7 A fluorescent lamp has a power input of 14 W.

The rate of transfer to thermal energy by the lamp is 9.8 W, the remainder of the energy becoming light.

Which of the following is the efficiency of the lamp?

☒ **A** 0.30

☒ **B** 0.43

☒ **C** 0.70

☒ **D** 1.43

(Total for Question 7 = 1 mark)

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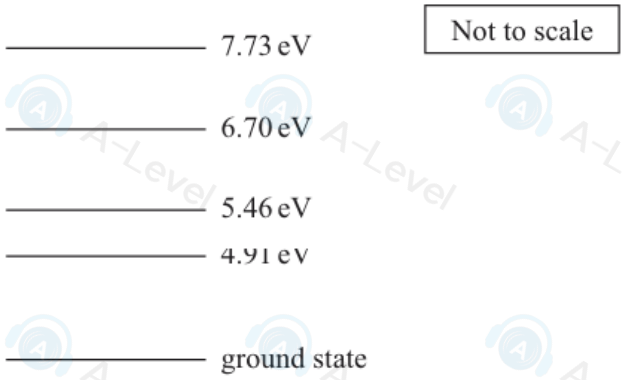
DO NOT WRITE IN THIS AREA

9 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 8.74×10^{-19} 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

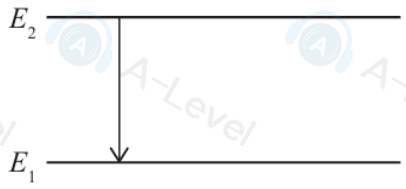
☒ **B** 3

☒ **C** 6

☒ **D** 10

(Total for Question 9 = 1 mark)

10 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.

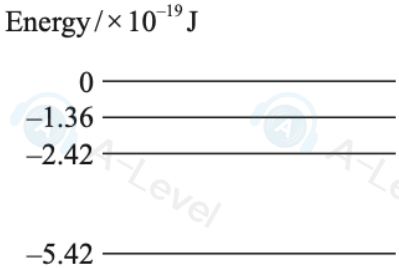
Which of the following expressions gives the energy E_2?

☒ **A** $\frac{hc}{\lambda} - E_1$

☒ **B** $\frac{hc}{\lambda} + E_1$

☒ **C** $\frac{h\lambda}{c} - E_1$

9 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 9 = 1 mark)

2 Light from a discharge tube is viewed through a diffraction grating. An emission line spectrum is observed.

Which of the following explains how electrons in the discharge tube produce the emission line spectrum?

☒ **A** Excited electrons move to higher energy levels and absorb photons.

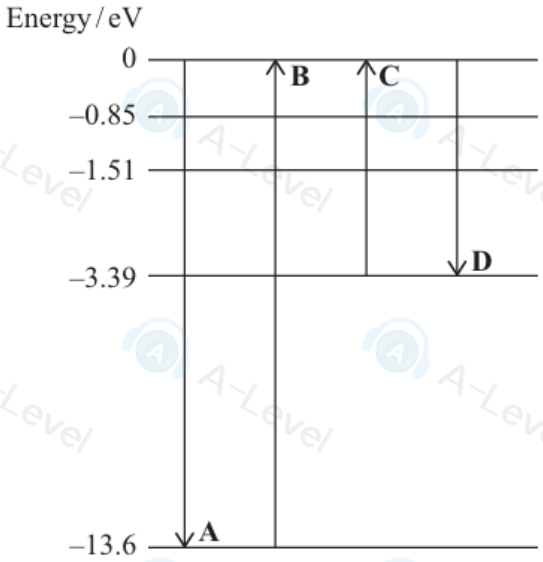
☒ **B** Excited electrons move to higher energy levels and emit photons.

☒ **C** Excited electrons move to lower energy levels and absorb photons.

☒ **D** Excited electrons move to lower energy levels and emit photons.

(Total for Question 2 = 1 mark)

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



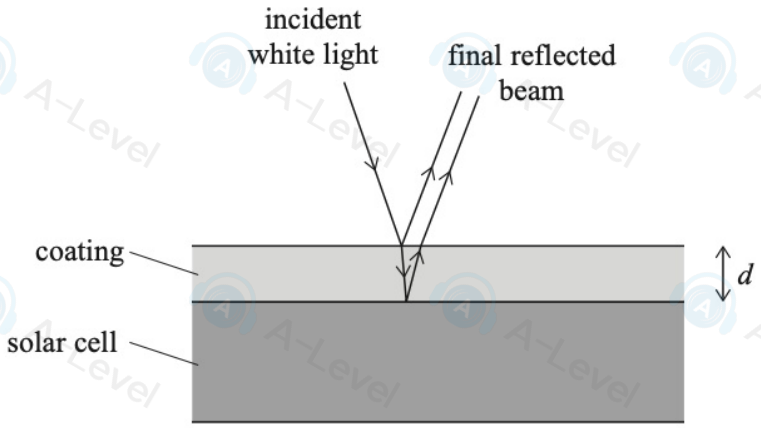
Not to scale

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

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 5 = 1 mark)

16 A solar cell has a thin coating of thickness d to reduce the reflection of light. White light incident on the coating is reflected from the top and bottom surfaces of the coating. This produces a final reflected beam, as shown.



(a) Explain why some wavelengths of the incident white light will be missing from the final reflected beam.

(3)

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(b) White light is incident perpendicular to the surface of the coating.

Calculate the wavelength that would be missing from the final reflected beam.
Assume the refractive index is 2.3 for all visible wavelengths.

