Study Guide 4
Part A

Outline

- Working out the nature of the Milky Way
    - Hard to tell where Sun is located, due to absorption by dust.
        - Star counts gave wrong answer.
        - Pulsating variable stars in globular clusters finally showed that Sun is far from the center.
    - This all culminated in the Curtis-Shapley debate (1920). The issues were:
        - The position of the Sun within our Galaxy.
        - The size of our galaxy.
        - Are there other galaxies outside our own Galaxy?
    - Each side had it partly right.
- Our Milky Way Galaxy
    - Parts of the Milky Way
        - Disk, bulge, halo, globular cluster system
    - Orbits
        - are circular in the disk
        - elongated in other parts
    - Gas, dust, and young stars are in the disk.
    - Formation of disk
        - Gas that formed into disk stars was orbiting MW in a circle
    - Formation of halo (two possibilities)
        - Stars in the halo formed in one giant collapsing gas cloud
        - Halo stars formed in many small galaxies that combined to form the Milky Way.
    - The old stars in the halo have a smaller proportion of heavy elements than do younger stars in the disk. We think that these heavy elements were created in supernovae as the Milky Way aged.
    - Most of the mass of the Milky Way is dark matter. The existence of the dark matter is inferred from the effect that its gravity has on stars in the outer part of the Galaxy. Those stars are orbiting faster than they would be expected to be moving if there were no dark matter. Nobody knows what the dark matter is.
    - A 4 million solar mass black hole may sit in the center of the Milky Way.
- Other Galaxies
    - Our Milky Way has
        - Young stars, dust, & gas in disk. Circular orbits.
        - Old stars in halo. Elongated orbits
    - There are three main types of galaxies: spiral, elliptical, and irregular.
    - Elliptical galaxies contain mainly old stars and have little interstellar gas
    - Spiral galaxies are similar to the Milky Way and have both young and old stars.
    - The Milky Way is in a small group of galaxies called the Local Group, but giant clusters of galaxies also exist
    - As we look through the universe to greater distances, we are also looking back in time
    - The two biggest Local Group galaxies are the Milky Way and the Andromeda Galaxy. They may eventually collide.
- The Hubble Law
    - Measuring distances: Within a few hundred light years we can measure the parallax of stars. Cepheid variable stars can be seen to distances of a few tens of

millions of light years and can be used to get the distances to the nearest galaxies. White dwarf supernovae are very bright standard candles, and can be seen to distances of a few billion light years.
    - Almost all galaxies that we see have redshifted spectra; according to the Doppler effect that implies that they are moving away from us
    - The Hubble Law: More distant galaxies are moving away faster.
        - Speed = H × Distance (v =Hd)
    - The Hubble Law implies
        - Universe is expanding
        - The expansion started at some definite time in the past (the Big Bang)Universe expands away from every galaxy. Every galaxy would see its own version of the Hubble Law.
- Quasars & Active Galactic Nuclei
    - Quasars and other active galaxies emit large amounts of energy from relatively small regions near their centers
    - Quasars generally have large redshifts, meaning that they are very distant. Because they are very distant, they must also be very luminous for us to see them.
    - In quasars, the nucleus is so bright that that the galaxy looks like a point.
    - It is thought that supermassive black holes power quasars and active galaxies
    - Some active galaxies show jets of material being shot out from near the center of the galaxy

Now go look at Study Guide 4, Part B.