

# [Spectrophotometric analysis of a two-component mixture](https://assignbuster.com/spectrophotometric-analysis-of-a-two-component-mixture/)

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Title: Spectrophotometric analysis of a two-component mixture Aim: i. To prepare working standards of dichromate and permanganate ii.

To measure the absorbance of the prepared working standards of dichromate and permanganate using a spectrophototometer iii. To determine the concentrations of permanganate in a mixture of unknown. Abstract: Working standards of dichromate and permanganate were prepared and absorbance for each found. This was done in order to plot a graph of absorbance versus concentration, from which the concentration of permanganate and dichromate in the unknown sample could be determined. Sulphuric acid was added to the standards in order to force the reaction to completion. Wavelengths of 430 nm and 525 nm were chosen as dichromate absorbs best at 430 nm, while permanganate absorbs best at 525 nm.

The concentrations of dichromate and permanganate in the unknown sample were 0. 0122 M and – 1. 94 x 10-3 M respectively. The negative value obtained for the permanganate ion concentration showed that the concentration was extremely low. Introduction: Spectrophotometry is the measurement of how different wavelengths of light are absorbed.

Using a spectrophotometer to determine how much of a particular wavelength of light is absorbed by a specimen can yield important insights into its characteristics apart from its mass, crystalline structure and other features. Spectrophotometers are useful because of the relation of intensity of colour in a sample and its relation to the amount of solute within the sample. A UV-Visible spectrophotometer makes use of the transmission of light through a solution to determine the concentration of a solute within the solution. A spectrophotometer consists of two instruments, namely a spectrometer for producing light of any selected colour (wavelength), and a photometer for measuring the intensity of light. The visible light can be divided into six principal colours. Therefore, a colour will appear as its complementary colour as it absorbs the colour from the incoming white radiation and transmits the principal colour component unaltered.

Solution of coloured compounds is known to absorb light in the UV visible region of the electromagnetic radiation. Transition metal compounds are known for this behaviour. Potassium permanganate (KMn04) in solution is purple / violet colour meaning maximum absorption should be at 500 – 550 nm The orange red coloured dichromate, the maximum absorption (? max ) is at 440 nm. However, at some point in the spectra, the wavelengths overlap each other, hence dichromate can absorb at 520 nm and permanganate at 440 nm, but only to a small extent. In simple words, both the species are able to absorb at both wavelengths mentioned.

Therefore, the absorption of the solution containing a mixture of both will equal to the sum of the absorbances of both species. In simultaneous determination of two species it is necessary to generate two equations in order to determine the unknown concentrations. This is developed by Beer-Lambert’s Law: Absorbance = c ? l Beer’s Law requires the use of monochromatic radiation and under these restrains, the linear dependence and absorption can occur. A spectrophotometer cannot distinguish between individual species, therefore total absorbance of two or species is as follows: A total = A1 + A2….? A two-component solution will be studied in this experiment.

The species being absorbed are permanganate and dichromate ions. Finally, the concentration of both species in an unknown sample will be determined. Results: Table 2 – CONCENTRATION AND ABSORBANCE OF K2Cr2O7 AND KMnO4 FOR EACH FLASK AT 430 nm | Flask | K2Cr2O7 conc. (M) | K2Cr2O7 Absorbance | KMnO4 conc. (M) | KMnO4 Absorbance | | Blank | | 0.

000 | | 0. 000 | | 1 | 3. 71 x 10-4 | 0. 149 | 1. 2 x 10-4 | 0.

014 | | 2 | 7. 52 x 10-4 | 0. 299 | 2. 04 x 10-4 | 0. 020 | | 3 | 1. 13 x 10-3 | 0.

685 | 3. 06 x 10-4 | 0. 025 | | 4 | 1. 50 x 10-3 | 0. 629 | 4. 08 x 10-4 | 0.

029 | | 5 | 1. 88 x 10-3 | 0. 90 | | | | Unknown | | 0. 788 | | | Table 3 – CONCENTRATION AND ABSORBANCE OF K2Cr2O7 AND KMnO4 FOR EACH FLASK AT 525 nm | Flask | K2Cr2O7 conc. (M) | K2Cr2O7 Absorbance | KMnO4 conc.

(M) | KMnO4 Absorbance | | Blank | | 0. 000 | | 0. 00 | | 1 | 3. 71 x 10-4 | 0. 014 | 1.

02 x 10-4 | 0. 252 | | 2 | 7. 52 x 10-4 | 0. 021 | 2. 04 x 10-4 | 0.

511 | | 3 | 1. 13 x 10-3 | 0. 053 | 3. 06 x 10-4 | 0. 771 | | 4 | 1.

50 x 10-3 | 0. 044 | 4. 8 x 10-4 | 0. 0941 | | 5 | 1. 88 x 10-3 | 0. 063 | | | Calculations: 1.

Calculating the actual concentrations of KMnO4 and K2Cr207 i. K2Cr2O7 Mass of K2Cr2O7 = 5. 5339 g in 1 L Molar mass of K2Cr2O7 = 294. 185 g/mol Moles = 5. 5339 g/294.

185 g/mol = 0. 018810 moles Molarity = 0. 018810 moles /1 L = 0. 018810 M ii. KMnO4 Mass of KMnO4 = 0.

8079 g in 500 ml Molar mass of KMnO4 = 158. 0339 g/mol Moles = 0. 8079 g/158. 0339 g/mol = 5. 12 x 10-3 moles Molarity = 5.

112 x 10-3 moles/0. 5 L = 0. 010224 M 2. Calculating concentrations of working standards Mass of K2Cr2O7 = 5. 5339 g in 1 L Molar mass of K2Cr2O7 = 294.

185 g/mol Moles = 5. 5339 g/294. 185 g/mol = 0. 018810 moles Moles in 2. 00 ml = (0. 018810 moles x 2.

