

Kinetics – observing the effect of temperature on the rate of a reaction with glowsticks

Kinetics is the science of reaction rates, i.e. how fast a reaction proceeds. The rate of a reaction is determined by several factors, one of which is temperature. As a rough guide, for every 10 degree Celsius rise in temperature, the rate of a reaction will double. This is because as the temperature rises molecules move faster and so collide more often and therefore the number of reactions per second increases.

In this experiment we will demonstrate that heating a reaction increases its rate because the molecules involved move faster, and therefore collide more frequently and cooling a reaction has the opposite effect, because the molecules will move slower, thus colliding less frequently and so the number of collisions (and therefore reactions) will be less.

Glowsticks are a plastic tube containing a glass phial which contains hydrogen peroxide. Also in the plastic tube is a solution of oxalate ester and a fluorescent dye. When the glowstick is bent, the glass phial breaks and the hydrogen peroxide mixes with the oxalate ester and they react to produce energy which causes the dye to glow. The rate at which this energy is produced is directly related to the temperature of the glowstick. The faster the rate of reaction, the more energy is produced per second and the brighter the glowstick will glow.

MATERIALS

You will need:

- Glowsticks. You can obtain these from various places but Illumiglow Ltd. offer discounted 10-packs of each of the standard colours and the ultra-orange. They also provide a further discounted classroom pack of 40 glowsticks (10 of each of the colours and 10 of the orange ultra). Email sales@illumiglow.com or call 01256 338444.
Prices are outlined below:
 - 10 x red 12 hour glowsticks = £9.75 (excl VAT)
 - 10 x yellow 12 hour glowsticks = £9.75 (excl VAT)
 - 10 x green 12 hour glowsticks = £9.75 (excl VAT)
 - 10 x orange ultra 5 minute glowsticks = £12.50 (excl VAT)
 - 40 pack: 10 each of red, yellow, green 12 hour glowsticks and 10 orange ultra = £36.00 (excl VAT)
 - Shipping (flat rate independent of size) = £6.95 (excl VAT)
- A transparent pudding bowl
- Ice
- Hot tap water

HEALTH & SAFETY

There are no particular health and safety issues with this experiment. Do not try to open glowsticks. Take care when using hot tap water.

METHOD

There are two ways of demonstrating the effect of temperature on the rate of reaction in a glowstick.

Method 1: fill the pudding bowl with ice cubes and add some water and salt. Adding salt reduces the temperature of the resulting slush. Break and shake a glowstick; then place it in the pudding bowl such that the lower half is immersed in the ice slush bath and the upper half isn't. After a few minutes you should notice a difference in the brightness of the lower half compared to the upper half. This is because the rate of the reaction in the lower half of the glowstick is lower than in the upper half since the molecules of hydrogen peroxide and oxalate ester are moving slower and therefore colliding less often than the molecules in the upper half.

Method 2: take two identical glowsticks; break and shake them both and place one in the freezer and the other in a bowl of hot water. Leave for 5-10 minutes then take both glowsticks out and compare their brightness; the glowstick from the freezer will be significantly dimmer than the one from the hot water. Now place the glowstick that had been in the freezer in the hot water for one minute then take it out and shake it, and repeat. The brightness of the glowstick should increase as it gets hotter since the molecules are colliding more frequently.

Discussion: The brightness of the glowsticks is directly proportional to the temperature; reactions get faster as they get hotter and slower as they get colder. This is the reason that freezing food allows it to be kept for longer because the reactions within the bacteria which would normally cause it to spoil, are slowed down by the lower temperature.

