Name:_____

Intro Astro Lab Prep Quiz: Lab 12: Cosmos

Instructions: There are X multiple-choice problems each worth 1 mark for a total of X marks altogether. Choose the **BEST** answer, completion, etc. Leave no answers blank. If you do not know answer, eliminate wrong ones and guess. Read all responses carefully. **NOTE** long detailed responses won't depend on hidden keywords: keywords in such responses are bold-faced capitalized.
This is a $2X$ minute quiz.

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
1.	O	O	O	O	O	11.	O	O	O	O	O
2.	O	O	O	O	O	12.	O	O	O	O	O
3.	O	O	O	O	O	13.	O	O	O	O	O
4.	O	O	O	O	O	14.	O	O	O	O	O
5.	O	O	O	O	O	15.	O	O	O	O	O
6.	O	O	O	O	O	16.	O	O	O	O	O
7.	O	O	O	O	O	17.	O	O	O	O	O
8.	O	O	O	O	O	18.	O	O	O	O	O
9.	O	O	O	O	O	19.	O	O	O	O	O
10.	O	O	O	O	O	20.	O	O	O	O	O

1. "Let's play *Jeopardy*! For $100, the answer is: This astronomer discovered the extragalactic nature of the spiral nebulae (now called spiral galaxies)."

   Who is _____, Alex?

   a) Vesto Slipher (1875–1969) b) Albert Einstein (1879–1955)
   c) Edwin Hubble (1889–1953) d) Georges Lemaitre (1894–1966)
   e) E.A. Milne (1896–1950)

2. Observed galaxies were originally not known to be galaxies though speculation that they were goes back to the 17th century. The spiral nature of some of the observed galaxies was known from mid-19th century on. These galaxies with a spiral nature were usually called _____ from the mid-19th century to circa 1924 and even in later years by some including Edwin Hubble (1889–1953) who had proven they were galaxies.

   a) island universes b) spiral nebulae c) other Milky Ways d) star clusters
   e) star whirlpools

3. The cosmological redshift and Doppler shift are both shifts in wavelength of spectrum of electromagnetic radiation between emission and absorption. They are related, but different, effects. The cosmological redshift is caused by the _____ and the Doppler shift by ordinary velocities relative to inertial frames. but

   a) space b) degrowth of space c) quarks d) growth of space e) general relativity

4. The 1st order cosmological redshift and 1st order Doppler shift have the same formula in appearance $v = (\Delta\lambda/\lambda)/c$, where $z = \Delta\lambda/\lambda$ is relative wavelength shift, v is the recession velocity for the cosmological redshift and ordinary velocity relative to an inertial frame for the Doppler shift, and c is the vacuum speed of light. Given $v = 1000\,\text{km/s}$ and $2.99792458 \times 10^5\,\text{km/s}$, what is $z = vc$ to 3-digit accuracy.

   a) $z = 0.00334$. b) $z = 0.333$. c) $z = 0.533$. d) $z = 0.00534$. e) $z = 1.00$.

5. The 1st order cosmological redshift and 1st order Doppler shift have the same formula in appearance _____, but the interpretation is of v is different. For the cosmological redshift, v is recession velocity which is a rate of growth of space literally according to general relativity. For the Doppler shift, v is ordinary velocity measured relative to an inertial frame.

   a) $z = vc$ b) $z = v/c$ c) $z = (v/c)^2$ d) $z = (vc)^2$ e) $z = 1/(vc)^2$

6. A fiducial value (i.e., reference value) for the Hubble constant is:

   a) 50 (km/s)/Mpc. b) 70 (km/s)/Mpc. c) 85 (km/s)/Mpc. d) 100 (km/s)/Mpc.
   e) 118 (km/s)/Mpc.

7. Characteristic ages and size scales for most expanding universe models are, respectively, the _____ and the _____.

   a) Hubble time $1/H_0$; Hubble length c/H_0 b) Hubble time c/H_0; Hubble length $1/H_0$
   c) Hubble length c/H_0; Hubble time $1/H_0$ d) Hubble time H_0; Hubble length cH_0
   e) Hubble length cH_0; Hubble time H_0

8. Two distance measures that arise in cosmology are _____ and _____.

   a) proper distance; improper distance b) improper distance; luminosity distance
   c) proper distance; proper distance d) improper distance; density distance
   e) density distance; luminosity distance

9. Luminosity distrance is

   a) the same as proper distance in all cases.
   b) determined using the formula $r_{\rm L} = [L/(4\pi F)]^{1/2}$ in all cases if extinction is negligible.
   c) that is the length of an object undergoing FitzGerald contraction in the inertial frame of measurement.
   d) is **NOT** an improper distance.
   e) is **NOT** an improper fraction.

