WebAssign
CH08-HW01-SP12 (Homework)

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PHYS 172-SPRING 2012, Spring 2012
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Current Score : 17.5 / 17.5 **Due :** Tuesday, March 6 2012 11:59 PM EST

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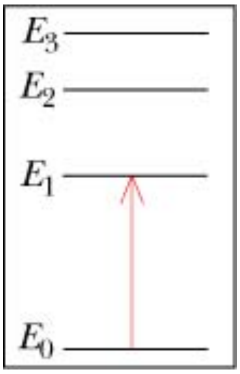
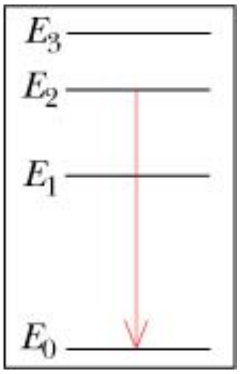
1. 4/4 points | Previous Answers MI3 8.3.X.017

Match the description of a process with the corresponding diagram:

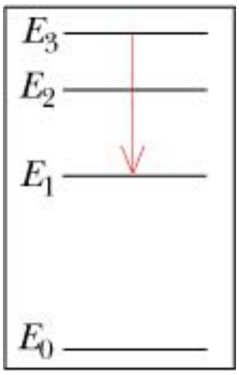
[a] Absorption of a photon whose energy is E_1-E_0 ("dark-line" spectrum)

a.


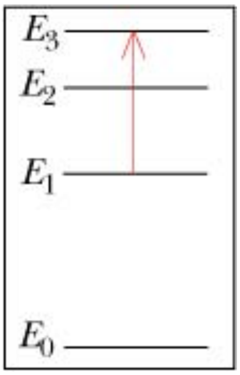
[c] Emission of a photon whose energy is E_3-E_1

b.


[b] Emission of a photon whose energy is E_2-E_0

c.


[d] Absorption from an excited state (this hardly ever happens in dark-line spectrum absorption experiments at low temperatures, because an excited state drops back to the ground state so quickly that there is never a significant number of atoms in an excited state capable of absorbing the photon)

d.


In drawing arrows to represent energy transitions, which of the following statements are correct?

- [ ] It doesn't matter which direction you draw the arrow as long as it connects the initial and final states.
- [x] The head of the arrow is drawn on the final state.
- [x] For absorption, the arrow points up.
- [x] For emission, the arrow points down.
- [x] The tail of the arrow is drawn on the initial state.

- *Read the eBook*
- Section 8.3

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2. 4/4 points | Previous Answers MI3 8.3.X.016

A hydrogen atom is in state N = 4, where N = 1 is the lowest energy state. What is $K+U$ in electron volts for this atomic hydrogen energy state?

E_4 = -0.85 eV

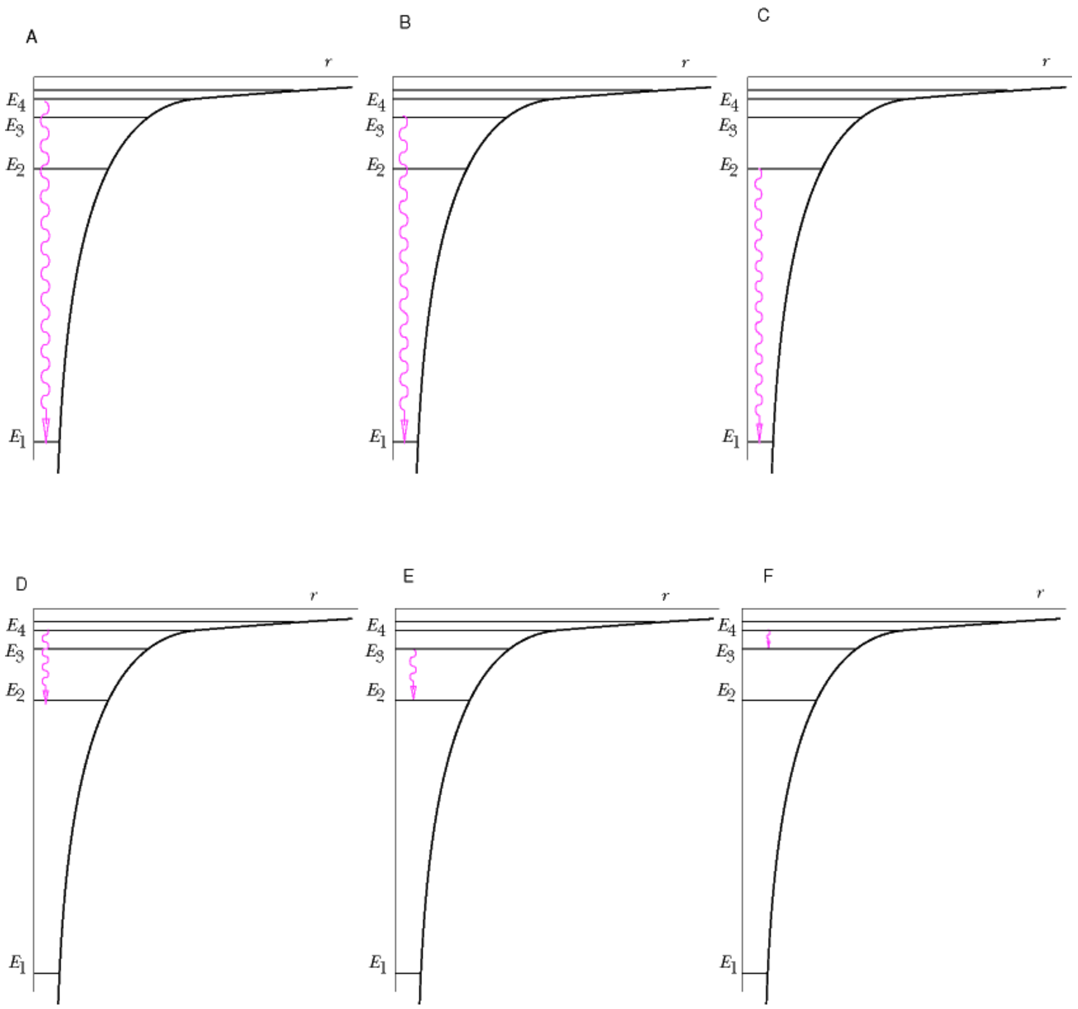
The hydrogen atom makes a transition to state N = 3. What is $K+U$ in electron volts for this lower atomic hydrogen energy state?

