1. A company claims that a quarter of the bolts sent to them are faulty. To test this claim the number of faulty bolts in a random sample of 50 is recorded.

(a) Give two reasons why a binomial distribution may be a suitable model for the number of faulty bolts in the sample.

(2)

(b) Using a 5% significance level, find the critical region for a two-tailed test of the hypothesis that the probability of a bolt being faulty is $\frac{1}{4}$. The probability of rejection in either tail should be as close as possible to 0.025

(3)

(c) Find the actual significance level of this test.

(2)

In the sample of 50 the actual number of faulty bolts was 8.

(d) Comment on the company's claim in the light of this value. Justify your answer.

(2)

The machine making the bolts was reset and another sample of 50 bolts was taken. Only 5 were found to be faulty.

(e) Test at the 1% level of significance whether or not the probability of a faulty bolt has decreased. State your hypotheses clearly.

(6)
(Total 15 marks)

2. (a) Define the critical region of a test statistic.

(2)

A discrete random variable x has a Binomial distribution B(30, p). A single observation is used to test $H_0 : p = 0.3$ against $H_1 : p \neq 0.3$

(b) Using a 1% level of significance find the critical region of this test. You should state the probability of rejection in each tail which should be as close as possible to 0.005

(5)

(c) Write down the actual significance level of the test.

(1)

The value of the observation was found to be 15.

(d) Comment on this finding in light of your critical region.

(2)
(Total 10 marks)

3. Past records suggest that 30% of customers who buy baked beans from a large supermarket buy them in single tins. A new manager questions whether or not there has been a change in the proportion of customers who buy baked beans in single tins. A random sample of 20 customers who had bought baked beans was taken.

(a) Using a 10% level of significance, find the critical region for a two-tailed test to answer the manager's question. You should state the probability of rejection in each tail which should be less than 0.05.

(5)

(b) Write down the actual significance level of a test based on your critical region from part (a).

(1)

The manager found that 11 customers from the sample of 20 had bought baked beans in single tins.

(c) Comment on this finding in the light of your critical region found in part (a).

(2)
(Total 8 marks)

4. A single observation x is to be taken from a Binomial distribution B(20, p).

This observation is used to test $H_0 : p = 0.3$ against $H_1 : p \neq 0.3$

(a) Using a 5% level of significance, find the critical region for this test. The probability of rejecting either tail should be as close as possible to 2.5%.

(3)

(b) State the actual significance level of this test.

(2)

The actual value of x obtained is 3.

(c) State a conclusion that can be drawn based on this value giving a reason for your answer.

(2)
(Total 7 marks)

5. Dhriti grows tomatoes. Over a period of time, she has found that there is a probability 0.3 of a ripe tomato having a diameter greater than 4 cm. She decides to try a new fertiliser. In a random sample of 40 ripe tomatoes, 18 have a diameter greater than 4 cm. Dhriti claims that the new fertiliser has increased the probability of a ripe tomato being greater than 4 cm in diameter.

Test Dhriti's claim at the 5% level of significance. State your hypotheses clearly.

(Total 7 marks)

6. Linda regularly takes a taxi to work five times a week. Over a long period of time she finds the taxi is late once a week. The taxi firm changes her driver and Linda thinks the taxi is late more often. In the first week, with the new driver, the taxi is late 3 times.

You may assume that the number of times a taxi is late in a week has a Binomial distribution.

Test, at the 5% level of significance, whether or not there is evidence of an increase in the proportion of times the taxi is late. State your hypotheses clearly.

(Total 7 marks)

7. Past records from a large supermarket show that 20% of people who buy chocolate bars buy the family size bar. On one particular day a random sample of 30 people was taken from those that had bought chocolate bars and 2 of them were found to have bought a family size bar.

(a) Test at the 5% significance level, whether or not the proportion p, of people who bought a family size bar of chocolate that day had decreased. State your hypotheses clearly.

(6)

The manager of the supermarket thinks that the probability of a person buying a gigantic chocolate bar is only 0.02. To test whether this hypothesis is true the manager decides to take a random sample of 200 people who bought chocolate bars.

(b) Find the critical region that would enable the manager to test whether or not there is evidence that the probability is different from 0.02. The probability of each tail should be as close to 2.5% as possible.

(6)

(c) Write down the significance level of this test.

(1)
(Total 13 marks)

8. It is known from past records that 1 in 5 bowls produced in a pottery have minor defects. To monitor production a random sample of 25 bowls was taken and the number of such bowls with defects was recorded.

(a) Using a 5% level of significance, find critical regions for a two-tailed test of the hypothesis that 1 in 5 bowls have defects. The probability of rejecting, in either tail, should be as close to 2.5% as possible.

(6)

(b) State the actual significance level of the above test.

