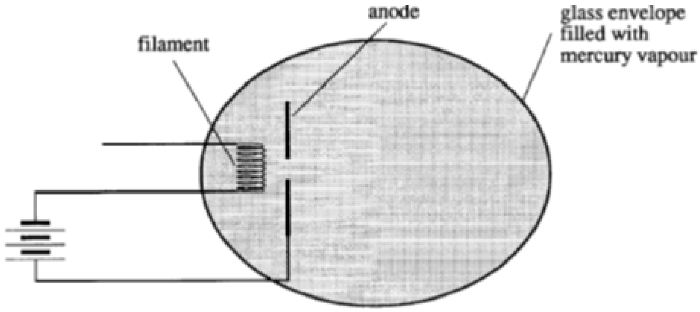


The figure below shows the energy levels of an atom of mercury.

(The speed of light $c = 3.00 \times 10^8$ m s^{-1}, Planck's constant, $h = 4.14 \times 10^{-15}$ eV s.)



In an experiment designed to study the effect of firing electrons onto mercury atoms, a student designs the apparatus shown below



Inside a sealed glass vessel filled with mercury vapour, electrons are accelerated from a hot cathode by a potential difference of +8.0 volt applied between the filament and the anode. They pass through a hole in the anode and thence through mercury vapour. The student examines the spectrum of radiation from mercury atoms in the path of the electrons.

Example 5 1991 Question 67, 1 mark

Which *one or more* of the photon energies listed below are present in the spectrum?

A. 1.8 eV **B.** 2.1 eV **C.** 4.9 eV **D.** 6.7 eV **E.** 8.0 eV **F.** 8.8 eV

The energy to raise a hydrogen atom to the first excited state above the ground level is 10.2 eV, and the ionization energy of hydrogen is 13.6 eV.

Example 6 1975 Question 94, 1 mark

Which of the following could happen if a photon of energy 14.8 eV enters a hydrogen atom in the ground state?

A. Two photons, of energy 13.6 eV and 1.2 eV, would be emitted.

B. An electron of energy 13.6 eV and a photon of energy 1.2 eV would be emitted.

C. The atom would be ionized, and an electron would be ejected with a kinetic energy of 1.2 eV

D. Two photons, of energy 10.2 eV and 4.6 eV, would be emitted.

A particular atomic system has energy levels as shown in the diagram.

ANSWER KEY

A. 20 eV photon and 1 eV photon emerge

B. 20 eV photon and 1 eV electron emerge

C. 1 eV electron only emerges

D. 1 eV photon only emerges

E. 15 eV photon only emerges

F. 15 eV electron only emerges

G. 21 eV photon only emerges

Use the answer key to specify what could emerge from the system under the circumstances of Questions **106** and **107**.

Example 7 1972 Question 106, 1 mark

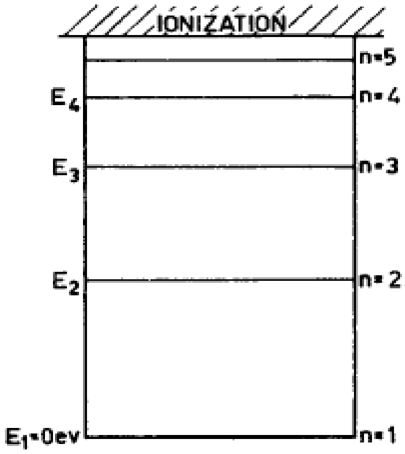
15 eV photon interacts with the system in its ground state.

Example 8 1972 Question 107, 1 mark

21 eV photon interacts with the system in its ground state.

Electrons in an atom exist in discrete energy states specified by a quantum number n. In changing from a high energy state to a lower one, a quantum of light is emitted. In the spectrum of hydrogen, the line of shortest wavelength corresponds to a quantum energy of 13.6 electron volt.
The quantum energies of several other hydrogen spectral lines are listed below, together with the initial and final values of n. The diagram represents the energy level diagram for hydrogen.

n_i	n_f	*Energy (ev)*
5	1	13·1
5	4	0·3
4	2	2·6
3	2	1·9



In Question **103** use the following additional data:
Planck's constant = 6.6×10^{-34} joule sec.
= 4.1×10^{-15} eV sec.
Velocity of light = 3.0×10^{8} m sec^{-1}.
Charge on electron = 1.6×10^{-19} coulomb.

