Answer on the Question #65323, Chemistry / Other

For the following analytical scenario below which involved initially diluting 20 ml of the original water sample into a 1000 ml volumetric flask. Subsequently, the sample was prepared and analyzed as depicted below:

Volumetric flask (500ml) #1
Sample Composition: 5 ml of sample + 0 mL of 300 ppm Na 0.5% $LiCl_2$
Absorbance: 0.12

Volumetric flask (500ml) #2
Sample Composition: 5 ml of sample + 1 ml of 300 ppm Na + 0.5% $LiCl_2$
Absorbance: 0.17

Volumetric flask (500ml) #3
Sample Composition: 5 ml sample + 2 ml of 300 ppm Na + 0.5% $LiCl_2$
Absorbance: 0.21

I. If all the flasks were diluted to a final volume of 500 ml with distilled water calculate the final concentration of sodium in the sample through a graphical and mathematical solution.
II. Why Lanthanum and Cesium or Lithium are added to solutions to be analyzed for Calcium and Sodium respectively?

Solution:

To solve this task the Beer-Lambert Law needed.

$$A = \varepsilon l c$$

where A is absorbance, ε is extinction coefficient, l is absorption path length in cm, c is concentration of solution in mol/l.
Conversion of concentration of standard solution from ppm to mol/l:

1 ppm is 0.001 g/l
300 ppm is 0.3 g/l
0.3 g/l is 0.013 mol/l

Concentration of standard solution in volumetric flask (500 ml):

$$c_{st} = \frac{V_{st} \cdot c_{st}}{V_{flask}}$$

Input data:

Volumetric flask (500ml)	#1	#2	#3
Volume of sample	5 ml	5 ml	5 ml
V_{st}	0 ml	1 ml	2 ml
c_{st}	300 ppm	300 ppm	300 ppm
c_{st} in volumetric flask	0	$2.6 \cdot 10^{-5}$ mol/l	$5.2 \cdot 10^{-5}$ mol/l
A	0.12	0.17	0.21

Mathematical solution:

$$\begin{cases} A_1 = \varepsilon l c_x \\ A_2 = \varepsilon l(c_x + c_{st}) \\ A_3 = \varepsilon l(c_x + c_{st}) \end{cases}$$

$$\frac{A_1}{A_2} = \frac{\varepsilon l c_x}{\varepsilon l(c_x + c_{st})} = \frac{c_x}{c_x + c_{st}}$$

$$\frac{0.12}{0.17} = \frac{c_x}{c_x + 2.6 \cdot 10^{-5}}$$

$$c_x = 6.24 \cdot 10^{-5}\ mol/l$$

$$\frac{A_1}{A_3} = \frac{\varepsilon l c_x}{\varepsilon l(c_x + c_{st})} = \frac{c_x}{c_x + c_{st}}$$

$$\frac{0.17}{0.21} = \frac{c_x}{c_x + 5.2 \cdot 10^{-5}}$$

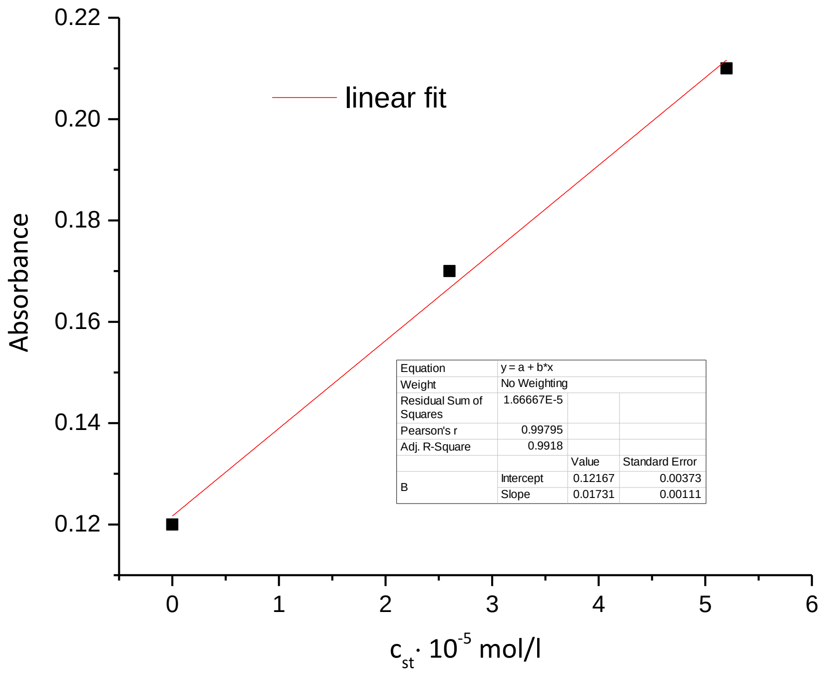
$$c_x = 6.90 \cdot 10^{-5} mol/l$$

$$\bar{c}_x = 6.57 \cdot 10^{-5} mol/l$$

Concentration of sodium in original sample of water:

$$\bar{c}_x = 6.57 \cdot 10^{-5} \frac{mol}{l} \cdot 5000 = 0.33 \frac{mol}{l}$$

Graphical solution:



$$c_x = \frac{Intercept}{Slope} = \frac{0.12167}{0.01731} = 7.03 \cdot 10^{-5} mol/l$$

$$c_x = 7.03 \cdot 10^{-5} \frac{mol}{l} \cdot 5000 = 0.35 \frac{mol}{l}$$

II. Lanthanum and Cesium or Lithium are added to solutions to be analyzed for Calcium and Sodium respectively like ionization suppression solution.