(1)

At a later date, a random sample of 20 bowls was taken and 2 of them were found to have defects.

(c) Test, at the 10% level of significance, whether or not there is evidence that the proportion of bowls with defects has decreased. State your hypotheses clearly.

(7)
(Total 14 marks)

9. A teacher thinks that 20% of the pupils in a school read the Deano comic regularly.

He chooses 20 pupils at random and finds 9 of them read Deano.

(a) (i) Test, at the 5% level of significance, whether or not there is evidence that the percentage of pupils that read Deano is different from 20%. State your hypotheses clearly.

(ii) State all the possible numbers of pupils that read Deano from a sample of size 20 that will make the test in part (a)(i) significant at the 5% level.

(9)

The teacher takes another 4 random samples of size 20 and they contain 1, 3, 1 and 4 pupils that read Deano.

(b) By combining all 5 samples and using a suitable approximation test, at the 5% level of significance, whether or not this provides evidence that the percentage of pupils in the school that read Deano is different from 20%.

(8)

(c) Comment on your results for the tests in part (a) and part (b).

(2)
(Total 19 marks)

10. In an experiment, there are 250 trials and each trial results in a success or a failure.

(a) Write down two other conditions needed to make this into a binomial experiment.

(2)

It is claimed that 10% of students can tell the difference between two brands of baked beans. In a random sample of 250 students, 40 of them were able to distinguish the difference between the two brands.

(b) Using a normal approximation, test at the 1% level of significance whether or not the claim is justified. Use a one-tailed test.

(6)

(c) Comment on the acceptability of the assumptions you needed to carry out the test.

(2)
(Total 10 marks)

11. Brad planted 25 seeds in his greenhouse. He has read in a gardening book that the probability of one of these seeds germinating is 0.25. Ten of Brad's seeds germinated. He claimed that the gardening book had underestimated this probability. Test, at the 5% level of significance, Brad's claim. State your hypotheses clearly.

(Total 7 marks)

12. From past records a manufacturer of ceramic plant pots knows that 20% of them will have defects. To monitor the production process, a random sample of 25 pots is checked each day and the number of pots with defects is recorded.

(a) Find the critical regions for a two-tailed test of the hypothesis that the probability that a plant pot has defects is 0.20. The probability of rejection in either tail should be as close as possible to 2.5%.

(5)

(b) Write down the significance level of the above test.

(1)

A garden centre sells these plant pots at a rate of 10 per week. In an attempt to increase sales, the price was reduced over a six-week period. During this period a total of 74 pots was sold.

(c) Using a 5% level of significance, test whether or not there is evidence that the rate of sales per week has increased during this six-week period.

(7)
(Total 13 marks)

13. From past records a manufacturer of glass vases knows that 15% of the production have slight defects. To monitor the production, a random sample of 20 vases is checked each day and the number of vases with slight defects is recorded.

(a) Using a 5% significance level, find the critical regions for a two-tailed test of the hypothesis that the probability of a vase with slight defects is 0.15. The probability of rejecting, in either tail, should be as close as possible to 2.5%.

(5)

(b) State the actual significance level of the test described in part (*a*).

(1)

A shop sells these vases at a rate of 2.5 per week. In the 4 weeks of December the shop sold 15 vases.

(c) Stating your hypotheses clearly test, at the 5% level of significance, whether or not there is evidence that the rate of sales per week had increased in December.

(6)
(Total 12 marks)

1.	(a)	2 outcomes/faulty or not faulty/success or fail	B1	
		A constant probability	B1	2
		Independence		
		Fixed number of trials (fixed n)		

Note

B1 B1 one mark for each of any of the four statements. Give first B1 if only one correct statement given. No context needed.

	(b)	$X \sim \text{B}(50, 0.25)$	M1	
		$\text{P}(X \leq 6) = 0.0194$		
		$\text{P}(X \leq 7) = 0.0453$		
		$\text{P}(X \geq 18) = 0.0551$		
		$\text{P}(X \geq 19) = 0.0287$		
		CR $X \leq 6$ and $X \geq 19$	A1 A1	3

Note

M1 for writing or using B(50, 0.25) also may be implied by both CR being correct. Condone use of P in critical region for the method mark.
A1 $(X) \leq 6$ o.e. [0, 6] DO NOT accept $\text{P}(X \leq 6)$
A1 $(X) \geq 19$ o.e. [19, 50] DO NOT accept $\text{P}(X \geq 19)$

	(c)	$0.0194 + 0.0287 = 0.0481$	M1 A1	2

Note

M1 Adding two probabilities for two tails. Both probabilities must be less than 0.5
A1 awrt 0.0481

	(d)	8(It) is not in the Critical region or 8(It) is not significant or $0.0916 > 0.025$;	M1	
		There is evidence that the probability of a faulty bolt is 0.25 or the company's claim is correct	A1ft	2