Example 9 1970 Question 103, 1 mark

Which of the following gives the energy in joule of a single photon emitted during a transition from the n = 3 state to the n = 2 state?

A $\frac{1.9 \times 10^{19}}{1.6}$

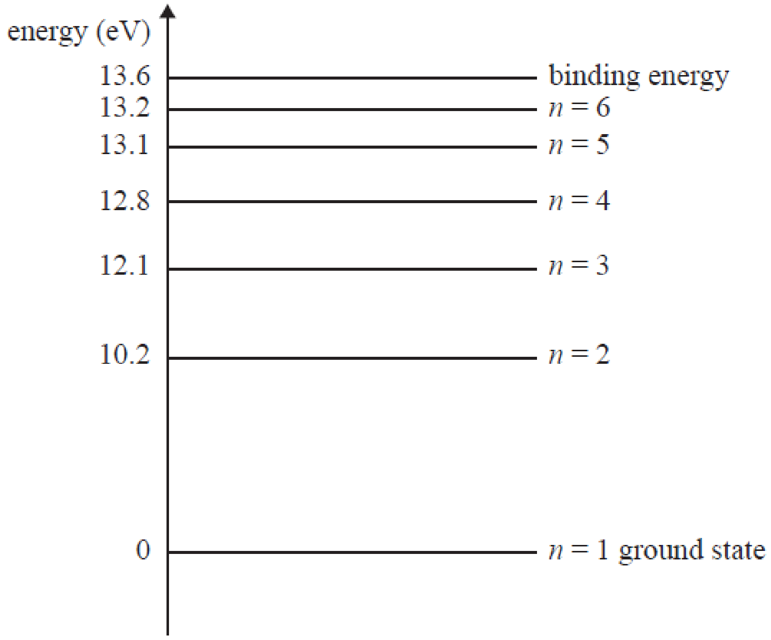
B $\frac{1.9 \times 10^{34}}{6.6}$

C $1.9 \times 1.6 \times 10^{-19}$

D $1.9 \times 6.6 \times 10^{34}$

E $\frac{1.9 \times 6.6 \times 10^{-15}}{1.6}$

The figure below shows the energy level diagram for the hydrogen atom.

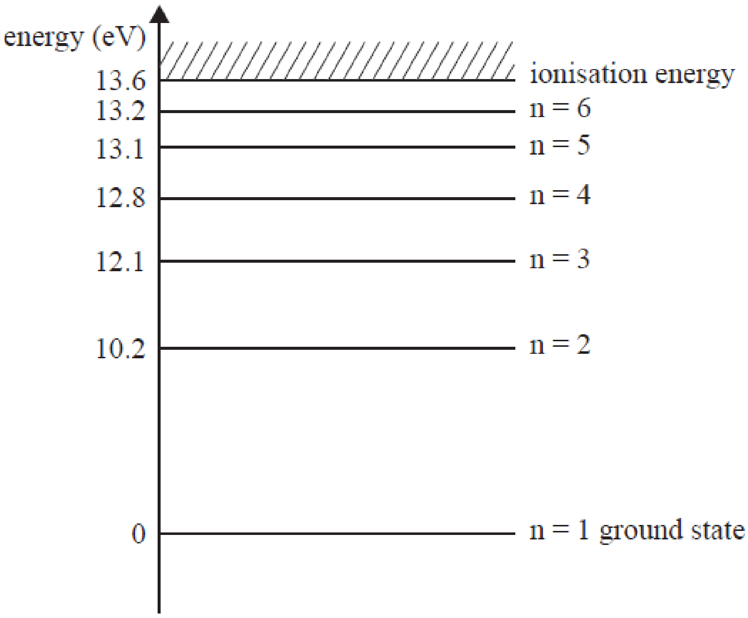


A particular hydrogen atom makes a transition from the $n = 2$ level to the $n = 4$ level by absorbing a photon.

Example 10 2012 Question 4a, 2 marks

Calculate the wavelength of the photon involved (in nm).

