EXERCISE 4

Investigating Transition Metal Complexes

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INTRODUCTION

Colour is a well known property of the transition metals. The colour produced as parts of the visible spectrum are due to electron transitions between energy levels. The colour we see is due to absorption by electrons in the d orbitals therefore, if the atom has no d electrons or a full d orbital with 10 electrons, the compound will absorb outside the visible region, and appear white or colourless.

Ligands – Splitting the d orbitals

In a transition metal atom the d orbitals all have the same energy level, however ligands split the d orbitals into two groups with a difference in energy of ΔE. If the ligand of a transition metal is changed it alters the value for ΔE and therefore the colour will also change.

Factors affecting the ΔE value include:

- The type and size of the ligand.
- The bond strength between the ligand and metal ion.
- The shape and co-ordination number of the complex.
- The oxidation state.

UV-Visible Spectroscopy - Analysis of Colour

A UV-visible spectrometer can be used to measure absorption of light in the ultra-violet and visible region. A typical spectrometer has two sources, usually a deuterium lamp to provide frequencies in the ultra-violet region and a tungsten lamp to provide the visible frequencies. To run a sample the instrument needs to compare the sample solution with a reference or blank solution. This reference solution is the solvent being used for the sample solution. The blank or reference is run first for a single beam instrument or in parallel with the samples for a double beam instrument. A diffraction grating or prism is used to separate the radiation into the different frequencies producing monochromatic radiation. The spectra plotted show the absorbance of the sample at particular wavelengths.

METHOD

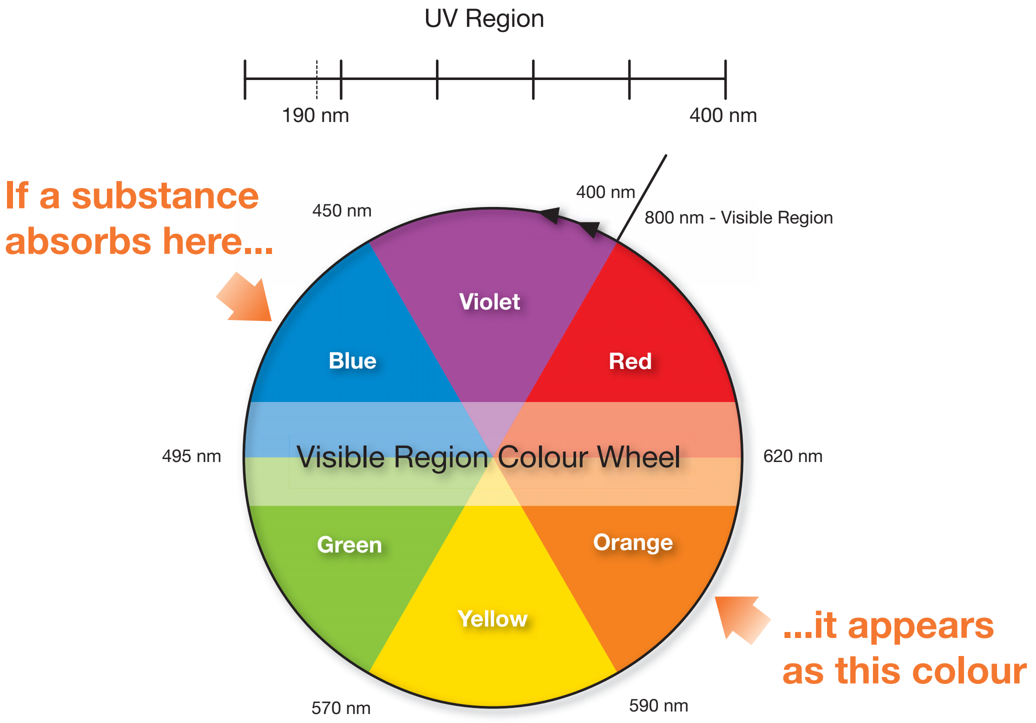
Investigation 1

The Colour in Transition Metal Complexes

1. Prepare a blank sample by filling a cuvette with the appropriate solvent and stopper with a lid.
2. The demonstrator will set up the spectrometer to scan the visible region from 350-900 nm. Run a blank and each sample as instructed. Print out the spectrum and note the wavelength for each of the absorbance peaks.
3. Investigate how the absorbance changes as the ligands are changed, record the changes in absorbance in the table provided.

Wavelengths of Different Coloured Visible Light

Red	620-750 nm
Orange	590-620 nm
Yellow	570-590 nm
Green	496-570 nm
Blue	450-495 nm
Violet	380-450 nm



If a substance absorbs here...

...it appears as this colour

Investigation 2

Beer-Lambert Law

Experiment

1. You are provided with a solution of potassium permanganate of accurately known concentration (4.0×10^{-4} mol dm^{-3}).
2. Use this solution to make up 50 cm^3 of each of the following potassium permanganate solutions using a 50 cm^3 burette to dispense your stock solution to the volumetric flasks.

Concentration	Stock solution in 50 cm^3 de-ionised water
3.2×10^{-4} mol dm^{-3}	40 cm^3
2.4×10^{-4} mol dm^{-3}	30 cm^3
1.6×10^{-4} mol dm^{-3}	20 cm^3
0.8×10^{-4} mol dm^{-3}	10 cm^3

3. Using the spectrophotometer measure the absorbance of each of your solutions in the visible region.
The peak should occur at 540 nm. Also measure the absorbance of the unknown solution and record all data in the table provided.
4. Show that the Beer-Lambert Law is obeyed by plotting a graph of absorbance (y- axis) versus concentration (x-axis) using the graph paper provided. Draw the line of best fit through your points and the origin. Determine the concentration of the unknown solution from the graph.

Questions

1. How do you know if the Beer-Lambert Law has been obeyed?
2. What is the concentration of the unknown solution?