UV-VISIBLE SPECTROSCOPY – TOPIC TEST 1

QUESTION 1
Which of the following statements is false about a UV-Visible spectrophotometer?

A A normal electric bulb can be used as a light source.
B A monochromator is used to select the optimum wavelength.
C All of the above.
D None of the above.

QUESTION 2
The **Blank** in UVVS consists of:

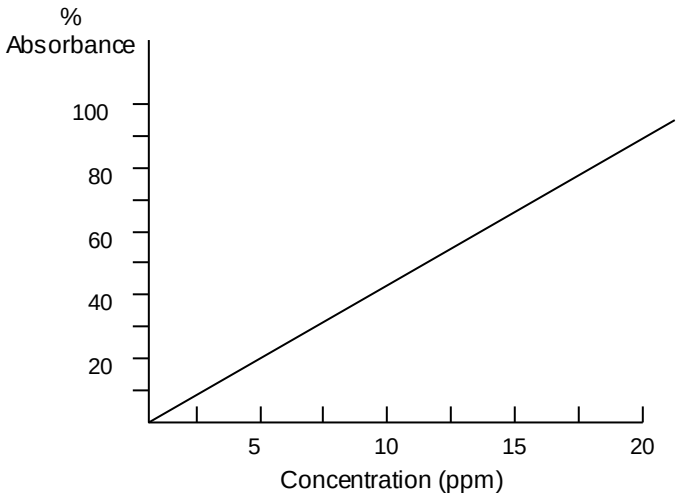
A A very dilute solution of the test sample to determine the sensitivity of the instrument.

B The solvent to be used in the analysis so that the instrument can be calibrated to zero against any radiation absorbed by the solvent alone.

C Plain distilled water used to calibrate the monochromator.

D A series of standard solutions of known concentration in order to construct a calibration curve.

QUESTION 3
The following is a calibration graph of a UV-Visible spectrophotometer used in the analysis of a certain food colour:



If the absorbance reading for the sample is 65% and the original sample was diluted by a factor of 10, the concentration of the original sample is:

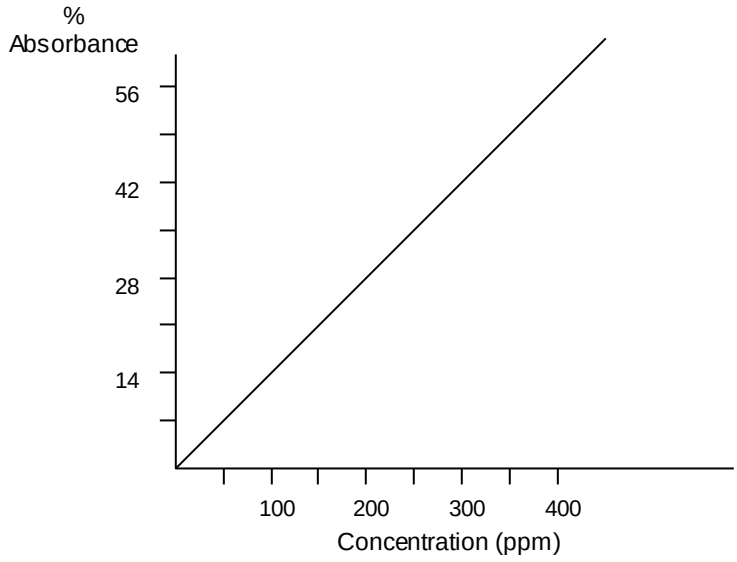
A 6.5ppm
B 65ppm
C 15ppm
D 150ppm

QUESTION 4
The following table shows the absorbance of a sample of bromine in a UV-Visible spectrophotometer, at different wavelengths:

Wavelength (nm)	***Absorbance (%)***
350	19%
400	27%
450	19%
500	2%

a State which of the above wavelengths you would choose to analyse bromine and give a reason for your choice. (2 marks)

Below is a calibration graph for bromine analysis by UV-Visible spectroscopy. Prior to analysing the standard solution, the instrument was "zeroed" by using a "blank" solution. The absorbance reading for the unknown sample was 21%.



b Determine the concentration of the unknown from the calibration graph. (1 mark)

c Explain the purpose of the “blank” solution. (1 mark)

QUESTION 5
Describe three similarities and three differences between a simple Visible Spectrometer and a UV-Visible spectrometer. (Half a mark per answer, round down at end of question).

