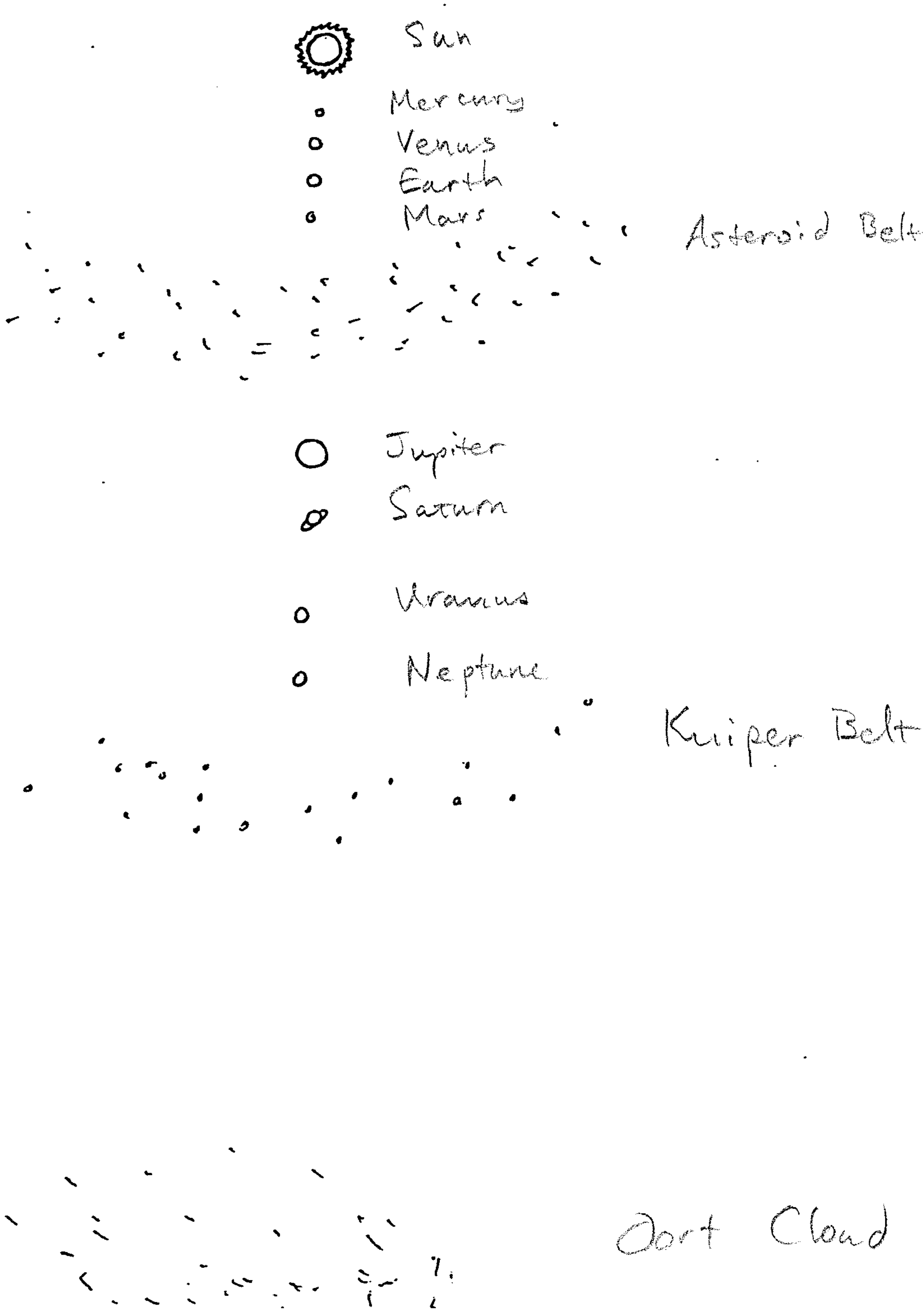
Part II: Short Answer Questions.

There are 5 short answer questions worth a total of 45 points. Give a full yet concise answer to each question posed, explicitly showing any mathematical work if required.

36. Solar System Architecture (12 points)

Label the planets and other parts of our solar system sketched below.



