**Catalytic Property of Cobalt(II) Ions**

**Teacher Notes**

**Remark on chemicals**

Hydrogen peroxide solution is commonly available in 30% and 3% (by weight). The molarities are 9.8 M and 0.8 M, respectively. They may contain additives such as stabiliser. The 3% solution, which is sold for medicinal purpose, may even contain painkillers. They should be tested to make sure that it works in this experiment before distributing them to students.

**Sample results**

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|  | Observations |
| Mixing of potassium sodium tartrate solution and hydrogen peroxide solution at room temperature. | No observable change. |
| Heating the reaction mixture in the hot water bath. | Solution remains colourless. |
| Addition of cobalt chloride solution into the mixture. | Solution changes from pale pink to green; then back to pale pink. |

**Answers for the questions:**

 ***(Teachers may choose the questions appropriate for their students to work out.)***

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|  | 1. | H2O2(aq) + 2H+(aq) + 2e–   2H2O(l) |
|  |  |  |  |
|  | 2. | C4H4O62–(aq) + 2H2O(l)  2CO2(g) + 2HCO2–(aq) + 6H+(aq) + 6e– |
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|  | 3. | There is a high energy barrier for the reaction. At room temperature, the reactant molecules do not have enough energy to go through the energy barrier to form products. |
|  |  |  |  |
|  | 4. | At higher temperature, the molecules process more energy and hence there is higher chance for them to go through the energy barrier. Yet, if the energy barrier is too high, the molecules may still not process enough energy to go through the barrier even though the solution is heated in a hot water bath. |
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|  | 5. | The bubbles are due to the formation of CO2 gas, which is one of the products. When catalyst is added, the reaction proceeds very quickly and a lot of CO2 gas were formed in a short time. The fast formation of CO2 gas results in vigorous formation of gas bubbles. |
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|  | 6. | The reaction mixture of potassium sodium tartrate and hydrogen peroxide is colourless whereas cobalt(II) chloride solution is pink in colour. When the latter is added into the former, the reaction mixture turns into green in colour. The green colour is due to the formation of cobalt(III) ions from the oxidation of cobalt(II) ions by hydrogen peroxide. The solution then changes from green to pink in colour because the cobalt(III) ions oxidises tartrate ions and return back to cobalt(II) ions. |
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|  | 7. | (a) | Low temperature makes the H2O2 molecules less energetic and fewer molecules have enough energy to overcome the energy barrier to form products. |
|  |  | (b) | Mn4+ (in MnO2) & Fe3+, see, for example: http://www.job-stiftung.de/pdf/versuche/H2O2\_Decomposition.pdf |
|  | 8. | (a) | Catalyst is regenerated after products are formed and is not consumed. |
|  |  | (b) | Number of moles of hydrogen peroxide = 1 × 0.006 = 0.006Number of moles of tartrate ions = 0.4 × 0.006 = 0.0024Number of moles of cobalt(II) ions = 0.1 × 0.001 = 0.0001 ∴Yes, the amount of the catalyst is much smaller than those of reactants. |
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|  | 9. |  |  |
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| Species | Colour of the species | Oxidation state of transition metal |
| Fe2+(aq) | Green | +2 |
| Fe3+(aq) | Pale yellow | +3 |
| Cr3+(aq) | Green | +3 |
| CrO42–(aq) | Yellow | +6 |
| Cr2O72–(aq) | Orange | +6 |
| Mn2+(aq) | Very pale pink | +3 |
| MnO4–(aq) | Purple | +7 |

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