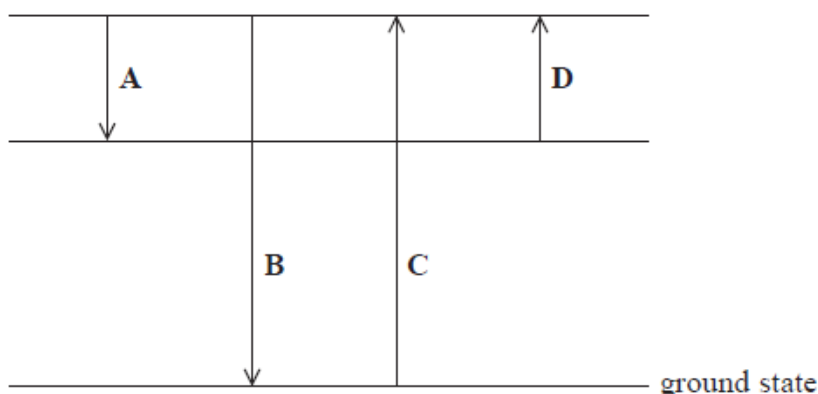


Questions

Q1.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The diagram shows four possible transitions of electrons in an atom.



Which of the transitions will result in the emission of a photon with the longest wavelength?

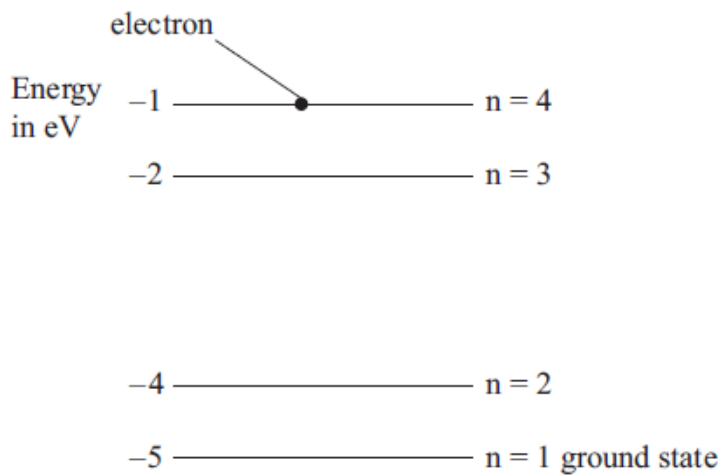
- ☒ A
- ☐ B
- ☐ C
- ☐ D

(Total for question = 1 mark)

Q2.

Answer the question with a cross in the box you think is correct (☐). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☐).

The diagram shows the energy levels in an atom.



When the electron moves from $n = 4$ to the ground state, a photon of frequency f is emitted.

Which of the following photon frequencies could **not** be emitted by this atom?

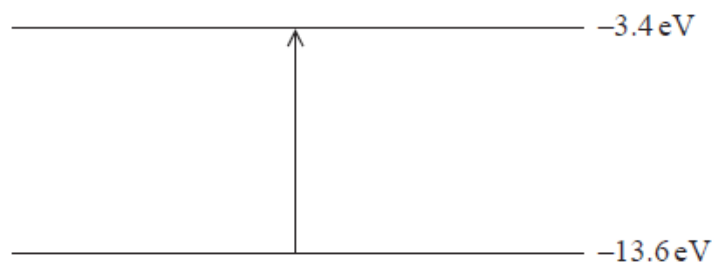
- ☐ A $\frac{f}{8}$
- ☐ B $\frac{f}{4}$
- ☐ C $\frac{f}{2}$
- ☐ D $\frac{3f}{4}$

(Total for question = 1 mark)

Q3.

Answer the question with a cross in the box you think is correct (☐). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☐).

The diagram shows an electron transition between two energy levels in a hydrogen atom.



Which of the following could **not** have caused this transition?

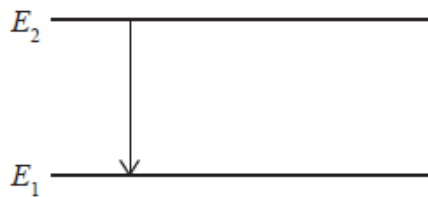
- ☐ **A** The atom absorbing a photon with an energy of 13.6 eV.
- ☐ **B** The atom absorbing a photon with an energy of 10.2 eV.
- ☐ **C** An electron with a kinetic energy of 13.6 eV colliding with the atom.
- ☐ **D** An electron with a kinetic energy of 10.2 eV colliding with the atom.