00 ml)/1000 ml = 3. 76 x 10-5 moles Molarity = 3. 76 x 10-5 moles/0. 1 L = 3. 76 x 10-4 M Following the same calculation, the molarity of the other volumes were found: In 4. 00 ml = 7.

52 x 10-4 M In 6. 00 ml = 1. 13 x 10-3 M In 8. 00 ml = 1. 50 x 10-3 M In 10. 00 ml = 1.

88 x 10-3 M Mass of KMnO4 = 0. 8079 g in 500 mlMolar mass of KMnO4 = 158. 0339 g/mol Moles = 0. 8079 g/158. 0339 g/mol = 5. 112 x 10-3 moles Moles in 1.

00 ml = (5. 112 x 10-3 moles x 1. 00 ml)/500 ml = 1. 0224 x 10-5 moles Molarity = 1. 02 x 10-5 moles/0.

1 L = 1. 02 x 10-4 M Following the same calculation, the molarities of the other volumes were found: In 2. 00 ml = 2. 04 x 10-4 M In 3. 00 ml = 3. 06 x 10-4 M In 4.

00 ml = 4. 08 x 10-4 M 3. Calculating concentration chromate and permanganate ions in unknown sample The general expressions for the simultaneous equations are: (eq. 1)A 430 = ? Cr (430) CA + ? Mn (430) CB (eq. 2)A 525 = ? Cr (525) CA + ? Mn (525) CB Where CA = [Cr2O72-], CB = [MnO4-] ? Cr (430) = 439.

45 L·mol? 1·cm? 1 ? Cr (525) = 33. 255 L·mol? 1·cm? 1 ? Mn (430) = 2353. 9 L·mol? 1·cm? 1 ? Mn (525) = 67. 647 L·mol? 1·cm? 1 A 430 = 0. 788 A 525 = 0.

425 Putting in values in equations, we get 0. 788 = 2353. 9 L·mol? 1·cm? 1 x [MnO4-] + 439. 45 L·mol? 1·cm? 1 x [Cr2O72-]…eq. 1 at 430 nm 0. 425 = 67.

647 L·mol? 1·cm? 1 x [MnO4-] + 33. 255 L·mol? 1·cm? 1 x [Cr2O72-]… eq. 2 at 525 nm Using (eq. 1), [MnO4-] = (0. 788 – 439. 45 L·mol? 1·cm? 1 x [Cr2O72-])/2353.

9 L·mol? 1·cm? 1 Sub. Above equation in (eq. 2) 0. 425 = 67. 647 L·mol? 1·cm? 1 x [(0. 788/2353.

L·mol? 1·cm? 1 – 439. 45 L·mol? 1·cm? 1 x [Cr2O72-])/2353. 9 L·mol? 1·cm? 1] + 33. 255 x [Cr2O72-] 0. 425 = 0. 02265 – 0.

1867 x [Cr2O72-] + 33. 255 x [Cr2O72-] = 0. 02265 + 33. 068 x [Cr2O72-] Therefore, [Cr2O72-] = 0. 0122 M Sub.

[Cr2O72-] value in eq. 1 [MnO4-] = (0. 788 – 439. 45 L·mol? 1·cm? 1 x 0. 0122 M)/2353.

9 L·mol? 1·cm? 1 Therefore, [MnO4-] = – 1. 94 x 10-3 M Discussion: The concentrations of permanganate and dichromate ions were determined in an unknown mixture. The results were obtained by using simultaneous equations of total absorptivity. The concentrations of dichromate and permanganate were 0. 122 M and – 1. 94 x 10-3 M respectively.

The negative value obtained for the permanganate ion concentration indicates that it was low. The absorbance readings obtained for dichromate and permanganate were higher at 430 nm and 525 nm respectively as these were the lambda maximum for each ion. However, both gave readings for 525 nm and 430 nm as there absorption spectrum overlaps, therefore, although to a small extent, the spectrophotometer will measure some amount of absorbance. The molar absorptivity, which indicates how strong a species absorb light at a given wavelength, was higher at 430 nm (439. 5 L·mol? 1·cm? 1) for dichromate compared to 525 nm (33.

255 L·mol? 1·cm? 1) as it absorbs light better at this wavelength. However, for permanganate, the molar absorptivity was higher at 430 nm (2353. 9 L·mol? 1·cm? 1) than at 525 nm (67. 647 L·mol? 1·cm? 1), which is the optimum absorbance for permanganate. Although the molar absorptivity varied, the absorbance of a species is more dependent on its concentration and pathlength than molar absorptivity as it is an intrinsic value. The R2 value obtained for each regression line showed that there was a strong goodness of fit and there was not much variation.

Some amount of error could have arisen during this experiment. Firstly, instrumental error could have been a factor, therefore giving a flawed reading of absorbance than will later result in inaccurate concentration calculations. Instrumental error is difficult to eliminate, however, ensuring that the solutions are concentrated enough to give a good absorbance reading can assist in minimizing such error. Secondly, error could arise in calculating the volume of each species to be added to the volumetric flask. Careful calculations and delivery could be taken into account to reduce such error significantly. Also, research of maximum absorbance for each species should be done by recording the highest concentration over a wavelength interval for each species to ensure that each species is measured at its maximum absorbance.

If not, then the absorbance readings not be at its optimum and can cause flawed results. However, this was given, therefore reduced error of readings. Conclusion: The concentration of permanganate and dichromate ions were calculated in a two-component mixture and calculations showed that the concentration of permanganate and dichromate was 0. 122 M and – 1. 94 x 10-3 M respectively.

This showed that there was a sufficient amount of dichromate present, but very low concentration of permanganate. References: Crouch, S. , Holler, F. , Skoog, D. & West, D.

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