E_3 = -1.5111 eV

What is the energy in electron volts of the photon emitted in the transition from level N = 4 to N = 3?

E_{photon} = 0.6611 eV

Which of the graphs below represents this transition? F



- *Read the eBook*
- [Section 8.3]

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3. 4.5/4.5 points | [Previous Answers] MI3 8.3.P.026

Suppose a hypothetical object has just four quantum states, with the following energies:

-1.3 eV (third excited state)
-1.7 eV (second excited state)
-2.7 eV (first excited state)
-4.6 eV (ground state)

(a) Suppose that material containing many such objects is hit with a beam of energetic electrons that ensures that there are always some objects in all of these states. What are the six energies of photons that could be strongly emitted by the material? (In actual quantum objects there are often "selection rules" that forbid certain emissions even though there is enough energy; assume that there are no such restrictions here.)

List the photon emission energies in order from largest to smallest. If two different transitions would produce photons of the same energy, list that energy twice:

3.3 eV (largest)
2.9 eV
1.9 eV
1.4 eV
1.0 eV
0.4 eV (smallest)

(b) Next, suppose that the beam of electrons is shut off so that all of the objects are in the ground state almost all the time. If electromagnetic radiation with a wide range of energies is passed through the material, what will be the three energies of photons corresponding to missing ("dark") lines in the spectrum? Remember that there is hardly any absorption from excited states, because emission from an excited state happens very quickly, so there is never a significant number of objects in an excited state. Assume that the detector is sensitive to a wide range of photon energies, not just energies in the visible region. List the dark-line energies in order from largest to smallest.

3.3 eV (largest)
2.9 eV
1.9 eV (smallest)

- *Read the eBook*
- Section 8.3

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4. 4/4 points | Previous Answers MI2 07.P.18

Suppose we have reason to suspect that a certain quantum object has only three quantum states. When we excite a collection of such objects we observe that they emit electromagnetic radiation of three different energies: 0.8 eV (infrared), 1.9 eV (visible), and 2.7 eV (visible).

(a) Draw a possible energy-level diagram for one of the quantum objects, which has three bound states. On the diagram, indicate the transitions corresponding to the emitted photons, and check that the possible transitions produce the observed photons and no others. When you are sure that your energy-level diagram is consistent with the observed photon energies, enter the energies of each level ($K+U$, which is *negative*). Enter ALL levels before submitting; all of the energies must be correct to be properly scored. The energy $K+U$ of the ground state is -4 eV.

-1.3 eV = energy of highest level (2nd excited state)
-2.1 eV = energy of next highest level (1st excited state)
-4 eV = energy of ground state

(b) The material is now cooled down to a very low temperature, and the photon detector stops detecting photon emissions. Next a beam of light with a continuous range of energies from infrared through ultraviolet shines on the material, and the photon detector observes the beam of light after it passes through the material. What photon energies in this beam of light are observed to be significantly reduced in intensity ("dark absorption lines")?

Energy of highest-energy dark line: 2.7 eV
Energy of lowest-energy dark line: 1.9 eV

(c) There exists another possible set of energy levels for these objects which produces the same photon emission spectrum. On an alternative energy-level diagram, **different from the one you drew in part (a)**, indicate the transitions corresponding to the emitted photons, and check that the possible transitions produce the observed photons and no others. When you are sure that your alternative energy-level diagram is consistent with the observed photon energies, enter the energies of each level ($K+U$, which is *negative*). Enter ALL levels before submitting; all of the energies must be correct to be properly scored.

-1.3 eV = energy of highest level (2nd excited state)

-3.2 eV = energy of next highest level (1st excited state)

-4 eV = energy of ground state

(d) For your second proposed energy-level scheme, what photon energies would be observed to be significantly reduced in intensity in an absorption experiment ("dark absorption lines")? (Given the differences from part (b), you can see that an absorption measurement can be used to tell which of your two energy-level schemes is correct.)

Energy of highest-energy dark line: 2.7 eV

Energy of lowest-energy dark line: 0.8 eV

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5. 1/1 points | Previous Answers MI3 8.2.X.015

A certain laser outputs pure green light (photon energy 2.5 eV) with power 850 milliwatts (0.85 watts). How many photons per second does this laser emit?

2.125e18 photons/s

- *Read the eBook*
- Section 8.2