Deacon's Challenge
No 140 - Answer

You have been asked to check the calibration of your laboratory's spectrophotometer. Using a solution of potassium dichromate (50.0 mg/L) in dilute sulphuric acid, you obtain absorption values of 0.523, 0.521, 0.524 and 0.523 at 350 nm. The absorptivity index of potassium dichromate at this wavelength is 10.7 ± 0.11 Lg^{-1} cm^{-1}. Given you have used cuvettes with a pathlength of 1 cm, calculate the probability that the spectrophotometer is correctly calibrated.

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First calculate the expected absorbance (A):

$$A = e \times c \times l$$

Where e = absorptivity index = 10.7 L.g^{-1}cm^{-1}

   c = concentration in g/L

   l = pathlength = 1 cm

Since the concentration is given in mg/L it must first be converted to g/L to be compatible with e:

$$\text{Concentration (g/L)} = \frac{50 \text{ mg/L}}{1000} = 0.05 \text{ g/L}$$

Therefore $A = 10.7 \times 0.05 \times 1 = 0.535$

Next calculate the mean and standard deviation (s) for the set of absorbance readings (x):

x	x^2
0.523	0.273529
0.521	0.271441
0.524	0.274576
0.523	0.273529
SUM: 2.091	1.093075

$$\text{Mean} = \frac{\Sigma x}{n} = \frac{2.091}{4} = 0.523 \text{ (to 3 sig figs)}$$

$$s^2 = \frac{x^2 - (\Sigma x)^2/n}{n-1} = \frac{1.093075 - (2.091^2)/4}{4-1}$$

$$= \frac{1.093075 - 1.0930703}{3} = \frac{0.0000047}{3} = 0.000001567$$

$$s = \sqrt{0.000001567} = 0.00125 \text{ (to 3 sig figs)}$$

Calculate t, with n^{-1} degrees of freedom, to compare the observed mean with the target value of 0.535:

$$t = \frac{\text{Target mean} - \text{measured mean}}{s/\sqrt{n}} = \frac{(\text{Target mean} - \text{Measured mean}) \times \sqrt{n}}{s}$$

$$= \frac{(0.535 - 0.523) \times \sqrt{4}}{0.00125} = \frac{0.012 \times 2}{0.00125} = 19.2$$

From tables, when $t = 19.2$ with n^{-1} (i.e. 3) degrees of freedom, the probability that the difference in mean absorbances arose purely by chance is less than 0.001. **Therefore the probability that the instrument is correctly calibrated is less than 0.001.**

Ideally an alternative t-test should be used which allows for the imprecision of the absoptivity index. However, this is not practicable since it is not clear if the quoted figure of ±0.11g^{-1}cm^{-1} is a variance, standard deviation or standard error. Furthermore, the number of observations on which it is based (n) is not given.

Question 141

The symptoms of ovarian cancer are non-specific. The prevalence of ovarian cancer in symptomatic women who present in general practice is 0.23%. If the sensitivity and specificity of CA 125 for detecting ovarian cancer are both 78%, calculate the post-test probability of disease given a positive result.

If the prevalence of ovarian cancer in women who carry the brca1 oncogene is approximately 15%, what would be the post-test probability of disease?

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