(Total for question = 1 mark)

Q4.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

In an atom, an electron drops from energy level E_2 to energy level E_1 , as shown.



A photon of wavelength λ is emitted.

Which of the following expressions gives the energy E_2 ?

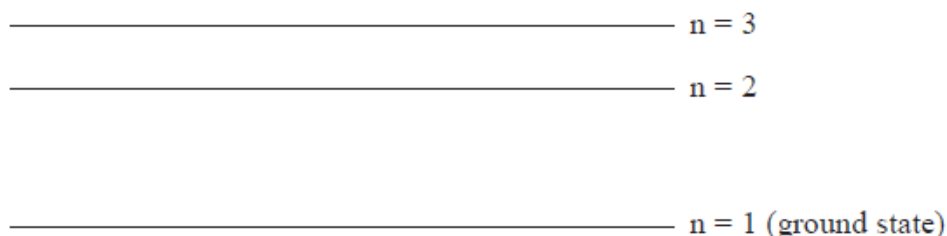
- ☐ **A** $\frac{hc}{\lambda} - E_1$
- ☐ **B** $\frac{hc}{\lambda} + E_1$
- ☐ **C** $\frac{h\lambda}{c} - E_1$
- ☐ **D** $\frac{h\lambda}{c} + E_1$

(Total for question = 1 mark)

Q5.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The diagram shows some of the energy levels in an atom.



Electrons in this atom are excited from the ground state to the energy level $n = 3$.

How many different frequencies of radiation can be emitted from this atom as electrons return to the ground state?

☐ **A** 1

☐ **B** 2

☐ **C** 3

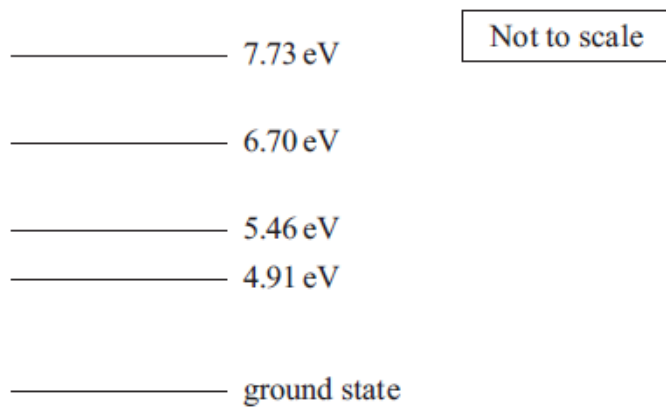
☐ **D** 4

(Total for question = 1 mark)

Q6.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The diagram shows the energy needed for an electron in the ground state of a mercury atom to move to different energy levels.



Photons transfer $8.74 \times 10^{-19} \text{ J}$ to electrons in the ground state of mercury atoms.

Which of the following gives the number of different frequencies of light that could be emitted?

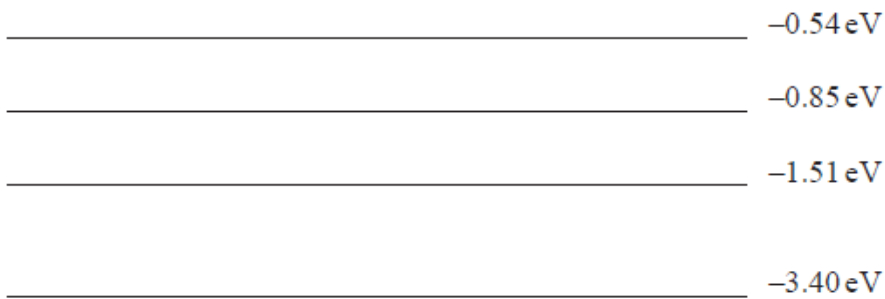
- ☐ **A** 1
- ☐ **B** 3
- ☐ **C** 6
- ☐ **D** 10

(Total for question = 1 mark)

Q7.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

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



An excited electron in the level -0.54 eV drops to the level -13.60 eV , resulting in the release of at least one photon.

Which of the following photon energy values could **not** be produced from this electron transition?

