



AP[®] Physics B 2003 Sample Student Responses Form B

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7. (10 points)

An experiment is performed on a sample of atoms known to have a ground state of -5.0 eV. The gas is illuminated with "white light" (400 - 700 nm). A spectrometer capable of analyzing radiation in this range is used to measure the radiation. The sample is observed to absorb light at only 400 nm. After the "white light" is turned off, the sample is observed to emit visible radiation of 400 nm and 600 nm.

(a) In the space below, determine the values of the energy levels and on the following scale sketch an energy-level diagram showing the energy values in eVs and the relative positions of:

i. the ground state

ii. the energy level to which the system was first excited

iii. one other energy level that the experiment suggests may exist

$$3 \times 10^3 = (400 \times 10^{-9}) f \quad f = 7.5 \times 10^{14}$$

$$hf = 4.97 \times 10^{-19} \text{ J}$$

$$3.10 \text{ eV}$$

$$3 \times 10^3 = (600 \times 10^{-9}) f$$

$$f = 5 \times 10^{14}$$

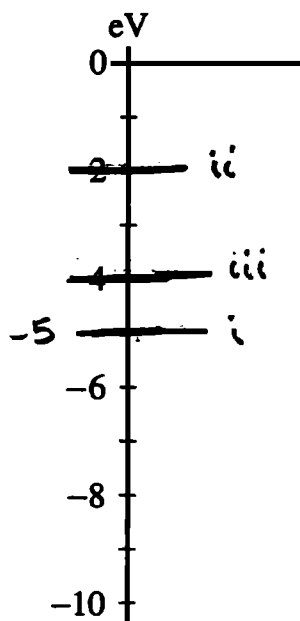
$$hf = 3.32 \times 10^{-19}$$

$$2.07 \text{ eV}$$

$$-5 \text{ eV}$$

$$-5 + 3.1 = -1.90 \text{ eV} \approx -2 \text{ eV}$$

$$-1.9 - 2.07 = -3.97 \text{ eV} \approx -4 \text{ eV}$$



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- (b) What is the wavelength of any other radiation, if any, that might have been emitted in the experiment?
Why was it not observed?

From $-4 \rightarrow -5$

1eV

$$1.6 \times 10^{-19} = \frac{h \cdot c}{\lambda}$$

$$\lambda = \boxed{1.24 \times 10^{-6} \text{ m}}$$

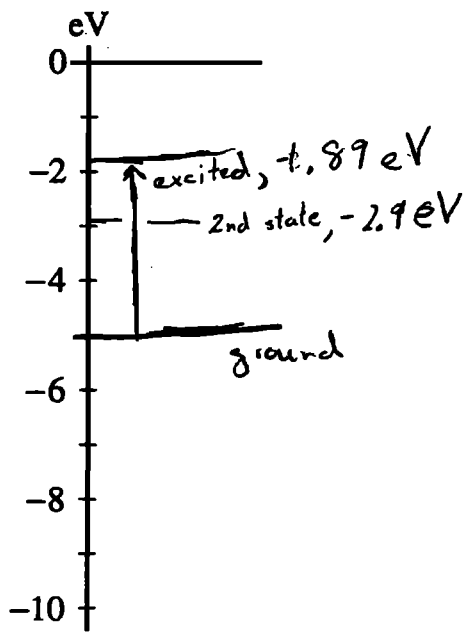
the λ is too
long to be detected by the spectrometer
whose range is only from 400-700 nm

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- (a) In the space below, determine the values of the energy levels and on the following scale sketch an energy-level diagram showing the energy values in eVs and the relative positions of:
- the ground state
 - the energy level to which the system was first excited
 - one other energy level that the experiment suggests may exist



determine emission's energy
 $E = hf$
 $c = \lambda f$
 $3e8 = 400e-9 f$
 $f = 7.5e14$
 $E = 6.63e-34 (7.5e14)$
 $E = 4.9725e-19 J$
 convert to eV
 $4.97e-19 / (1.6e-19)$
 $= 3.107 eV$
 $-5 - 3.107 = -1.89$

determine frequency
 $3e8 = 600e-9 f$
 $f = 5e14$
 determine photon energy
 $E = hf$
 $E = 6.63e-34 (5e14)$
 convert to eV
 $E = 3.315e-19 J / 1.6e-19$
 $E = 2.07 eV$
 $-5 - 2.07 = -2.9$

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- (b) What is the wavelength of any other radiation, if any, that might have been emitted in the experiment? Why was it not observed?

any other radiation released would have had to have been above or below 700 - 400 nm respectively. They wouldn't have shown up on the spectrometer's analysis because those wavelengths would have been beyond its 'visible' range

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