ESS 100 (Stapleton) Name: _____

Notes: Formation of Our Solar System Part 1 – Gravitational Contraction

Drawing #1 -- The Solar Nebula (Over 4.6 Billion years ago) – the solar system is ready to form

More than 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. The supernovae scattered those bits into space, where they became part of our nebula.

In the space below, create a labeled drawing representing the nebula, including its movement, and component materials.

The Nebula Begins to Contract

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? What about ice?

2. According to your answer to question number 1, what must have begun to happen to the overall size of the nebula?

   Why?

The Nebula's Motion Changes

3. Imagine a bunch of gas molecules in a container. What happens to their speed and temperature if the container is compressed?

4. What happens to the speed and temperature of some compressed molecules if the container is allowed to expand?

5. A spinning figure skater is like a container of gas molecules. What happens to the motion of the figure skater's particles when the skater compresses inward by pulling in their arms and legs? *[Try it! And Watch a video.]*

6. What happens to their motion when they relax and expand, by spreading out their arms and legs? *[Try it!]*

7. The nebula that formed our solar system was huge, and it was rotating very slowly. What happened to the speed of its rotation? Why?

The Nebula's Shape Changes

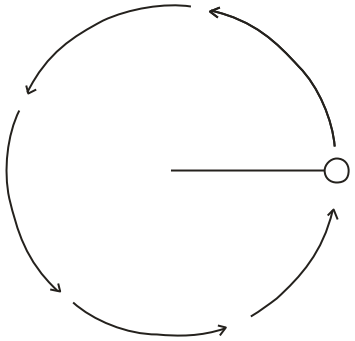
8. Fill in the missing part of Newton's 1st Law: *Objects at rest stay at rest, and objects in motion stay in motion in a* _____ _____ *and at a constant speed, unless they are acted on by an unbalanced force.*

9. _____ is sometimes referred to as "mass in motion," and it is a measure of something's tendency to keep moving in a straight line.

10. What is the formula for momentum?

11. What kinds of things have the most momentum?

12. 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. *[Try it!]*

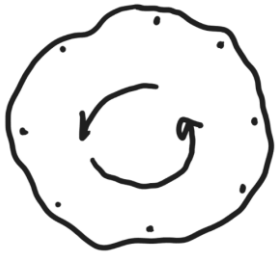


13. What causes the ball to continue flying in this direction?

14. When a pizza maker spins a ball of soft dough in the air, what shape does it make? *[Watch a video]*

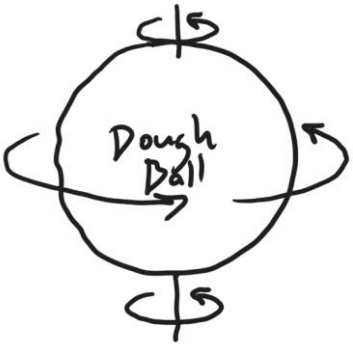
15. A spinning lump of pizza dough forms this shape because it's middle is pulled outward. What is stretching the dough outward?

16. The dough isn't really being pulled directly outward (away from the center). A force directly away from the center is called "centrifugal force," and it does not really exist. On the diagram to the right, use arrows to show the directions that some dough particles (the dots) are actually being carried by their momentum.



