ESS 100 (Stapleton)
Notes: Formation of Our Solar System

Name: Answers B 1/2

Part 1: The Nebula Contracts

1. Gravity is a force of attraction between bits of matter. Anything that has mass will be pulled by gravity toward anything else that has mass.

Is dust affected by gravity? Yes

What about ice? Yes

2. About 4.6 billion years ago, a **nebula** (cloud of dust and ice) was floating freely in space. The "dust" was rock and metal, and the "ice" was mostly frozen Hydrogen, plus some Helium. This nebula contained matter from other stars that had lived, died, and destroyed themselves in events called supernovae. According to your answer to question number 1, what must have begun to happen to the bits of dust and ice in the nebula?

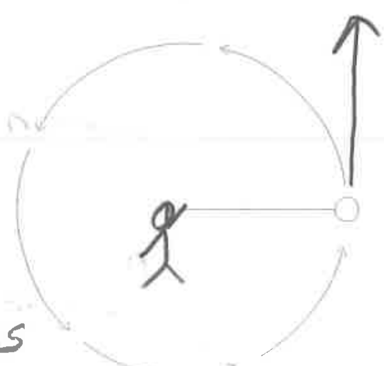
Why? The nebula shrank. It was pulled together by gravitational attraction between dust and ice particles.

Part 2: The Nebula's Motion Changes

3. The nebula that formed our solar system was vast in size, and it was rotating very slowly. What happened to the rotation of the nebula as it began to contract (be pulled together) by gravity? Hint: think of a spinning figure skater pulling in his/her arms and legs.

It started to spin faster as it pulled together.

4. Imagine you have a ball on a string, and you begin swinging the ball in circles over your head. As you swing the ball, you feel a pull. If you let go, this pull will cause the ball to fly away. On the diagram to the right, show the direction in which the ball will fly after you let it go.



5. What causes the ball to continue flying in this direction?
The ball's momentum (inertia) carries it in a straight line.

6. Newton's 1st Law of Motion says that *objects in motion remain in motion in a straight line and at a constant speed unless they are acted upon by an outside force.*

a. In the case of the ball, when is there a force acting on the ball, before you let it go or after you let it go?

b. What is that force?
The person holding the string pulling on the string.

c. After you let the ball go, will it travel in a straight path or a curved path?

d. After you let the ball go, will it travel directly away from you, or will it keep moving in the same direction that it was traveling when you let it go?

same direction

7. Newton's 1st Law is also called the Law of ___inertia___. **Inertia** means *resistance to change in motion*. **Momentum** is the inertia of a moving object.

When you swing a ball on a string, the pull that you feel resisting you is the ball's ___inertia___. (or momentum)

Part 3: The Nebula's Shape Changes

8. When a pizza maker spins a ball of soft dough in the air, what shape does it make?

disk

9. A ball of pizza dough forms this shape because it's middle is pulled outward. What is stretching the dough outward?

inertia / momentum

10. *(Will not be on a test)* When the spinning pizza dough ball that gets stretched outward, it is only the middle (equator) that gets pulled outward. Why is the middle pulled outward (as opposed to the poles)?

The middle is fastest, so it has more momentum

11. What would happen if you were to spin a water balloon faster and faster and faster, using a drill?

It would form a disk.

Part 4: The Nebula's Temperature Changes:

12. What happens to the ~~speed and~~ temperature of molecules when you squeeze them into a small space?

~~Speed:~~ Temperature: Increases

13. As gravity caused our **solar nebula** to contract, what happened to the nebula's temperature?

Temp. increased

Why? because it was compressed (squeezed)

14. Where in the nebula do you think the temperatures were the hottest? Why? [This area is where the *sun is soon to be "born."*]

At the center, because that's where pressure is the highest.

Part 5: The Sun is Born (and the Nebula's temperature *really* changes)

15. The Sun's energy comes from nuclear fusion. Most of this nuclear fusion is the fusion of hydrogen atoms into helium atoms. In this process, the nuclei (centers) of four hydrogen atoms get squeezed together with so much force that they fuse to create one helium atom. Fortunately for us, one helium atom does not have as much mass as four hydrogen atoms. This means some mass gets "lost" during the fusion process. This mass isn't really lost; it is turned into energy. Continued↓

a. The amount of energy that is produced by nuclear fusion can be calculated using the formula $E=mc^2$. E = the energy. m = the mass that is "lost." c = the speed of light. c^2 = the speed of light, squared. Even if the lost mass is very small, an enormous amount of energy is produced by this process. Use the formula to explain why.

The speed of light squared (c^2) is a really big number.

b. Atomic nuclei are all positive, and positive charges are repelled by other positive charges. It takes an incredible amount of force to slam hydrogen atoms together and cause them to fuse. Where in the solar nebula did nuclear fusion begin? Why?

Center, because that's the only place with enough heat and pressure.

c. What is the "fuel" of most nuclear fusion in our Sun?

Hydrogen

d. What is produced when nuclear fusion occurs in our Sun?

Helium

Part 6: The Nebula Clears Up

16. Before nuclear fusion began in the sun, the solar system had been a rotating disk of ice ("frozen gas") and dust. When nuclear fusion began and the sun was born, what do you suppose happened to the frozen gases near the center of the center of the solar system?

