

ASTR101
Unit 8 Assessment
Answer Key

1. The early universe was too hot for any structures to exist. As space expanded, the universe cooled, allowing structures to form in the order of the strengths of the force that holds them together. The first structures were protons and neutrons, which formed from the binding together of quarks (a type of elementary particle). The next structures were nuclei formed from the binding together of neutrons and protons. Mostly the nuclei were helium-4, a combination of two protons and two neutrons. Finally, the expansion of space reduced the temperature sufficiently for electrons to bind with protons and helium nuclei to form neutral hydrogen and helium atoms. It was at this time, when the universe went from consisting of charged matter to neutral matter, that the cosmic background radiation was released.

2. They are structures formed from quarks, which are elementary particles.

3. The force between protons and neutrons (the strong nuclear force) that holds nuclei together is much stronger than the force between electrons and nuclei that holds atoms together (the electromagnetic force). Therefore, atoms are easier to break apart than nuclei and lower temperatures are required for their existence.

4. The cosmic background radiation was released when atoms formed about 380,000 years after the big bang. Prior to the formation of atoms, the ordinary matter in the universe consisted of protons, helium nuclei, and electrons. That is, it was completely ionized. Electromagnetic radiation interacts strongly with charged particles and photons created at this time were almost immediately absorbed. After atoms formed, the ordinary matter was neutral and the probability of photons being absorbed went to almost zero, releasing the radiation. The vast majority of photons present at this time are still in the universe today. However, the radiation has been cooled by the expansion of space from its initial value of about 3,000 K to its present value of 2.73 K.