Name: ....

ASTRONOMY 1102 – 1

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First Test –FALL 1999– Friday September 17

Part I – Multiple Choice questions (3 pts/question; total = 60 pts)
Identify the correct answers by placing a check between the brackets [ ]. Check **ALL** correct answers in the questions identified by a *.

*1) Some are wrong; which are correct?
- [x] The Milky Way is in the Local Group.
- [x] The Milky Way results from seeing the Galaxy (our galaxy) from the inside.
- [ ] The Local Supercluster is inside the Galaxy.
- [x] α Centauri is within the Milky Way.
- [ ] M31 is within the Galaxy.

*2) The following are material waves:
- [ ] infrared waves.
- [x] sound.
- [x] ocean waves.
- [ ] gamma-rays.
- [ ] X-rays.

3) The temperature at which all thermal motion ceases is
- [ ] 0 °C.
- [ ] 100 °C.
- [ ] 32 °F.
- [x] 0 K.
- [ ] 0 °F.

4) The temperature of an object is a measure of the
- [ ] total thermal energy of the object.
- [ ] potential energy of the object.
- [x] average kinetic energy of the atoms/molecules of the object.
- [ ] chemical potential energy of the object.
- [ ] radiative energy contained in the object.

5) The wavelength of UV (ultraviolet) radiation is
- [ ] longer than 700 nm.
- [ ] shorter than the wavelength of X-rays
- [ ] longer than the wavelength of IR (infrared).
- [ ] longer than 400 nm.
- [x] shorter than the wavelength of any visible radiation.

6) The correct symbol for an atom or ion with 2 protons, 2 neutrons and one electron is
- [x] ${}^{4}\mathrm{He}_2^{+}$.
- [ ] ${}^{4}\mathrm{C}_4^{-}$.
- [ ] ${}^{12}\mathrm{C}_6^{+}$.
- [ ] ${}^{4}\mathrm{He}_2$.
- [ ] ${}^{18}\mathrm{O}_8^{+}$.

7) The spectrum of a perfect thermal emitter of surface temperature T looks like
[x] a blackbody curve with the temperature T without any lines.
[ ] a pure emission line spectrum.
[ ] a blackbody curve with the temperature T with absorption lines.
[ ] a blackbody curve with the temperature T with emission lines.
[ ] the spectrum of a low density gas at a temperature T.

8) The total radiative power per unit surface emitted by a blackbody
[ ] increases linearly with temperature $\propto T$.
[ ] decreases in inverse proportion to the temperature $\propto 1/T$.
[ ] increases as the square of the temperature $\propto T^2$.
[x] increases as the fourth power of the temperature $\propto T^4$.
[ ] does not depend on the temperature.

9) Hot solids, liquids and dense gases emit
[ ] an emission line spectrum.
[x] a continuous spectrum.
[ ] an absorption line spectrum.
[ ] visible light only.
[ ] only infrared radiation.

10) Spectral "bands" due to vibrational and rotational transitions
[ ] are seen in the spectrum of atomic Helium.
[x] may be present in the spectra of molecules.
[ ] are only produced by single gaseous elements.
[ ] were first discovered by Newton.
[ ] are all caused by electrons jumping from one level to another.

*11) The higher the frequency of electromagnetic radiation,
[x] the shorter its wavelength.
[ ] the longer its wavelength.
[x] the higher the energy of the photons.
[ ] the lower the energy of the photons.
[ ] the faster it moves through space.

12) The lowest electronic energy state/level in an atom is the
[ ] ionized state.
[ ] first excited state/level and that is the normal state.
[ ] second excited state/level.
[x] ground state/level and that is the normal state.
[ ] unstable state.

*13) Changes in apparent position of a star due to the revolution of the Earth:
[x] parallax.
[ ] proper motion.
[ ] radial velocity.
[x] aberration of starlight.
[ ] precession.

14) What is wrong with the statement "It will be light years before we get to α Cen"?
   [ ] It will be much longer.
   [ ] It will happen a lot earlier.
   [ ] Time units used to denote distance.
   [ ] Nothing wrong with this statement, it is correct.
   [x] Distance units used as time units.

15) One true statement:
   [ ] The Solar System is at the center of the Galaxy.
   [x] The Local Group contains many billions of stars.
   [ ] The Local Supercluster contains fewer than a billion stars.
   [ ] The observable universe has a radius of 10 Mpc.
   [ ] The Solar System is 280 LY from the galactic center.

16) As a baseball thrown upward ascends
   [ ] kinetic energy is converted to thermal energy only.
   [ ] chemical potential energy is converted into kinetic energy.
   [x] kinetic energy is converted into gravitational potential energy.
   [ ] gravitational potential energy is converted into kinetic energy.
   [ ] energy is not conserved.

