

**Answer all questions in the space provided. If you have any questions, raise your hand.  
100 points possible. No calculators or electronic devices of any type.**

**1** (4 pts) Explain what is meant when we say that Pluto is in a 2:3 resonance with Neptune.

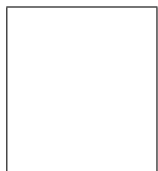
**2** (12 pts) Describe two different ways we can determine the composition of the surface of an asteroid in the asteroid belt without having to go there, land, collect a sample and bring it back to Earth.



**3** (5 pts) Define the term **Crater Population**.

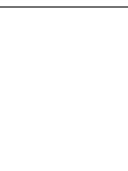
**4** (5 pts) Define the term **Tidal Force**.

**5** (8 pts) Explain why liquids (of any composition) are much more common in the **subsurfaces** of outer solar system satellites than on their surfaces.



**6** (8 pts) Jupiter is a world composed mostly of Hydrogen and Helium gas. Explain why it is important that Jupiter formed in an area with lots of ice and rock.

**7** (8 pts) Explain why the parent body of an ordinary chondrite meteorite would **never** have had a magnetic field.



The giant planets (Jupiter, Saturn, Uranus, and Neptune) each have a large family of natural satellites. For each of the satellite types listed below, tell me (1) the approximate size of the satellite (with units), (2) describe the shape of the orbit around the giant planet, and (3) describe how they formed.

**8 (6 pts) Ring Particle**

**Size:**

**Orbit Shape:**

**Describe Formation:**

**9 (6 pts) Regular Satellite**

**Size:**

**Orbit Shape:**

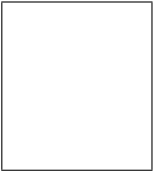
**Describe Formation:**

**10 (6 pts) Irregular Satellite**

**Size:**

**Orbit Shape:**

**Describe Formation:**



**11** (8 pts) There is new evidence that the permanently shadowed craters on the poles of Mercury contain traces of water-ice. This water-ice certainly did not form there. **Where** did it form and **how** did it get there?

**12** (8 pts) Explain why the detection of oxygen ( $O_2$ ) in the atmosphere of an exoplanet would be a good indicator of biology on the surface.



**13** (8 pts) Imagine you completely fragment a **1 km** diameter asteroid into hand-sized pieces (assume the asteroid was never larger than 1 km). List the **types** of meteorite samples you would have. Then indicate the (very) approximate percentage of each type (For example: 80% type A and 20% type B ).

**14** (8 pts) Same question as above, but with a **1000 km** diameter asteroid.