Note

M1 one of the given statements followed through from their CR.
A1 contextual comment followed through from their CR.
NB A correct contextual comment **alone** followed through from their CR.will get M1 A1

	(e)	$\text{H}_0 : p = 0.25$ $\text{H}_1 : p < 0.25$	B1 B1	
		$\text{P}(X \leq 5) = 0.0070$ or CR $X \leq 5$	M1 A1	
		$0.007 < 0.01$,		
		5 is in the critical region, reject H_0, significant.	M1	
		There is evidence that the probability of faulty bolts has decreased	A1ft	6

Note

B1 for H_0 must use p or π (pi)
B1 for H_1 must use p or π (pi)
M1 for finding or writing $\text{P}(X \leq 5)$ or attempting to find a critical region or a correct critical region
A1 awrt 0.007/CR $X \leq 5$

M1 correct statement using their Probability and 0.01 if one tail test
or a correct statement using their Probability and 0.005 if two tail test.
The 0.01 or 0.005 needn't be explicitly seen but implied by correct statement compatible with their H_1. If no H_1 given M0
A1 correct contextual statement follow through from their prob and H1. Need faulty bolts and decreased.
NB A correct contextual statement **alone** followed through from their prob and H_1 get M1 A1

[15]

2.	(a)	The set of values of the test statistic for which	B1	
		the null hypothesis is rejected in a hypothesis test.	B1	2

Note

1st **B1** for **"values/ numbers"**

2nd **B1** for "reject the null hypothesis" o.e or the test is significant

(b)	$X \sim B(30,0.3)$	M1	
	$P(X \le 3) = 0.0093$		
	$P(X \le 2) = 0.0021$	A1	
	$P(X \ge 16) = 1 – 0.9936 = 0.0064$		
	$P(X \ge 17) = 1 – 0.9979 = 0.0021$	A1	
	Critical region is $(0 \le)x \le 2$ or $16 \le x(\le 30)$	A1A1	5

Note

M1 for using B(30,0.3)

1st **A1** $P(X \le 2) = 0.0021$

2nd **A1** 0.0064

3rd **A1** for $(X) \le 2$ or $(X) < 3$ They get **A0** if they write **P**$(X \le 2/ X \le 3)$

4th **A1** $(X) \ge 16$ or $(X) > 15$ They get **A0** if they write **P**$(X \ge 16\ X \ge 15$

NB these are B1 B1 but mark as A1 A1

$16 \le X \le 2$ etc is accepted

To describe the critical regions they can use any letter or no letter at all. It does not have to be X.

(c)	Actual significance level 0.0021+0.0064=0.0085 or 0.85%	B1	1

Note

B1 correct answer only

(d)	15 (it) is not in the critical region		Bft 2, 1, 0	
	not significant			
	No significant evidence of a change in $P = 0.3$ accept H_0, (reject H_1) $P(x \geq 15) = 0.0169$			2

Note

Follow through 15 and their critical region

B1 for any one of the 5 correct statements up to a maximum of B2

– B1 for any incorrect statements

[10]

3.	(a)	$X \sim B(20, 0.3)$		M1	
			$P(X \leq 2) = 0.0355$	A1	
		$P(X \leq 9) = 0.9520$ so	$P(X \geq 10) = 0.0480$	A1	
		Therefore the critical region is $\{X \leq 2\} \cup \{X \geq 10\}$		A1A1	5

Note

M1 for B(20,0.3) seen or used

1st A1 for 0.0355

2nd A1 for 0.048

3rd A1 for $(X) \leq 2$ or $(X) < 3$ or [0,2] They get **A0** if they write $P(X \leq 2/ X < 3)$

4th A1 $(X) \geq 10$ or $(X) > 9$ or [10,20] They get **A0** if they write $P(X \geq 10/ X > 9)$ $\mathbf{10} \leq X \leq 2$ etc is accepted
To describe the critical regions they can use any letter or no letter at all. It does not have to be X.

(b)	$0.0355 + 0.0480 = 0.0835$	awrt (0.083 or 0.084)	B1	1

Note

B1 correct answer only

(c)	11 is in the critical region	B1ft	
	there is evidence of a <u>change/ increase</u> in the <u>proportion/number</u> of <u>customers buying single tins</u>	B1ft	2

Note

1stB1 for a correct statement about 11 and their critical region.

2nd B1 for a correct comment in context consistent with their CR and the value 11

<u>Alternative</u>

1st B0 $P(X \geq 11) = 1 - 0.9829 = 0.0171$ since no comment about the critical region

2nd B1 a correct contextual statement.