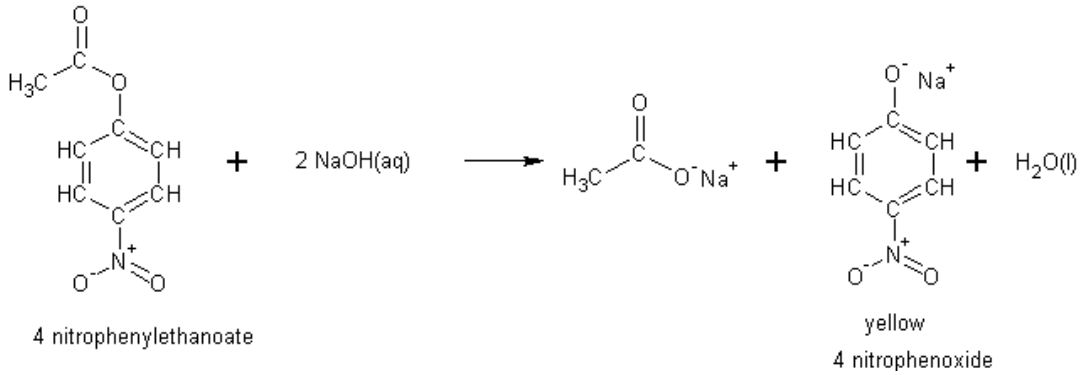
Solution

QUESTION 6
Describe the steps involved in the analysis of a food dye sample by UV-Visible spectroscopy. Assume the following are already available: a stock standard solution, a prepared unknown sample and a wavelength-absorbance graph. The sample is dissolved in distilled water. (4 marks)

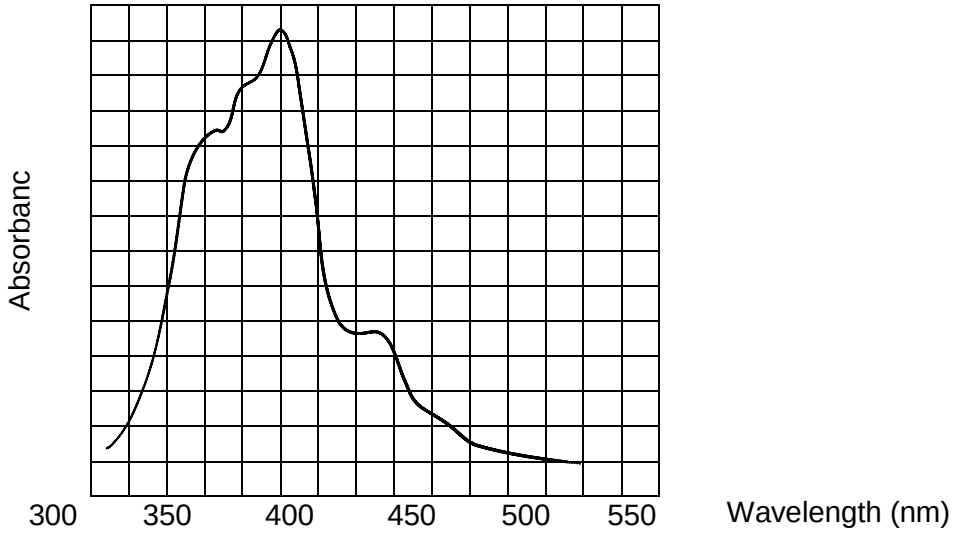
Solution

QUESTION 7

The ion 4-nitrophenoxide is used in the production of pesticides, pharmaceuticals, reagent and dyes. It forms a yellow solution and is produced from the hydrolysis of 4-nitrophenylethanoate, as described below.

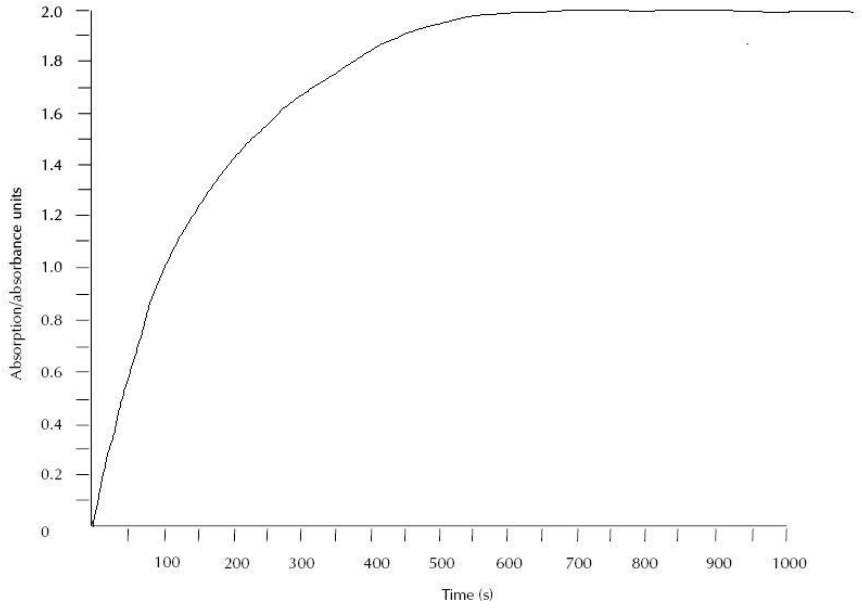


The UV-Visible spectrum of 4-nitrophenoxide is illustrated below.



