Phys333 – sample questions for final

USEFUL INFO: \( c = 300,000 \text{ km/s} \); \( 1 \text{ AU} = 1.5 \times 10^{11} \text{ m} \); \( 1000 \text{ nm} \approx \frac{hc}{eV} \); \( eV/k \approx 10^4 \text{ K} \)

H-ionization energy is 13.6 eV

Name___________________________________

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Why do we call dark matter "dark"?
   A) We cannot detect the type of radiation that it emits.
   B) It emits no visible light.
   C) It blocks out the light of stars in a galaxy.
   D) It emits no or very little radiation of any wavelength.

2) What two quantities did Edwin Hubble plot against each other to discover the expansion of the Universe?
   A) age and distance
   B) velocity and temperature
   C) luminosity and temperature
   D) luminosity and distance
   E) velocity and distance

3) Why should galaxy collisions have been more common in the past than they are today?
   A) Galaxy collisions shouldn't have been more common in the past than they are now.
   B) Galaxies attracted each other more strongly in the past because they were more massive; they had not yet turned most of their mass into stars and light.
   C) Galaxies were closer together in the past because the universe was smaller.
   D) Galaxies were more active in the past and therefore would have collided with each other more frequently.
   E) Galaxies were much bigger in the past since they had not contracted completely.

4) How do we know that there is much more mass in the halo of our galaxy than in the disk?
   A) Stars in the outskirts of the Milky Way orbit the galaxy at much higher speeds than we would expect if all the mass were concentrated in the disk.
   B) There are so many globular clusters in the halo that their total mass is greater than the mass of stars in the disk.
   C) Although the question of mass in the halo was long mysterious, we now know it exists because we see so many brown dwarfs in the halo.
   D) We don't know that there is more mass in the halo; it is only a guess based on theory.
   E) The recent discovery of photinos, combined with theoretical predictions, tells us that there must be a huge mass of photinos in the halo.
5) Suppose we observe a Cepheid variable in another galaxy. The Cepheid brightens and dims with a regular period of about 10 days. What good will this observation do us?
   A) We will be able to use its period to determine its luminosity and hence to calculate the distance to its galaxy.
   B) It will allow us to calculate the rotation rate of the galaxy.
   C) It will allow us to determine the mass of the galaxy.
   D) Under the rules of the International Astronomical Union, we will be entitled to naming rights for the galaxy.

6) How does the diameter of the disk of the Milky Way Galaxy compare to its thickness?
   A) The diameter is about 100 times greater than the thickness.
   B) The diameter is about 10 times greater than the thickness.
   C) The diameter is about 100,000 times greater than the thickness.
   D) The diameter and thickness are roughly equal.

7) What is Einstein's cosmological constant?
   A) the value of the acceleration of the universe
   B) the value that measures the strength of gravity across the universe
   C) the size of the cosmological horizon
   D) a repulsive force that counteracts gravity and was introduced to allow for a static universe
   E) the value of the expansion rate of the universe

8) Approximately how long does it take the Sun to orbit the Milky Way Galaxy?
   A) 23 billion years
   B) 23,000 years
   C) 230 million years
   D) 230,000 years
   E) 2.3 million years

9) What makes white-dwarf supernovae good standard candles?
   A) They are very bright, so they can be used to determine the distances to galaxies billions of light-years away.
   B) They should all have approximately the same luminosity.
   C) They occur so frequently that we can use them to measure the distances to virtually all galaxies.
   D) We have had several occur close to us in the Milky Way, so we have been able to determine their luminosities very accurately.
   E) both A and B

10) What kinds of objects lie in the halo of our galaxy?
    A) gas and dust
    B) O and B stars
    C) open clusters
    D) globular clusters
    E) all of the above
11) What is meant by the critical density of the universe?
   A) the average density of the space between galaxies
   B) the minimum density that a universe needs in order to form stars
   C) the precise density marking the dividing line between a universe that has enough mass to contract again and a universe that will continue to expand forever
   D) the minimum density that a universe needs in order to create hydrogen
   E) the minimum density that a universe needs in order to form galaxies

12) Suppose a galaxy with a distance of 500 Megaparsec follows Hubble's expansion law with a Hubble constant of $H_0 = 70$ km/s/Mpc. How fast is the galaxy receding from us?
   A) 7 km/s
   B) 70 Mpc/s
   C) 35,000 km/s
   D) 70 km/s
   E) 0.70 times the speed of light

13) What does the universe look like on very large scales?
   A) Galaxies are distributed in a great shell expanding outward from the center of the universe.
   B) Galaxies are distributed in a hierarchy of clusters, superclusters, and hyperclusters.
   C) Galaxies appear to be distributed in chains and sheets that surround great voids.
   D) Galaxies are randomly distributed.
   E) Galaxies are uniformly distributed.