[8]

4.	(a)	X ~ B(20, 0.3)	M1	
		$P(X \leq 2) = 0.0355$		
		$P(X \geq 11) = 1 - 0.9829 = 0.0171$		
		Critical region is $(X \leq 2) \cup (X \geq 11)$	A1 A1	3
	(b)	Significance level = 0.0355 + 0.0171, = 0.0526 or 5.26%	M1 A1	2
	(c)	Insufficient evidence to reject H_0 **Or** sufficient evidence to accept H0 /not significant	B1 ft	
		$x = 3$ (or the value) is not in the critical region or 0.1071> 0.025	B1 ft	2
		Do not allow inconsistent comments		

[7]

5.	$H_0 : p = 0.3$; $H_1 : p > 0.3$		B1B1	
	Let X represent the number of tomatoes greater than 4 cm : X ~ B(40, 0.3)		B1	
	$P(X \geq 18) = 1 - P(X \leq 17)$	$P(X \geq 18) = 1 - P(X \leq 17) = 0.0320$ $P(X \geq 17) = 1 - P(X \leq 16) = 0.0633$	M1	
	= 0.0320	CR $X \geq 18$	A1	
	0.0320 < 0.05	18 ≥ 18 or 18 in the critical region		
	no evidence to Reject H_0 or it is significant		M1	
	New fertiliser has <u>increased</u> the probability of a <u>tomato</u> being greater than 4 cm **Or** Dhriti's claim is true		B1d cao	7

B1 for correct H_0 . must use p or pi

B1 for correct H_1 must use p and be one tail.

B1 using B(40, 0.3). This may be implied by their calculation

M1 attempt to find $1 - P(X \leq 17)$ or get a correct probability.
For CR method must attempt to find $P(X \geq 18)$ or give the correct critical region

A1 awrt 0.032 or correct CR.

M1 correct statement based on their probability , H_1 and 0.05
or a correct contextualised statement that implies that.

B1 this is not a follow through .conclusion in context. Must use the words increased, tomato and some reference to size or diameter.
This is dependent on them getting the previous M1

If they do a **<u>two tail test</u>** they may get B1 B0 B1 M1 A1 M1 B0

For the second M1 they must have accept H_0 or it is not significant or a correct contextualised statement that implies that.

[7]

6. <u>One tail test</u>

<u>Method 1</u>

H_0: p = 0.2 B1
H_1: p > 0.2 B1

$X \sim B(5, 0.2)$ may be implied M1

$P(X \geq 3) = 1 - P(X \leq 2)$ $= 1 - 0.9421$	$[P(X \geq 3) = 1 - 0.9421 = 0.0579]$ $P(X \geq 4) = 1 - 0.9933 = 0.0067$	att $P(X \geq 3)$	$P(X \geq 4)$	M1
$= 0.0579$	CR $X \geq 4$	awrt 0.0579		A1
$0.0579 > 0.05$	$3 \leq 4$ or 3 is not in critical region or 3 is not significant			

(Do not reject H_0.) There is insufficient evidence at the 5% significance level that there is an increase in the number of times <u>the taxi/driver is late</u>. B1 7
<u>or</u>
Linda's claim is not justified

Method 2

H_0: p = 0.2 B1
H_1: p > 0.2 B1

X ~ B(5, 0.2) may be implied M1

$P(X < 3) =$	$[P(X < 3) = 0.9421]$ $P(X < 4) = 0.9933$	att $P(X < 3)$	$P(X < 4)$	
0.9421	CR $X \geq 4$	awrt 0.942		M1A1
0.9421 < 0.95	$3 \leq 4$ or 3 is not in critical region or 3 is not significant			M1

(Do not reject H_0.) There is insufficient evidence at the 5% significance level that there is an increase in the number of times the taxi/driver is late. B1
or
Linda's claim is not justified

Two tail test

Method 1

H_0: p = 0.2 B1
H_1: p ≠ 0.2 B0

X ~ X ~ B(5, 0.2) may be implied M1

$P(X \geq 3) = 1 - P(X \leq 2)$ $= 1 - 0.9421$	$[P(X \geq 3) = 1 - 0.9421 = 0.0579]$ $P(X \geq 4) = 1 - 0.9933 = 0.0067$	att $P(X \geq 3)$	$P(X \geq 4)$	
= 0.0579	CR $X \geq 4$	awrt 0.0579		A1
0.0579 > 0.025	$3 \leq 4$ or 3 is not in critical region or 3 is not significant			M1

(Do not reject H_0.) There is insufficient evidence at the 5% significance level that there is an increase in the number of times the taxi/driver is late. B1 7
or
Linda's claim is not justified

Method 2

H_0: p = 0.2 B1
H_1: p ≠ 0.2 B0

X ~ X ~ B(5, 0.2) may be implied M1

$P(X < 3) =$	$[P(X < 3) = 0.9421]$ $P(X < 4) = 0.9933$	att $P(X < 3)$	$P(X < 4)$	
0.9421	CR $X \geq 4$	awrt 0.942		M1A1
0.9421 < 0.975	$3 \leq 4$ or 3 is not in critical region or 3 is not significant			M1

(Do not reject H_0.) There is insufficient evidence at the 5% significance level that there is an increase in the number of times the taxi/driver is late. B1
or
Linda's claim is not justified

<u>Special Case</u>

If they use a probability of $\frac{1}{7}$ throughout the question they may gain B1B1M0M1A0M1B1.