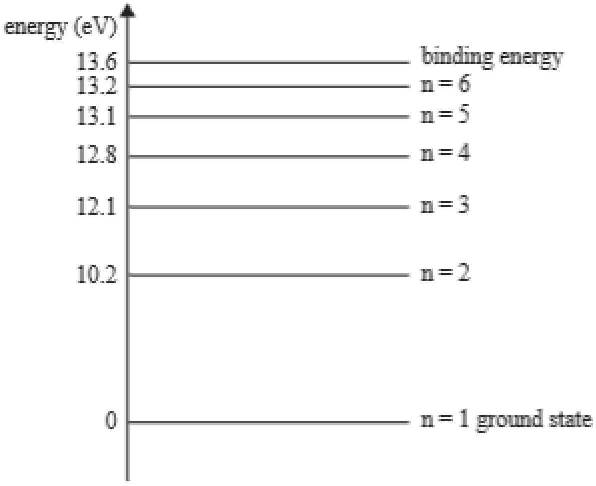
The figure below shows the energy level diagram for the hydrogen atom.



Example 11 2011 Question 13, 2 marks

An atom of hydrogen is in the n = 4 state.
List below all the possible energies, in eV, of photons that could be emitted as this atom decays to the ground state.

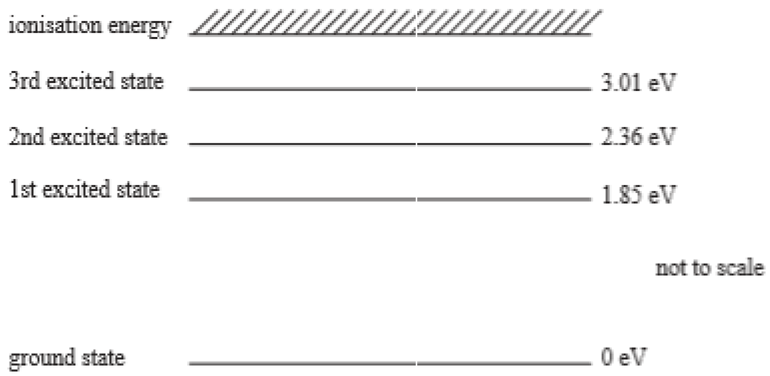
The figure below shows the energy level diagram for the hydrogen atom.



Example 12 2010 Question 11, 2 marks

A photon of wavelength 478 nm is emitted from an excited hydrogen atom. The emerging photon is caused by a transition between two energy states. Draw an arrow on the diagram that shows this transition from the initial to the final energy state.

The following information relates to Questions 10 and 11.
The figure below shows the energy level diagram of an atom



Example 13 2009 Question 10, 2 marks

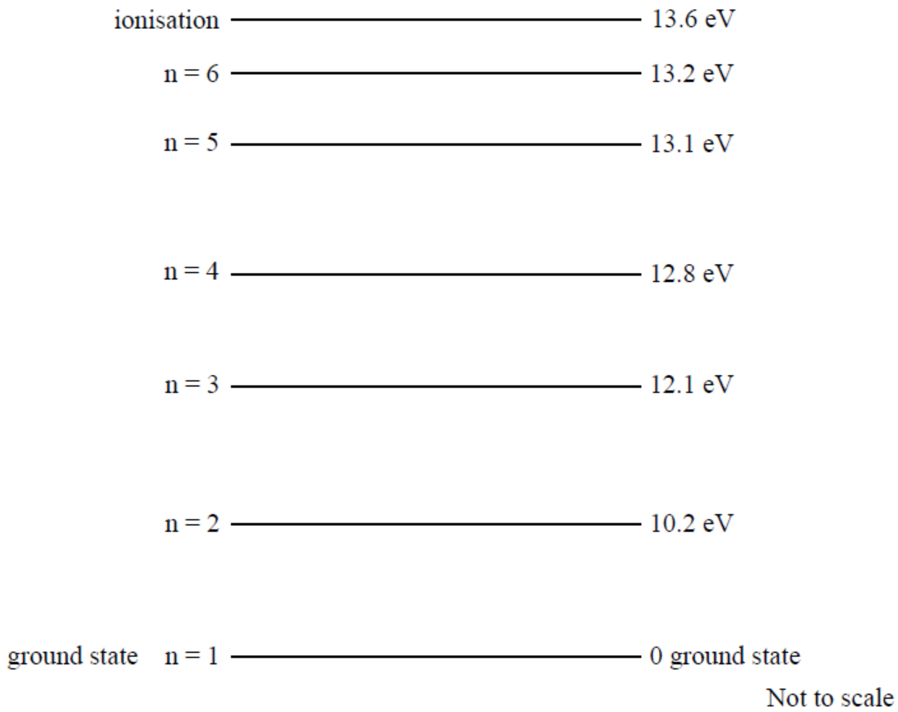
When an atom is in the third excited state, it can emit photons with six different values of energy. Use arrows on the diagram above to show the transitions that produce these six possible photon energies.