14) Spiral galaxy rotation curves are generally fairly flat out to large distances. Suppose that spiral galaxies did not contain dark matter. How would their rotation curves be different?
   A) The rotation curve would look the same with or without the presence of dark matter.
   B) The orbital speeds would fall off with increasing distance from the galactic center.
   C) The rotation curve would be a straight, upward-sloping diagonal line, like the rotation curve of a merry-go-round.
   D) The orbital speeds would rise upward with increasing distance from the galactic center, rather than remaining approximately constant.

15) Why did the solar nebula heat up as it collapsed?
   A) As the cloud shrank, its gravitational potential energy was converted to thermal energy.
   B) As the cloud shrank, its kinetic energy was converted to gravitational potential energy.
   C) Radiation from other nearby stars that had formed earlier heated the nebula.
   D) The shock wave from a nearby supernova heated the gas.
   E) Nuclear fusion occurring in the core of the protosun produced energy that heated the nebula.

16) The depth of the dip in a star's brightness due to the transit of a planet depends most directly on
   A) the planet's size.
   B) the planet's density.
   C) the size of the planet's orbit.
   D) the planet's mass.
   E) the eccentricity of the planet's orbit.
17) The Doppler method of discovering extrasolar planets works best for
   A) high mass planets far from their host star.
   B) planets that have been ejected from their systems.
   C) low mass planets close to their host star.
   D) low mass planets far from their host star.
   E) high mass planets close to their host star.

18) What are greenhouse gases?
   A) gases that absorb infrared light
   B) gases that absorb visible light
   C) gases that transmit visible light
   D) gases that transmit infrared light
   E) gases that absorb ultraviolet light

PROBLEMS: Answer the question(s), showing the work of any calculations needed. For multiple part problems, if you can't answer an initial part, just define a symbol for it to use as needed in any subsequent part.

19) (4 points) At the distance of 8 kpc to the galactic center:
   a. What is the physical size (in AU) of an angle \( \alpha = 1 \) arcsec?

b. What is the angle \( \alpha_c \) subtended by the central parsec cluster? Give your answer in both radians and arcsec.
20) (8 points) A main sequence star with effective temperature of 5800 K shows a periodic drop of 0.25% in apparent brightness every 2.8 years.

a. What is the star's radius and mass, in solar units.

b. Assuming the decrease in brightness is due to a transiting planet, estimate the planet's radius, in units of the stellar radius.

c. What is the planet's distance in au) from the star.

d. About what is the planet's equilibrium temperature, in K.

21) (4 points) Consider accretion down to a radius $R_a$ that is a factor $R_a/R_s = 10$ times the Schwarzschild radius $R_s$.

a. Compute the efficiency $\epsilon = E_g/mc^2$ for the gravitational energy gain $E_g$ as a fraction of the rest-mass energy $mc^2$ of the accreted mass.

b. If this energy is radiated away by light, what would be the associated luminosity (in units of $L_{\text{sun}}$) for an accretion rate of 1 $M_{\text{sun}}/\text{yr}$.
22) (8 points) Suppose a quasar shows absorption from a Lyman-alpha cloud at an observed wavelength \( \lambda_{\text{obs}} = 183 \text{ nm} \).

a. Given that Lyman-alpha has a rest wavelength of about \( \lambda_{21} = 122 \text{ nm} \), what is the redshift \( z \) for this cloud.

b. What is its inferred recession speed \( v_r \) (in km/s)?

c. For a Hubble constant \( H_0 = 67 \text{ (km/s)/Mpc} \), what is its distance, in Mpc?

d. What was the universe's scale factor \( R \) when the quasar emitted the light we now observe?