PHAS1511 – problem sheet 1

1. From a given point on the Earth's surface, briefly describe why the view of the night sky on a clear night changes

a) over the course of a night [1]
b) over the course of a year [1]
c) over the course of thousands of years [3]

a) The Earth rotates on its axis. Therefore, if you are looking straight up, for example, your view changes throughout the day and night.
b) As well as rotating on its axis, the Earth orbits the Sun. When the Earth is on one side of its orbit, some stars are never seen because they only rise during daylight hours. Six months later, those stars will rise during the night and other stars which were visible will now only rise during the day.
c) Over thousands of years, the direction in which the Earth's rotational axis points changes slowly. Polaris is the pole star now, but in a few thousand years it will not be, and the sky will appear to revolve around a different point during the course of the night. In addition, some very nearby stars are moving rapidly enough through space that their positions relative to other stars will change. For example, 1000 years from now, Barnard's Star will have moved by almost 3 degrees from its current position.

2. Describe how the part of the night sky that you can see depends on where you are on the Earth's surface. [3]

From any position on the Earth's surface, half the sky is visible at any given time. During the night, the rotation of the Earth changes the hemisphere that is visible. If you were at the equator, then you would see the north pole on the north horizon, and the south pole at the south horizon, and so during a 24 hour period, the entire sky would be visible. If, on the other hand, you were at a pole, then stars on the celestial equator would be on your horizon, and half the sky would be permanently hidden. At intermediate latitudes, part of the sky is permanently visible, part is permanently invisible, and part is visible some of the time.

3. a) What is meant if a star or astronomical object is described as *circumpolar*? [2]
b) If you are at a latitude of 60 degrees north, circumpolar objects will have a declination higher than what value? [2]
c) If you are at a latitude of 20 degrees south, circumpolar objects will have a declination higher than what value? [2]

a) A circumpolar object is one which is always above the horizon as seen from a given point on the Earth's surface.
b) Which part of the sky is circumpolar depends on your latitude. Stars with a declination greater than (90-l) where l is your latitude are circumpolar in the northern hemisphere, and stars with a declination greater than (-90+l) are circumpolar in the southern hemisphere. So, if you are at a latitude of 60N, then any star with a declination between +30 and +90 will be circumpolar
c) If you are at 20 degrees south, then any star with a declination between -70 and -90 will be circumpolar.

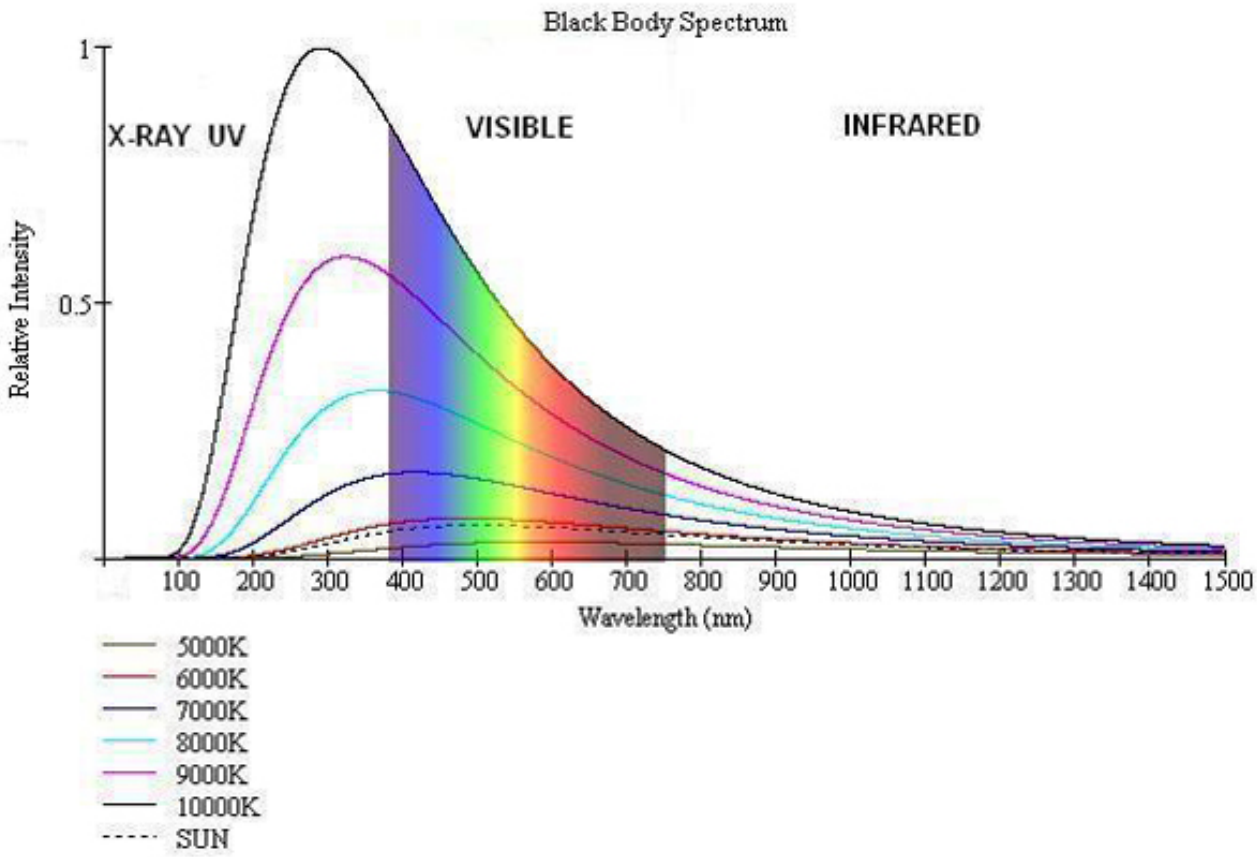
4.a) Describe one piece of evidence that light behaves like a wave [2]
b) Describe one piece of evidence that light behaves like a particle [3]