17) We see today a galaxy 3×10^7 LY away as it was (lookback time)
   [ ] 0 years ago.
   [ ] 30 thousand years ago.
   [ ] 3 million years ago.
   [x] 30 million years ago.
   [ ] 3 billion years ago.

18) The total mass of all the planets in the solar system added together is
   [x] less than 0.01 $M_\odot$.
   [ ] more than 0.01 $M_\odot$.
   [ ] about 10 $M_\odot$.
   [ ] less than a millionth of the mass of the sun.
   [ ] approximately 0.5 $M_\odot$.

19) The solar system completes one revolution around the galactic center in
   [ ] 23 years.
   [ ] 2.3×10^6 years.
   [ ] 2.3×10^{10} years.
   [ ] 1 year.
   [x] 2.3×10^8 years.

20) The speed of a star or galaxy along the line of sight is the
   [ ] proper motion.
   [ ] aberration.
   [ ] tangential velocity.
   [x] radial velocity.
   [ ] thermal velocity.

Part II – Problems (10 pts/problem; total = 40 pts) **NO CALCULATORS!**

Problem 1: Powers of Ten: The sun has an enormous mass of $M_\odot = 2 \times 10^{30}$ kg. A typical galaxy such as M31 contains about 100 billion stars. Assume the average mass of these stars is about 1 $M_\odot$.

a) Estimate the mass of the Andromeda Nebula in kg.

Mass of M31 = Number of stars × typical or average mass of these stars

$$M(\mathrm{M31}) = 100 \times 10^9 \times 2 \times 10^{30}\mathrm{kg}$$

$$M(\mathrm{M31}) = 10^{11} \times 2 \times 10^{30}\mathrm{kg} = 2 \times 10^{11+30}\mathrm{kg} = 2 \times 10^{41}\mathrm{kg}$$

b) The sun radiates 4×10^{26} joules every second. According to Einstein's equation 1kg of matter is equivalent to 10^{17} joule. Estimate how many kg does the sun lose every second.

$$\textit{Mass loss in one second due to fusion of H into He} =$$

$$\frac{\textit{Energy released every second})}{(\textit{Energy release per unit mass due to fusion of H into He})}$$

Therefore

$$\textit{Mass loss} = \frac{4 \times 10^{26}\mathrm{joule}}{10^{17}\mathrm{joule/kg}} = 4 \times 10^9\mathrm{kg}$$

Problem 2: Suppose a Saturn rocket can travel at 10 km/s and that its kinetic energy is 10^{14} joule. A new model Super-Saturn rocket can travel 10 times faster and is ten times lighter (less mass). What would be the kinetic energy for the Super-Saturn rocket? Show your reasoning.

The kinetic energy is given in general by an expression like

$$KE = \frac{1}{2}mv^2 ,$$

directly proportional to the mass and the square of the velocity. So, the KE of the Super Saturn is reduced by a factor of ten because of the mass being ten times smaller byut increased bya a factor of a hundred because of the higher speed. Therefore the KE of the Super Saturn is 10^{15} *joule.*

Problem 3: Two stars of the same dimensions but *different* surface temperatures are at the *same* distance from us. Star A has a surface temperature of 4000K while star B has a surface temperature of 8000K. Which appears brighter (or more luminous) and by how much (what factor)?

The luminosity of a star can be calculated using Stefan-Boltzmann's Law if we know the surface area and the surface temperature as follows:

$$L = 4\pi R^2 \sigma T^4$$

where $4\pi R^2$ *is the surface area of a sphere of radius* R *and* σ *is a radiation constant. Since in the above case the stars have the same dimensions their luminosities must simply be in proportion to the 4th power of the temperature. Therefore star B, which is 2 times hotter than star A, is* $2^4 = 16$ *times more luminous. Finally, since the stars are at the same distance, their apparent brightnesses must be in the same ratio. Recall that the flux or apparent brightness is given by the inverse square law*

$$Flux = \frac{L}{4\pi d^2},$$

where d *is the distance. Since* d *is the same, the flux ratio is equal to the ratio of luminosities.*

Problem 4: The diagram below shows a hot source whose spectrum can be considered to be like a perfect thermal emitter, and a cloud of gaseous Nitrogen at a lower temperature than the source. Several lines of sight are drawn with the "eye" indicating the point of view, and labelled with numbers. Write in the space provided the type of spectrum you should see from each of the chosen vantage points.

See Figure

1.– *Continuous spectrum, blackbody*

2.– *Emission spectrum of Nitrogen: bright lines, no emission at wavelengths other than those of Nitrogen*

3.– *Absorption spectrum of Nitrogen: the same blackbody as in 1., broken by dark absorption lines of Nitrogen.*

4.– *As in 2.*

5.– *As in 1.*