

Qu	Scheme	Marks	AO
1. (a)	[ $R =$ no. of red beads in Aliya's bracelet] $R \sim B(18, 0.14)$	B1 (1)	3.3
(b)(i)	$P(R = 1) = 0.19403\dots$ awrt <b>0.194</b>	B1	1.1b
(ii)	$P(R \dots 4) = 1 - P(R \dots 3) = 1 - [0.76184\dots]$ $= 0.2381588\dots$ awrt <b>0.238</b>	M1 A1 (3)	3.4 1.1b
(c)	Requires $p = 0.14$ to be constant so need a large number of beads in the sack to ensure that removing 18 beads does not appreciably affect this probability, then it could be suitable.	B1 (1)	3.5b
(d)	$H_0 : p = 0.14$ $H_1 : p \neq 0.14$ [ $X =$ number of red beads in the sample] $X \sim B(75, 0.14)$ $P(X \dots 4) = 0.01506\dots$ or if $B(75, 0.14)$ seen awrt 0.02 { $0.02 < 0.025$ so significant <u>or</u> reject $H_0$ } There is evidence that the proportion of red beads has changed	B1 M1 A1 A1 (4)	2.5 3.3 3.4 2.2b
(e)	$p$ -value is $2 \times "0.01506\dots" = 0.030123\dots =$ awrt 0.03	B1ft (1)	1.1b
<b>(10 marks)</b>			
<b>Notes</b>			
(a)	B1 for $B(18, 0.14)$ accept in words e.g. <u>binomial</u> with $n = 18$ and $p = 0.14$		
(b)(i)	B1 for awrt 0.194		
(ii)	M1 for interpreting "at least 4" Need $1 - P(R \dots 3)$ <u>and</u> $1 - p$ [ $0 < p < 1$ ] $P(R = 3) = 0.233\dots$ OK A1 for awrt 0.238		
(c)	B1 for mention of <u>large number of beads</u> and need for <u><math>p = 0.14</math> to be constant</u> for it to be suitable. Do NOT accept e.g. "events are independent"		
(d)	B1 for both hypotheses correct with use of $p$ or $\pi$ M1 for selecting a suitable model: sight or correct use of $B(75, 0.14)$ May be implied by sight of 0.015 or better <u>or</u> [ $P(X > 4) =$ ] 0.9849... i.e. 0.985 or better 1 <sup>st</sup> A1 for use of the correct model awrt 0.015 (accept awrt 0.02 following a correct expression) Allow 1 <sup>st</sup> A1 for awrt 0.985 <u>only if</u> correct comparison with 0.975 is seen. Sight of $B(75, 0.14)$ and $P(X \dots 4) =$ awrt 0.02 scores M1A1 <u>No sight</u> of $B(75, 0.14)$ <u>but</u> sight of awrt 0.015 scores M1( $\Rightarrow$ )A1[Condone $P(X = 4) = \dots$ ] 2 <sup>nd</sup> A1 ( <b>dep on M1A1</b> ) for a correct conclusion in context mentioning "proportion", "red" and "changed"		
NB	If there is a statement about $H_0$ or significance it must be compatible. May see CR i.e. $X \dots 4$ (mark when prob seen) and $X \dots 18$ (prob = 0.01406..) Ignore upper limit NB for information $P(X = 4) = 0.0104\dots$ and can only score M1A0A0 if $B(75, 0.14)$ seen		
(e)	B1ft for awrt 0.03 Allow ft of their probability in (d) provided at least 3sf used NB an answer of 0.02 in (d) leading to 0.04 in (e) is B0		
SC	Use of CR will give significance level of $0.01506\dots + 0.01406\dots = 0.029\dots$ score B1 <b>no ft</b>		

Que.	Scheme	Marks	AOs
<b>2(a)</b>	$[H_1 : ] p \neq 0.25$	B1	2.5
		(1)	
<b>(b)</b>	$X \sim B(50, 0.25)$	B1	3.3
	$[P(X_{,,} 6) = ] 0.0194$ or $[P(X_{,,} 18) = ] 0.9713$ or $[P(X_{..} 19) = ] 0.0287$ or $X_{,,} 6$ or $X_{..} 19$	M1	3.4
	$[P(X_{,,} 6) = ]$ awrt 0.0194 and $[P(X_{..} 19) = ]$ awrt 0.0287	A1	1.1b
	CR: $X_{,,} 6$ or $X_{..} 19$	A1	1.1b
		(4)	
<b>(c)</b>	$[0.0194 + 0.0287 = ]$ awrt 0.048	B1ft	1.1b
		(1)	
<b>(d)</b>	(Do not reject $H_0$ .) there is insufficient evidence to suggest that the <b>proportion</b> of those with the <b>allergy</b> differs from 25%/Rylan's belief not supported	B1	2.2b
		(1)	
<b>(7 marks)</b>			
<b>Notes</b>			