Example 14 2009 Question 11, 2 marks

In an experiment with a large number of these atoms, virtually all of the atoms are in one particular excited state. Photons with a range of energies are directed at the atoms in order to produce an absorption spectrum. It is found that the atoms strongly absorb photons of 0.51 eV and 1.16 eV. Determine **the initial excited state** of the atoms. Show your reasoning clearly and relate your explanation to the energy level diagram above.

Use the following information to answer Questions 11 and 12.

The figure below shows the quantised energy levels in the hydrogen atom, relative to the ground state.



Example 15 2008 Question 10, 2 marks

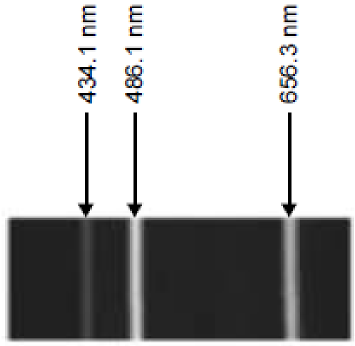
A photon has an energy of 2.6 eV.
Indicate, by an arrow, on the energy level diagram, the transition corresponding to the emission of this photon.

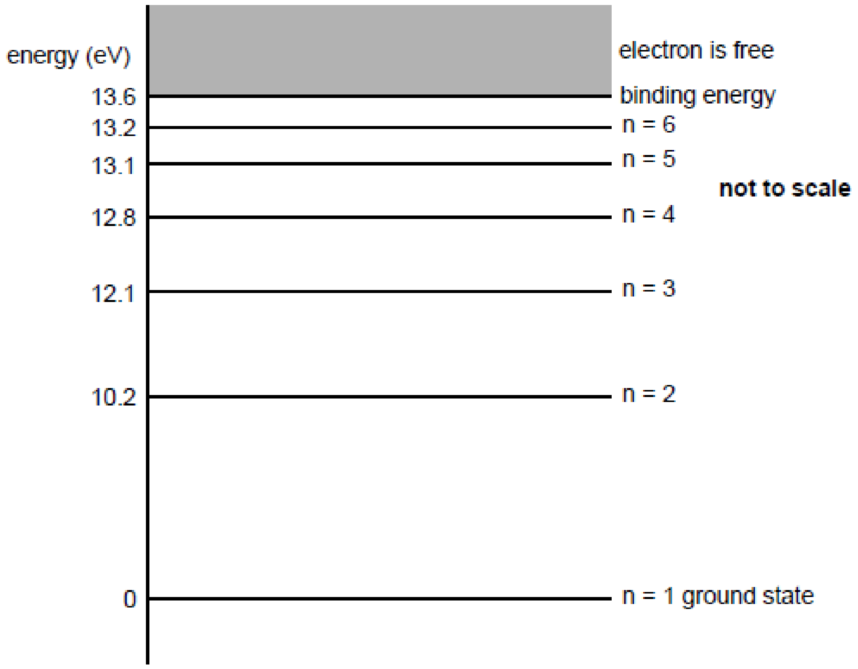
Example 16 2008 Question 11, 2 marks

What is the shortest wavelength photon that can be emitted when an atom decays from the n = 4 level?

Use the following information to answer Questions 7 and 8.

Part of the visible region of the spectrum of light emitted from excited hydrogen gas has three lines as shown below. The energy level diagram for the hydrogen atom is also shown. The binding energy is 13.6 eV.





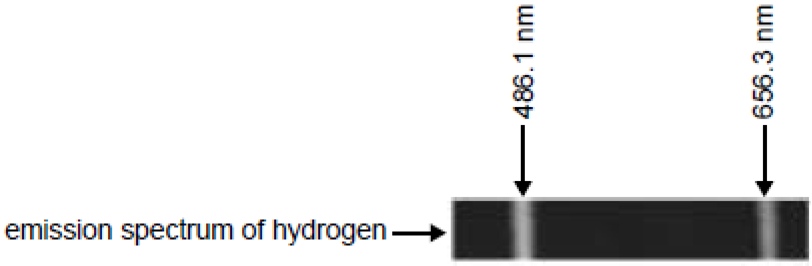
Example 17 2007 Question 7, 3 marks

What is the energy of the photons with a wavelength 434.1 nm?

