

**12** A student carried out an investigation to compare the antibacterial effect of a garlic extract with that of three antibiotics, all at the same concentration.

- (a) (i) To obtain the extract, a clove of garlic was cut into lots of small pieces and soaked in 0.1% ethanol for a long time.

Explain why this is an effective method of extraction.

(2)

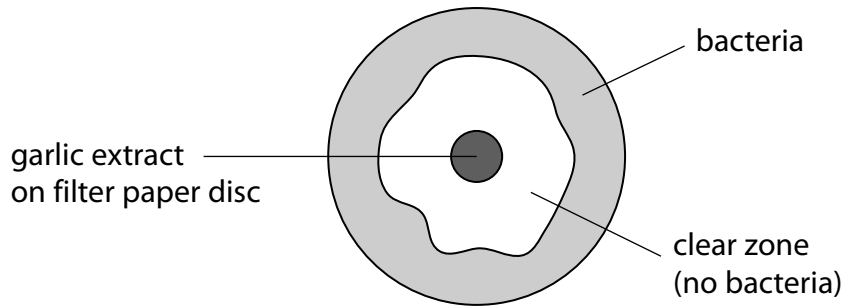
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- (ii) The diagram shows the effect of the garlic extract on bacteria growing on an agar plate.



The area of the clear zone was calculated by assuming it is a circle and estimating the diameter. The estimate made was 4.3 cm.

Calculate the estimated area of the clear zone.

(2)

Answer.....

(b) The results of the investigation are shown in the table.

Sample number	Estimated area of clear zone / mm <sup>2</sup>			
	Antibiotics			Plant extract
	Chloramphenicol	Tetracycline	Streptomycin	Garlic
1	28	16	15	20
2	26	19	13	28
3	29	11	14	18
4	28	21	12	25
5	26	7	14	27
6	29	11	15	26
7	22	8	9	25
8	25	21	14	25
9	29	10	12	29
Mean	27	14	13	25
Standard deviation	2.37	5.54	1.90	3.60

These data were analysed using *t*-tests.

- (i) Several statistical tests were available to the student to analyse these data, including the *t*-test, Chi squared and the correlation coefficient.

Explain why the *t*-test was chosen to analyse these data, rather than the other two tests.

(3)

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- (ii) Calculate the  $t$  value for the data to compare garlic with chloramphenicol, using the formula:

$$t = \frac{|\bar{x}^1 - \bar{x}^2|}{\sqrt{\left(\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}\right)}}$$

(3)

Answer.....

(iii) The table shows the critical values of  $t$  with 16 degrees of freedom.

<b>Significance level (p)</b>	0.20	0.10	0.05	0.01	0.001
<b>Critical value of <math>t</math></b>	1.34	1.75	2.12	2.92	4.02

Use your value of  $t$  to test the validity of a stated null hypothesis.

(4)