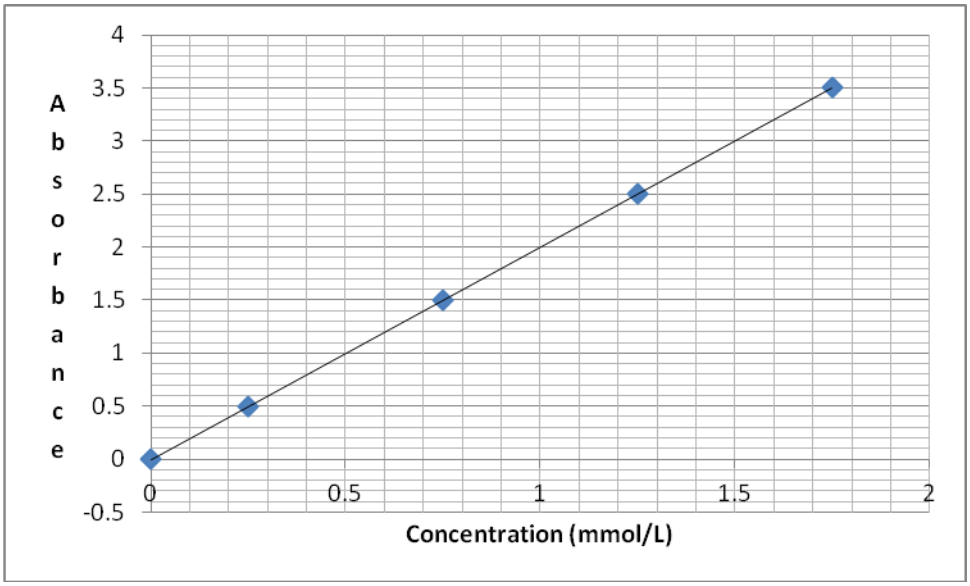
a. Choose the most suitable wavelength to quantitatively analyse a solution of 4-nitrophenoxide. (1 mark)

0.250 mL of a solution of the starting material (4-nitrophenylethanoate) was injected into a cuvette. An excess of NaOH solution was then added and the volume in the cuvette increased to 2.50 mL. The progress of the above reaction was monitored using UV-Visible spectroscopy and the results are illustrated below.



b. At what time was the reaction complete? (1 mark)

Standard solutions of 4-nitrophenoxide were then analysed in the same spectrometer. The results are shown below.



c. (i) Determine the concentration of 4-nitrophenoxide present when the reaction is complete. (1 mark)

(ii) How many mole of 4-nitrophenoxide were produced? (1 mark)

(iii) What would be the minimum concentration (mol/L) of sodium hydroxide required in order for this reaction to proceed to completion? (2 marks)

(iv) Double beam UV-Visible spectrometers send light of the chosen wavelength through the sample as well as through a reference cell. Explain the significance of this reference cell indicating the effects that would be observed on the calculated concentration of unknown if this double beam system was not employed. (2 marks)

SOLUTIONS

QUESTION 1 Answer is A

QUESTION 2 Answer is B

QUESTION 3 Answer is D

QUESTION 4

a Best wavelength is 400nm as it gives the highest absorbance, 27%.

b An absorbance of 21% corresponds to a concentration of 150 ppm.

c A blank is used to allow for any radiation absorbed by the solvent alone. The instrument is set to zero with a blank solution so that the extra absorbance does not interfere with the sample readings.

QUESTION 5

Similarities: Any 3 of the following:

- Both use the same principle of absorbance of radiation by solutions.
- Both use a light detector.
- Both display the amount of light absorbed.
- Any other sensible suggestion.

Differences: Any 3 of the following:

- Different light sources.
- Monochromator used in UV-VS instead of filter in VS.
- Solutions absorbing UV radiation need not be coloured.
- Any other sensible suggestion.

QUESTION 6

Suggested order of steps:

- Select the best wavelength for the particular sample from wavelength-absorbance graph.
- Prepare a suitable series of standards by serial dilution of stock standard solution.
- Zero the instrument by using a blank solution of distilled water.
- Read and record absorbance for standard solutions.
- Draw a calibration graph.
- Measure absorbance from unknown sample.
- Calculate concentration of unknown from calibration graph.
- Make necessary adjustments for dilution factors.

Half a mark for each step. Round down at the end of the question.

QUESTION 7

a. 400 nm

b. 600 sec

c. (i) 1.0mmol/l

(ii) n(4-nitrophenoxide) = c x V
= 1.00 x 10^{-}3 x 0.0025
= 2.50 x 10^{-6} mol

(iii) $n(\text{4-nitrophenylethanoate})_{\text{initially added}} = n(\text{4-nitrophenoxide})_{\text{produced in reaction}}$
= 2.50 x 10^{-6} mol

c(4-nitrophenylethanoate) = n/V
= 2.50 x 10^{-6} / 0.00025
= 0.0100 M (1 markZ)

n(NaOH) = 2 x n(4-nitrophenylethanoate) = 2 x 2.50 x 10^{-6}
= 5.00 x 10^{-6} mol

c(NaOH) = n/V
= 5.00 x 10^{-6} / 0.00225
= 0.00222 M (1 mark)

V = 2.5 ml – 0.25
= 2.25ml
= 0.00225 L

(iv) Light is shone through a reference cell which contains the solvent used in the sample cell so that any absorbance due to the solvent and cuvette is disregarded by the spectrometer. (1 mark) If this did not occur, the absorbance reading would be higher than it should be and so would the calculated concentration of the sample. (1 mark)