Astro 102
Group Problems #1
2006-June-08

Useful Data

$$1\,\text{year} \;=\; 365.24\,\text{days}$$

$$24\,\text{h} \;=\; 1\,\text{day}$$

$$60\,\text{m} \;=\; 1\,\text{h}$$

$$60\,\text{s} \;=\; 1\,\text{m}$$

$$1\,\text{pc} \;=\; 3.26\,\text{light} - \text{years}$$

$$206265\,\text{AU} \;=\; 1\,\text{pc}$$

$$1\,\text{AU} \;=\; 1.5 \times 10^{8}\,\text{km}$$

$$1\,\text{km} \;=\; 1,000\,\text{m}$$

Mass of Hydrogen Atom: 1.7×10^{-27} kg

Mass of the Sun: 2.0×10^{30} kg

Age of Solar System: 4.6 billion years

Speed of light: $c = 3.00 \times 10^{8}\ \text{m}\,\text{s}^{-1}$

1. Suppose that a black hole at the core of a quasar eats 2×10^{30} kg of mass every year. How long will it take this back hole to eat 1×10^{38} kg of mass?

2. **(a)** How many times the mass of the Sun does the black hole in the previous problem eat each year?

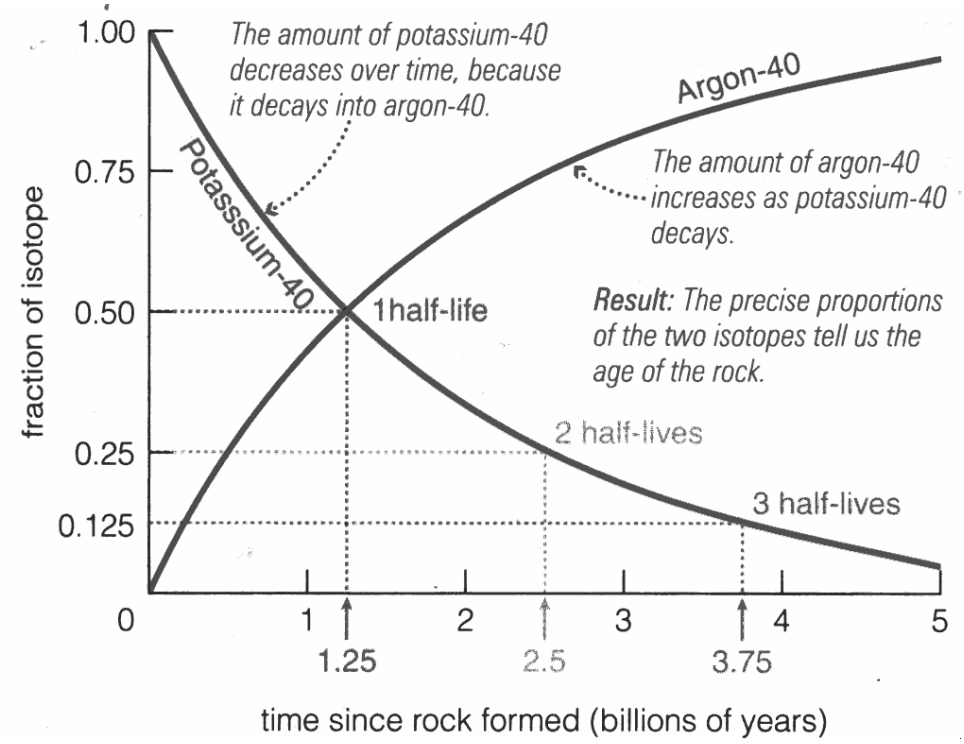
   (b) How many times the mass of the Sun does the black hole eat over the period of time that was your answer to the previous problem?

3. The Solar Wind is a stream of particles coming off of the surface of the Sun. Most of those particles are protons and electrons— that is, Hydrogen atoms where the electrons have been stripped off and are free. The Sun loses about 1×10^{36} protons a second to the Solar Wind.

   (a) How much mass does the Sun lose to the Solar Wind in a million years?

   (b) What fraction of the Sun's mass is lost during a million years?

4. **Reading Graphs**. Consider the plots below, showing the decay in the fraction of K-40 and the rise in the fraction of A-40 over time:



Answer the following questions:

(a) What is the ratio of Potassium-40/Argon-40 for the oldest rocks in the Solar System?

(b) How old must a rock be for the ratio of Potassium-40/Argon-40 to be 1/3?

(c) How old must a rock be for the ratio of Postassium-40/Argon-40 to be 3?

5. Estimate how wide this room is in light-seconds.

6. A Geiger Counter measures the rate of emission of particles it is sensitive to. If you are measuring an unstable isotope that emits particles the Geiger Counter is sensitive to, you will register one "click" for each decay.

   Consider Carbon-14, which has a half life of about 5,700 years. Suppose you have a sample with 1.0×10^{12} Carbon-14 atoms embedded in it. Roughly estimate how may clicks will your Geiger Counter will register in the next 10 seconds.

7. The Virgo Cluster is 65 million light-years away. Galaxies in the Virgo Cluster are receeding at a rate of 1,400 km/s. Consider the distance to the Virgo Cluster now, and the distance to the Virgo Cluster in 100 years. What is the ratio of the *difference* in those distances to the current distance?

   (That ratio is the same as the *fractional increase* in the size of the Universe over 100 years, due to the expansion of the Universe.)