<b>(a)</b>	<b>B1:</b> correct alternative hypothesis may be stated in terms of $p$ or $\pi$ Ignore null hypothesis if stated		
	<b>Mark part (b) and part (c) together</b>		
<b>(b)</b>	<p><b>B1:</b> setting up a Binomial model with <math>n = 50</math> and <math>p = 0.25</math> (allow if seen previously) May be implied by M mark</p> <p><b>M1:</b> use of Binomial (50, 0.25) to find a tail probability or a CR tail May be implied by a relevant probability e.g. <math>P(X_{,,} 7) = 0.0453</math>, <math>P(X_{,,} 19) = 0.986</math>, <math>P(X_{..} 20) = 0.0139</math> For this mark allow 2sf or better.</p> <p>Watch out for <math>P(X = 6) = 0.0123</math>, <math>P(X = 7) = 0.02586</math>, <math>P(X = 18) = 0.0262</math> which on their own score M0 as these are not tail probabilities.</p> <p><b>A1:</b> both correct probabilities <b>seen</b> (condone awrt 0.0193 and awrt 0.0288)</p> <p><b>A1:</b> correct CR oe e.g. <math>X &lt; 7</math>, <math>X &gt; 18</math> Condone <math>X_{,,} 6</math> and <math>X_{..} 19</math></p>		
<b>(c)</b>	<b>B1ft:</b> awrt 0.048 or ft their two-tailed CR from $B(50, p)$ to 2sf accuracy Each tail probability must be $< 0.05$		
<b>(d)</b>	<p><b>B1:</b> correct inference in context.</p> <p>Do not allow contradictory non-contextual statement e.g. 'Reject <math>H_0</math>' or '10 is in CR'</p> <p>Allow 'proportion' or 'probability' or 'percent(age)/%' but not 'number'.</p> <p>'Rylan's hypothesis is not supported' is B1, but 'Rylan's hypothesis test is not supported' is B0.</p>		

Question	Scheme	Marks	AOs
<b>3(a)</b>	$H_0: p = 0.1 \quad H_1: p \neq 0.1$	B1	2.5
		(1)	
<b>(b)</b>	Use of $X \sim B(50, 0.1)$ implied by sight of one of awrt 0.0052 or awrt 0.9755 or awrt 0.0245	M1	3.4
	Critical regions $X = 0$ or $X \geq 10$	A1	1.1b
	$X = 0$ and $X \geq 10$ plus $P(X = 0) = \text{awrt } 0.0052$ and $P(X \geq 10) = \text{awrt } 0.0245$	A1	1.1b
	<b>SC:</b> Both CR correct with no probabilities and no distribution seen scores M0A1A0		
		(3)	
<b>(c)</b>	0.0297	B1ft	1.1b
		(1)	
<b>(d)</b>	15 is <u>in the critical region</u> therefore there is evidence to support the <u>manager's</u> belief	B1ft	2.2b
		(1)	
<b>(6 marks)</b>			
<b>Notes</b>			
<b>(a)</b>	<b>B1</b>	For both hypotheses in terms of $p$ or $\pi$ . Connected to $H_0$ and $H_1$ correctly Condone 10% but not 10	
<b>(b)</b>	<b>M1</b>	Using correct distribution to find the probability associated with one tail of the CR If the correct distribution is <u>stated</u> (may be seen in part(a)) allow for one tail of the correct CR <b>or</b> one of (awrt 0.025 or awrt 0.005 or awrt 0.975) seen connected to a correct probability statement	
	<b>A1</b>	Lower CR $X = 0 / X < 1 / X \leq 0/$ [condone eg $P(X = 0)$ labelled as CR] Or Upper CR $X \geq 10$ or $X > 9$ [condone $P(X \geq 10)$ oe labelled as CR]	
	<b>A1</b>	Both CR's correct with the relevant probabilities Allow $\cup$ for "and" and $X > 9, X < 1, X \leq 0$ [ <b>do not allow</b> $P(X = 0)$ or $P(X \geq 10)$ oe] Allow CR in different form eg $(9, \infty), [10, \infty)$	
<b>(c)</b>	<b>B1ft</b>	awrt 0.0297 or 2.97% or ft for the sum of the probabilities in (b) for "their 2 critical regions" if seen. If none seen it must be awrt 0.0297 <b>SC M0 in (b) for a one tail test</b> Allow B1ft for their one tail CR in (b) eg 0.0338 or 0.0245 or 0.0579	
