Introductory Astronomy

Homework 6: Light and Electromagnetic Radiation Not to be handed in. Homework solutions are posted already.

1. "Let's play *Jeopardy*! For $100, the answer is: In modern physics, it is the highest physical speed: i.e., the highest speed at which information can propagate."

   What is the speed of _____, Alex?

   a) sound b) thought c) rumor d) light in vacuum e) rumor in an information vacuum

2. At firework displays, the explosions produce a light flash and sound.

   a) The sound is heard before the flash is seen.
   b) The flash is seen before the sound is heard.
   c) Sound and flash come simultaneously.
   d) The sound is seen before the flash is heard.
   e) Neither effect is noticed by the spectators.

3. Visible light is conventionally divided into:

   a) violet, blue, green, yellow, orange, radio.
   b) X-ray, violet, blue green, yellow, orange, tangerine, red.
   c) Gamma-ray, X-ray, ultraviolet, visible, infrared, microwave, radio.
   d) mauve, navy, forest lawn, goldenrod, tamarind, cerise.
   e) violet, blue, green, yellow, orange, red.

4. Electromagnetic radiation (EMR) is:

   a) a wave phenomenon. The propagation speed is that of sound.
   b) a wave phenomenon. However, EMR also acts as if it came in packets called **protons**.
   c) a wave phenomenon. However, EMR also acts as if it came in packets called **photons**.
   d) a wave phenomenon. However, EMR also acts as if it came in packets called **electrons**.
   e) a particle phenomenon.

5. AM radio typically broadcasts at about $1\,\mathrm{MHz} = 10^6$ cycles per second. What is the approximate wavelength of this radiation? (Just use the vacuum speed of light $c = 2.99792458 \times 10^{10}\,\mathrm{cm/s}$ for the calculation: it is good enough for the present purpose.)

   a) $\sim 3 \times 10^4\,\mathrm{cm} = 300\,\mathrm{m}$. b) $\sim 1 \times 10^4\,\mathrm{cm} = 100\,\mathrm{m}$. c) $\sim 3 \times 10^{-4}\,\mathrm{cm}$. d) $\sim 3 \times 10^4\,\mathrm{m}$.
   e) $\sim 3 \times 10^2\,\mathrm{cm} = 3\,\mathrm{m}$.

6. The electromagnetic spectrum is:

   a) the distribution of electromagnetic radiation with respect to temperature.
   b) the spectrum of radiation emitted by a non-reflecting (i.e., blackbody) object at a uniform temperature.
   c) the entire wavelength range of electromagnetic radiation: i.e., the electromagnetic radiation range from zero to infinite wavelength, not counting the limit end points themselves.
   d) the magnetic field of the Sun.
   e) independent of wavelength.

7. What is the form of electromagnetic radiation that is usually most dangerous for life?

   a) Gamma-rays. b) Protons. c) Radio waves. d) Visible light. e) Ultraviolet light.

8. The wavelength range of visible light is about:

   a) 1–20 cm. b) 0.1–10 nm. c) 400–700 nm. d) 700–1000 nm. e) 0.700–1000 microns.

9. The Earth's atmosphere has various windows in which it is relatively transparent to electromagnetic radiation. The visible window extends from the very near ultraviolet to the near infrared. The intensity maximum of the solar spectrum actually falls in this window. Now the human eye is sensitive to electromagnetic radiation in the wavelength band $\sim$ 400–700 nm which falls in the visible window and which spans the maximum intensity region of the solar spectrum. Why might the human-eye sensitivity wavelength region be located where it is?

   a) Well the visible window is round and so is the eye.
   b) The eye may have evolved to be sensitive to the form of radiation that was **LEAST ABUNDANT** on the Earth's surface. In this way radio emission for communication would be unnecessary, except during geomagnetic storms. Finally, the conclusion has to be that X-rays are not ordinarily visible.
   c) The eye may have evolved to be sensitive to a form of radiation that was **ABUNDANT** on the Earth's surface thereby making a **BAD USE** of the electromagnetic radiation resource.
   d) The eye may have evolved to be sensitive to a form of radiation that was **ABUNDANT** on the Earth's surface thereby making a **GOOD USE** of the electromagnetic radiation resource.
   e) The eye may have evolved to be sensitive to a form of radiation that was **ABUNDANT** on the Earth's surface thereby making use of **RADIO WAVES**.

10. Why do nocturnal animals usually have large pupils in their eyes?

    a) For better vision in **DAY** conditions (when light levels are high) they have evolved large pupils (which are the apertures of the eyes). Light gathering power is proportional to the **SQUARE OF APERTURE DIAMETER**.
    b) For better vision in **NIGHT** conditions (when light levels are low), they have evolved large pupils (which are the apertures of the eyes). Light gathering power is proportional to the **SQUARE OF APERTURE DIAMETER**.
    c) For better vision in **NIGHT** conditions (when light levels are low), they have evolved large pupils (which are the apertures of the eyes). Light gathering power is proportional to the **APERTURE DIAMETER**.
    d) For better vision in **NIGHT** conditions (when light levels are low), they have evolved large pupils (which are the apertures of the eyes). Light gathering power is proportional to the **4TH POWER OF APERTURE DIAMETER**.
    e) For better vision in **NIGHT** conditions (when light levels are low), they have evolved large pupils (which are the apertures of the eyes). The large pupils allow them to see in the **RADIO**. All animals can actually see in the radio, but diffraction effects with small apertures make radio images too blurry to notice ordinarily.

11. The "particle" of light is the photon. The energy of an individual photon is inversely proportional to the wavelength of the light:

$$E = \frac{hc}{\lambda} ,$$

    where h is a universal constant called Planck's constant, c is the vacuum speed of light, and λ is wavelength. If the wavelength of light is changed by a multiplicative factor of 3, the energy of its

photons is changed by a multiplicative factor of:

a) 1/3. b) 3. c) 9. d) 1/9. e) 1 (i.e., it is unchanged).