Name _____ Class _____ Date _____

Summary

THE BIG IDEA **The colors of the objects depend on the color of the light that illuminates them.**

28.1 The Color Spectrum

By passing a narrow beam of sunlight through a triangular-shaped glass prism, Newton showed that sunlight is composed of a mixture of all the colors of the rainbow.

- A prism casts sunlight into a **spectrum**—a spread of colors formed in the order red, orange, yellow, green, blue, and violet.
- Under white light, white objects appear white and colored objects appear in their individual colors.
- **White light** is not a color, but a combination of all of the colors. Black is also not a color, but the absence of light. Objects appear black when they absorb light of all visible frequencies.

28.2 Color by Reflection

The color of an opaque object is the color of the light it reflects.

- Different materials have different natural frequencies for absorbing and emitting radiation. At resonant frequencies where the amplitudes of oscillation are large, light is absorbed.
- At frequencies above and below resonant frequencies, light is reemitted. If a material is transparent, the remitted light passes through it. If a material is opaque, the reemitted light passes back into the medium from which it came. This is reflection.
- Cells that contain chlorophyll absorb most frequencies incident upon them and reflect the green part, so they appear green.
- A candle flame emits light that is deficient in the higher frequencies; thus, it emits a yellowish light.
- An incandescent lamp emits light of all the visible frequencies, but is richer toward the lower frequencies, enhancing the reds. A fluorescent lamp is richer in the higher frequencies, so the blues are enhanced.

28.3 Color by Transmission

The color of a transparent object is the color of light it transmits.

- A piece of blue glass appears blue because it transmits primarily blue light and absorbs the other colors that illuminate it.
- The material in glass that selectively absorbs colored light is known as a **pigment.**
- The energy of the light absorbed by glass increases the kinetic energy of the atoms, and the glass is warmed.
- Ordinary window glass is colorless because it transmits light of all visible frequencies equally well.

28.4 Sunlight

Yellow-green light is the brightest part of sunlight.

- The brightness of solar frequencies is uneven. The lowest frequencies are in the red region.
- The graphical distribution of the sun's brightness versus frequency is called the *radiation curve* of sunlight.

28.5 Mixing Colored Light

You can make almost any color at all by overlapping red, green, and blue light and adjusting the brightness of each color of light.

- Light of all the visible frequencies mixed together produces white. White also results from the combination of only red, green, and blue light.
- When only red and green light overlap, yellow is produced. When red and blue light overlap, the bluish red color called *magenta* is produced. Green and blue light alone produce the greenish blue color called *cyan*.
- Red, green, and blue are called the **additive primary colors.**
- Color television is based on the ability of the human eye to see combinations of the three additive primary colors as a variety of different colors.

28.6 Complementary Colors

Every color has some complementary color that when added to it will produce white.

- When two colors are added together to produce white, they are called **complementary colors.**
- Yellow and blue are complementary colors. Magenta and green are complementary colors, as are cyan and red.
- Whenever you subtract some color from white light, you end up with the complementary color of the subtracted color.

28.7 Mixing Colored Pigments

When paints and dyes are mixed, the mixture absorbs all the frequencies each paint or dye absorbs.

- The mixing of paints and dyes is an entirely different process from the mixing of colored light.
- The mixing of pigments is called *color mixing by subtraction*, to distinguish it from the effect of mixing colored light, which is called *color mixing by addition*.
- Magenta, yellow, and cyan are the **subtractive primary colors,** and are the most useful in color mixing by subtraction.
- Color printing is done on a press that prints each page with four differently colored inks (magenta, yellow, cyan, and black) in succession.

28.8 Why the Sky Is Blue

The sky is blue because its component particles scatter high-frequency light.

- **Scattering** is a process in which sound or light is absorbed and reemitted in all directions. Atoms and molecules behave like tiny optical tuning forks and reemit light waves that shine on them. The reemitted light is sent in all directions; it is scattered.
- Of the visible frequencies, violet light is scattered the most, followed by blue, green, yellow, orange, and red, in that order. Although violet light is scattered more than blue, our eyes are more sensitive to blue, so we see a blue sky.
- In places where there are a lot of particles of dust and other particles larger than oxygen and nitrogen molecules, the lower frequencies of light are scattered more and the sky takes on a whitish appearance.

28.9 Why Sunsets Are Red

By the time a beam of light gets to the ground at sunset, all of the high-frequency light has already been scattered. Only the lower frequencies remain, resulting in a red sunset.

- Red light, which is scattered the least, passes through more of the atmosphere without interacting with matter than light of any other color.
- The relative amounts of scattering depend on atmospheric conditions, which change from day to day and give us a variety of sunsets.

28.10 Why Water Is Greenish Blue

Water is greenish blue because water molecules absorb red.

- Water molecules resonate somewhat to the visible-red frequencies, causing a gradual absorption of red light by water.

28.11 The Atomic Color Code—Atomic Spectra

After an excited atom emits light, it returns to its normal state.

- The **excited state** of an atom is a state with greater energy than the atom's lowest energy state. When an electron transitions from an excited state to its original state, it emits a pulse of light—a photon.
- The frequency of an emitted photon, or its color, is directly proportional to the energy transition of the electron.
- The light from glowing elements can be analysed with an instrument called a **spectroscope.**
- The spectrum of an element appears not as a continuous band of color, but as a series of lines. This spectrum is known as a **line spectrum.** Each line corresponds to a distinct frequency of light.