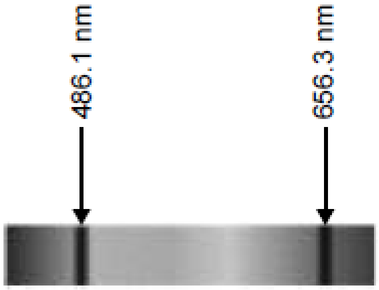
Example 18 2007 Question 8, 2 marks

A different photon has an energy of 3.0 eV. On the figure indicate with an arrow the electron transition that leads to emission of a photon of light with this energy.

The figure shows part of the emission spectrum of hydrogen in more detail.



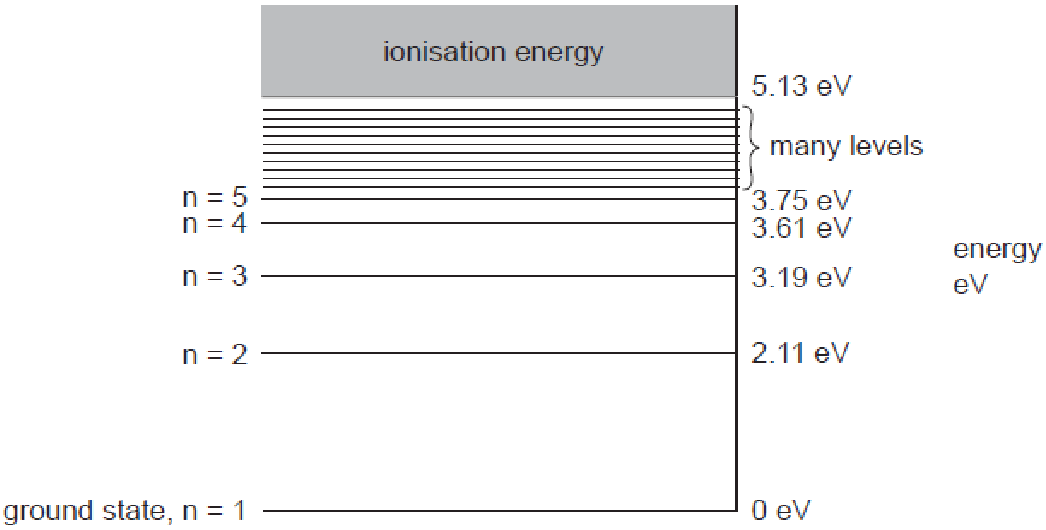
With a spectroscope, Val examines the spectrum of light from the sun. The spectrum is continuous, with colours ranging from red to violet. However there were black lines in the spectrum, as shown below.



Example 19 2007 Question 9, 3 marks

Explain why these dark lines are present in the spectrum from the sun.

The figure below shows the energy levels of a sodium atom.



A sodium atom is initially in an n = 4 excited state.

Example 20 2006 Question 5, 2 marks

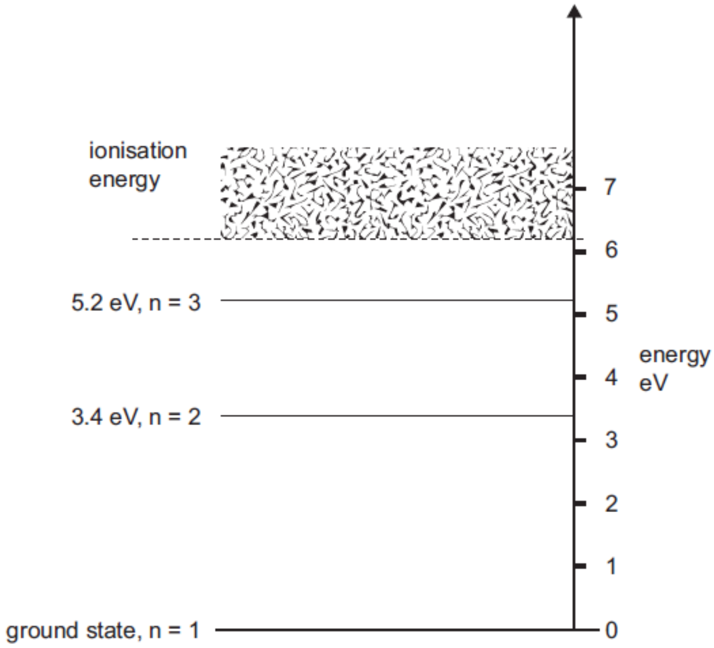
Calculate the highest frequency of light that this sodium atom could emit.