- ☐ **A** 0.31 eV
- ☐ **B** 0.54 eV
- ☐ **C** 12.09 eV
- ☐ **D** 13.06 eV

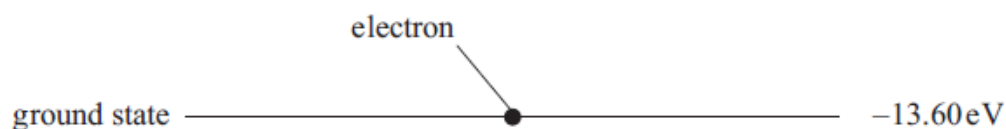
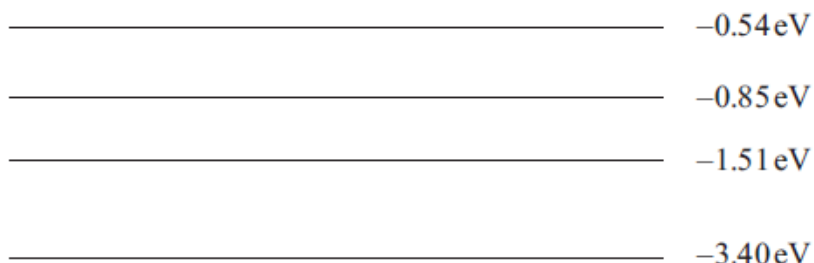
(Total for question = 1 mark)

Q8.

Answer the question with a cross in the box you think is correct (☐). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☐).

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

Not to scale



An electron in the ground state absorbs a photon.

Which of the following could **not** be the energy of the photon?

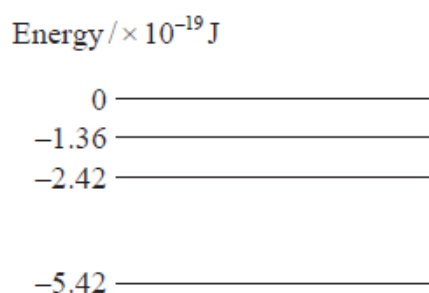
- ☐ **A** 9.8 eV
- ☐ **B** 10.2 eV
- ☐ **C** 12.09 eV
- ☐ **D** 12.75 eV

(Total for question = 1 mark)

Q9.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

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



Which of the following expressions is equal to the lowest frequency of light possible from a transition between these energy levels?

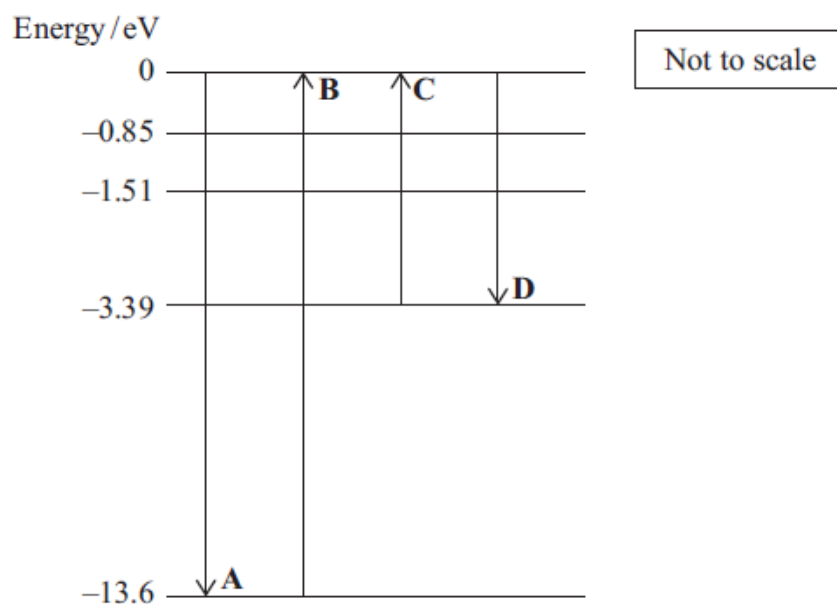
- ☐ A $\frac{5.42 \times 10^{-19}}{6.63 \times 10^{-34}}$
- ☐ B $\frac{1.36 \times 10^{-19}}{6.63 \times 10^{-34}}$
- ☐ C $\frac{2.42 \times 10^{-19} + 1.36 \times 10^{-19}}{6.63 \times 10^{-34}}$
- ☐ D $\frac{2.42 \times 10^{-19} - 1.36 \times 10^{-19}}{6.63 \times 10^{-34}}$

(Total for question = 1 mark)

Q10.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

An energy level diagram for the hydrogen atom is shown. Arrows A, B, C and D show four possible electron transitions.