$d = 6.5 \times 10^{-8}$ m

(4)

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Wavelength = ...

(c) A solar cell array is placed on the roof of a house as shown.

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

An electron is in the −13.6 eV (ground state) level of this atom.

(a) A photon interacts with this electron.

Explain why this interaction causes the emission of another photon.

(2)

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(b) A photon has a wavelength of 218 nm.

(i) Determine the energy, in eV, of this photon.

(4)

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Photon energy = ... eV

(ii) Explain whether the atom of hydrogen could emit a photon with this energy.

(2)

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18 The photograph shows a typical lightning strike which occurs as a result of an electrical discharge through the atmosphere in a narrow channel between a cloud and the ground.

(Source: © Joshua Lewis/EyeEm/Getty Images)

The high current in a lightning strike heats the air sufficiently to cause rapid expansion; the resulting shock wave is heard as thunder.

(a) A teacher says that a lightning strike taking place 1 km away from the observer will result in a time of 3 s between seeing the lightning and hearing the thunder.

Determine whether the teacher is correct.

speed of sound in air = 340 m s^{-1}

(3)

(b) The following data was collected for one particular lightning strike:

distance between cloud and ground = 400 m
current = 25 000 A
duration of lightning strike = 30 μs
potential difference between cloud and ground = 1.2×10^9 V
diameter of lightning channel = 5.0 cm

(i) Calculate the total charge transferred during the lightning strike.

(2)

Total charge transferred = ...

(ii) Calculate the power dissipated by the lightning strike.

(2)

Power dissipated = ...

(iii) Show that the resistivity of the air in the lightning channel is about 0.2 Ω m.

(3)

(iv) The accepted value for the resistivity of air is $10^{16}\,\Omega$m.

Suggest why the value calculated from the data is so much less than the accepted value.

(1)

(c) Air consists mainly of nitrogen and oxygen molecules. Analysis of the light produced during a lightning strike shows a weak line spectrum.

(i) Explain the process by which nitrogen atoms produce a line spectrum.

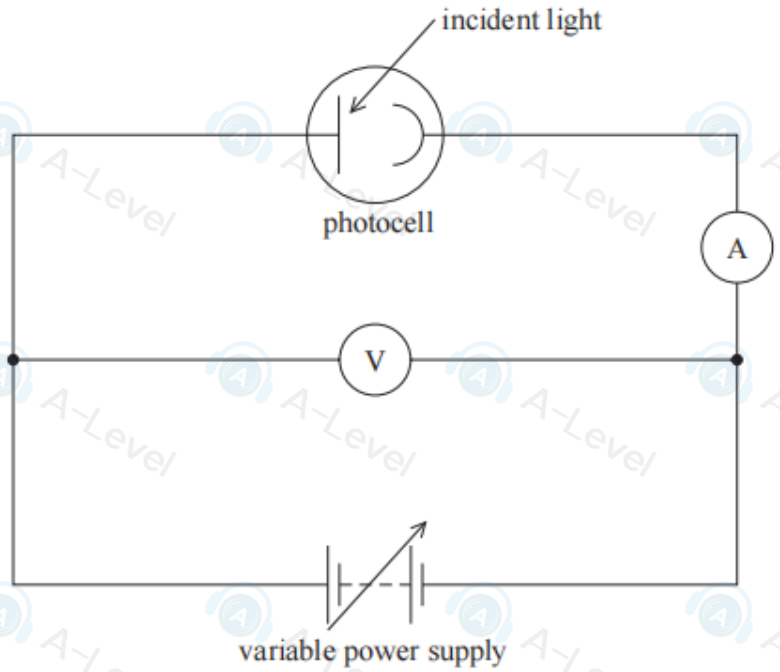
(4)

(ii) State why the line spectrum produced by oxygen atoms in the air would be different from the line spectrum produced by nitrogen atoms.

(1)

(Total for Question 18 = 16 marks)

14 Photocells make use of the photoelectric effect. The following circuit can be used to determine the work function of a metal used in a photocell.



(a) State what is meant by the work function of a metal.

(1)

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(b) This photocell works with ultraviolet light but does not work with visible light.

Explain why.

(2)

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(c) An experiment was carried out using this circuit. The potential difference applied to the photocell opposes the movement of the electrons through the photocell, reducing the current.

(i) The variable power supply was initially set at 0 V and the reading on the ammeter was 2.4 μA.

The intensity of the ultraviolet light was then increased without changing the frequency.

Explain what happened to the reading on the ammeter.

(3)

(ii) The variable power supply was adjusted until the reading on the ammeter became 0 μA. The reading on the voltmeter was 3.59 V.

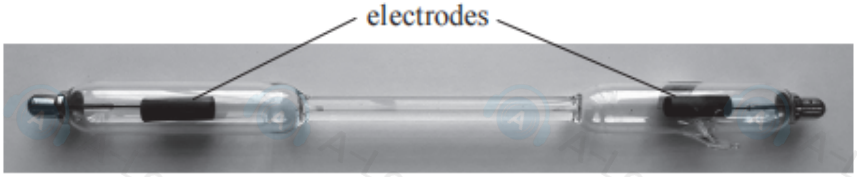
Calculate the work function, in joules, of the metal used in the photocell.

frequency of ultraviolet used = 2.00×10^{15} Hz

(4)

Work function = ... J

16 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.

(3)

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

(3)

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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.

$s = 0.234$ m
$D = 1.30$ m
$\lambda = 589$ nm

(3)

(Total for Question 16 = 9 marks)