The figure above shows that electrons in a sodium atom can only occupy specific energy levels.

Example 21 2006 Question 6, 2 marks

Describe how the wave nature of electrons can explain this.

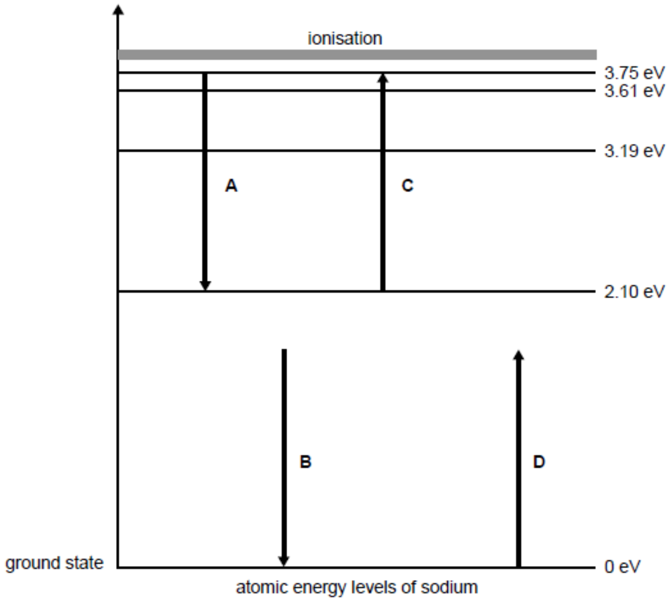
The spectrum of photons emitted by excited atoms is being investigated. Shown below is the atomic energy level diagram of the particular atom being studied. Although most of the atoms are in the ground state, some atoms are known to be in n = 2 and n = 3 excited states.



Example 22 2005 Question 9, 2 marks

What is the lowest energy photon that could be emitted from the excited atoms (in eV)?

Part of the emission spectrum of sodium vapour produces a photon of energy 1.65 eV.

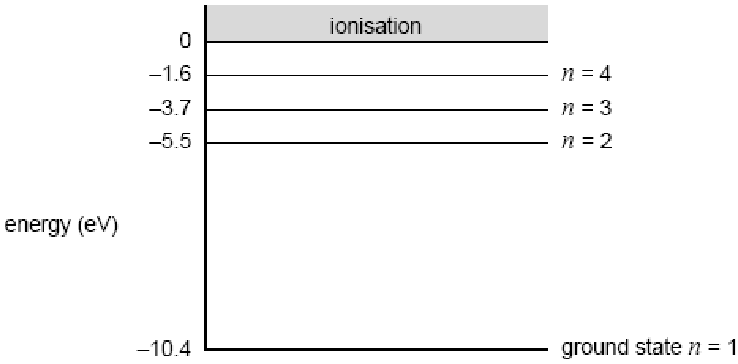


The sodium atom is in the first excited state.

Example 23 2003 Question 2, 3 marks

Calculate the wavelength of the photon of energy emitted as the excited atom returns to the ground state.

