Cold light

This practical on cold light provides an interesting way to emphasise the importance of making detailed observations. It allows students to practice following a flow chart and is a good lead-in to teaching spectroscopy. It could also be followed up with individual or group projects on the applications of cold light – these could include examples of bioluminescence or research on how a TV or flat screen works for instance. If teaching a biology unit, the example of chlorophyll from spinach may well be worth using to show a little more clearly how chlorophyll works.

Equipment required

A darkened room or a box for each group of students to create their own dark area.
For each group of students:

- White light – from a lamp or torch
- UV lamp (these can be purchased at reasonable prices from many internet sites – they are often sold as security devices for checking whether bank notes are genuine)
- 2 or 3 spinach leaves
- Knife (blunt ones such as ordinary table knives are fine)
- Tile or plate
- Approx 20 cm^3 ethanol
- Beaker (100 or 250 cm^3)
- Boiling tube with bung
- Glass rod
- Wrapped clear boiled sweet – if you can get Lifesavers® from the USA in 'oil of wintergreen' flavour they work best, but mints such as Fox's Glacier Mints or similar are fine
- Clear plastic bag (eg sandwich bag)
- Pliers
- White paper
- Washing machine powder
- Fluorescent pens
- Brown paper (back of an old envelope is fine)
- Glow-in-the-dark sheet (available at a reasonable price from http://www.mutr.co.uk (accessed November 2005))
- Tonic water (the bottle does not need to be opened so the same one will last for a long time)
- Samples of gypsum, calcite and/or fluorite minerals
- Some resealable envelopes – optional (they give a flash of light when opened in a darkened room but not all work so it is worth checking before giving them to students)
- Eye protection.

Health and safety

- Read our standard health and safety guidance at https://rsc.li/47oJ5xH
- Warn students not to look at the UV lights. They should always be pointing away from the eyes and students should shine the light only on the item that they are observing.
- Ethanol is flammable – it should not be used near flames.
- Pliers can crush fingers if they are not used correctly.
- Warn students not to eat in the laboratory

Sample results and observations

Item	White light on	White light off	UV light on	UV light off	Luminescent	Type of luminescence
boiled sweet	nothing	gives out a flash of light as it is crushed	nothing	nothing	yes	triboluminescence
fluorescent pens	glow a little	nothing	glow brightly – especially against the brown paper	nothing	yes	fluorescence
Glow-in-the-dark sheet	glows a little	glows brightly	glows a little more	glows extremely brightly and for far longer than with white light	yes	phosphorescence
tonic water	nothing	nothing	glows a dull greeny blue	nothing	yes	fluorescence
mineral samples	nothing	nothing	glows – colour depends on which mineral is used	nothing	yes	fluorescence
spinach solution	looks green	nothing	glows red	nothing	yes	fluorescence
white paper	nothing	nothing	glows	nothing	yes	fluorescence
washing powder	nothing	nothing	glows a bluey colour	nothing	yes	fluorescence due to optical brighteners in the powder

If you wish, you can also add chemiluminescence to the above. Experiment details are in the following RSC publications:

T. Lister, Classic Chemistry Demonstrations, London: Royal Society of Chemistry 1995.

How it works

The way in which the light is produced varies according to which type of luminescence occurs. Fluorescence and phosphorescence are most closely related to the way in which Infra-red (IR) and UV-VIS spectroscopy work.

In both fluorescence and phosphorescence, light is absorbed at one wavelength and released at another. When the substance is exposed to certain wavelengths of light this radiation is absorbed and causes electrons in the atoms to be excited to a higher energy level. As these electrons fall back to a lower energy level (which may or may not be the original one) they release the 'extra' energy in the form of light. The diagram below helps to explain this:

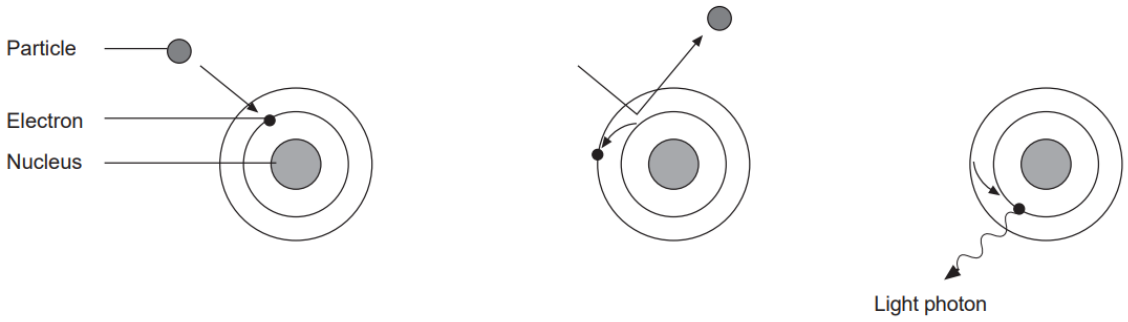


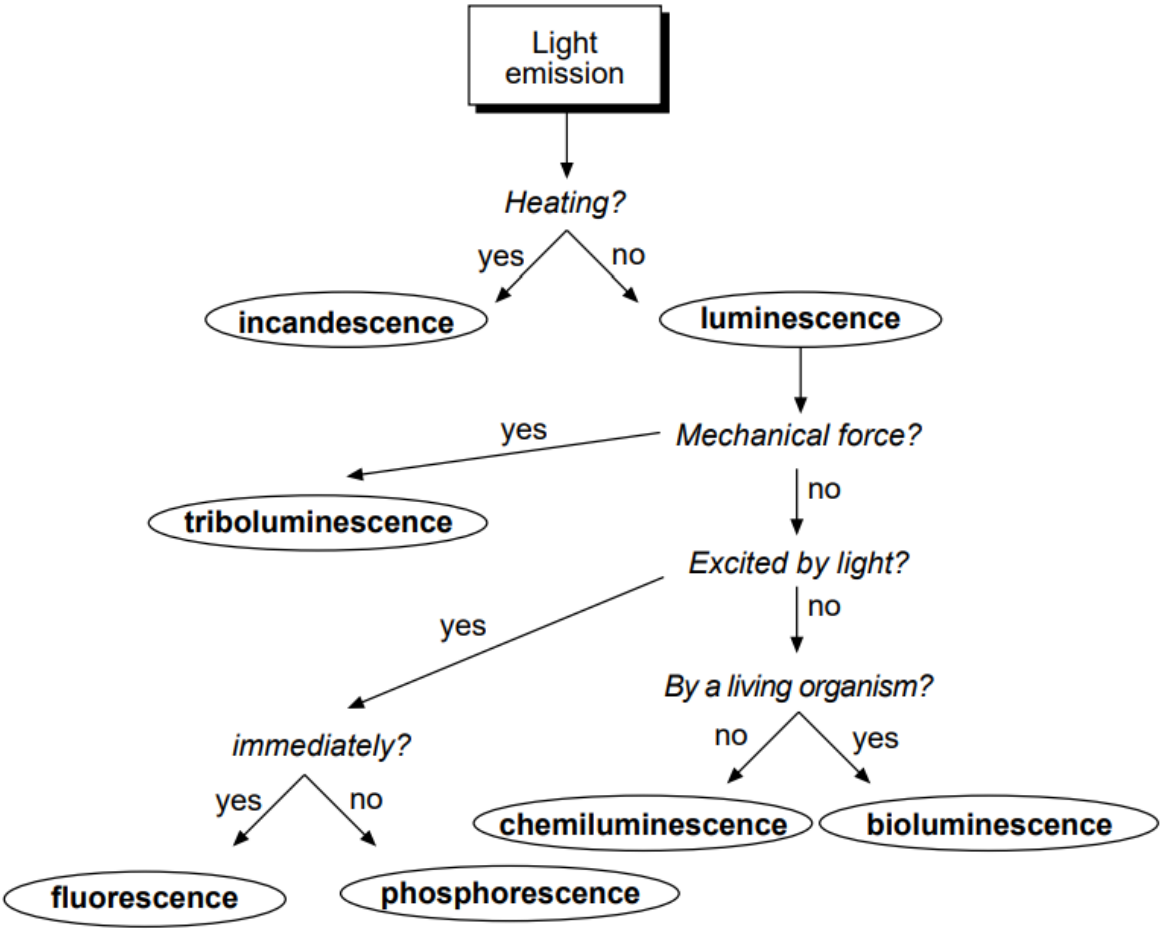
Figure 1 How atoms emit light

In the case of chemiluminescence (and bioluminescence, which is just a form of chemiluminescence) the light is the energy that is released during the course of a reaction. Some reactions produce light rather than heat or sound.

Triboluminescence is light emitted when mechanical forces act on the structure of a substance.

Cold light

Cold light is also known as luminescence. It is light that is emitted when things are cold. Light emitted when things get hot is called incandescence – for example, the light from a Bunsen burner, a standard light bulb or an electric cooker when hot. There are many types of cold light, given different names depending on the conditions under which the light is emitted. The flow chart below shows how you can decide which type of light an object is emitting.



You are going to examine a number of different items under white and UV light and observe what happens. From your observations it will be possible to decide which type of light emission you have observed.

You will need

- White light – lamp or torch
- UV light
- A few spinach leaves
- Knife
- Tile or plate
- Ethanol (Flammable)
- Beaker
- Boiling tube and bung
- Glass rod
- Clear boiled sweet in wrapping

- Plastic bag
- Pliers
- White paper
- Washing machine powder
- Fluorescent pens
- Brown paper
- Glow-in-the-dark sheet
- Tonic water
- Gypsum, calcite or fluorite (minerals)
- Eye protection.

Health and safety

Do not look at the UV light, always have it pointing away from your eyes and shine it only on the items you are observing.
Ethanol is flammable – do not use it near flames.
When using the pliers take care not to crush your fingers.
Do not eat anything in a laboratory.
Wear eye protection,

What to do

- Set up a table like the one below for your observations.

Item	White light on	White light off	UV light on	UV light off	Luminescent	Type of luminescence

- Cut up the spinach into very small pieces. Wearing eye protection, scrape these into the beaker and just cover them with ethanol. With the beaker on the bench, gently press on the spinach leaves with the glass rod. When the leaves are looking pale and the ethanol is very green, carefully decant the ethanol into the boiling tube and put a bung into it.
- Using the fluorescent pens, write or colour on the brown paper.
- In a darkened room, shine a white light on each of the items in turn. Look carefully at the items and note the colour and intensity (bright, dim etc) of any light given off by them. Make sure you observe the spinach extract in the boiling tube from several angles and note any differences.
- Turn off the light and make the same observations.
- Repeat the above using UV light.
- Leave the boiled sweet in its wrapper and place it inside the plastic bag. Make sure that the area where you are working is dark and then crush the sweet using the pliers. Watch the sweet carefully as you crush it.
- Decide if each item is luminescent and what type of luminescence it shows.