NB they must attempt to work out the probabilities using $\frac{1}{7}$

[7]

7. (a) $H_0 : p = 0.20$, $H_1: p < 0.20$ B1, B1

Let X represent the number of people buying family size bar.

$X \sim B(30, 0.20)$

$P(X \leq 2) = 0.0442$ or $P(X \leq 2) = 0.0442$ awrt 0.044 M1A1

$P(X \leq 3) = 0.1227$

CR $X \leq 2$

0.0442 < 5%, so significant. Significant M1

There is evidence that the no. of family size bars sold is lower than usual. A1 6

(b) $H_0 : p = 0.02$, $H_1: p \neq 0.02$ $\lambda = 4$ etc ok both B1

Let Y represent the number of gigantic bars sold. B1

$Y \sim B(200, 0.02) \Rightarrow Y \sim Po(4)$ can be implied below M1

$P(Y = 0) = \mathbf{0.0183}$ and $P(Y \leq 8) = \mathbf{0.9786} \Rightarrow P(Y \geq 9) = \mathbf{0.0214}$

first, either B1,B1

Critical region $Y = 0 \cup Y \geq 9$ $Y \leq 0$ ok B1,B1 6

N.B. Accept exact Bin: 0.0176 and 0.0202

(c) Significance level = 0.0183 + 0.0214 = 0.0397 awrt 0.04 B1 1

[13]

8. (a) Let X represent the number of bowls with minor defects.

$\therefore X \sim B; (25, 0.20)$ B1; B1

may be implied

$P(X \leq 1) = 0.0274$ or $P(X = 0) = 0.0038$ M1A1

need to see at least one.

prob for $X \leq$ no For M1

$P(X \leq 9) = 0.9827; \Rightarrow P(X \geq 10) = 0.0173$ A1

either

$\therefore$ CR is $\{X \leq 1 \cup X \geq 10\}$ A1 6

(b)	Significance level = 0.0274 + 0.0173		
	= 0.0447 or 4.477% *awrt 0.0447*	B1	
	H_0: p = 0.20; H_1 : p < 0.20;	B1 B1	
	Let Y represent number of bowls with minor defects		
	Under H_0 Y ~ B (20, 0.20) *may be implied*	B1	
	P($Y \le 2$) or P($Y \le 2$) = 0.2061 *either*	M1	
	P($Y \le 1$) = 0.0692		
	= 0.2061 CR $Y \le 1$	A1	
	0.2061 > 0.10 or 0.7939 < 0.9 or 2 > 1 *their p*	M1	
	Insufficient evidence to suggest that the proportion of defective bowls has decreased.	Blft	7

[14]

9.	(a)	(i)	Two tail	B1 B1	
			H_0: p = 0.2, H_1 : p ≠ 0.2 *p* =		
			P($X \ge 9$) = 1 – P($X \le 8$) or attempt critical value/region		
			= 1 – 0.9900 = 0.01 CR $X \ge 9$	A1	
			0.01 < 0.025 or 9 ≥ 9 or 0.99 > 0.975 or 0.02 < 0.05 or lies in interval with correct interval stated. Evidence that the percentage of pupils that read Deano is not 20%	A1	
		(ii)	X ~ Bin (20, 0.2) may be implied or seen in (i) or (ii)	B1	
			So 0 or [9,20] make test significant. 0,9, between "their 9" and 20	B1 B1 B1	9

(b)	$H_0 : p = 0.2$, $H_1 : p \neq 0.2$		B1	
	$W \sim \text{Bin}(100, 0.2)$			
	$W \sim \text{N}(20, 16)$	normal; 20 and 16	B1; B1	
	$\text{P}(X \leq 18) = \text{P}(Z \leq \frac{18.5 - 20}{4})$ or $\frac{x(+\frac{1}{2}) - 20}{4} = \pm 1.96$			
	$\pm$ cc, standardise or use z value, standardise		M1 M1 A1	
	$= \text{P}(Z \leq -0.375)$			
	$= 0.352 - 0.354$	CR $X < 12.16$ or 11.66 for ½	A1	
	[0.352 > 0.025 or 18 > 12.16 therefore insufficient evidence to reject H_0			
	Combined numbers of Deano readers suggests 20% of pupils read Deano		A1	8
(c)	Conclusion that they are different.		B1	
	Either large sample size gives better result Or Looks as though they are not all drawn from the same population.		B1	2

