Physics 101

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***Solutions to Problems - Chapter 4 (Role of Atmosphere)***

Note: In Tables, solutions are given in italics.

1. We have seen that mixing certain colors together can give white. Any two colors that add together to produce white are called *complementary* colors. For each of the following colors state what is the complementary color: blue, magenta, red, yellow, cyan, green

| ***Color*** | ***Complement*** | ***Color*** | ***Complement*** |
|---|---|---|---|
| blue | *yellow* | yellow | *blue* |
| magenta | *green* | cyan | *red* |
| red | *cyan* | green | *magenta* |

2. Complete the following "color equations":

R + C = W

B + G = C

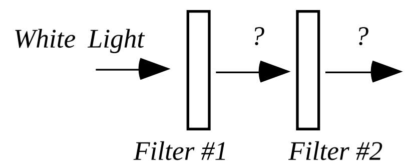
M + G - R = (W) - R = C

Y - G = (R + G) - G = R

C + R - B - G = (B + G) + R - B - G = R

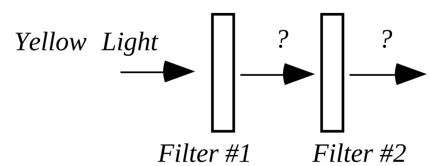
3. Imagine that you have white light entering a colored filter (Filter #1 in the figure to the right) and then entering a second filter (Filter #2 in the figure). For each of the following arrangements, fill in the missing colors in the table.

Note: the absence of color is "black", i.e., if neither red, blue, or green light is present, the "color" appears "black".




| ***Color of Filter #1*** | ***Color of Filter #2*** | ***Color of light leaving Filter #1*** | ***Color of light leaving Filter #2*** |
|---|---|---|---|
| blue | blue | *blue* | *blue* |
| magenta | cyan | *magenta* | *blue* |
| green | yellow | *green* | *green* |
| cyan | red | *cyan* | *black* |
| red | *blue, green, or cyan* | red | black |
| *magenta* | *red* | magenta | red |

4. Repeat question 3, but assume that there is yellow light entering Filter #1, rather than white light.




| ***Color of Filter #1*** | ***Color of Filter #2*** | ***Color of light leaving Filter #1*** | ***Color of light leaving Filter #2*** |
|---|---|---|---|
| green | blue | *green* | *black* |
| magenta | cyan | *red* | *black* |
| green | yellow | *green* | *green* |
| cyan | yellow | *green* | *green* |
| red | magenta | red | *red* |
| *yellow* | green | yellow | *green* |

5. Why will the leaves of a red rose be heated more than the petals when illuminated with red light? What does this have to do with people in the hot desert wearing white clothes?

*The petals are red because they reflect red light and absorb blue and green. The leaves are green because they reflect green and absorb red and blue. If red light illuminates the rose, the light is absorbed by the leaves and there is no green or blue light available to be absorbed by the petals. Consequently, the leaves get warm from absorption of the energy in the red light.*

*Black clothing efficiently absorbs all colors whereas white reflects colors. The energy absorbed by a piece of black clothing heats the garment.*

6. If the sunlight were somehow green instead of white, what color garment would be most advisable on an uncomfortably hot day? On a very cold day?
*On a hot day, you do not want your clothing to absorb the radiant energy that falls on it. If the available radiant energy is green, then this is the color that you want to wear, since a green garment will reflect green light, not absorb it. On a cold day, you want clothing to absorb the radiant energy since this absorbed energy keeps you warm. Thus, on a cold day you want to wear something that absorbs green light. Blue or red would work, so would magenta.*

7. What color would red cloth appear if it were illuminated by sunlight? By red light? By cyan light?
*If a red cloth was irradiated by sunlight (white light), it would absorb the blue and green, but reflect the red, so the cloth would appear red. If the cloth was illuminated by red light, the light would be reflected and the cloth would also appear red in this case. If the cloth was illuminated by cyan light, it would absorb both the blue and green components of the light and none would be reflected. Thus, in cyan light, the cloth would appear black.*

8. A glass of water is "colorless". From this observation, what can you conclude about the colors (or wavelengths) of visible light that are absorbed by water?
*The fact that water is colorless, means that it does not absorb any colors of the visible light spectrum. Assume for a moment that water absorbed some color (any color). When white light entered the water, the absorbed color would be subtracted from the white light and the complementary color would transmit through the water. When this transmitted light reaches your eyes, the water would appear to have this color. The colorless appearance of water means that all colors are transmitted through the water—none is absorbed.*

9. The reddish-orange color in the air on a very smoggy day is due to the presence in the atmosphere of a gas called nitrogen dioxide, which comes from automobile exhaust. Can you offer a suggestion for why the presence of nitrogen dioxide in the air produces a reddish-orange color?
*To appear reddish-orange means that these colors can transmit through the gas. In other words, the blue and green portion of the visible light spectrum is absorbed. Nitrogen dioxide gas does indeed absorb blue and green light.*

10. Imagine that, besides water and carbon dioxide present in the atmosphere there are two other gases, A and B present which absorb radiation. A absorbs mostly at 500 nm and B absorbs mostly radiation at 9000 nm. Which of the following statements is true?
A. Only gas A contributes to the Greenhouse Effect.
B. Only gas B contributes to the Greenhouse Effect.
C. Both gas A and B contribute equally to the Greenhouse Effect.
D. Neither gas A nor gas B contributes to the Greenhouse Effect.
*B. The Greenhouse Effect results from the fact that the atmosphere is transparent (i.e., does not absorb) the visible light passing through the atmosphere coming in from the sun but absorbs the longer wavelength infrared radiation being radiated by the earth back out towards space. Since gas B absorbs infrared radiation (9000 nm is infrared) it will contribute more to the absorption of the outgoing earth's radiation.*

11. Stare at a piece of colored paper, say red paper, for about 45 seconds or so. Then look at a plain white surface. What color do you think the white paper will look? Try it! Then try to think about how you can explain what you see. (Hint: The cone cells in your eyes can become "overworked" and temporarily lose sensitivity).
*The cone cells in your eyes that are sensitive to the red paper become fatigued while you are staring at the red paper. When you look at the white surface, your eyes will receive essentially equal doses of red, green and blue light. However, because of the "red fatigue" the temporarily fatigued red cone cells send a weaker signal to the brain. Thus, your brain receives signals sent predominantly by the green and blue cone cells and will sense that you are seeing cyan, not white. Thus, when you stare at any color long enough to temporarily fatigue the cone cells that are sensitive to that color, a white surface will then appear to have the color that is the complement of the color that was stared at. If you stare at green paper, then look at a white surface, it will appear to be magenta. If you stare at a yellow surface, then turn to a white surface, it will appear to be blue, etc.*