Lecture 8 - Exoplanets and life in the Universe

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

1) According to our theory of solar system formation, which law best explains why the solar nebula spun faster as it shrank in size? 1) ________
   A) the law of universal gravitation
   B) the law of conservation of angular momentum
   C) Einstein's law $E = mc^2$
   D) the law of conservation of energy

2) What is the primary basis upon which we divide the ingredients of the solar nebula into four categories (hydrogen/helium; hydrogen compound; rock; metal)? 2) ________
   A) the atomic mass numbers of various materials
   B) the amounts of energy required to ionize various materials
   C) the locations of various materials in the solar nebula
   D) the temperatures at which various materials will condense from gaseous form to solid form

3) According to our present theory of solar system formation, which of the following statements about the growth of terrestrial and jovian planets is *not* true? 3) ________
   A) The jovian planets began from planetesimals made only of ice, while the terrestrial planets began from planetesimals made only of rock and metal.
   B) The terrestrial planets formed inside the frost line of the solar nebula and the jovian planets formed beyond it.
   C) Both types of planet begun with planetesimals growing through the process of accretion, but only the jovian planets were able to capture hydrogen and helium gas from the solar nebula.
   D) Swirling disks of gas, like the solar nebula in miniature, formed around the growing jovian planets but not around the growing terrestrial planets.

4) Why are terrestrial planets denser than jovian planets? 4) ________
   A) Actually, the jovian planets are denser than the terrestrial planets.
   B) Gravity compresses terrestrial planets to a higher degree, making them denser.
   C) The Sun's gravity gathered dense materials into the inner solar system.
   D) Only dense materials could condense in the inner solar nebula.

5) Current evidence suggests that many massive jovian planets orbit at very close orbital distances to their stars. How do we think these planets ended up on these close orbits? 5) ________
   A) These planets migrated inward after being born on orbits much farther from their stars.
   B) Despite their large masses, these planets are terrestrial in nature and therefore could form in their inner solar systems.
   C) These planets are jovian in nature and were able to form close to their stars because their solar nebulas were very cold in temperature.
   D) These planets were captured from other solar systems.

6) Suppose you are using the Doppler technique to look for planets around another star. What must you do? 6) ________
   A) Compare many spectra *of the star* taken over a period of many months or years.
   B) Compare many spectra *of an orbiting planet* taken over a period of many months or years.
   C) Carefully examine a single spectrum of an orbiting planet.
   D) Compare the brightness *of the star* over a period of many months or years.

7) In general, which type of planet would you expect to cause the largest Doppler shift in the spectrum of its star? 7) _______

A) a massive planet that is close to its star
B) a low-mass planet that is far from its star
C) a massive planet that is far from its star
D) a low-mass planet that is close to its star

8) Suppose a planet is discovered by the Doppler technique and is then discovered to have transits. In that case, we can determine all the following about the planet *except* 8) _______

A) its physical size (radius).
B) its rotation period.
C) its precise mass.
D) its density.
E) its orbital period.

9) You observe a star very similar to our own Sun in size and mass. This star moves very slightly back and forth in the sky once every four months, and you attribute this motion to the effect of an orbiting planet. What can you conclude about the orbiting planet? 9) _______

A) The planet must be farther from the star than Neptune is from the Sun.
B) The planet must have a mass about the same as the mass of Jupiter.
C) The planet must be closer to the star than Earth is to the Sun.
D) You do not have enough information to say anything at all about the planet.

10) All the following statements about known extrasolar planets are true. Which one came as a surprise to scientists who expected other solar systems to be like ours? 10) ______

A) Most of the planets orbit stars that are quite nearby compared to the scale of the entire Milky Way Galaxy.
B) In some cases, we've found more than one planet orbiting the same star.
C) Most of the planets are quite massive—much more like Jupiter than like Earth.
D) Some of the planets orbit their star more closely than Mercury orbits the Sun.

Problems

11) Assume a planet (mass = 1 $M_{jupiter}$ = 1.9 x 10^{30} g) is in circular orbit at 5.2 au around its 1$M_\odot$ - host star. 11) _____________

(a) Calculate the orbital period of the planet.
(b) Using the properties of the centre of mass, calculate the radius of the star's orbitabout the centre of mass of the system.
(c) If this system is at 10 pc, what is the angular amplitude (in arcsec) of the star'smotion in response to the gravitational force exerted on it by the exoplanet? Assumethe inclination of the orbit is 90^o, such that sin(i)=1.
(d) By how much will a spectral line from the star be Doppler-shifted due to theexoplanet's orbital motion? Hint: You might find it more useful to use Kepler's thirdlaw in terms of velocities (as we derived in the lecture "Binary star systems").
(e) Recalculate item (d) now assuming that this exoplanet orbits at 0.05 au (a factor of100 smaller).

12) Calculate the relative flux of the star that is blocked by a transiting exoplanet in the following systems: 12) ____________

(a) an Earth-sized planet (radius = 6400 km) orbiting around an M dwarf star with radius of 0.2 $R_\odot$.(
b) a Jupiter-sized planet (radius = $7.2x10^4$ km) orbiting around a solar twin (ie., star with same mass and radius as the Sun) .