[19]

(a)	(i)	One tail			
		H_0: $p = 0.2$,H_1 : p $\neq$ 0.2		B1B1	
		$\text{P}(X \geq 9) = 1 - \text{P}(X \leq 8)$ or	attempt critical value/region	M1	
		$= 1 - 0.9900 = 0.01$	CR $X \geq 8$	A1	
		$0.01 < 0.025$ or $9 \geq 9$ or $0.99 > 0.975$ or $0.02 < 0.05$ or lies in interval with correct interval stated. Evidence that the percentage of pupils that read Deano is not 20%		A1	
	(ii)	X ~ Bin (20, 0.2)	may be implied or seen in (i) or (ii)	B1	
		So 0 or [9,20] make test significant.	0,9, between "their 9" and 20	B1 B1 B1	9

(b) $H_0 : p = 0.2$, $H_1 : p \neq 0.2$ B1

$W \sim$ Bin (100, 0.2)

$W \sim$ N (20, 16) normal; 20 and 16 B1; B1

$P(X \leq 18) = P(Z \leq \frac{18.5 - 20}{4})$ or $\frac{x - 20}{4} = -1.6449$

± cc, standardise or standardise, use z value M1 M1 A1

$= P(Z \leq -0.375)$

$= 0.3520$ CR $X < 13.4$ or 12.9 awrt 0.352 A1

[0.352 > 0.025 or 18 > 12.16 therefore insufficient evidence to reject H_0

Combined numbers of Deano readers suggests 20% of pupils read Deano A1 8

(c) Conclusion that they are different. B1

Either large sample size gives better result
Or
Looks as though they are not all drawn from the same population. B1 2

[19]

10. (a) Probability of success/failure is constant B1
Trials are independent B1 2

(b) Let p represent proportion of students who can distinguish between brands
H_0: $p = 0.1$; H_1: $p > 0.1$ B1
both

$\alpha = 0.01$; CR: $\delta > 2.3263$ B1
2.3263

$np = 25$; $npq = 22.5$ B1
both
Can be implied

$\delta = \frac{39.5 - 25}{\sqrt{22.5}} = 3.0568\ldots$ M1 A1

Standardisation with ±0.5 their $\sqrt{npq}$

AWRT 3.06

Reject H_0: claim cannot be accepted A1ft 6

Based on clear evidence from δ *or* p

(c) eg:– np, nq both 75 – true or acceptable
p close tp 0.5 – not true, assumption not met — B1
success/failure not clear cut necessarily — B1 — 2
independence – one student influences another

[10]

(b) Aliter $\delta = 3.06 \Rightarrow p = 0.9989 > 0.99$
or p $0.0011 < 0.01$
B1 eqn to 2.3263

11. H_0: $p = 0.25$, $H_1 = p > 0.25$ — B1B1
1 tailed

Under H_0, $X \sim \text{Bin}(25, 0.25)$ — B1
Implied by probability

$P(X \geq 10) = 1 - P(X \leq 9) = 0.0713 > 0.05$ — M1A1
Correct inequality, 0.0713

Do not reject H_0, there is insufficient evidence to support Brad's claim. — A1A1 — 7
DNR, context

[7]

12. (a) Let X represent the number of plant pots with defects, $X \sim B(25,0.20)$ — B1
Implied

$P(X \leq 1) = 0.0274$, $P(X \geq 10) = 0.0173$ — M1A1A1
*Clear attempt at both tails required***,** *4dp*

Critical region is $X \leq 1$, $X \geq 10$ — A1 — 5

(b) Significance level = 0.0274 + 0.0173 = 0.0447 — B1 cao — 1
Accept % 4dp

	(c)	H_0: $\lambda = 10$, H_1: $\lambda > 10$ (or H_0: $\lambda = 60$, H_1: $\lambda > 60$)	B1B1	
		Let Y represent the number sold in 6 weeks, under H_0, $Y \sim \text{Po}(60)$		
		$P(Y \geq 74) \approx P(W > 73.5)$ where $W \sim N(60,60)$	M1A1	
		±0.5 for cc, 73.5		
		$\approx P(Z \geq \dfrac{73.5 - 60}{\sqrt{60}}) = P(Z > 1.74) =, 0.047 - 0.0409 < 0.05$	M1,A1	
		Standardise using 60 $\sqrt{60}$		
		Evidence that rate of sales per week has increased.	A1ft	7

[13]