<b>(d)</b>	<b>B1ft</b>	A correct statement about 15 and "their CR" or sight $P(X \geq 15) = 0.0000738\dots$ and comparison with "their 0.0245" <b>and</b> a compatible correct statement in context. eg There is evidence that there has been a change in the <u>proportion/probability</u> arriving <u>late</u> Condone increase rather than change Do not allow contradicting statements. NB No CR given in (b) then B0	

Qu 4	Scheme	Marks	AO
(a)	Comment in context about either <b>independence</b> or <b>random</b> packing e.g. “ <u>prizes must be placed in packets at random/independently</u> of each other” <b>or</b> about <b>constant probability</b> e.g. “ <u>the probability of a packet containing a prize is constant/ the same/fixed</u> ”	B1 (1)	3.5b
(b)(i)	$[P(T = 6) = ]$ 0.17273... awrt <b>0.173</b>	B1	1.1b
(ii)	$[P(T < 3) = P(T \leq 2) = ]$ 0.061587... awrt <b>0.0616</b>	B1 (2)	1.1b
(c)	$[K = \text{no. of boxes with fewer than 3 packets containing a prize}]$ $K \sim B(5, \text{“0.0616”})$ $P(K = 2) = 0.031344...$ in the range <b>[0.0313~0.0314]</b>	M1 A1 (2)	1.1b 1.1b
(d)	$H_0 : p = \frac{1}{7}$ $H_1 : p < \frac{1}{7}$ $[X = \text{no of packets containing a prize}] X \sim B(110, \frac{1}{7})$ $[P(X \leq 9)] = 0.038292...$ $[\text{Significant result or reject } H_0]$ E.g. there <u>is</u> evidence to <u>support</u> Kamil’s <u>claim</u>	B1 M1 A1 A1 (4)	2.5 3.3 3.4 2.2b
		<b>( 9 marks)</b>	
<b>Notes</b>			
(a)	B1 <b>May use idea of independent events:</b> a suitable reason, <b>in context</b> , covering idea of <u>random</u> packing or packets filled <u>independently</u> . Should mention key words/ideas of: <u>prizes in packets</u> <b>or</b> <u>packets in boxes</u> <b>May use idea of constant probability.</b> Must see key words underlined in scheme. Idea of probability with “independence” or “not affected by other packets” is B0 B0 for: <b>Idea of only 2 cases.</b> E.g. <u>Packet</u> contains a <u>prize</u> or not <b>or</b> <b>Idea of a fixed number of trials.</b> E.g. Need a <u>fixed</u> number of <u>packets</u> in each <u>box</u>		
(b)(i)	B1 for awrt 0.173		
(ii)	B1 for awrt 0.0616		
(c)	M1 for sight of $B(5, \text{“0.0616”})$ <b>or</b> ${}^5C_2 (\text{“0.0616”})^2 (1 - \text{“0.0616”})^3$ ft their answer to (b)(ii). A1 for an answer in the range [0.0313 to 0.0314] Use of 0.0616 gives 0.031356..ans only 2/2		
(d)	B1 for both hypotheses correct in terms of $p$ or $\pi$ M1 for selecting an appropriate model, may be implied by 1 <sup>st</sup> A1 or $P(X = 9) = 0.0199(2...)$ 1 <sup>st</sup> A1 for 0.038 or better <b>or</b> allow 0.04 with sight of $P(X \leq 9)$		
<b>ALT</b>	<b>Critical Region.</b> Allow CR of $X \leq 9$ (or $X < 10$ ) provided a supporting probability is seen e.g. A1 for correct CR plus $P(X \leq 10) = 0.0718...$ (accept 2sf or 1sf if prob statement seen) 2 <sup>nd</sup> A1 (dep on 1 <sup>st</sup> A1 but indep of hyp’s) for a suitable conclusion in context that suggests <u>support</u> for (Kamil’s) <u>claim</u> <b>or</b> states that there is evidence that <u>proportion</u> <u>/probability/chance</u> of packets containing a <u>prize</u> is less than $\frac{1}{7}$		
<b>Normal</b>	Do not award 2 <sup>nd</sup> A1 for contradictory statements e.g. “not significant” so “supports claim” Sight of $N\left(\frac{110}{7}, \frac{660}{49}\right)$ <b>or</b> awrt 13.5 <b>or</b> probability of 0.045(20..) <b>or</b> 0.033(66..) scores M1		