10. What kind of supernovae provided the luminosity distances that were the first convincing evidence for the accelerating universe?

    a) Type II supernovae (SNe II). b) core collapse supernovae.
    c) Type Ib supernova (SNe Ib). d) Type Ia supernovae (SNe Ia).
    e) Type IIn supernovae (SNe IIn).

11. Luminosity distances for Type Ia supernovae (SNe Ia) provided the first convincing evidence for the:

    a) expanding universe. b) Einstein universe. c) accelerating universe.
    d) de Sitter universe. e) big rip universe.

12. Luminosity distances for Type Ia supernovae (SNe Ia) are determined by fitting _____ for known-distance SNe Ia to _____ for unknown-distance SNe Ia.

    a) radio emission. b) spectra. c) light curves. d) color index. e) age.

13. The proper distances between all points that participate in the mean expansion vary according to the cosmic scale factor $a(t)$ (where t is cosmic time since the Big Bang) according to the formula:

    a) $r = ar_0$. b) $r = a^2 r_0$. c) $r = a^{-2} r_0$. d) $r = a^{-1} r_0$. e) $r = e^a r_0$.

14. Given the energy density E of a blackbody radiation field scales as T^4 (i.e., temperature to the 4th power) and the cosmic background radiation (CBR) energy density E scales (which is a blackbody radiation field) scales as a^{-4} (where a is the cosmic scale factor), what is the formula for cosmic temperature T in terms of T_0, a_0 and a?

    a) $T = T_0(a/a_0)$ b) $T = T_0(a/a_0)^4$ c) $T = T_0(a/a_0)^2$ d) $T = T_0(a_0/a)^4$
    e) $T = T_0(a_0/a)$

15. The cosmological redshift is the primary cosmic distance measure because it is:

    a) a direct observable and relatively easy to measure from **SPECTROSCOPY**.
    b) a direct observable and relatively easy to measure from **PHOTOMETRY**.
    c) an indirect observable and relatively easy to measure from **PHOTOMETRY**.

d) an indirect observable and relatively easy to measure from **SPECTROSCOPY**.
e) in indirect observable and relatively hard to measure from **PHOTOMETRY**.

16. The relationships between cosmological redshit z and cosmic scale factor $a(t)$ are very simple:

$$\frac{a_0}{a} = z + 1 \ , \qquad z = \frac{a_0}{a} - 1 \ , \qquad \frac{a}{a_0} = \frac{1}{z+1} \ .$$

So getting a/a_0 from z is easy. But we do not get $a(t)$ directly: i.e., a as a function of cosmic time t. If we did, we would know a lot more about the observable universe. It's a pity galaxies do not have big clock faces on them from which we could read cosmic time.

Now for $z >> 1$ (i.e., cosmological remote astronomical objects), we find:

a) $a/a_0 = z$. b) $a/a_0 = 1/z$. c) $a/a_0 = 1/z^2$. d) $a/a_0 = z^2$. e) $a/a_0 = 1$.

17. Given

$$\frac{a_0}{a} = z + 1 \ ,$$

what is the ratio a/a_0 for recombination (i.e., the recombination era of the evolution of the universe) for which $z \approx 1100$?

a) $a/a_0 \approx 1100$. b) $a/a_0 \approx 0.9 \times 10^3$. c) $a/a_0 \approx 0.9 \times 10^{-3}$. d) $a/a_0 \approx 900$.
e) $a/a_0 \approx 110$.

18. The dominant component of the diffuse extragalactic background radiation (DEBRA) is the:

a) cosmic gamma-ray background (CGB). b) cosmic X-ray background (CXB).
c) cosmic ultraviolet-optical-infrared background (CUVOIRB).
d) cosmic microwave background (CMB). e) cosmic radio background (CRB).

19. The term accelerating universe is used to describe a cosmological model in which the rate of expansion of the universe (i.e., the rate of change of the rate of change of the cosmic scale factor $a(t)$) is:

a) increasing. b) decreasing. c) zero. d) undetermined. e) indeterminable.

20. According to the Λ-CDM model (with parameter values fitted year 2018) the age of the universe is and the transition time from deceleration to acceleration is _____.

a) 13.8 Gyr; 6.2 Gyr b) 6.2 Gyr; 13.8 Gyr c) 13.8 Gyr; 10.02 Gyr
d) 10.02 Gyr; 13.8 Gyr e) infinite; inapplicable.