

EXAM #3 ANSWERS
ASTR 1101-001, Spring 2008

Refer to Figure 1 when answering the first 7 questions of this exam.

1. Which series of electron transitions in the energy-level diagram for Hydrogen produce the lines shown in the absorption-line spectrum of Hydrogen?

ANSWER. Series #2

2. Which series of electron transitions in the energy-level diagram produce the “Balmer” series of lines in a Hydrogen spectrum?

ANSWER. Series #2

3. Of the five separate electron transitions that have been labeled with letters in the energy-level diagram, which results in the production (or destruction) of the shortest wavelength photon?

ANSWER. The transition labeled “e”.

4. Of the five separate electron transitions that have been labeled with letters in the energy-level diagram, which results in the production (or destruction) of the longest wavelength photon?

ANSWER. The transition labeled “c”.

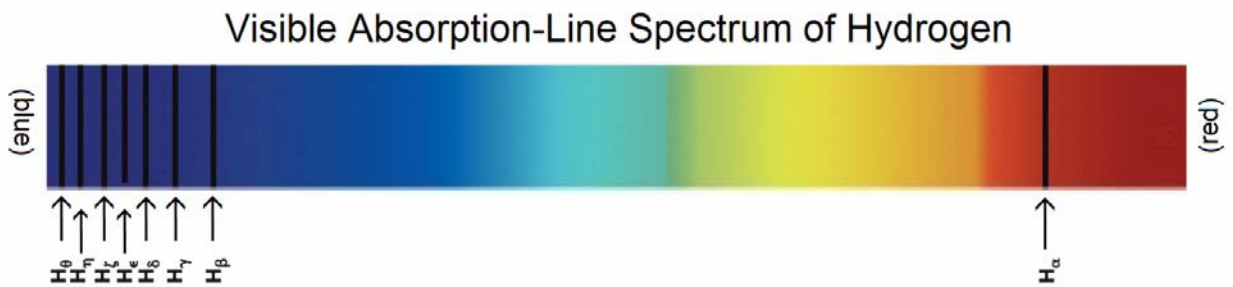
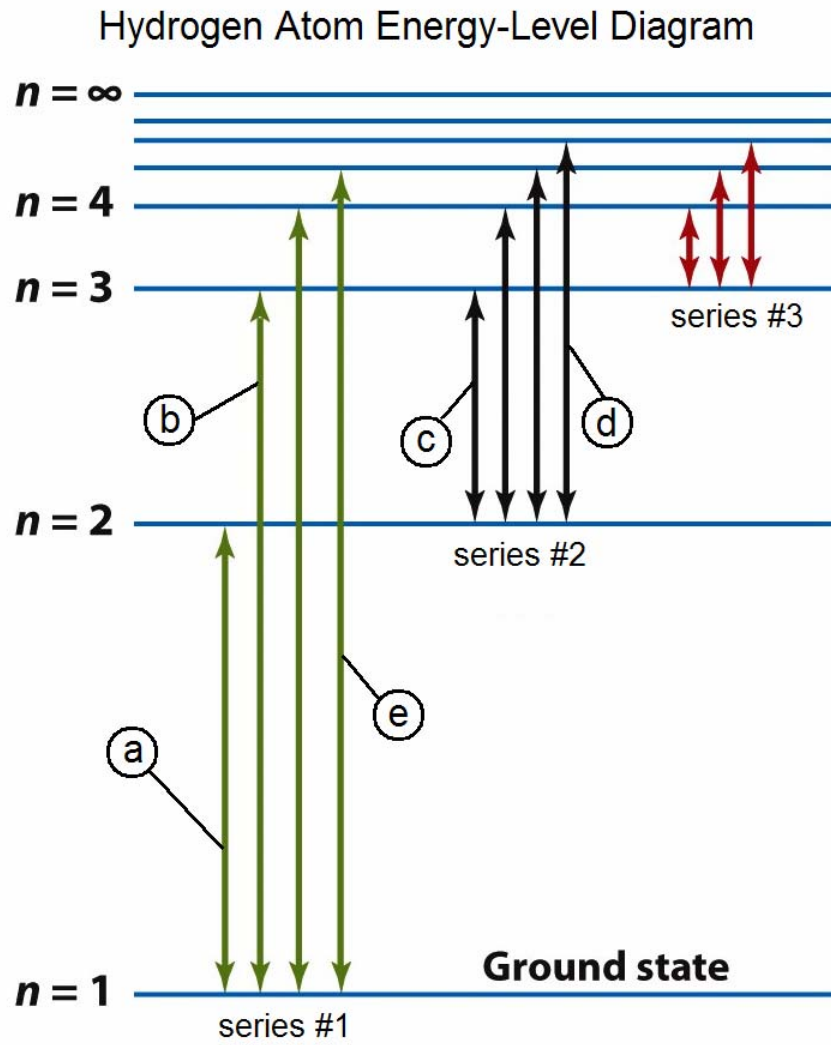
5. Given that the “H α ” absorption line identified in the hydrogen spectrum corresponds to the electron transition marked “c” in the hydrogen energy-level diagram, which absorption line corresponds to the electron transition marked “d”?