13.	(a)	X = no. of vases with defects $X \sim B(20, 0.15)$	B1	
		$P(X \leq 0) = 0.0388$		
		Use of tables to find each tail	M1	
		$P(X \leq 6) = 0.9781 \quad \therefore P(X \geq 7) = 0.0219$	M1	
		$\therefore$ critical region is $X \leq 0$, or $X \geq 7$	A1 A1	5
		Significance level = $P(X \leq 0) + P(X \geq 7) = 0.0388 + 0.0219 = 0.0607$	(B1)	1
		H_0: $\lambda = 2.5$, H_1: $\lambda > 2.5$ [or H_0: $\lambda = 10$, H_1: $\lambda > 10$]	B1, B1	
		Y = no. sold in 4 weeks. Under H_0 $Y \sim \text{Po}(10)$	M1	
		$P(Y \geq 15) = 1 - P(Y \leq 14) =, 1 - 0.9165 = 0.0835$	M1, A1	
		More than 5% so not significant. Insufficient evidence of an increase in the rate of sales.	A1	6

[12]

1. Part (a) was well answered as no context was required.

In part (b) candidates identified the correct distribution and with much of the working being correct. However although the lower limit for the critical region was identified the upper limit was often incorrect. It is disappointing to note that many candidates are still losing marks when they clearly understand the topic thoroughly and all their work is correct except for the notation in the final answer. It cannot be overstressed that $P(X \leq 6)$ is not acceptable notation for a critical region. Others gave the critical region as $6 \leq X \leq 19$.

In part (c) the majority of candidates knew what to do and just lost the accuracy mark because of errors from part (b) carried forward.

Part (d) tested the understanding of what a critical region actually is, with candidates correctly noting that 8 was outside the critical region but then failing to make the correct deduction from it. Some were clearly conditioned to associate a claim with the alternative hypothesis rather than the null hypothesis. A substantial number of responses where candidates were confident with the language of double-negatives wrote "8 is not in the critical region so there is insufficient evidence to disprove the company's claim". Other candidates did not write this, but clearly understood when they said, more simply "the company is correct".

Part (e) was generally well done with correct deductions being made and the contextual statement being made. A few worked out $P(X = 5)$ rather than $P(X \leq 5)$.

2. Part (a) tested candidates' understanding of the critical region of a test statistic and responses were very varied, with many giving answers in terms of a 'region' or 'area' and making no reference to the null hypothesis or the test being significant. Many candidates lost at least one mark in part (b), either through not showing the working to get the probability for the upper critical value, i.e. $1 – P(X \leq 15) = P(X \geq 16) = 0.0064$, or by not showing any results that indicated that they had used B(30, 0.3) and just writing down the critical regions, often incorrectly. A minority of candidates still write their critical regions in terms of probabilities and lose the final two marks. Responses in part (c) were generally good with the majority of candidates making a comment about the observed value and their critical region. A small percentage of responses contained contradictory statements.

3. This was a very well answered question. Candidates were able to use binomial tables and gave the answer to the required number of decimal places. As in previous years there were some candidates who confused the critical region with the probability of the test statistic being in that region but this error has decreased. Candidates were able to describe the acceptance of the hypothesis in context although sometimes it would be better if they just repeated the wording from the question which would help them avoid some of the mistakes seen. There were still a few candidates who did not give a reason in context at all.

In part (a) many candidates failed to read this question carefully assuming it was identical to similar ones set previously. Most candidates correctly identified B(20,0.3) to earn the method mark and many had 0.0355 written down to earn the first A mark, although in light of their subsequent work, this may often have been accidental. A majority of candidates did not gain the second A mark as they failed to respond to the instruction "state the probability of rejection in each case". In the more serious cases, candidates had shown no probabilities from the tables, doing all their work mentally, only writing their general strategy: "$P(X \leq c) < 0.05$". Whilst many candidates were able to write down the critical region using the correct notation there are still some candidates who are losing marks they should have earned, by writing $P(X \leq 2)$ for the critical region $X \leq 2$

Part (b) was usually correct.

Part (c) provided yet more evidence of candidates who had failed to read the question: "in the light of your critical region". Some candidates chose not to mention the critical region and a number of those candidates who identified that 11 was in the critical region did not refer to the manager's question.

4. Part (a) of this question was poorly done. Candidates would appear unfamiliar with the standard mathematical notation for a Critical Region. Thus $11 \le X \le 2$ made its usual appearances, along with $c_1 = 2$ and $P(X \le 2)$
In part (b) candidates knew what was expected of them although many with incorrect critical regions were happy to give a probability greater than 1 for the critical region.

Part (c) was well answered. A few candidates did contradict themselves by saying it was "significant" and "there is no evidence to reject H0" so losing the first mark.

5. The majority of candidates appeared to have coped with this question in a straightforward manner and made good attempts at a conclusion in context, which was easily understood.

