Astronomy — PS 7 — Solar System Properties

My Solution — many answers are of course subjective, but please review mine as a good way of reviewing Chapter 8 and Section 9.1

Planets vs. Dwarf Planets

1. What are the diameters of Pluto and Charon as quoted by Pasachoff and Filippenko, in Section 8.1?

Pluto is 2300km in diameter (more recently measured as 2377km) and Charon is 1200km.

Kuiper Belt Objects

2. Would it be fair to say — based on size and distance — that Pluto and Charon are just especially large KBOs?

Yes, although they are quite large for KBOs, there is a whole spectrum of KBO sizes, and they just happen to be the largest and therefore the one we found most easily and first.

3. Why is this object, now called Eris, thought to be in such a highly tilted orbit relative to the ecliptic?

Eris is about the size of Charon and it is on a highly tilted orbit (44° relative to the ecliptic plane), so it was slow to be found. Initially it was thought to be even larger than Pluto. Now it is though to be about the size of Charon. Pasachoff and Filippenko say that it was likely flung into its gonzo orbit by a close encounter with Neptune.

Comets and the Oort Cloud

On p. 236, Pasachoff and Filippenko discuss two categories of comets, one of which is “nearly isotropic” meaning that they are not concentrated along the plane of the ecliptic.

4. What is the other major category of comets?

The other major category is the ecliptic category. So, to summarize, there are comets coming in from all directions (the “nearly isotropic” ones), and comets that are concentrated along the ecliptic plane.

Reading between the lines, one can assume that Pasachoff and Filippenko prefer this categorization, but in the caption to Figure 8-12, they say that it hasn't "taken over" from the more popular categorization which is short period and long period.

Meteoroids

Meteoroids are small chunks from the size of a grain of sand to a boulder (about 1m). Anything larger than that is usually called an asteroid.

5. What is the distinction between a meteoroid and a meteorite according to Pasachoff and Filippenko?

A meteorite is just a meteor that has made it through the Earth's atmosphere and landed on Earth. Whatever didn't burn up in the atmosphere joins the rocks here on Earth. So "meteorite" is a categorization of rocks, like granite, or basalt.

Asteroids

Due to the large number of asteroids, with vast numbers still being found, Pasachoff and Filippenko quote a roughly 1% chance each century (or once in 10,000 years) that an asteroid greater than 200m will collide with Earth. Objects 50-60m across are expected to arrive about once every 1,000 years.

6. How often are objects in the 20m size range expected to arrive?

The estimate on p. 255 is once per century.

So to summarize:

Every 10,000 years, >200m
Every 1,000 years, 50-60m
Every 100 years, 20m

The Formation of the Solar System

It is highly worth studying the story described in Figure 9-5 to know the best story we currently have about the formation of the solar system.

7. As the gas and dust started sticking together, the first thing it formed were _____ and this category is objects that are about _____ in diameter.

The blanks are "planetesimals" and "1km to a few hundred km."

It is important to note that these are just categorizations. What is really happening is a process of accretion by gravity into larger and larger chunks, and where you draw the lines between the objects of various sizes is a bit arbitrary.

8. What is the frost line (referred to in Section 9.1b and on p. 218, and what is distinctive about objects that form inside the frost line vs. outside it?

Inside the frost line, water ($H_2 0$), ammonia (NH_3) and methane (CH_4) are vaporized and then blown away by the solar wind. Farther from the Sun (outside the frost line), these molecules can hang around as chunks of ice, because the Sun's light is too weak to vaporize them.

9. How did the gas giants get so ridiculously large?

They started off as accumulating planetesimals, but out at their orbit, which is beyond the frost line, there was a large amount of the various kinds of ices that could add to their mass. Once their mass got large enough, Pasachoff and Filippenko say that they then "attracted large amounts of nearby hydrogen and helium gas in the nebula, growing dramatically, especially in the cases of Saturn and (more spectacularly) Jupiter.

The key idea here is that we have an understanding of why the inner planets are rocky and the outer planets are gas giants.

10. The asteroids in the asteroid belt today have only _____ per cent of the mass that was initially at their location. Why did no planet form where the asteroid belt is now?

The blank is ambiguous because the story isn't completely and compellingly worked out. Whatever it is it is only a few percent of what was originally there. Pasachoff and Filippenko say that "Jupiter 'bullied' the asteroid belt, gravitationally kicking out material that orbited an integer number of times in the time that Jupiter itself made one orbit." They also say that is is hypothesized that "Jupiter and Saturn achieved a 2:1 resonance for a time and this resonance served to eject asteroids," and that 90-95% of what was left was ejected because of this resonance.