a) If you shine a light at a piece of card with two narrow slits in it, you see that the light produces an interference pattern, which shows that it has diffracted as it passed through the slits. This is analogous to parallel sea waves spreading out into a hemispheric pattern when they pass through a narrow gap such as a harbour, and shows that light also behaves like a wave.

b) The *photoelectric effect* occurs when light shines on a metal. If the light has a frequency higher than a certain threshold value, then electrons are emitted by the surface of the metal. The speed that the electrons are moving at doesn't depend on the intensity of the beam of light, but on its frequency. This does not make sense if light is behaving as a wave, but can be understood if it is behaving like a particle.

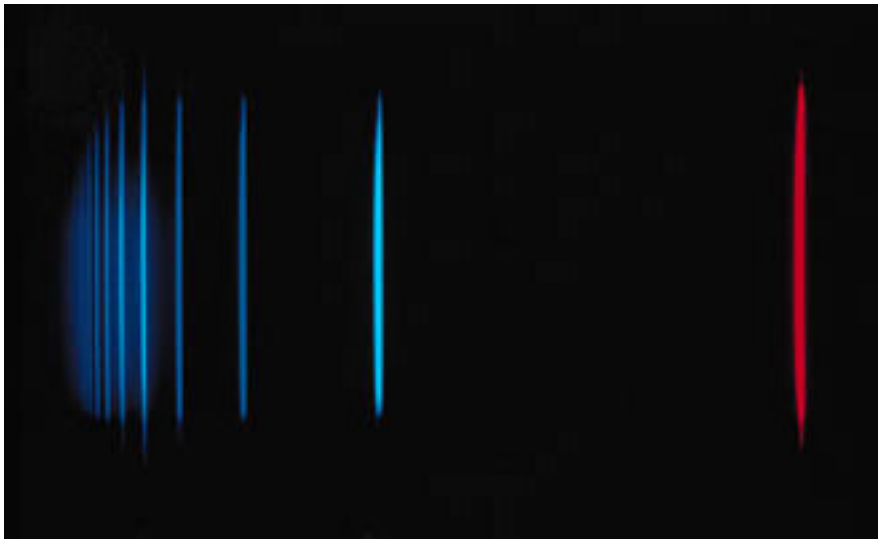
5. Describe what is meant by a *black body*. With the use of diagrams if necessary, describe how the temperature of a black body is related to its spectrum. [5]

A black body is a theoretical object which absorbs all radiation that falls upon it. The radiation that it emits is then determined only by its temperature, and not by what it is made of. The spectrum it emits covers all wavelengths, with a peak at a wavelength proportional to 1/T, and a total amount of energy emitted proportional to T^4. This diagram shows several black body spectra:

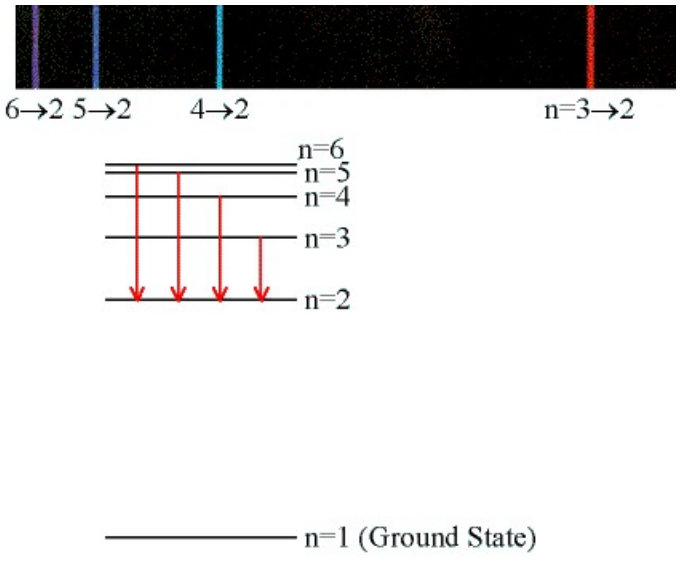


6.Hydrogen is the most common chemical element in the universe. What is the *Balmer Series* of Hydrogen? What does this series tell us about the structure of the hydrogen atom? [6]

The Balmer series is the name given to the spectral lines of hydrogen that are seen at optical wavelengths. Their spacing in wavelength follows a regular pattern, first noticed by Johann Jakob Balmer: from the line at the longest wavelength of 656.3nm, the gap to lines at shorter wavelengths becomes smaller at each successive step.



Niels Bohr interpreted the Balmer series as showing that electrons can orbit the nucleus of an atom only in certain fixed orbits or *energy levels*, and not at arbitrary positions. When an electron moves from one energy level to a lower one, a photon is emitted, at a fixed wavelength.



Total: [30]

Please hand in by **14 December**
(in person, to my pigeonhole, or e-mail to rwesson@star.ucl.ac.uk)