PHYSICS 1020

Homework set 9

2 October 1996

[**9.4**] What evidence is there that the medium that carries light waves is not air?
Answer:
We receive light from the Sun and from stars even though it has to travel through space containing no air. Communication by radio waves with the space probes launched from the Earth is possible even after the probes have left the Earth's atmosphere.

[**9.12**] Light from the Sun takes about 8 minutes to reach Earth, whereas light from the nearest star (other than the Sun) (Proxima Centauri) takes about 4 years. How many times farther is it to this star than it is to the Sun?
Answer:
One year is 365 days with 24 hours each, each of which has 60 minutes. Assuming that the speed of light is the same everywhere, the ratio of distances is equal to the ratio of travel times, i.e.

$$= \frac{4 \cdot 365 \cdot 24 \cdot 60}{8} = 365 \cdot 12 \cdot 60 = 262800.$$

So, Proxima Centauri is about 260000 times farther from us than the Sun.

[**9.14**] You can get a sunburn even on a cloudy day. Why?
Answer:
Because ultraviolet radiation, which causes sunburn, can penetrate clouds (if the cloud layer is not too thick).

[**9.18**] What energy transformation occurs (from what type to what type?)
(a) when solar radiation warms your skin?
(b) In a flashlight?
(c) When microwaves warm your food?
Answer:

(a) radiant energy to thermal energy;

(b) chemical to electric, electric to radiant (visible and thermal radiation) and thermal energy;

(c) radiant to thermal energy.

[**9.22**] According to Table 9.2, which will be the first ozone-destroying chemical to decrease to harmless levels, and how long will it take? Which will be the last, and how long will it take?

Answer:

From table 9.2 we conclude that it will take seven years for the level of methyl chloroform in the Earth's atmosphere go down to harmless levels, while for CFC-12 it will take 130 years.

[**9.30**] Making estimates: The mass of one liter of gasoline is about 0.7 kg, and the mass of 1 gallon is about 2.7 kg. A CO_2 molecule is about three times as massive as a carbon atom. Using the fact that about 85% of the mass of gasoline is carbon, estimate the mass of CO_2 that a typical automobile puts into the atmosphere each year. Compare this with Table 9.3.

Answer:

Let's assume that you drive roughly 12000 miles (20000 km) per year. At about 20 miles to the gallon, this corresponds to a gasoline consumption of about 600 gallons (i.e. 2340 liters), which is about 1600 kg per year. We conclude that the emissions from your car add about $3 \cdot 0.85 \cdot 1600 =$ about 4 tonnes of carbon dioxide per year to the atmosphere. This corresponds to about a quarter of the per capita contribution from the U.S, or about half that from Japan.