AY2 Homework for Quiz 4: Fall 2019

1. **In the spectrum of a distant galaxy the absorption line of hydrogen that in the lab is at a wavelength of 656.3 nm is measured at 690.3 nm.**
   a. What is the redshift, z, of this galaxy?

   b. What is the recession velocity, v, of the galaxy?

   c. By what factor has the size of the Universe changed since the light left the galaxy?

2. **For many years, the value of the Hubble Constant was the subject of many studies and some controversy. The values from different studies clustered around two values: 50 km·s^{-1}·Mpc^{-1} and 100 km·s^{-1}·Mpc^{-1}. For each of these values calculate the expansion age of the Universe assuming no acceleration or deceleration.**

3. **Dark matter has been invoked to explain three observations on very different spatial scales. What are these observations?**

4. **A period of rapid inflation in the size of the Universe at very early times can be used to resolve four problems associated with non-inflation cosmologies. What are these four problems?**

5. **What is the evidence for an acceleration of the expansion of the Universe?**

6. **Based on our current data and models, what is the most likely long-term fate of the Universe?**

___ Eventual slowing of the expansion and a recollapse and "Big Crunch"

___ Ever-increasing expansion rate and cold, dark Universe

___ Radioactive decay of matter will light up the Universe for as long as we can predict

___ Star formation in galaxies will keep the Universe heated and light for at least the next 10^{20} years

7. **Which of the following best describes the large-scale distribution of galaxies in the Universe?**

___ Uniform in all directions

___ Clusters of galaxies, filaments and voids

___ Uniform except for small density variations at the level of ~1 in 100,000

___ completely random

8. **Which of the following are thought to be properties of or true of Dark Matter?**

___ it is "cold" (i.e. moves slowly compared to the speed of light)

___ it does not readily interact directly with photons or other matter (i.e. it has a small cross-section for interations)

___ it does not emit or absorb electromagnetic radiation

___ it is primarily inferred by its gravitational effect on other matter

9. **Which of the following are true (T), which false (F)?**

___ the total star formation rate in the Universe has been relatively steady since about 1 billion years after the Big Bang

___ Quasars were much more common in the period between 1 and 3 billion years after the Big Bang than they were before or after that time

____ the merger rate of galaxies has been steadily increasing over time as the Universe expands

____ Dark Matter is much more common than the type of matter that makes up stars, planets and humans

10. Which of the following are fundamental particles?

___ Proton
___ Electron
___ Hydrogen atom
___ Neutron
___ Up quark
___ positron (anti-electron)
___ electron neutrino

11. What was the temperature of the Universe in kelvins and the average energy of a particle in eV at 10^{-4} seconds after the Big Bang?

12. When was the last instant after the Big Bang when it was possible to form Top quark/anti Top quark pairs in interactions in the expanding Universe?

13. Where is the formation site for each of the following elements? equilibrium fusion in stars (A), SNII explosions (B), Hot Big Bang (C)