ANSWER. H δ

6. Suppose that the electron in a hydrogen atom is initially found to be orbiting the nucleus of the atom in its $n = 3$ orbital level. What photon (or photons) *could* the atom emit when the electron drops directly or cascades down to the ground state? (Circle all that apply.)

ANSWER. The transitions labeled “b,” “c,” and “a”.

Figure 1



7. Starting from the $n = 3$ orbital level, is it possible for the atom to emit a photon in the visible part of the electromagnetic spectrum when the electron drops directly or cascades down to the ground state?

ANSWER. Yes. The electron can drop from level $n = 3$ to level $n = 2$ and, in so doing, emit $H\alpha$, which is a Balmer series (visible) photon.

8. One night you look up in the sky and notice that two of the brightest visible stars have distinctly different colors: One star is red while the other star is blue. Which of the two stars has the hotter surface?

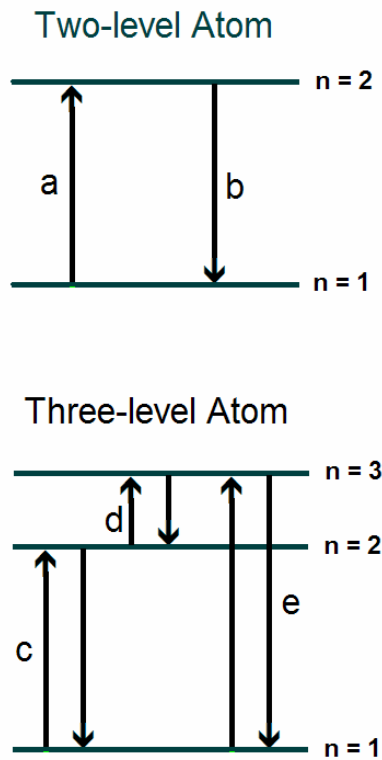
ANSWER. The blue star's surface is hotter than the surface of the red star.

9. By carefully studying a spectrum of the light that is being emitted by a star or planet, astronomers can determine _____ (circle all that apply):

ANSWER. Three of the five choices are correct...

- The surface temperature of the star or planet.
- The chemical composition of gas in the atmosphere of the star or planet.
- The relative speed at which the star or planet is moving toward or away from us.

Figure 2



Refer to Figure 2 when answering questions #10 and #11.

10. In the two-level atom shown in Figure 2, which electron transition is associated with the emission of light?

ANSWER. The transition labeled “b”.

11. If the “c” transition marked in the three-level atom is associated with the absorption or emission of a *red* photon, what color photon would be absorbed in making the transition marked “d”?

ANSWER. It must be longer wavelength than “red.”
Hence, infrared.

Answer questions #12 and #13 using the following information: Suppose the absorption-line spectrum of a star named 'Q2' shows a clear "fingerprint" of the atomic element, hydrogen, but you notice that all of the Balmer lines in 'Q2' have been shifted to much longer wavelengths than you would see if you were looking at a spectrum of hydrogen in a laboratory here on Earth. In particular, you notice that the H β line has been shifted to the wavelength usually occupied by the H α line.

12. If this line shift is caused by the Doppler Effect, what can you conclude about Q2?

ANSWER. Q2 is moving away from us at a high speed.

13. Into what region of the electromagnetic spectrum has the H α line in Q2's spectrum been shifted?

ANSWER. H α has been shifted into the 'infrared' region of the spectrum.

14. Which type of photon is more likely to be able to ionize a hydrogen atom?

ANSWER. An x-ray photon.

15. For which region(s) of the electromagnetic spectrum is the Earth's atmosphere opaque? (Circle all that apply.)

ANSWER. The Earth's atmosphere is opaque to both x-rays and gamma-rays.