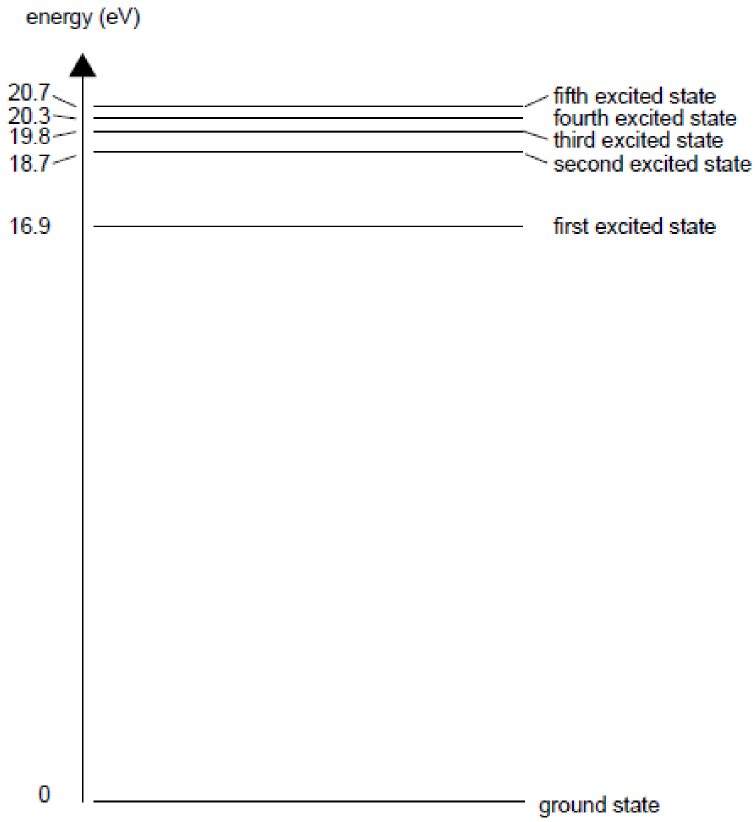
Light from a mercury vapour lamp shows a line spectrum related to discrete energy levels. Some of the energy levels for the mercury atom are shown below.



Example 24 1999 Question 7, 4 marks

Determine the wavelength of the light emitted when the mercury atom makes a transition from the third energy level (n = 3) to the ground state (n = 1).

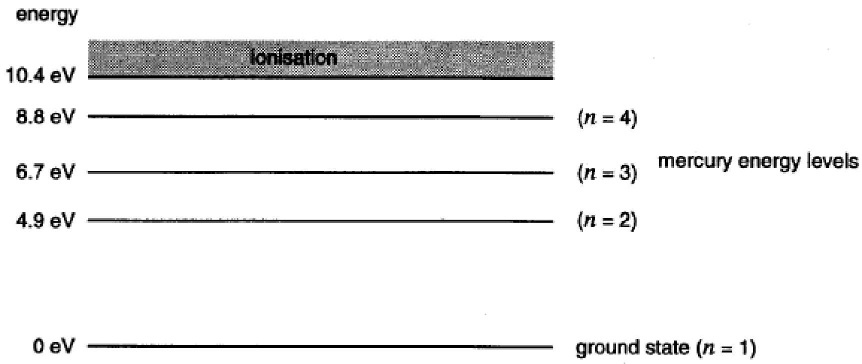
Photons of light from a helium-neon laser have an energy of 2.0 eV. The energy level diagram for neon atoms that produce this light is shown below.



Example 25 1997 Question 5, 2 marks

Explain how the neon atoms, that have been given extra energy, emit light having a photon energy of 2.0 eV.

Light from a fluorescent tube is produced by accelerating electrons along a semi-evacuated tube of mercury gas. These electrons collide with mercury atoms, exciting these atoms to energy levels as shown below.



When the atom makes a transition from a higher to lower energy level a photon is emitted.

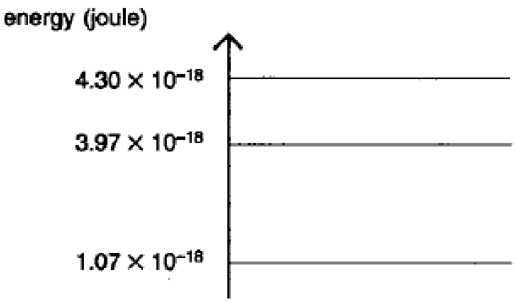
Example 26 1996 Question 5, 1 mark

Calculate the wavelength of the photon emitted in the transition from the first excited state (n = 2) to the ground state (n = 1) of the mercury atom.

Example 27 1996 Question 6, 1 mark

Calculate the momentum of the photon emitted in the transition described in the question above.

The red light was produced by atoms of neon in the light source. Each photon of the red light had an energy of 3.3×10^{-19} J. The figure below shows some of the possible energies of a neon atom.



Example 28 1994 Question 3, 1 mark

By referring to the figure above explain how the red light can be emitted from a neon atom.
