1. **Discovery of the first quasar**. In 1962, Maarten Schmidt observed the spectrum of an object that emitted radio waves and visually looked like a star. Since stars do not emit radio waves, this was a very unusual object. He observed the part of the spectrum from 4860 Å to 6030 Å. He found spectral lines at 5571 Å and 4974 Å. You are going to figure out the redshift.

    a. (not graded) What are the big ideas needed to answer this question?

    b. (1 pts.) *Assume* Hβ accounts for the line at 4974 Å. What then is the redshift?

    c. (1 pt.) Assume the redshift in part (a) is correct. What is the wavelength at which the line Hε appears in the spectrum of the object?

    d. (not graded) Why is the identification of the line at 4974 Å as Hβ incorrect?

    e. (2 pts.) Now you know the line at 4974 Å is not due to Hβ. Identify (determine the element and the particular spectral line of that element) these two lines and determine the redshift of this object. Note: Not all of the lines in the table are present in all astronomical objects. However, a line in the hydrogen series cannot occur by itself.

    Table 1. Spectral lines of hydrogen and oxygen and their laboratory wavelengths. OII means oxygen with one electron removed, and OIII is oxygen with two electrons removed.

Line	*Wavelength*	*Line*	*Wavelength*
Hα	6562 Å	OII	3727 Å
Hβ	4861 Å	OIII	5007 Å
Hγ	4340 Å		
Hδ	4101 Å		
Hε	3970 Å		

2. (not graded) Your parents ask, "How do astronomers know that the Big Bang did happen?" Write a simple answer for your parents, who, let's assume, are not scientists.

3. Simplicio reasons, "The universe is expanding. The sun, being part of the universe, is expanding too. Therefore the sun is steadily moving away from us, and the sun is getting bigger."

    a. (not graded) Modify Simplicio's statement so that it is correct.

    b. (3 pts.) Write a history of the earth and sun to show that Simplicio is incorrect.

4. The present distance to Coma is 100 Mpc, and its speed is 6,000 km/s. For Hubble's constant, use the value 60 km/s/Mpc (equal to 0.061/Byr). A Mpc is 3.1×10^{19} km. A billion years is 3×10^{16} s.

    a. (not graded) A billion years ago, Coma was moving away from us at about the same speed. What is the reason for that?

    b. (not graded) How far from us was Coma at that time?

    c. (3 pts.) What was the value of Hubble's constant at that time? Is Hubble's constant a constant (one that does not change with time)?