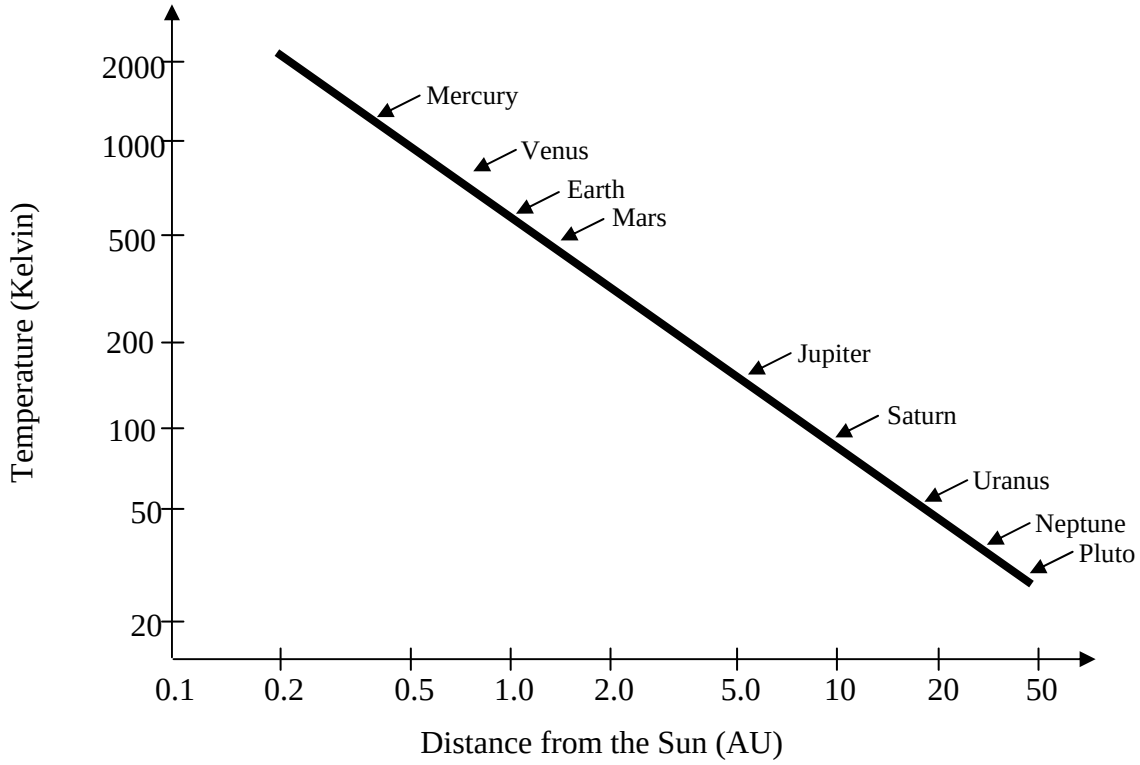
Name:_**ANSWERS**_____ Section:_____

Temperature and Formation of Our Solar System

Consider the information provided in the graph and table below. The graph shows the temperature (expressed in Kelvin) at different distances from the Sun (expressed in Astronomical Units, AU) in the solar system during the time when the planets were originally forming. The table provides some common temperatures to use for comparison.



Condition	Temp. Fahrenheit	Temp. Celsius	Temp. Kelvin
Severe Earth Cold	-100	- 73	199
Water Freezes	32	0	273
Room Temp	72	22	296
Human Body	98.6	37	310
Water Boils	212	100	373

1) What was the temperature at the location of Earth?
   About 600K
2) What was the temperature at the location of Mars?
   About 500K
3) Which planets formed at temperatures hotter than the boiling point of water?
   Boilng point of water = 373K so Mercury, Venus, Earth, and Mars formed at temperatures above the boiling point of water

4) Which planets formed at temperatures cooler than the freezing point of water?
   Freezing point of water = 273K so Jupiter, Saturn, Uranus, Neptune, and Pluto formed at temperatures below the freezing point of water.

To retain molecules of a gas requires that a planet be cold enough that the thermal motions of the molecules are less than the escape velocity from the planet. It we assume a planetesimal that is 10% as massive as the earth and 40% its size, then this requirement comes out to

Temperature less than 30K times the square root of the molecular mass. For reference, the square roots of 2, 4, 16, and 32 are respectively 1.4, 2, 4, and 5.6.

The molecular mass of hydrogen is 2 (2 atoms in a molecule); of helium is 4; of methane is 16; and of oxygen is 32 (2 atoms in a molecule again). For a planetesimal of the characteristics above in various orbits, which molecules could be retained? Put an X in the spaces where the molecule will stay put:

To retain H, T< 30K x 1.14 = 42K, methane, T< 30K x 4 = 120K
He, T< 30K x 2 = 60K, oxygen, T< 30K x 5.6 = 168K

Orbit	hydrogen	helium	methane	oxygen
Mercury	_____	_____	_____	_____
Venus	_____	_____	_____	_____
Earth	_____	_____	_____	_____
Mars	_____	_____	_____	_____
Jupiter	_____	_____	_____	X

Hydrogen and helium are so light they can only be retained by a massive “seed” body. At temperatures hotter than the freezing point of water, icy small bodies cannot form, and it is not possible to build a sufficiently massive seed out of just the rocky material. Thus, light gases, like hydrogen and helium, can only condense to form giant planets where water forms solid ice.

6) What planets would be able to retain hydrogen and helium by this theory?

Jupiter, Saturn, Uranus, Neptune

7) Is it likely that a large, Jupiter-like planet would have formed at the location of Mercury?
Explain your reasoning.

It would seem very unlikely that a Jovian planet would form as close to the Sun as Mercury since the temperature would have been over 1000K and it would have been very difficult to capture and collect gas.

Surprisingly, a number of the planets recently discovered around other stars have masses like Jovian planets but lie at a distance from their stars like Mercury’s distance from the Sun. This has led to the speculation that such planets must have formed at a greater distance and then migrated inwards towards the star.