



(v) The students used a Student's  $t$ -test to compare the results at 30 °C and 35 °C.

They calculated a  $t$  value of 2.200.

The critical value for  $p = 0.05$  is 2.306.

Assuming their final method was valid, what can the students conclude from the result of the  $t$ -test?

[1]

0 6 . 3

The scientists tested their null hypothesis using the chi-squared statistical test. After 1 cycle their calculated chi-squared value was 350  
The critical value at  $P=0.05$  is 3.841

What does this result suggest about the difference between the observed and expected results and what can the scientists therefore conclude?

[2 marks]



**0 4 . 4** The scientists calculated a P value of 0.03 when testing their null hypothesis.

What can you conclude from this result? Explain your answer.

**[3 marks]**

**10**

- 4** A student investigated the effect of salt concentration on the growth of one species of brine shrimp.

The student placed 100 shrimp eggs in a beaker containing 1dm<sup>3</sup> of 3% salt solution. Three days after the eggs hatched, 10 shrimps were collected and their lengths measured. Seven days after hatching, another 10 shrimps were collected and their lengths measured.

The procedure was repeated using a 5% salt solution. All other variables were kept constant.

- (v) The calculated *t*-value is greater than the critical value at  $p = 0.05$ .

Describe what this result indicates about the effect of salt concentration on the length of brine shrimp.

(2)



**0 3** . **2**

Scientists investigated the use of a drug called Tenapanor to reduce salt absorption in the gut. Tenapanor inhibits the carrier protein, NHE3.

The scientists fed a diet containing a high concentration of salt to two groups of rats, **A** and **B**.

- The rats in Group **A** were **not** given Tenapanor ( $0 \text{ mg kg}^{-1}$ ).
- The rats in Group **B** were given  $3 \text{ mg kg}^{-1}$  Tenapanor.

One hour after treatment, the scientists removed the gut contents of the rats and immediately weighed them.

Their results are shown in **Table 2**.

**Table 2**

Concentration of Tenapanor / $\text{mg kg}^{-1}$	Mean mass of contents of the gut / g
0	2.0
3	4.1

The scientists carried out a statistical test to see whether the difference in the means was significant. They calculated a P value of less than 0.05.

They concluded that Tenapanor did reduce salt absorption in the gut.

Use all the information provided and your knowledge of water potential to explain how they reached this conclusion.

**[4 marks]**



**0 5**

The crown-of-thorns starfish (COTS) is one of the main causes of the decline of the world's coral reefs.

Marine biologists used a choice chamber to investigate the effects of flashing and constant light on the behaviour of COTS.

**Table 1** shows their results as they presented them. The P values show results from a statistical test.

**Table 1**

Behaviour of COTS	Type of light used in choice chamber	
	Flashing	Constant
COTS moving towards the stimulus	22	12
COTS moving away from the stimulus	28	38
P value	0.69	0.02

**0 5 . 3**

A journalist studying **Table 1** suggested that **either** type of light could be used to cause COTS to move away from coral reefs.

Evaluate the journalist's suggestion.

**[3 marks]**



The gene that codes for the AR has a variable number of CAG repeats. Some studies have shown an association between the number of CAG repeats and the risk of developing prostate cancer.

**Table 1** shows the results of a statistical test from one study.

**Table 1**

Number of CAG repeats in the AR gene	Probability (P) value
$\leq 16$	0.02
$\leq 17$	0.30
$\leq 18$	0.07
$\leq 19$	0.09
$\geq 20$	0.06

AQA A P2 20 Q2.4

0 2 . 4

What can you conclude from the data in **Table 1**?

**[3 marks]**



outside the  
box

**0 5 . 4** Scientists investigated the link between the lung disease asthma and three risk factors. They studied a large number of people. They recorded if the people had asthma and if they:

- were obese
- burned wood indoors as a fuel
- lived in a house with a cat or dog.

The scientists used a statistical test to calculate the probability of the link between asthma and each risk factor being due to chance.

**Table 2** shows their results.

**Table 2**

Risk Factor	Probability (P value)
Obese	< 0.001
Burned wood indoors	= 0.06
Lived with a cat or dog	< 0.05

A student who looked at these results concluded that all three risk factors are linked with asthma. Evaluate this conclusion.

**[3 marks]**



Scientists investigated the biodiversity of butterflies in a rainforest. Their investigation lasted several months.

The scientists set one canopy trap and one understorey trap at five sites.

- The canopy traps were set among the leaves of the trees 16–27 m above ground level.
- The understorey traps were set under trees at 1.0–1.5 m above ground level.

The scientists recorded the number of each species of butterfly caught in the traps.

