



COLD FIRE

PATTER

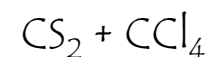
How do people juggle balls of fire or make it emerging from the mouth! In folklore, burning camphor in the palm, without hurting it, was asked for to prove innocence. I can be perfectly guilty and still escape unscathed with the right chemistry! The basic reason for such fascination is the belief that a flame is hot. It need not be!

MAGIC

Set fire to a ball of cotton, which was immersed in carbon disulfide: carbon tetrachloride = 40: 20 ml and solvents partially squeezed out, placed in the palm. The flame will hardly warm the hand. It can be tossed around from hand to hand and even passed around.

TRUTH/EXPLANATION/SCIENCE

A very interesting meeting of several aspects find manifestation in this simple experiment! Carbon dioxide will not burn and is used to extinguish fire. Its elder brother, carbon disulfide, just burns, without generating much heats (low heat of combustion). Besides, carbon disulfide has a very high vapor pressure, and the vapor blankets the uncovered cotton-ball. On the other hand, carbon tetrachloride is heavy, has relatively low vapor pressure and is non combustible. Therefore it settles close to the palm and the core of the ball making contact not harmful.



HINTS/SAFETY

Carbon disulfide and its combustion products have an acrid and obnoxious smell; the experiment should not be prolonged more than two minutes. Dump the burning ball in a bucket of sand and cover it. Carbon tetrachloride is deemed carcinogenic! The success of the experiment depends on judicious retention of solvents in the cotton ball.



SETTING SUN

PATTER

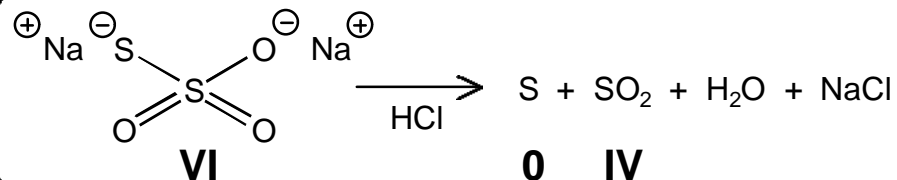
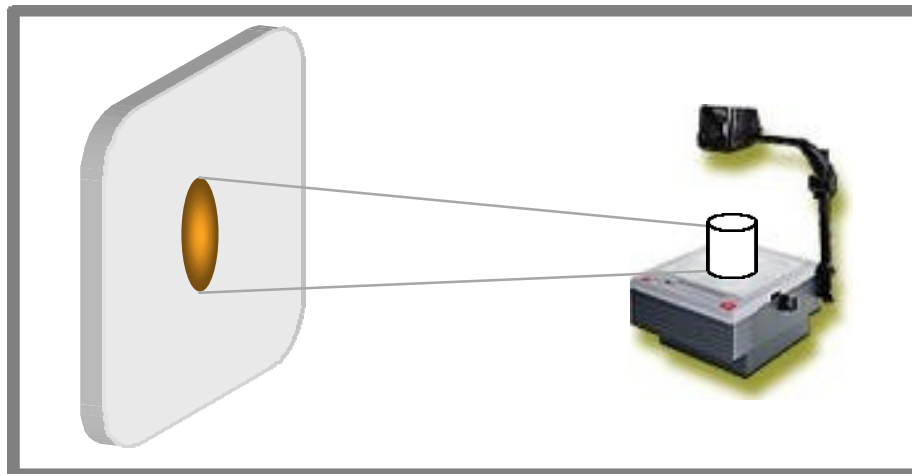
The rising and setting Sun, marking the beginning or end of a day in our lives, will always hold a fascination, since it evokes a surrealistic feeling and has been so extolled in our ancient literature as the charms of *sandhya*. On cloudless days, the sun will be orange to red with surroundings a brilliant blue! On cloudy days bright colors appear and this has been captured in the scores of paintings by the famous artist, Constable. Added to these are cries of birds, returning home and the gentle breeze that make the leaves dance in the dusk. We will now simulate the magic of sun set!

MAGIC

To 100 ml of 2% aqueous sodium thiosulfate contained in a 1 liter beaker, placed in a clear slot in the covered overhead projector (OHP), 20 drops of water : hydrochloric acid = 7:1 are added. The projected bright disc of Sun gradually becomes orange and then red, in about 3 minutes. On the other hand, the beaker shines with an intense whitish blue hue. Stirring with a glass rod may be needed if the color is not evenly distributed. In the beginning, set the Sun at the lower middle of the screen and towards the end pull it out of the screen by simultaneously pushing a blank board. To complete the illusion of sunset, create the chirping of birds by using a calling-bell gadget!