Which transition would result in the emission of a photon with the shortest wavelength?

- ☒ A

☐ B

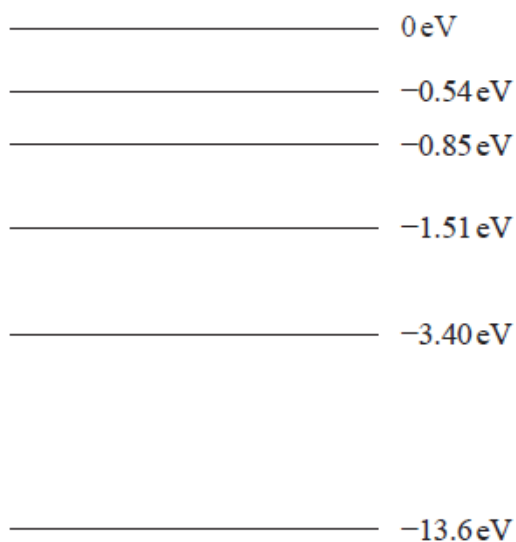
☐ C

☐ D

(Total for question = 1 mark)

Q11.

The diagram shows some of the energy levels for an atom of hydrogen.



Determine the transition between energy levels that would result in the release of a photon with a frequency of 7.48×10^{13} Hz.

(3)

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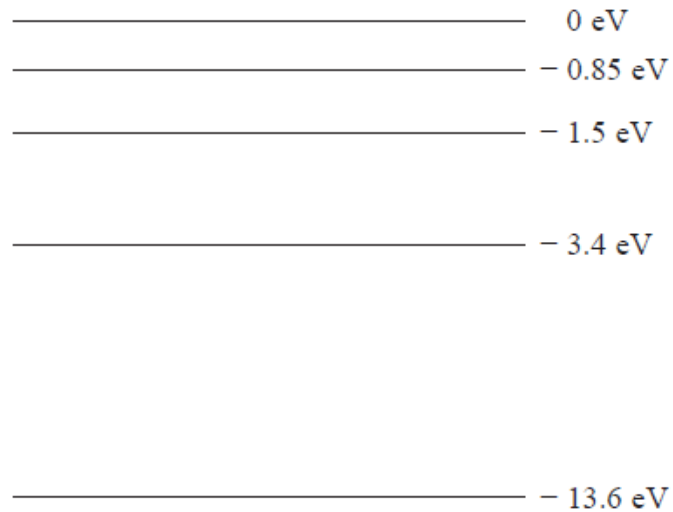
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Transition from eV to eV

Q12.

The diagram shows some of the energy levels for an atom of hydrogen.



When an electron with a kinetic energy of 12.3 eV interacts with this atom, an electron in the atom moves from the -13.6 eV level to the -1.5 eV level.

When a photon with a photon energy of 12.3 eV is incident on this atom, the electron in the atom at the -13.6 eV level remains at the 13.6 eV level.

Explain these observations.

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Q13.

After an atom of hydrogen has been exposed to suitable electromagnetic radiation, the atom can emit visible light. The emitted light contains a small number of different wavelengths of visible light.

* (a) Explain the process that results in the emission of different wavelengths of visible light. Your answer should include reference to energy levels in atoms.

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(b) It is also possible to make the atoms in a sample of air emit visible light.

Explain why the light emitted by the air has a large number of different wavelengths.

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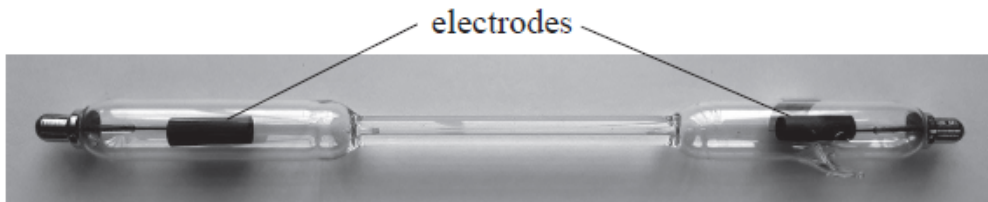
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Q14.

In 1857, Heinrich Geissler invented the first gas discharge tube. A sodium gas discharge tube is shown.