**Table 1** summarises their results.

**Table 1**

Species of butterfly	Mean number of butterflies		P value
	In canopy	In understorey	
<i>Prepona laertes</i>	15	0	< 0.001
<i>Archaeoprepona demophon</i>	14	37	< 0.001
<i>Zaretis itys</i>	25	11	> 0.05
<i>Memphis arachne</i>	89	23	< 0.001
<i>Memphis offa</i>	21	3	< 0.001
<i>Memphis xenocles</i>	32	8	< 0.001

0 3 . 4

The scientists carried out a statistical test to see if the difference in the distribution of each species between the canopy and understorey was due to chance. The P values obtained are shown in **Table 1**.

Explain what the results of these statistical tests show.

**[3 marks]**



- (v) The students used a Student's  $t$ -test to compare the results at 30 °C and 35 °C.

They calculated a  $t$  value of 2.200.

The critical value for  $p = 0.05$  is 2.306.

Assuming their final method was valid, what can the students conclude from the result of the  $t$ -test?

difference (between the means), is not significant / can be explained by chance (at  $p = 0.05$ ) ✓

**ACCEPT** null hypothesis /  $H_0$ , can be accepted

**DO NOT ACCEPT** null hypothesis /  $H_0$  can be rejected

**ACCEPT** the results are not significantly different ( $p = 0.05$ )

[1]

0 6 . 3

The scientists tested their null hypothesis using the chi-squared statistical test. After 1 cycle their calculated chi-squared value was 350  
The critical value at  $P=0.05$  is 3.841

What does this result suggest about the difference between the observed and expected results and what can the scientists therefore conclude?

[2 marks]

1. There is a less than 0.05/5% probability that the difference(s) (between observed and expected) occurred by chance;
2. Calculated value is greater than critical value so the null hypothesis can be rejected;
3. (The scientists can conclude that) the proportion of plants that produce  $2n$  gametes does change from one breeding cycle to the next;

1. Reject 'results (without reference to difference) occurring by chance'. Overall max 1 with this statement.

1. Accept 'there is a greater than 0.95/95% probability that the difference did **not** occur by chance'.

1. and 2. Ignore 'difference is significant'

2. Do not accept 'P value' for 'critical value'.





**0 4 . 4** The scientists calculated a P value of 0.03 when testing their null hypothesis.

What can you conclude from this result? Explain your answer.

**[3 marks]**

1. Probability that difference (in frequency of births above 4500 g) is due to chance is **less than** 0.05

**OR**

Probability that difference (in frequency of births above 4500 g) is due to chance is 0.03;

2. Reject null hypothesis;

3. Presence of *KIR2DS1*/allele does (significantly) affect the frequency of high birth mass;

Ignore reference to critical value.

1. Accept 5% for 0.05 1. Accept 3% for 0.03

1. Ignore results due to chance.

1. Accept 'Probability that difference (in frequency of births above 4500 g) is **not** due to chance is **greater than** 0.95'

**OR**

'Probability that difference (in frequency of births above 4500 g) is **not** due to chance is 0.97'

2. Accept ' $H_0$ ' for null hypothesis.

2. For 'reject' accept 'do not accept' but not 'disprove/wrong'.

2. Accept 'Accept the alternate hypothesis/ $H_1$ '

3. Do not accept 'number' for 'frequency'.

- 4** A student investigated the effect of salt concentration on the growth of one species of brine shrimp.

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The procedure was repeated using a 5% salt solution. All other variables were kept constant.

- (v) The calculated *t*-value is greater than the critical value at  $p = 0.05$ .

Describe what this result indicates about the effect of salt concentration on the length of brine shrimp.

**(2)**

An explanation that makes reference to the following:

1. there was a significant difference between {the 3% and the 5% salt solution / groups} (1)
2. at the 5% significance level (1)

1. IGNORE significant correlation / significant relationship
2. ALLOW 95% probability there is a difference  
e.g. '5% chance that the difference is due to chance' or with 95% certainty' IGNORE  $p = 0.05$



03 . 2

Scientists investigated the use of a drug called Tenapanor to reduce salt absorption in the gut. Tenapanor inhibits the carrier protein, NHE3.

The scientists fed a diet containing a high concentration of salt to two groups of rats, **A** and **B**.

- The rats in Group **A** were **not** given Tenapanor ( $0 \text{ mg kg}^{-1}$ ).
- The rats in Group **B** were given  $3 \text{ mg kg}^{-1}$  Tenapanor.

One hour after treatment, the scientists removed the gut contents of the rats and immediately weighed them.

Their results are shown in **Table 2**.