17. What part of a spinning blob has the most momentum? Why?

18. What would happen to a water balloon if we used a drill to spin it rapidly? Why?



19. Where is the "biggest part of the Earth?" Why?

20. As the solar nebula contracted (compressed together), what happened to its shape? Why?

Drawing #2: The Solar Nebula Begins Gravitational Contraction

- The size became _____ because

  _____

- The speed of rotation became _____ because

  _____

  _____

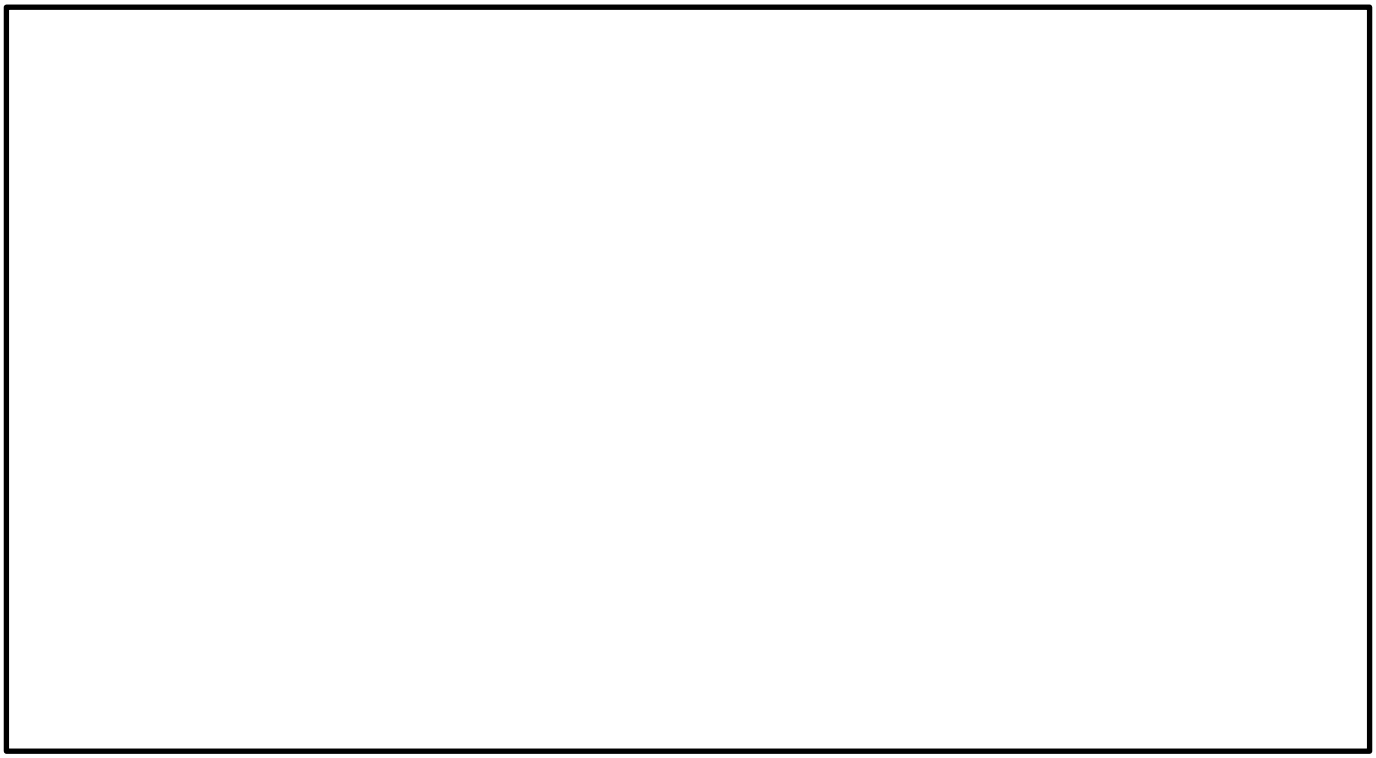
- The shape turned from _____ into a _____
- The shape changed because the _____ was moving fastest, so it had the most

  _____, which prevented it from being _____

  by _____.

- The nebula's temperature became _____ because _____

  _____



Part 2A: The Nebula's Temperature Continues To Change, and The "Frost Line" Forms

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

    Why?

12. Where in the nebula were the temperatures were the hottest?

13. Why were the temperatures hottest in this location?

14. The hot center of the forming solar system was called the _____.

16. The nebula had been a rotating disk of ice ("frozen gas") and dust. As the center heated up what do you suppose happened to the ice ("frozen gases") near the protosun?

17. 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?

Drawing #2: The Solar Nebula (Around 4.55 Billion years ago)
Draw and list the changes in the Solar Nebula after the

- The Ice _____ melted and vaporized because

  _____

15. The Sun's energy comes from **nuclear fusion**.

a. Define "fuse."

b. Where is an atom's nucleus?

c. Why are very high temperatures necessary for nuclear fusion to happen?

d. Where in the nebula was there high enough temperatures for fusion to begin?

e. In the Sun, what is the main element that fuses, and what gets created when it fuses?

16. Why does fusion of Hydrogen into Helium produce so much energy? The answer is that it takes four hydrogen atoms to fuse into one helium atom, and 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.

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. Calculate the amount of energy produced when one gram of mass is turned to energy.

b. Why don't we use nuclear fusion to create energy here on Earth?

Part 7: Planets Form and Continue To Orbit

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

. What causes static electricity? If you rub a balloon on your head, why does the balloon then stick to your head?

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?

b. What prevents planets from falling into the sun?

Add-in orbit activity? With tube and weight?

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

Shrinking caused the nebula’s rotation to

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

The nebula began to heat up because of

The sun was “born” as nuclear fusion began in the center of the nebula. Nuclear fusion could only happen here because

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

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

The outer planetsprobably formed thick gas layers around rocky cores, but the inner planets only formed rocky cores without large amounts of gas because

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