

IAL A level

Statistics 2

Hypothesis Test MS

1.Jan 2025-5

5(a)	No of meteors in 20 mins, $M \sim \text{Po}(5)$ oe	B1
(i)	$P(M \leq 6) = 1 - P(M \geq 5)$ $= 1 - 0.6160 = 0.3840$	M1
	awrt 0.384	A1
(ii)	$P(M \leq 3)$ $= 0.2650$	A1
	awrt 0.265	A1
		(4)
(b)	$H_0 : \lambda = 15 \quad H_1 : \lambda > 15$	B1
		(1)
(c)	For 30 mins use $X \sim \text{Po}(7.5) \quad P(X \leq 12) = 0.9573$	M1
	Correct probability statement: $P(X \leq 13) = 0.0427$	A1
	Critical Region $X \leq 13$	B1
		(3)
(d)	Test statistic $x = 12$ is not in critical region oe (so insufficient evidence to reject H_0 / insignificant result) No significant evidence that the number of meteors to be seen has increased /no significant evidence to support the astronomy club's claim	M1
		A1
		(2)
		Total 10

(a)	B1	Po(5) seen, used or implied by correct answer in (i) or (ii). Sight (to 3sf) of any of 0.265(0) (or 0.765(0), 0.4405 (or 0.5595), 0.616(0) (or 0.384(0)), 0.7622 (or 0.2378) implies this mark.
(i)	M1	For an attempt at calculating $1 - P(M \geq 5)$ with a Poisson distribution. Imp. by correct answer
	A1	awrt 0.384 (condone $\frac{48}{125}$)
(ii)	A1	awrt 0.265 (independent of the M mark in (i) so B1M0A0A1 is possible)
(b)	B1	written in terms of λ or μ only (accept 7.5 instead of 15 if consistently used for both)
(c)	M1	evidence of Po(7.5) stated or used. Sight of any of 0.0203 or 0.9208 (or 0.0792), 0.9573 (or 0.0427), 0.9784 (or 0.0216), 0.9897 (or 0.0103) to 2sf with probability statement or 3sf on their own implies this mark.
	A1	correct probability statement $P(X \leq 13)$ oe and awrt 0.0427 oe (awrt 4.27%).
	B1	correct critical region $X \leq 13$ (or $X > 12$) only , with or without probability given and independent of their (b). Allow a different letter for X but do not allow CR.
(d)	M1	For a correct comparison fit their CR $X \leq a$ oe (may be written as $P(X \leq a)$) where $a \leq 13$ indicating 12 is not in the critical region. e.g. $12 < "13"$ so accept H_0 Alternatively compares e.g. $P(X \leq 12) = 0.0792 (> 0.05)$ or $P(X \leq 11) = 0.9208 < 0.95$ and indicates do not reject H_0 . Do not ignore contradictory non-contextual statements. Allow if they have a 2-tail CR provided upper CR is $P(X \leq a)$ oe where $a \leq 13$
	A1	Correct conclusion indep. of hypotheses and must be in context. Must mention meteors and increase OR the club's claim oe e.g. insufficient evidence to suggest the number of meteors is greater. Condone e.g. there are not more meteors / the number of meteors has not changed.

2.Jan 2024-3

3 (a)	The vacuum tubes shatter independently	B1
	The probability of a vacuum tube shattering is constant	B1
		(2)
(b)	$C \sim B(15, 0.35)$ plus $[P(C \leq 9) = 0.0142 \text{ or } P(C \geq 10) = 0.0124 \text{ or } P(C \leq 9) = 0.9876]$	M1
	Critical regions $[0, \dots, C \leq 1 \text{ or } 10, \dots, C \leq 15]$	M1
	$[0, \dots, C \leq 1 \text{ and } 10, \dots, C \leq 15]$ plus $P(C \leq 9) = 0.0142 \text{ and } P(C \geq 10) = 0.0124$	A1
		(3)
(c)	0.0266	B1ft
		(1)
(d)	[4 is not in the CR therefore] there is no evidence to reject Rowan's belief	B1ft
		(1)
(e)	$F \sim B(40, 0.35)$	
	$H_0: p = 0.35$ and $H_1: p < 0.35$	B1
	$P(F \leq 8) = 0.0303$ or CR $F \leq 8$	M1A1
	Sufficient evidence to reject H_0 or significant or 8 lies in the Critical region	M1
	There is sufficient evidence to support that the proportion of type B vacuum tubes that shatter when exposed to alternating high and low temperatures is less than 35%	A1
		(5)
Notes		Total 12

