Astronomy Final Study Guide

Make sure to study the chapters and class notes on the information contained in this study guide, the questions are only a mechanism to help you prepare.

Mercury and Venus

- **Inferior planets**: planets with orbits smaller than that of the Earth
- Both planets are observed in the morning or evening sky (i.e., leading or trailing the Sun in the sky)
- **Easter/Western Elongation**: the maximum distance the inferior planets appear to get in the sky from the Sun
- Mercury
  - Closest planet to the Sun (0.4 AU)
  - Negligible atmosphere
  - Heavily cratered surface
  - Unusually large iron core
  - Weak magnetic field
  - Tidal Effects
    - Mercury year = 88 Earth days
    - Mercury day = 59 Earth days
    - The orbit of mercury is eccentric
      - Perihelion = 0.31 AU
      - Aphelion = 0.41 AU
    - Rotation period minimizes the tidal dissipation near perihelion
  - The Mercury Surface, Space Environment, Geochemistry and Ranging (MESSENGER)
    - Launch—August 3,2004, impact with Mercury's surface—April 30,2015
    - Objectives: "to characterize the chemical composition of Mercury's surface, the geological history, the nature of the magnetic field, the size and state of the core the volatile inventory at the poles, and the nature of Mercury's exosphere and magnetosphere over a nominal orbital mission of on Earth year"
    - 3 flybys gathered information for planning main mission
  - Surface of Mercury
    - Lots of impact craters over much of the surface = old surface
    - Lower crater density than some lunar regions
      - Resurfacing by lava flows?
      - Small lava plains
      - Mercury probably volcanically active when young. Maybe still active?
    - Surface Composition
      - Ratio of potassium (low vaporization temperature) to thorium, which is a measure of **volatile abundance, is like other terrestrial planets**
      - But higher than the Moon. Potassium lost during the giant impact that formed the Moon
      - Ten times the Sulfur abundance of other terrestrial planets; more evidence of volatile rich environment
      - **Very low iron relative to other terrestrial planets**
      - **Mercury formed in water-free environment rich in comet dust-like material**
      - **Polar cap**: permanent deposit of **water** or other **frozen volatiles** in the cool polar regions of the planet
      - Initially discovered via radar mapping of Mercury. These regions have high radar reflectivity
      - Tilt of rotational axis with respect to the ecliptic plane is zero degrees, thus polar regions receive little sunlight
      - But where did the volatiles come from? Impacts with comets? Outgassing? We now know that Mercury's surface is rich in volatiles

        - **Caloris Basin**: largest structure on Mercury (1000 km), created by an impact with an asteroid. Circumference of Mercury is 15400 km
            - A similar feature is seen on the western edge of the Moon—Mare Orientale
            - The impact that resulted in the Caloris Basin generated compression on the surface of Mercury
    - Geology: Flood Volcanism
        - Flood volcanism plains cover 6% of the surface
        - Flood volcanism plains formed after Caloris impact basin
        - Large scale volcanism occurred after the period of heavy bombardment
        - Mosaic of western side of planet showing lave filled craters and plains
    - Mercury has significant contraction
        - …From the large core cooling down. Cliff length = 100s of km
        - Amount of contraction: 7 km in radius
        - Contraction may have closed off volcanic vents
    - Geology: Hollows
        - Rimless, hollowed out depressions on the surface—similar in appearance to holes in Swiss cheese
        - Highly reflective
        - **No equivalent features on the Moon**
        - Likely formed from recent loss of volatiles through sublimation, space weathering, outgassing, or pyroclastic (airborne ejecta) volcanism
        - **Importance:** the interior of Mercury contains higher abundance of volatiles than previously predicted
    - Model of Polar Ice Deposit Formation
        - A high latitude impact crater illuminated by the angled rays of the Sun creates a region of very warm temperatures on the illuminated rim, lower temperatures on the illuminated floor of the crater, and extremely cold temperatures in regions of permanent shadow
        - A comet or water-rich asteroid that also contains organic compounds impacts Mercury
        - The water and organic compounds are spread over a wide geographic region, and a small fraction of both compound migrate to the poles where they can become cold-trapped as ices
        - Over time, the water ice in the warmer regions vaporizes, leaving behind the more stable organic impurities at that have been darkened by exposure to Mercury's space environment
    - Magnetic Field
        - Offset from the planet's spin axis: molten material near the interior's core-mantle boundary?
    - Origin of Mercury
        - **Issue 1**: Mercury contains a high level of volatiles
        - **Issue 2**: Mercury has a large core-to-mantle ratio
        - Models
            - Violent young Sun baked the primordial dust that would become Mercury
            - Outbursts from the Sun blasted Mercury, evaporating away enough rock to reduce it to its present size
            - Mercury was struck by large objects which stripped away much of its rock
            - Is the surface composition representative of the Mantle?

- Venus

- Second planet from the Sun (0.7 AU)
- Thick atmosphere composed primarily of CO_2
- High surface temperature
- Clouds of sulfuric acid
- Extreme Greenhouse heating; 800K at the surface
- Rotation of Venus
  - Retrograde motion
  - Long sidereal day = -243 Earth days
  - Solar day = -117 Earth days
- Clouds
  - Highly reflective (**75%**)
  - Cloud temperature (**-35 degrees C**)
  - Upper atmosphere—Clouds rotate around the planet in four days due to
    - **Rotation of planet**
    - **Thin upper atmosphere**
    - **Heating by solar radiation**
  - Lower atmosphere
    - **Wind speed—0-2 m/s**
    - **Coriolis is negligible—slow rotation of the planet**
    - **Hadley cells—air traveling via convection from equator to poles**
- Topography
  - Contrast between high and lowlands is not as dramatic as it is on Earth
- Surface Features: Craters on the Venusian Surface
  - 1000 impact craters
  - Sizes: 2-280 km
    - **No large craters: surface doesn't date back to heavy bombardment period**
    - **No small craters: small impactors burn up in the thick atmosphere**
  - Craters are pristine: low erosion rate
- Surface Features: Tectonic Features
  - Created via tension or compression in the crust of the planet
  - No well-defined tectonic plates
  - Band near equator: crustal compression
- Surface Features: Pancake Domes
  - 45 km in diameter
  - 2-3 km high
  - created when lava is belched up all at once
- Surface Features: Coronae
  - Circular/oval features 100s-1000s km across
  - Characterized by concentric and radial tectonic patterns, and often by associated volcanic eruptions
  - What are they?
    - **Failed hot spots**
    - **Developing hot spots**
- The Greenhouse Effect
  - About 80% of the solar radiation is reflected back into space
  - 10% absorbed by atmosphere
  - 10% reaches the ground
  - the greenhouse effect driven by the dense atmosphere causes the high surface temperatures
  - Runaway Greenhouse Effect: Could Venus have been more Earth like in the past?
    - At 0.72 AU, Venus receives a higher flux of solar radiation
    - Evaporation of oceans→water vapor (greenhouse gas)
    - Higher temperature→more evaporation