_____ Hydrogen

_____ Thorium

_____ Iron

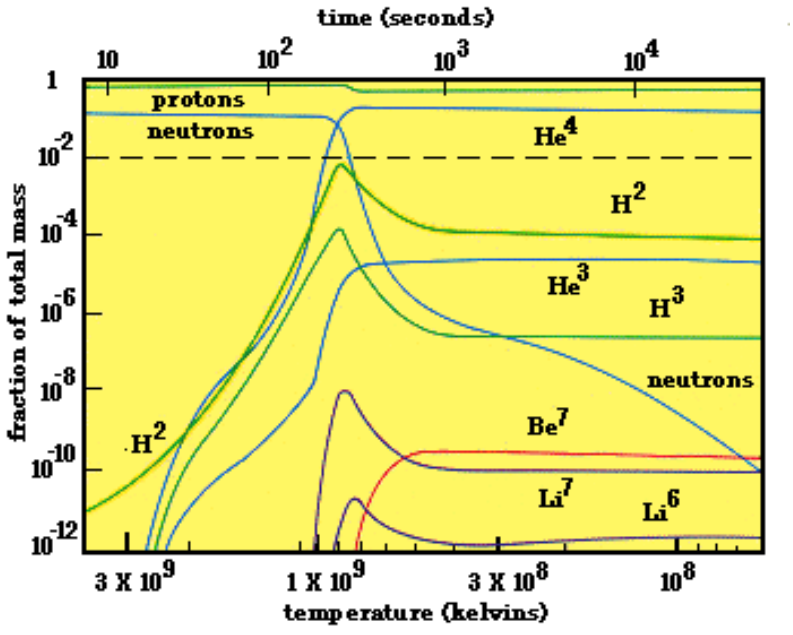
_____ Helium

14. Use the diagram below (next page) to answer the following questions:

a) At what times is the neutron abundance at its largest?

b) What is the ratio of He^4 to He^3 after nucleosynthesis has ended?

c) At what temperature does nucleosynthesis in the early Universe end?



15. What was the nature of the transition in the Universe that occurred around 380,000 years after the Big Bang?

___ the end of the era of nucleosynthesis

___ electrons recombined with hydrogen nuclei and the Universe became transparent to electromagnetic radiation

___ the first stars were formed

___ quarks combined to make protons and neutrons

16. Which of the following provide supporting evidence for the Hot Big Bang model?

___ The abundances of elements heavier than He are lower than the solar values in older stars

___ The predicted abundances for He^4, He^3, H^2, and Li^7 at the time of "element freezeout" around 300 seconds after the Big Bang match observations

___ The presence of a ubiquitous background radiation characteristic of that from a 3K solid

___ fluctuations of around 1 part in 100,000 in the temperature of the cosmic microwave background

17. The temperature of the gas in the Universe at the time it became neutral was ~3000K. Why does the cosmic microwave background appear to arise from a 3K source?

18. Which of the following describe the "horizon problem" in cosmology?

_____ the cosmic microwave background is at a uniform temperature over the entire sky yet regions separated by large angles would not have been in causal contact in a Universe that had expanded uniformly since the Big Bang

_____ we see the same galaxies looking directly forward and directly back because light is curved around the universe which confuses investigations of large-scale structure

_____ if the Universe was not spatially flat it would have collapsed back on itself

_____ because of the curvature of the Universe we can not see a large part of the observable Universe

19. The theory of cosmic inflation was originally motivated to understand why magnetic monopoles were so rare in the Universe. What other cosmological puzzles does inflation resolve?

___ That we appear to live in a spatially "flat" universe with Ω_{total} =1.0

___ The energy released during the inflationary period that resulted in the formation of the light elements H, He and Li

___ The growth of quantum fluctuations during inflation provided the small fluctuations in the cosmic microwave background that were the seeds of galaxy and structure formation

___ Inflation allows us to understand what existed before the Big Bang

20. Which of the following are true (T), which false (F)?

___ the merger rate of galaxies has been steadily increasing over time as the Universe expands

___ Dark Matter is much more common in the Universe than the type of matter that makes up stars, planets and humans (baryonic matter)

21. Which of the following techniques are used to detect planets orbiting stars other than the Sun?

___ measuring small periodic radial velocity variations in the exoplanet host stars

___ measuring small changes in the total light from a host star when the exoplanet passes in front of the star

___ directly imaging exoplanets orbiting their host stars

___ using the boost in brightness of a background star when an exoplanet passes directly between the back star and the Earth and gravitationally lenses the star

22. Which of the following are true (T) which false (F) regarding what we know about exoplanets as of 2019?

___ Although we have now discovered many exoplanets, to date we have not found another system with more than one planet

___ The most common type of exoplanet discovered to date is approximately ½ the mass of the Earth

___ Most exoplanets discovered to date are very close to or in the "habitable zone" of their host stars

___ the majority of exoplanets discovered to date have been detected via the light curve/transit technique

23. Which of the following statements are true (T), which false (F) regarding the "habitable" zone for exoplanets?

____ It is the region in possible orbits for exoplanets where the temperatures allow for liquid water

____ For smaller-mass, cooler stars than the Sun, the habitable zone is closer to the star

____ For a given mass exoplanet, it is easier to detect the planet in the habitable zone of a low-mass star than to detect it in a higher-mass star

____ The only planet known to existing in the habitable zone of a star is the Earth