TIPS

Measure board to the size of the overhead-projector and cut hole in the middle corresponding to the base of a 1l beaker. Place the beaker containing the thiosulfate, focus and add 20 drops of dilute acid. Stir with a glass rod occasionally.



TRUTH/EXPLANATION/SCIENCE

Profound principles of science are involved in this simple experiment! In presence of acid, the thiosulfate disproportionates to sulfur and sulfur dioxide. The former, under the exact conditions of the reaction, forms colloidal particles of the correct size to scatter light most efficiently (Tyndall effect). The brilliant white light emitted around 5000 Å is split to bright blue in the beaker by scattering and vivid orange on the screen by the lack of it. Notice on a clear day, the sky will have the same hues at both sunrise and sunset! The splitting of white light to high energy (blue) and low energy (red) components are brought about by materials that exhibit non linear optical activity, the foremost amongst which is, surprisingly, urea. Such operations have many uses.



ELECTRON TRANSFER

PATTER

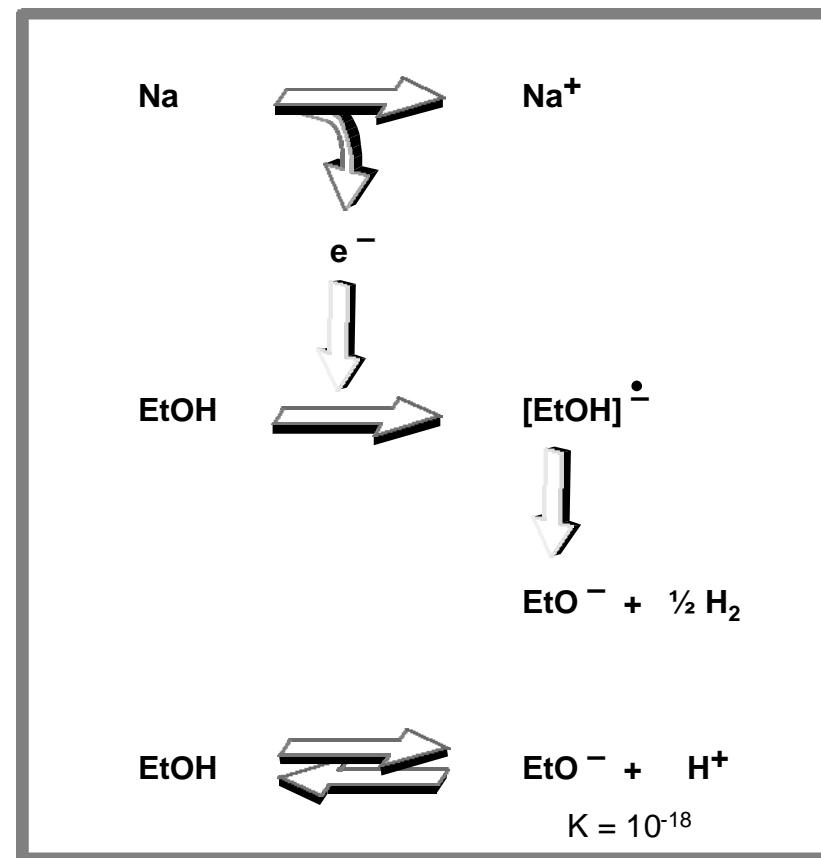
The transfer of an electron is perhaps the most fundamental of all processes that take place in this universe. You do not see it, but its manifestations, one abundantly does. The transfer can be attended with color, form and energy. The simple process of a single electron transfer is shown in this experiment.

MAGIC

To ethanol to which three drops of a solution of phenolphthalein had been added, in a petridish, placed in the clear slot of an OHP, small pieces of sodium are added, one at a time. The vigorous transfer of electron from the sodium to the solvent, accompanied by gas evolution would make the metal move around emitting gases and with a bright pink halo that slowly permeates the medium giving a illusion of a bleeding fly!

TRUTH/EXPLANATION/SCIENCE

One electron is transferred from sodium to ethanol and this excess electron makes the ethanol break down to ethoxide and hydrogen. The former transforms the indicator to a pink color, regenerating alcohol and the anion of the indicator. Till recently, the hydrogen formation was considered arising from direct transfer of the electron to a proton. This is held unlikely since, alcohol being a very weak acid, cannot produce enough of matching protons for the transfer!



HINTS/SAFETY

Sodium reacts violently with air and water. It should be handled under kerosene and excess metal should be destroyed by ethanol.



