

**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 (2 pts) What is the most abundant **solid** material in the outer solar system?

2 (6 pts) Explain how we determined the composition of the **surface** of the Earth's Moon.

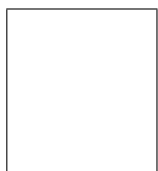
3 (8 pts) Explain how we determined the composition of the **surface** of Saturn's satellite Mimas.



4 (4 pts) What does it mean to determine the **Absolute Age** of a surface?

5 (8 pts) Explain why you cannot determine the **Absolute Age** of a crater-saturated surface in the outer solar system using crater counting.

6 (8 pts) Explain why you cannot determine the **Absolute Age** of a surface whose crater population is different from the Moon's using crater counting.

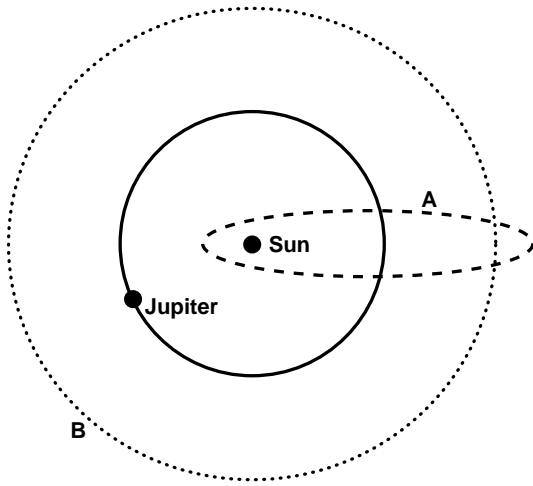


7 (2 pts) Define the term **Tidal Force**.

8 (6 pts) List three ways to melt the interior of a world that is the size of the Moon ($D \sim 3000$ km). Just list, you do not need to explain.

9 (8 pts) Explain why the parent body of an ordinary chondrite meteorite would **never** have had a magnetic field.



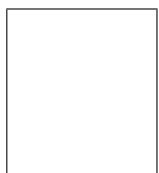


The plot on the left shows the orbits of two comets as they go around the Sun. Comet **A** is the dashed line, and Comet **B** is the dotted line. The orbit of Jupiter is also shown.

The period of Jupiter's orbit is 12 years.
 The period of the orbit of Comet **A** is 15 years.
 The period of the orbit of Comet **B** is 24 years.

10 (8 pts) In 1 billion years, Comet **A** will no longer exist. Explain why.

11 (8 pts) In 1 billion years, Comet **B** will no longer be in the orbit shown. Explain why.



12 (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?

13 (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.



14 (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).

15 (8 pts) Same question as above, but with a **3,000 km** diameter asteroid.

