Quiz II

Each question worth 6 points

1. “We see very little of the world.” Explain this statement with respect to the electromagnetic spectrum. We see all the colors, isn’t that everything?
   Our eyes can only see a very small portion of the electromagnetic spectrum. We give names to the colors but they are just our response to different frequencies all within the visible spectrum.

2. Explain why the spectrum of an element is unique.
   The element uniquely identifies the number of protons in the nucleus. The number of protons fixes the electron energy levels which in turn fixes the possible energies of photons that can be emitted or absorbed by the atom.

3. Where fuel heating costs are an issue homeowners can request a survey of where their houses leak heat. A special photo is taken and they are shown where the heat leaks are.
   a. What is so special about the photo?
      The photo is made using infrared film.
   b. How does it find heat leaks?
      Because of blackbody radiation hot air escaping is brighter in the infrared than the rest of the house and shows up on infrared sensitive film.

4. Explain what physical conditions are needed to form an absorption spectrum? Give an example?
   An absorption spectrum is formed when light passes through a cool low density gas. This occurs, for example, in the atmospheres of stars or when an interstellar cloud is between us and a source as in the case of quasars.

5. Why is the phrase “heat to red hot” a valid procedure for heating to a fixed temperature? Why can’t we heat to “Blue heat”
   Any mass will glow red hot if its temperature is high enough so that its blackbody emission enters the visible spectrum. This occurs at the red or low energy part of the spectrum. As the object gets hotter its spectrum shifts towards the blue but because the blackbody spectrum is broad we get emission across the visible spectrum so the object emits all colors and emits white light rather than blue.

6. Explain why yellow or blue fluorescent light used at night in some parking lots can change the color of a car? Does the car really have a color?
   The paint on the car has a reflectance at each wavelength. The car’s color is determined by the spectrum of light shining on it times its reflectance at each wavelength. We think of the color of the car as its color when sunlight is shining on it. When we illuminate it with a different spectrum, as in the parking lots lights, we are shining a different mix of light colors on it so we get a different mix of light reflected from it and appears to change color. So the color the car appears depends on a combination of the paint properties and the light we shine on it.
7. The Moon is orbiting the Earth at about 1km/sec yet it shows virtually no Doppler shift. Explain why?
The Moon’s orbit is nearly circular. Therefore its velocity is about at right angles to the line of sight to the Moon. The Doppler shift only measures the component of velocity along the line of sight which is nearly zero for the Moon.

8. Describe two ways in which the atmosphere significantly alters what we can see from the ground.
The atmosphere absorbs light in certain wavelengths so that we cannot see UV or X-ray light on the ground for example.
Atmospheric turbulence causes the images of objects to be broadened compared to those without an atmosphere. This reduces the resolution of images we can get on the ground.

9. Describe two ways in which telescopes enhance the capabilities of the eye.
They increase the sensitivity of the eye by increasing the collecting area.
They increase the resolution of the eye by increasing its effective diameter.
They extend the wavelength sensitivity of the eye by being able to image at wavelengths the eye cannot see.

10. Describe two features of the solar system that argue for its formation from a disk of material.
The planets orbit the Sun in a disk.
The all orbit in the same sense and this sense is the same as the sense that the Sun itself is spinning

11. How do we measure the age of the solar system? Why are the ages of meteorites greater than the oldest rocks on earth?
We use the natural radioactive decay of some elements as a clock. The ratio of the decay products to parent nuclei varies with time.
Meteorites represent some of the earliest material formed in the inner solar system whereas the clock in the Earth’s crust was started when it solidified which means the Earth was already formed, melted and radially differentiated.

12. Why do we think of an inner and outer solar system? How are they different?
The inner solar system consists of terrestrial planets which are small rocky (high density) and relatively slowly rotating. The outer system consists of Jovian planets that are large, low density (gaseous) and rapidly rotating. The gap in planetary orbits between Mars (~1.5AU) and Jupiter (~5AU) make the division into an inner and outer solar system a natural one.

13. We believe that the terrestrial planets were built up from small dust grains sticking together so any piece of the early earth should look like any other piece. Why doesn’t the earth look like that now? How does it differ from this?
The early Earth was more or less homogeneous because it was made up of many smaller planetesimals stuck together. When it got big enough, the energy from collisions on its surface and the internal heat generated by natural radioactivity were sufficient to melt the Earth so that heavy elements sank to the center of the Earth and light elements rose to the surface. Currently, the Earth has a heavy
Nickel-Iron core, a mantle of denser rock with a crust of relatively light materials floating on it.