CHEMILUMINESCENCE

PATTER

Pack a dozen fireflies in a glass and you can get enough light to traverse the darkest of lanes. In deep villages this is done, as I have, long ago. In Japan, thousands of firefly roost in a single tree lighting it up, far prettier than a Christmas tree. Even the bird-brained birds know that fireflies cannot create fire. In Panchatantra this advice, given to a bunch of monkeys who were blowing at a flock of fireflies to make fire, to keep them warm, by a bird, was not appreciated! The understanding of how the flies make the glow is at the root of all kinds of procedures to produce this cold light. The organic chemist, Emil White, collected thousands of fireflies, by enticing sex signals by a pen-light torch - decidedly a low trick! The keen flies so attracted met the net than the mate! From these he isolated the chemicals involved and clarified how light is produced.

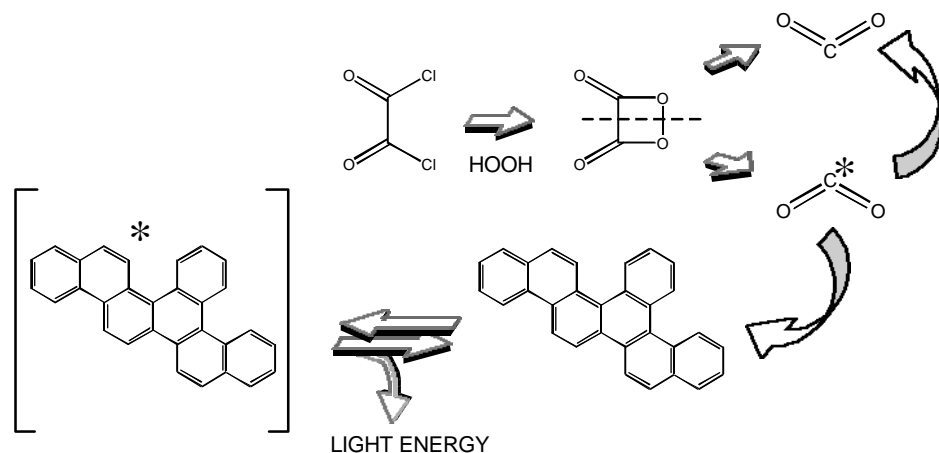
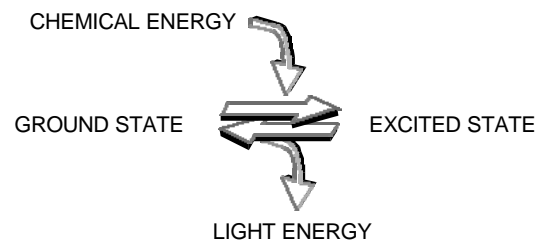
I am going to entice you with cold light!

MAGIC

In a 100 ml round-bottomed flask place 10 g of neutral alumina, add 3 ml of 30% hydrogen peroxide and 20 ml of methylene chloride. Swirl. Now add ~5 mg of rubrene. To this swirled mixture add, in drops, a solution of 3 ml of oxalyl chloride in 20 ml of methylene chloride. Intense blue light!

HINTS/SAFETY

The dye rubrene can be replaced with other sensitizers, a good one being 9,10-diphenyl anthracene. The lifetime of the glow and its color would depend on the dye used. Oxalyl chloride is a corrosive and low boiling substance



TRUTH/EXPLANATION/SCIENCE

All reactions that produce cold light chemiluminescence have a common pattern. A kinetically driven reaction produces a reactive molecule imprisoned in a bond cage. To escape from this, it splits, producing a ground state molecule and an excited one. The latter goes back giving up its excess energy to a sensitizer, a dye, which goes back emitting the light. The events are graphically presented above.

Cold light enjoys significant applications like, in mines, hazardous operations, underwater exploration, camping and so on. Commercial kits to specifications are also available.



DISORDER [ENTROPY] DRIVEN REACTION

PATTER

Emperor Jehangir was fond of chilled wine. With no machines to make ice, at that time, he either got the mules to bring it from Himalayas or from frost collected in winter from pits lined with hay. Indeed, ice was a luxurious commodity! If Jehangir were a chemist, he would have had the know-how to freeze water. We will do so!

MAGIC

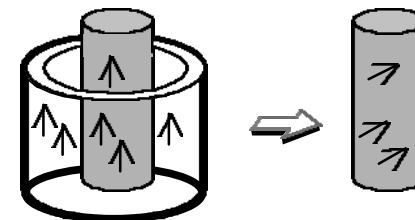
In a silver glass placed in a wine glass containing water, which touches the bottom of the glass, are placed 45 g of barium hydroxide octahydrate and 15 g of ammonium thiocyanate. Stir with a thermometer. In two minutes the inside temperature would fall from +20 °C to less than -20 °C - the mass becomes a liquid and water vapour and ammonia rise. The outside water will freeze to ice!