The hypotheses were stated correctly by most candidates – they seem more at ease with writing "p =" than in Q7 where λ is the parameter. Most used the correct distribution B(40, 0.3). Those who stated the correct inequality usually also found the correct probability/critical region and thus rejected H_0. The main errors were to calculate $1 - P(X \le 18)$ or $P(X = 18)$. Some candidates used a critical region approach but the majority calculated a probability. A minority of candidates still attempted to find a probability to compare with 0.95. This was only successful in a few cases and it is recommended that this method is not used. Most candidates who took this route found $P(X \le 18)$ rather than $P(X \le 17)$.There were difficulties for some in expressing an accurate contextualised statement. The candidates who used a critical region method here found it harder to explain their reasoning and made many more mistakes.

6. There was clear evidence that candidates had been well prepared for a question on hypothesis testing with many candidates scoring full marks on this question. Candidates who used the probability method were generally more successful than those who used critical regions. They were less familiar with writing hypotheses for p than for the mean and so used λ or μ instead of p. A few candidates mistakenly used a B(5, 1/7) or B(7,1/7) distribution. In a minority of cases the final mark was lost through not writing the conclusion in context using wording from the question.

7. Weaker candidates found this question difficult and even some otherwise very strong candidates failed to attain full marks. Differentiating between hypothesis testing and finding critical regions and the statements required, working with inequalities and placing answers in context all caused problems. In part (a) a large number of candidates were able to state the hypotheses correctly but a sizeable minority made errors such as missing the p or using an alternative (incorrect) symbol. Some found $P(X = 2)$ instead of $P(X \le 2)$ and not all were able to place their solution in the correct context. Not all candidates stated the hypotheses they were using to calculate the critical regions in part (b). In a practical situation this makes these regions pointless. The lower critical region was identified correctly by many candidates but many either failed to realise that $P(X \le 8)=0.9786$ would give them the correct critical region and/or that this is $X \ge 9$. The final part was often correct.

8. Part (a) was one of the poorest answered questions in the paper. Many candidates quoted the inequalities with little or no understanding of how to apply them and too many merely stated the critical values with no figures to back them up and without going on to give the critical region. It was unclear in some cases whether they knew that the critical region was the two tails rather than the central section. A few candidates used diagrams and this almost always enabled them to give a correct solution. Many misunderstood the wording of the question and thought that one of the tails could be slightly larger than 2.5%. Those that got Part (a) correct usually got part (b) correct, although a minority of weaker candidates did not understand what was meant by significance level. Part (c) was well answered. Those candidates who used the critical region approach did less well, tending to get themselves muddled. A few did not make the correct implication at the end and too many did not state that $0.2061 > 0.10$ but merely said the result was not significant. The context for accepting/rejecting the null hypothesis was not always given.

9. In part (a)(i) the null and alternative hypotheses were stated correctly by most candidates but then many had difficulties in either calculating the probability or obtaining the correct critical region and then comparing it to the significance level or given value. Most of those obtaining a result were able to place this in context but not always accurately or fully. Candidates still do not seem to realise that just saying accept or reject the hypothesis is inadequate.
In (a)(ii) although some candidates obtained the critical regions the list of values was not always given. Many candidates got the 9 but forgot the 0 and a minority gave a value of ≥ 9 but did not give the upper limit.

In part (b) there was a wide variety of errors in the solutions provided including using the incorrect approximation, failing to include the original sample in the calculations, not using a continuity correction and errors in using the normal tables. Again in this part many candidates lost the interpretation mark.
Most candidates attempting part (c) of the question noted that the results for the two hypothesis tests were different but few suggested that either the populations were possibly not the same for the samples or that larger samples are likely to yield better results.

10. Most candidates wrote down two other conditions associated with the binomial experiment but too many did not use ‘trials’ when referring to independence. The alternative hypothesis was often wrongly defined and far too many of those using the normal approximation ignored the need to use the continuity correction. The conclusion needed to be in context but many did not do this. Few candidates made any sensible attempt to answer part (c).

11. Most candidates were able to state the correct distribution, Bin(25, 0.25), and the hypotheses correctly. However, a sizeable minority were unable to identify the correct test statistic. The most common error was examining $P(X=10)$ instead of $P(X\geq10)$.

12. Many candidates found this question difficult. A few candidates failed to look for the two tails in part (a) and, of those that did, many chose any value that was less than 2.5% rather than the closest value. Many identified the correct probability for the upper region, but then failed to interpret this as a correct critical region. Marks were lost by those who failed to show which values they had extracted from the tables to obtain their results. Nearly all of those who achieved full marks in part (a) answered part (b) correctly.

In part (c) weaker candidates had difficulty in stating hypotheses correctly and then attempted to use a Poisson distribution with a parameter obtained from dividing 74 by 6. However, the best candidates realised that a normal approximation was appropriate, with the most common error being an incorrect application of the continuity correction. Most solutions were placed in context.

13. No Report available for this question.