Melted and were blown away by the solar wind

17. The ice in the solar system was mostly hydrogen gas that had been so cold that it was frozen. As the sun heated up, where did most of this gas survive, near the center or at the edge of the solar system?

18. The planets near the sun (inner planets) are rocky, with very little gas around them. The outer planets are *gas giants*, made of mostly hydrogen gas. What accounts for this difference between the inner and outer planets?

Most gas near sun was melted and blown away.

Part 7: Planets Form and Continue To Orbit

19. What force caused the dust and gas in the solar system to clump together to form planets?

gravity

20. Today we have a solar system of planets that orbit the sun in relatively stable orbits. In a stable orbit, two opposing tendencies are in balance. One tendency pulls planets away from the sun. The other pulls them toward the sun.

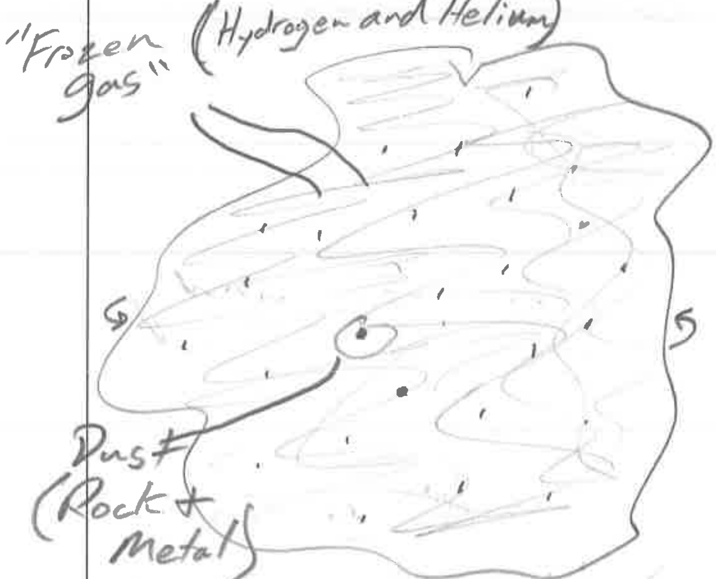
a. What prevents planets from flying away from the sun?

gravity

b. What prevents planets from falling into the sun?

momentum/inertia

Approximately 4.6by ago, the solar system was a giant, slowly rotating cloud of dust and *frozen gas* (a nebula). The "frozen gas" wasn't really a gas, since it was frozen, but it was an element that is usually a gas at ordinary temperatures.

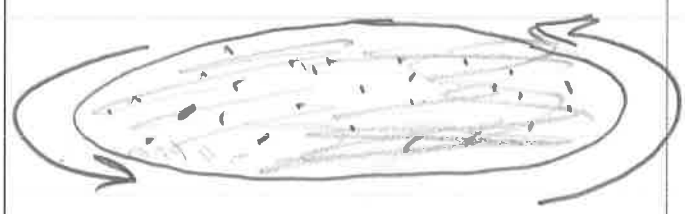


The cloud began to shrink due to gravity

Shrinking caused the nebula's rotation to speed up

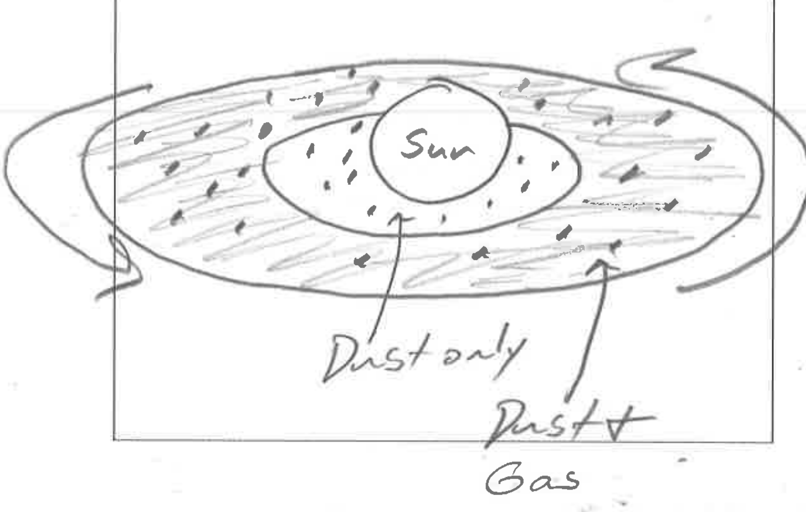
The nebulastretched into a disc because its momentum pulled it outward.

The nebula began to heat up because of compression (squeezing)



The sun was "born" as nuclear fusion began in the center of the nebula. Nuclear fusion could only happen here because it had high heat and pressure

Only the frozen gases far from the sun survived. Near the sun, dust and gas remained , but the frozen gases were melted and blown away by the sun.



Particles of matter in the cloud gradually clumped together due to the force of Gravity

The outer planetsprobably formed thick gas layers around rocky cores, but the inner planets only formed rocky cores without large amounts of gas because gas near ~~s~~ sun was blown away

The planets are stable in their orbits because momentum pulls them away from the sun about as hard as gravity pulls them toward the sun.