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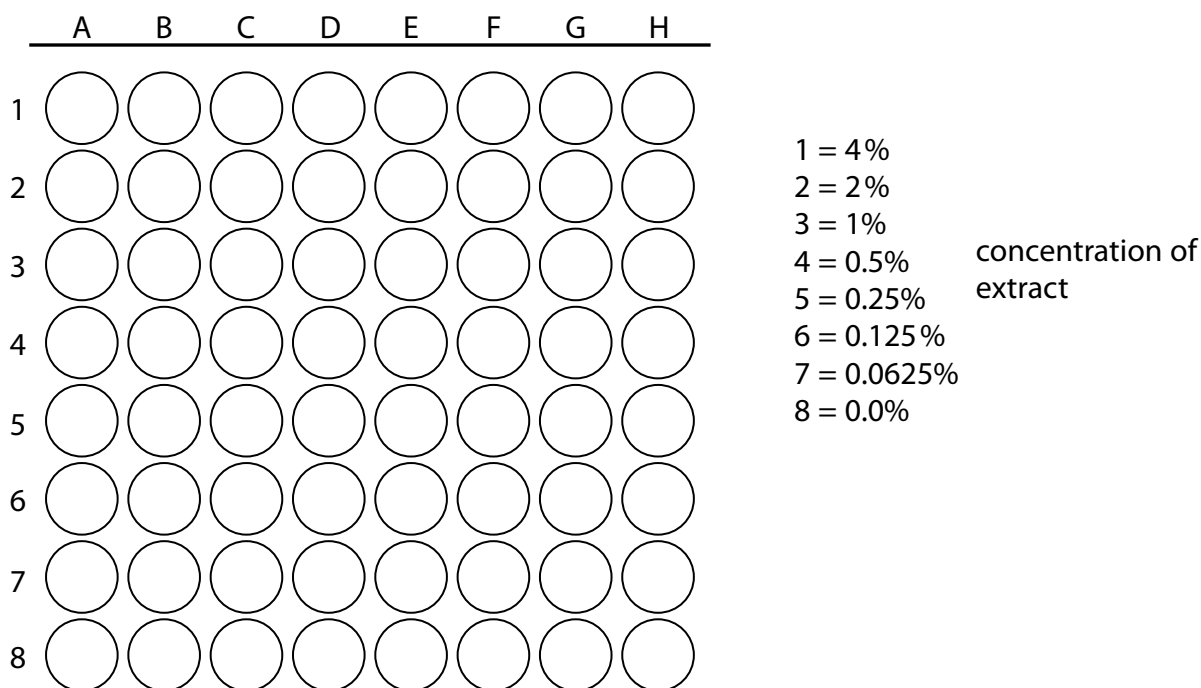
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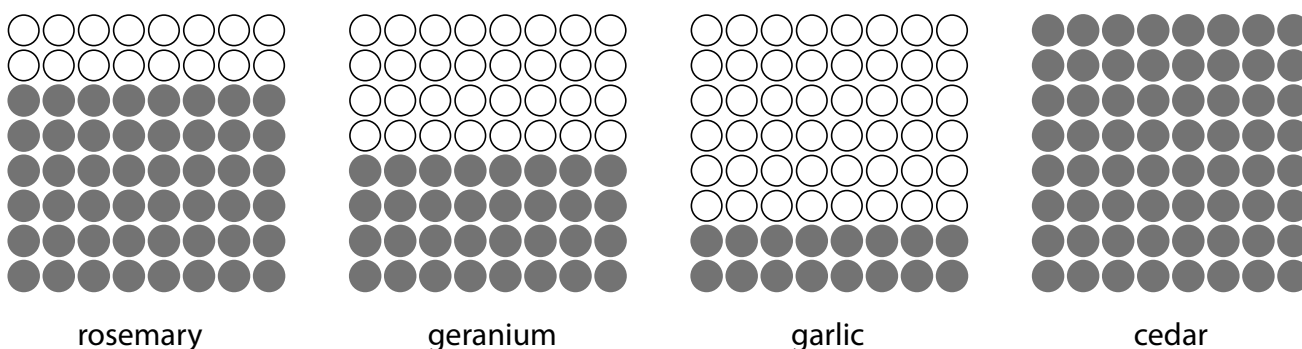
- (c) The size of the clear zone depends on variables other than the antibacterial properties of the substances used, such as size and solubility of the antimicrobial molecules in the extract.

A new method was developed in which the minimum concentration of extract that causes inhibition of bacterial growth (Minimum Inhibitory Concentration, MIC), was found.

Samples of extract, bacteria (*E. coli*) and a respiration indicator were placed in a micro-titre tray.



The diagrams show the results obtained. The tubes are black when respiration occurs and clear when no respiration occurs.



(i) Analyse the data to explain the results of this experiment.

(2)

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(ii) Give **two** changes that can be made to the procedure to get a more accurate measure of MIC.

(2)

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(iii) It was concluded that plant extracts inhibit respiration of bacteria. This conclusion may not be valid because the investigation has limitations.

Describe how the investigation could be modified to reduce the effect of two named limitations.

(2)

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**(Total for Question 12 = 20 marks)**

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**TOTAL FOR PAPER = 100 MARKS**