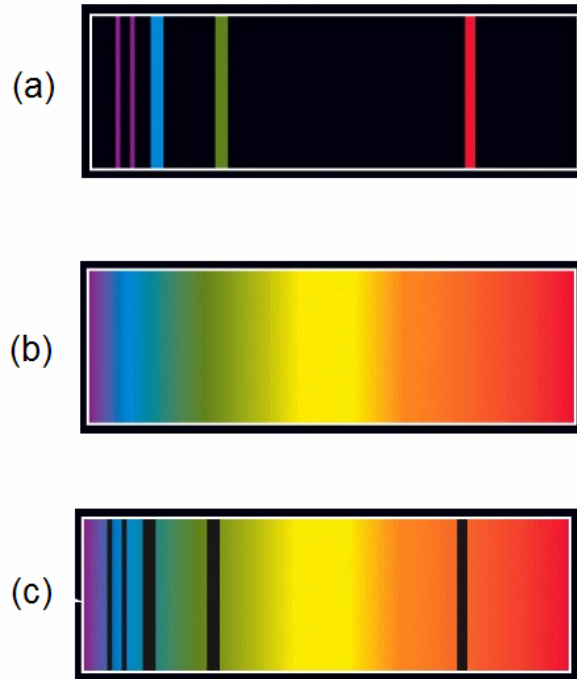
16. Why is the Hubble Space Telescope a better telescope to use than large ground-based telescopes, such as the Gemini North telescope in Hawaii?

ANSWER.

Primarily because the HST is in orbit, above the Earth's atmosphere, so light from remote astronomical sources does not get distorted by turbulence in the Earth's atmosphere before being detected by the telescope.

Figure 3 illustrates three general types of spectra that are frequently observed by astronomers: (a) An emission-line spectrum; (b) a blackbody continuous spectrum; and (c) an absorption-line spectrum. Refer to Figure 3 when answering questions #17 and #18.

Figure 3



17. When light from the sun is passed through a prism to create a spectrum, which of these general types of spectra does the sun's spectrum best resemble?

ANSWER. An absorption-line spectrum.

18. One day during class I distributed some cardboard-mounted transmission gratings that allowed you to view the spectrum of light that was being emitted from two separate, special light bulbs: One bulb contained hot, diffuse neon gas; the other bulb contained hot, diffuse mercury gas. Which of the three general types of spectra was being emitted by these bulbs of hot, diffuse gas?

ANSWER. An emission-line spectrum.

19. Suppose, as you are driving your car down the highway, you are approaching a police car and the police officer uses her radar gun to measure your speed. Will the radar-frequency electromagnetic (EM) radiation that is detected by the police officer (after the radiation bounces off your car and returns to the police officer) have a shorter or longer wavelength than the EM radiation that was originally emitted by the radar gun?

ANSWER. The detected radiation will have a shorter wavelength than the emitted radiation.

20. A star whose surface temperature is 50,000 °K will appear bluer in color than a star whose surface temperature is 6000 °K. (True or False?)

ANSWER. True.

21. Ground-based optical telescopes can either use a transparent lens or a reflecting mirror to collect the light from faint astronomical sources. Modern optical telescopes that have the largest collecting area use which one of these techniques?

ANSWER. They all use reflecting mirrors.

22. Which one of the following is not an example of electromagnetic radiation?

ANSWER. Sound waves.

23. Explain how you (or anyone else living on Earth) could measure the speed of light by carefully tracking and timing the motion of Jupiter's moons throughout the year.

ANSWER. See text discussion accompanying Fig. 5-1.

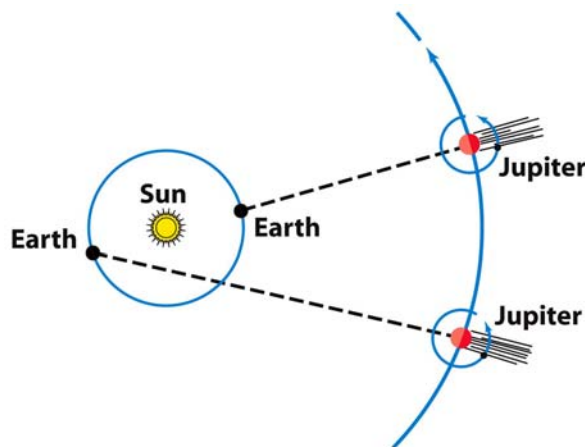


Figure 5-1
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