14. How and why is the thickness of the lithosphere of a planet related to its geologic activity?
The lithosphere of the planet is the rigid part of the planet that resists flexing of the planet. Thus when forces like tidal flexing or thermal stress are applied to the planet if the lithosphere is very thick it will resist changing shape and prevent volcanism or tectonics.

15. Why does the earth have a magnetic field but not the moon? How does the earth’s magnetic field protect us?
The moon is geologically dead because its core has already frozen so it is almost all lithosphere. In particular, there can be no current circulating within the moon so there can be no magnetic field. The Earth still has a molten core. The Earth’s magnetic field traps and deflects the stream of charged particles emitted by the Sun. These particles could do a great deal of damage on the Earth including stripping away the Earth’s atmosphere—this happened on Mars.

16. The lunar landscape has smooth, dark lowlands and heavily cratered lighter colored uplands. What history does this imply for the lunar surface?
The heavily cratered uplands must be very old. The smoother regions represent frozen lava flows that filled in the lowlands. The lava is a dark basalt which accounts for the color difference. So the Moon was geologically active in the past but not now.

17. Explain the greenhouse effect and show how it has worked differently on Mars, the Earth and Venus.
The greenhouse effect occurs when light from the Sun is absorbed by a planet surface and reradiated as blackbody radiation at the cooler surface temperature of the plane. The reradiated energy is in the infrared and can be absorbed by certain gases in the atmosphere, trapping the energy and heating up the atmosphere. On Mars, the atmosphere is very thin with a low fraction of greenhouse gases so Mars is cold. On Venus there is a very large fraction of greenhouse gases and the temperature has become very dense and very hot. The Earth is an intermediate case balanced between these two alternatives.

18. How were the jovian planets able to build up cores that are many earth masses in the same time frame that terrestrial planets couldn’t get more massive than the Earth? Why is there Hydrogen on Jupiter but no Hydrogen in the Earth’s atmosphere?
The Jovian planets formed in an environment which had ice grains as well as dust grains. The ice grains were so much more abundant and so much better at bonding that they speeded up the accretion process significantly resulting in much larger cores formed in the Jovian planets. As the Jovian planets built up more massive cores their gravity was sufficient to bond elements as light as Hydrogen. On the Earth, any Hydrogen in the atmosphere would evaporate into space because it would have escape velocity.

19. The Earth’s rotation causes terrestrial storm to circulate like whirlpools. Why don’t storms on Jupiter look like this in general? What do they end up looking like?
Because Jupiter is spinning so rapidly storms are stretched out into bands that circle the planet.

20. How do the cores of jovian planets differ from the cores of terrestrial planets?
The cores of the terrestrial planets consist almost entirely of iron and nickel whereas the cores of the Jovian planets also include hydrogen compounds and rock.

21. When we look at Jupiter we see a series of light and dark bands. What accounts for the difference in color? How does convection play a role in these bands.
These colors come from differences on composition and temperature. The higher features are colder with a higher proportion of ammonia and ices. Because of convection, material is rising in the lighter regions and falling in the darker regions.

22. Why do we believe that the large and small satellites of the jovian planets have different origins? What are these origins?
The larger satellites are all orbiting in the same direction that the planet is spinning, in the equatorial plane of the planet and with nearly circular orbits. Many of the smaller satellites are in highly elliptical and/or inclined orbits some are orbiting in the opposite direction that the planet is rotating. The larger satellites probably formed in place in the same process that formed the planets but the smaller satellites are most likely captured after the planet formed.

23. What signs are there that the extinction of the dinosaurs was catastrophic and caused by an object of extraterrestrial origin?
The dinosaur extinction is recorded in a very thin geologic layer that seems to occur at the same time all over the world. This thin layer also contains a high proportion of Iridium which is relatively rare on Earth but found in higher concentrations in meteorites.

24. The pressure of air at sea level is 14.7 pounds per square inch. What does this mean? Why must the air pressure at the top of a mountain be less than this?
If we take a square column of air one inch on a side and extending from sea level to outer space then all the air in it weights 14.7 pounds. In order to support this air the pressure at sea level has to be 14.7 pounds per square inch. At the top of a mountain that same column of air would start at the altitude of the mountain instead of sea level and therefore contain less air. Since it contains less air it would weigh less so the corresponding pressure at the top of the mountain to support that air can be less.

25. How does the way hydrostatic equilibrium works in Jupiter differ with how it works in a star?
On Jupiter the gravity that opposes the pressure of its atmosphere comes partly from the mass of the atmosphere and partly from the mass in the core. In a star however, there is no core and all the gravity comes from the gaseous material of the star. The star is all atmosphere.