Activity 9: Black & White Photography

Why?

- From the first photograph, almost 200 years ago, to the digital prints of today, the artist's ability to capture an exact image has intrigued humankind. We love the beauty of photographs as they permanently arrange atoms or molecules on film or paper such that memories are forever preserved.

Learning Objectives

- Understanding of the chemicals involved in traditional black and white film photography.
- Understanding of the reactions and electron transfers in traditional film photography.

New Concepts

- Ionic compounds
- Silver halide compounds
- Reduction equations

Vocabulary

- Halide
- Camera obscura

Black and White Film Photography

Traditional black and white photography utilized a chemical process that has been observed since ancient times – that of the photo-sensitivity of silver (Ag) compounds. This ability was harnessed by the19th century photography pioneers by coating silver halides (molecules of Ag and halide gases) in an emulsion of gelatin onto a glass or plastic backer.

The process of making traditional film has not changed much from the basic chemical reactions discovered in the 1800's. Initially, elemental silver is reacted with nitric acid to form silver nitrate. Complete and balance the reaction below:

$$Ag\ (s)\ +\ HNO_3 \rightarrow AgNO_3\ +\ H_2$$

Identify the element oxidized and that reduced in the above equation.

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The silver nitrate is then converted to the silver halide (usually bromide) by fuming the film with potassium bromide. Complete and balance the next reaction:

$AgNO_3$ + KBr →

The AgBr is an ionic compound that forms a crystalline structure in grains. **What does it mean to be an ionic compound?**

The film now is ready for exposure and the creating of the intended image. Stored within a light sealed container, the AgBr film is a uniform darkish yellow. The light exposure occurs when an opening allows light to enter the dark container and strike the film. These "storage" containers that subsequently allow light exposure are more commonly referred to as cameras.

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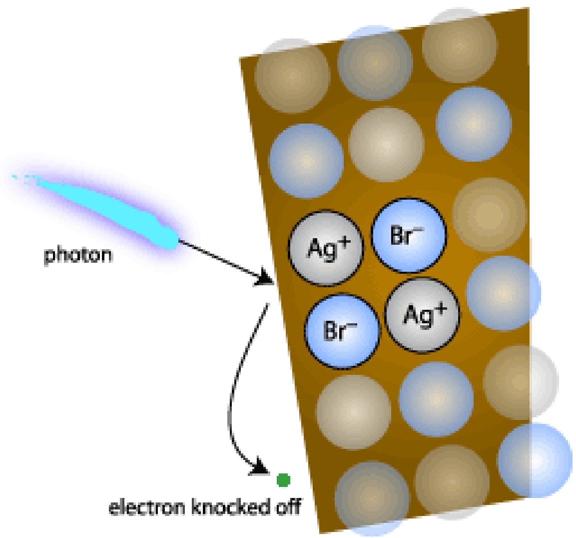
The first cameras were called "***camera obscura,***" meaning vault with no light. The unexposed film is placed at an end opposite a potential opening in the camera box. When the opening is revealed (ie. lens is opened in modern cameras) light is allowed to enter, traverse the box and strike a location on the film. Remember that light is energy in the form of photons, therefore a striking photon will transfer its energy to the film and dislodge an electron from a Br- ion. See the diagram below.



Below, John. CS 39J: Session 7. 7 Mar. 2002. 31 Mar. 2003 <http://www-inst.eecs.berkeley.edu/~cs39j/session07.html>

Why would the Br- ion be more susceptible to losing an electron than an Ag+ ion?

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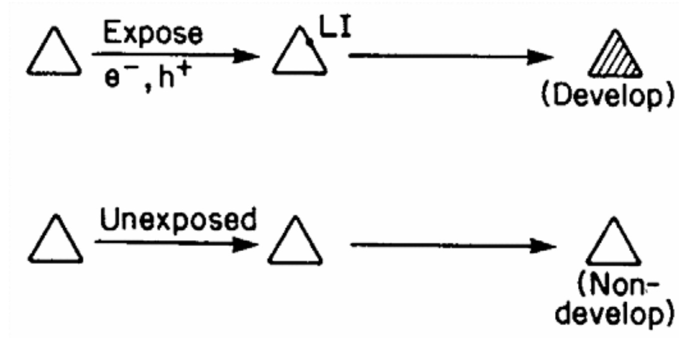


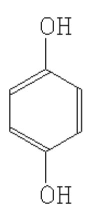
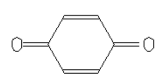
As incoming photons bump electrons from the Br^- ions they form Br and "positive holes". The free electron is acquired by a neighboring Ag^+ ion to form an atom of elemental Ag. Where incoming light has transformed Ag^+ to Ag there remains a "latent" or invisible image (LI). To make the latent image visible to the eye, the film must be processed to remove unexposed AgBr and fix the Ag image making it permanent as a "negative". The negative is as it sounds – the reverse of the actual image ie. where the actual image is light the negative is dark and the reverse.

http://silvergrain.org/Photo-Tech/latent-model.png

Chemically, what is the Latent Image composed of?

Black and White Film Processing

To make the latent image apparent grains of AgBr that contain some Ag+ due to light exposure must be completely processed to Ag(s). This is accomplished using a "developer". Most commonly, developers are reducing agents which are willing to give away electrons. An example of a reducing developer is hydroquinone – the organic aromatic ringed structure (we will talk more about organic molecules later but at each joining of lines in the ring is a carbon atom). Balance the equation below:

 + AgBr + OH- →  + Ag(s) + H_2O + Br^-

Identify the element reduced in the above equation. Any idea as to which is oxidized?

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The above reaction proceeds only in an alkaline environment as evidenced by the hydroxide (OH) ions. In order to end the reaction so that overdevelopment of non-exposed AgBr grains does not occur, a “stop” solution of acid is applied. Generally, the stop bath is merely acetic acid which drops the pH sufficiently to inhibit further reduction. The image can now be visualized but any remaining non-exposed AgBr is still subject to degradation and must be made permanent by “fixation”.

The fixation is accomplished with a sulfur compound (usually sodium thiosulfate or more commonly called “hypo” for its old name of hyposulfate) reacting with remaining AgBr rendering it soluble by producing a silver thiosulfate and completing the formation of the negative image. Fill in the blanks of the resulting products of this reaction below.

$$AgBr + Na_2S_2O_3 \rightarrow Ag\_\_\_\_\_\_\_\_ + Na\_\_\_\_\_\_$$

Using the supplied black and white print paper and camera obscura, design an object to photograph and complete the exposure.

Have you created a positive or negative? ________________________________

Why?

DONE!

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