37. Kepler's Laws (11 points)

a) State Kepler's Three Laws of Planetary Motion (4 points)

1. Orbits are ellipses with the sun at one focus ← one point for ellipses ← one point for sun at one focus
2. Equal areas swept out in equal times
3. $P^2 = a^3$

b) A very remote dwarf planet, in the outer reaches of the Kuiper belt, has an orbital period of 1,000 years. What is the semi-major axis of its orbit? (2 points)

$P = 1000$ yr

$P^2 = a^3$

$a = P^{2/3} = 1000^{2/3} = (10^3)^{2/3} = 10^2$

$a = 100$ AU

Use the data table below to help answer these questions.

c) How many orbits does the Saturn complete for every one orbit of Pluto? (4 points)

$a_S = 10$ AU

$a_P = 40$ AU

$P^2 = a^3$ so

$\left(\frac{P_P}{P_S}\right)^2 = \left(\frac{a_P}{a_S}\right)^3 = \left(\frac{40}{10}\right)^3 = 4^3 = 2^6$

$P_P = 2^3 = 8 P_S$

Saturn completes 8 orbits for every one of Pluto

d) It takes Uranus 84 years to complete one orbit. This is longer than your life expectancy. Presuming there are no dramatic changes in life expectancy, can you expect to live long enough to see Neptune complete one full orbit? (1 point)

$a_N > a_U$

so $P_N > P_U$ so NO

PLANETARY DATA

outer planet	orbital distance
Saturn	10 AU
Uranus	19 AU
Neptune	30 AU
Pluto	40 AU

38. Wien's Law and the Stefan-Boltzmann Relation (10 points)

The Stefan-Boltzmann Relation is a relation between the luminosity of an object, its surface area, and its temperature.
For a hot, spherical object like a star, it can be written

$$L = 4\pi R^2 \sigma T^4$$

where L is the luminosity, R is the radius, T is the Temperature and σ is the Stefan-Boltzmann constant.

a. Suppose we doubled the size of the sun.
How much brighter or fainter would it be? (3 points)
(i.e., twice as bright, or factor of ten fainter, or what?)

double size: $R \to 2R$

$L \sim R^2 \to (2R)^2 = 4\times$ brighter

b. Suppose instead we doubled the temperature of the sun.
How much brighter or fainter would it be? (3 points)

$L \sim T^4 \quad T \to 2T$

$L \to (2T)^4 \to 2^4 = 16\times$ brighter

c. Normally, the wavelength at which the Sun's radiation peaks is 500 nm. If we double the temperature of the sun, at what wavelength does its radiation now peak? (3 points)
[Recall Wien's Law] $\lambda_p \sim \frac{1}{T}$

so doubling temperature means halving $\lambda_p = 250$ nm

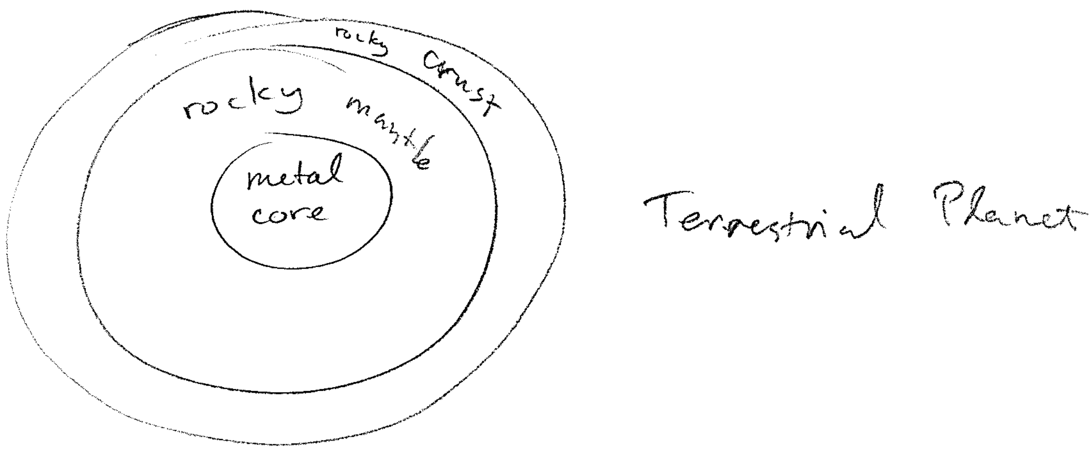
d. Is this new peak in the infrared or ultraviolet part of the electromagnetic spectrum? (1 point)
[Hint: would a hotter sun be safer for sun bathers?]

ultraviolet

40. Planetary Structure (6 points)

Sketch the cross section of the internal structure typical of
(a) a terrestrial planet, and
(b) a dwarf planet.
Specify the type of material that dominates each section.

a)



b)