**Table 2**

Concentration of Tenapanor / $\text{mg kg}^{-1}$	Mean mass of contents of the gut / g
0	2.0
3	4.1

The scientists carried out a statistical test to see whether the difference in the means was significant. They calculated a P value of less than 0.05.

They concluded that Tenapanor did reduce salt absorption in the gut.

Use all the information provided and your knowledge of water potential to explain how they reached this conclusion.

**[4 marks]**

1. Tenapanor/(Group)B/drug causes a significant increase;

OR

There is a significant difference with Tenapanor/drug/between A and B;

2. There is a less than 0.05 probability that the difference is due to chance;

3. (More salt in gut) reduces water potential in gut (contents);

4. (so) less water absorbed out of gut (contents) by osmosis

OR

Less water absorbed into cells by osmosis

OR

Water moves into the gut (contents) by osmosis.

OR

(so) water moves out of cells by osmosis;

1. and 2. Reject references to 'results' being significant/due to chance once only.

2. Do not credit suggestion that probability is 0.05% or 5.

2. Accept 'There is a greater than 0.95/95% probability that any difference between observed and expected is not due to chance



0 5

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A journalist studying **Table 1** suggested that **either** type of light could be used to cause COTS to move away from coral reefs.

Evaluate the journalist's suggestion.

Yes (no mark)

**[3 marks]**

1. Movement is away from either type/both types of light

**OR**

Negative (photo) taxis to both types/either types of light;

2. Significant movement away from constant light as  $p=0.02/<0.05/=2%/<5\%$

**OR**

Movement away from constant light is not due to chance **as**  $p=0.02/<0.05/=2%/<5\%$ ;

No (no mark)

3. Movement away from flashing light is not significant **as**  $p=0.69/>0.05/=69%/>5\%$

**OR**

Movement away from flashing light is due to chance **as**  $p=0.69/>0.05/=69%/>5\%$ ;

2. and 3. Ignore 'results' in the context of significance or chance



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AQA A P2 20 Q2.4

0 2 . 4

What can you conclude from the data in **Table 1**?

[3 marks]

3 max

- With 16 or fewer than 16 (repeats the association) is significant;
- With 17 or more than 17 (repeats the association) is not significant;
- With 16 or fewer than 16 (repeats) there is less than a 5% or less than 0.05 probability of being due to chance

**OR**

With 17 or more than 17 (repeats) there is more than a 5% or more than 0.05 probability of being due to chance

**OR**

Explanation of a probability value e.g. 0.30 is a 0.30 or 30% probability of being due to chance;

- With 16 or fewer than 16 (repeats) reject the null hypothesis

**OR**

With 17 or more (repeats) accept the null hypothesis;

If none of the marks is awarded allow principle mark of (prostate) cancer more likely with 16 or less than 16 (repeats) or (prostate) cancer less likely with 17 or more than 17 (repeats)

**OR**

Alternative principle mark: Correctly links significant/not significant to correct probability value/percentage or to rejecting/accepting the null hypothesis.

- Reject 'the results are significant'.
- Accept 'difference in results is significant'.
- 2, 3 and 4. Accept reference to any number of repeats (e.g. 18) between 17 to 20 for 17 or more than 17 (repeats).
- Accept equivalent responses in terms of 95% or 0.95 probability.



**0 5 . 4** Scientists investigated the link between the lung disease asthma and three risk factors. They studied a large number of people. They recorded if the people had asthma and if they:

- were obese
- burned wood indoors as a fuel
- lived in a house with a cat or dog.

The scientists used a statistical test to calculate the probability of the link between asthma and each risk factor being due to chance.

**Table 2** shows their results.

**Table 2**

Risk Factor	Probability (P value)
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A student who looked at these results concluded that all three risk factors are linked with asthma. Evaluate this conclusion.

**[3 marks]**

**In support**

1. (Link/risk with asthma and) living with cat or dog is (statistically) significant;
2. (Link with) obesity is most/highly significant;

**Not supported**

3. (Link/risk with asthma and) burned wood (indoors) is not (statistically) significant;

Reject 'results are significant'

Accept 'due to chance' for 'not significant' and converse



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0 3 . 4

The scientists carried out a statistical test to see if the difference in the distribution of each species between the canopy and understorey was due to chance. The P values obtained are shown in **Table 1**.

Explain what the results of these statistical tests show.

**[3 marks]**

1. For *Zaretis itys*, difference in distribution is probably due to chance / probability of being due to chance is more than 5%;
2. For all species other than *Zaretis itys*, difference in distribution is (highly) unlikely to be due to chance;
3. Because  $P < 0.001$  which is highly significant/is much lower than 5%;