When a high potential difference is applied between the electrodes, electrons move through the sodium gas in the tube. The electrons collide with the sodium atoms. The tube then gives out visible light with a wavelength of 589 nm.

(a) Describe the process by which visible light is emitted from the sodium atoms.

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(b) Calculate the energy, in eV, of a photon of visible light with a wavelength of 589 nm.

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Photon energy = eV

(c) Light from the tube was directed through a diffraction grating, labelled as having 300 lines per mm. The diffraction pattern produced was displayed on a flat screen. The student measured the distance s between the central maximum and the first-order maximum on the screen. He also measured the distance D from the diffraction grating to the screen.

Determine whether the labelling of the diffraction grating as having 300 lines per mm was correct.

$$s = 0.234 \text{ m}$$

$$D = 1.30 \text{ m}$$

$$\lambda = 589 \text{ nm}$$

(3)

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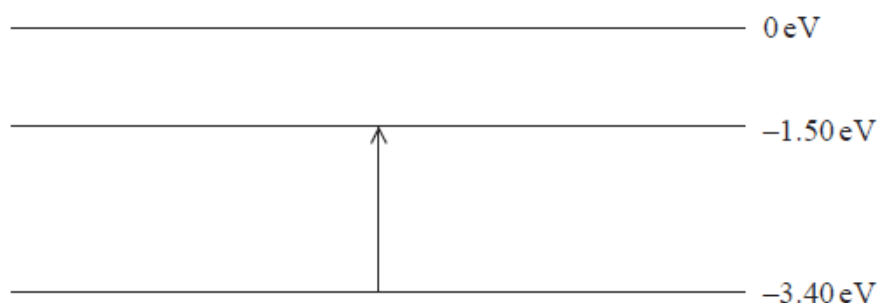
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(Total for question = 9 marks)

Q15.

Sirius A is the brightest star in the night sky and is mostly composed of hydrogen.

(a) When light from Sirius A passes through the hydrogen in the outer layers of the star, some light is absorbed. This causes electrons in the hydrogen to be excited. The diagram shows an electron being excited from the -3.40 eV level to the -1.50 eV level.



Ground state ————— -13.6 eV

The wavelengths of the different colours of visible light are shown in the table below.

violet	blue	green	yellow	orange	red
380–450 nm	450–495 nm	495–570 nm	570–590 nm	590–620 nm	620–750 nm

Deduce the colour of the visible light that caused the electron transition shown in the diagram.

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(b) A light year is the distance travelled by light in one year.

Sirius A is 8.60 light years from Earth. The intensity of radiation from Sirius A received on Earth is $1.17 \times 10^{-7} \text{ Wm}^{-2}$.

Calculate the power of Sirius A.

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Power of Sirius A =

(c) When hydrogen gas is excited in the laboratory, only certain wavelengths of light are emitted.

Explain why.

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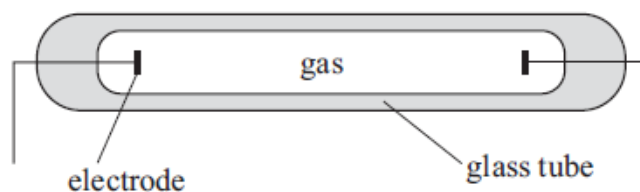
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(Total for question = 10 marks)

Q16.

In the second half of the 19th century, scientists began to investigate interactions between photons and electrons.

(a) A discharge tube is a glass tube containing gas, as shown.



When the discharge tube is connected into an electrical circuit, the gas atoms emit photons. The photons have specific frequencies.

(i) One of the emitted photons has an energy of $3.44 \times 10^{-19} \text{ J}$.

Calculate the frequency of this photon.

(2)

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Frequency of photon =

*(ii) The electrical circuit applies a large potential difference (p.d.) across the discharge tube.

Explain how the p.d. across the discharge tube causes photons to be emitted by the gas atoms.

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(b) Photons with energy 4.75 eV are incident on a metal surface. These photons cause electrons to be emitted from the metal surface.

(i) Show that the maximum speed of the emitted electrons is about $5.3 \times 10^5 \text{ ms}^{-1}$.

work function of metal = $6.30 \times 10^{-19} \text{ J}$

(3)

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(ii) Calculate the de Broglie wavelength of electrons moving at $5.3 \times 10^5 \text{ ms}^{-1}$.

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de Broglie wavelength =

(Total for question = 13 marks)