HINTS/SAFETY

The process can be made time efficient by using chilled water.



EARTHEN POT



ADIABATIC DEMAGNETIZATION



TRUTH/EXPLANATION/SCIENCE

In all systems, heating up which increase disorder, is easier than cooling down which brings more order! Universally also, disorder is spontaneous and order is imposed. Normally in a disorder (entropy) driven reaction, the basic system is constrained to pay for the entropy increase, making it to cool. Good examples are the cooling of water in a mud pot, arising from being constrained to pay for the escape of surface water molecules. Another example is adiabatic demagnetization, where the order of spins maintained by an external field collapses on removal of it. The disordered spins take away energy from the medium thus cooling it. Solid helium can be made by this procedure. In the present experiment, ammonia and water escape leaving the system deprived of energy.



GEL SHAKTI

PATTER

The north of India is eternally indebted to king Bagirath, for having brought Ganges from heavens, to wash away the sins of his forebears! After a long stint of penance, the powers agreed to release Ganges, provided a person of strength was found to receive it. Another stint and Shiva agreed to do so. The Ganges was naughty, thought of taking the lord downstream but was punished by containing it on his hair! Another stint of penance, the lord deigned to release the now chastened Ganga, but unfortunately on her way she washed down the hut of sage. The enraged sire drank the whole river!

Another stint...

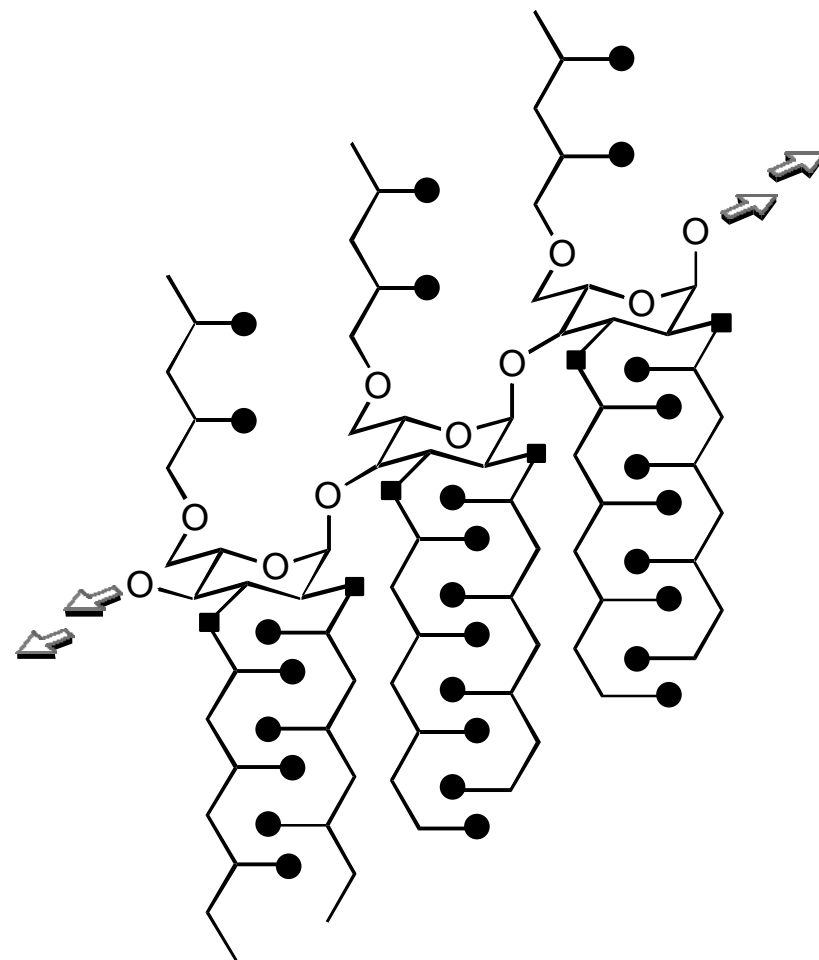
So people have been thinking of containing water. Now I will show you a gel that drinks so much water.

MAGIC

To a glass of water, add one spoon of *Gel Shakti* and stir. In two minutes the gel takes all the water. Invert the glass for effect!

TRUTH/EXPLANATION/SCIENCE

The gel is prepared by grafting polymers of acrylic acid or its amides on to a basic cellulose structure. The concentration of acid and amide groups makes it very thirsty for water, to derive stabilization by a vast network of hydrogen bonding. Hence the formation of the gel. Scientists at the National Chemical Laboratory, Pune, designed *Gel Shakti*. It has enormous application in water management.



■ = -O-CH₂-

● = COOH / CONH₂