	Notes		Total 12
(a)	B1	for one correct reason which must mention tube(s) and shatter/shattering or 2 correct reasons not in context	
	B1	for 2 correct reasons which must mention tube(s) and shatter/shattering at least once	
(b)	M1	for using the correct distribution to find awrt 0.0142 or awrt 0.0124 or awrt 0.988 Allow $B(15, 0.35)$ is written and one of awrt 0.014 or awrt 0.012 or awrt 0.99 is seen	
	M1	for lower CR or $C \leq 1$ oe e.g. $C < 2$ or upper CR $C \geq 10$ oe e.g. $C > 9$ Allow other notation and any letter(s) for CR Do not allow CR written as a probability statement	
	A1	for both CR correct with the relevant probabilities (3 sf and must be seen in part (b)). Do not allow CR written as a probability statement	
	B1ft	for awrt 0.0266 or 2.66% or ft the sum of the probabilities in (b) for "their 2 critical regions" if seen. If no probabilities for their CR given then the answer must be 0.0266	
(d)	B1ft	for a correct statement consistent with their CR Must mention Rowan/his/her or a correct conclusion based on Rowan's belief with the words highlighted in bold e.g. no evidence to suggest that the proportion/probability/number/amount (allow 35% as proportion) of tubes that shatter has changed oe	
	B1	for both hypotheses correct in terms of p or π	
(e)	M1	for using or writing $P(F \leq 8)$ or awrt 0.0303	
	A1	for awrt 0.0303 or correct CR Allow $F \leq 8$ or $F < 9$ but not if part of a probability statement	
	M1	for a correct conclusion – need not be in context. ft their probability or CR. Ignore hypotheses. do not allow contradicting non contextual comments. May be implied by a correct contextual statement on its own	
	A1	for a correct conclusion – must be in context, with words highlighted in bold. ft their probability or CR only. Independent of hypotheses. Do not allow contradicting statements. Allow probability/number/amount/35% for proportion. Allow decreased for less than 35%	

3.June 2024-3

3(a)	A list of all the shops	B1
		(1)
(b)	The shops	B1
		(1)
(c)	Advantage - A sample is quicker/ cheaper / easier to process	B1
	Disadvantage – less accurate/ may be biased / may not be representative	B1
		(2)
(d)	$P(X_{,,} 6) = 0.0172$ <u>or</u> $P(X \dots 18) = 0.0212$ <u>or</u> $P(X_{,,} 17) = 0.9788$ <u>or</u> $X_{,,} 6$ <u>or</u> $X \dots 18$	M1
	$[P(X_{,,} 6)] = 0.0172$ and $[P(X \dots 18)] = 0.0212$	A1
	CR: $[0_{,,}]X_{,,} 6 , 18_{,,} X [, 30]$	A1
		(3)
(e)	20 is in the critical region therefore there is evidence that Jian's belief is incorrect	B1ft
		(1)
(f)	$H_0 : p = 0.4 \quad H_1 : p < 0.4$	B1
	$J \sim B(150, 0.4) \Rightarrow \approx N(60, 36)$	M1A1
	$P(J_{,,} 47) \approx P\left(Z_{,,} \frac{47.5 - 60}{6} [= -2.08333...]\right)$	M1 M1
	$= 0.0188$ (calc 0.018610...)	CR: $J < \text{awrt } 49.6$ A1
	There is sufficient evidence to suggest that the proportion of shops where the stocktaking system is being used incorrectly is less than 0.4/decreased	A1
		(7)

	Notes		Total 15
(a)	B1	for the idea of a list/database(oe) of all shops list of all stocktaking systems is B0	
(b)	B1	for allow shop or store(s) the number of shops is B0 the stocktaking systems at each shop is B0	
(c)	B1	for a correct advantage for a sample oe eg allow census take longer than a sample e.g. 'a sample is more uncertain' on its own is B0	
	B1	for a correct disadvantage for a sample oe eg a census is more accurate than a sample	
		If there is no reference to sample or census assume referring to sample. Ignore extraneous non-contradictory comments	
(d)	M1	for one of these probability statements correct <u>or</u> awrt 0.017 <u>or</u> awrt 0.021 <u>or</u> awrt 0.98 <u>or</u> one correct CR	
	A1	for both probabilities awrt 0.0172 and awrt 0.0212	
	A1	for both CR correct oe e.g. $X < 7$, $X > 17$ ignore any symbol used between the two CR tails allow any or no letter (do not allow CR stated as probabilities)	
(e)	B1ft	for stating 20 is in the CR and give correct statement. Allow the belief in words. Only ft if their CR is in the form X , $C_1 \cup X \dots C_2$ (allow as probability statements)	
(f)	B1	for both hypotheses correct, using p or π . Must be attached to H_0 and H_1	
	M1	for writing or using $N(60, \dots)$	
	A1	for writing or using $N(60, 36)$	
	M1	for standardising (allow $\pm$) using their "60" and "6" with either 46.5, 47 or 47.5 for CR method n , $n + 0.5$ or $n - 0.5$ and equate to -1.6449 or better	
	M1	for using the correct continuity correction 47.5 or $(n + 0.5)$	
	A1	for awrt 0.019 <u>or</u> CR: $J < \text{awrt } 49.6$ or $J + 0.5 < \text{awrt } 50.1$ Exact binomial gives 0.01756...and scores M0A0M0M0A0	
	A1	dep on previous A1 for a correct conclusion in context using bold word (oe) Do not allow 'number' for 'proportion'	

4.Jan 2023-3

3 (a) (i)	$X \sim B(10, 0.1)$	
	$P(X \geq 4) = 1 - P(X \leq 3) = 1 - 0.9872$	M1
	$= 0.0128$	awrt 0.0128
	$P(1 < X < 5) = P(X \leq 4) - P(X \leq 1) = 0.9984 - 0.7361$	M1
	or $P(X=2) + P(X=3) + P(X=4) = 0.1937 + 0.0574 + 0.0112$	A1
(ii)	$= 0.2623$	awrt 0.262
		(4)
	$H_0 : p = 0.1 \quad H_1 : p < 0.1$	B1
	$X \sim B(50, 0.1)$	
	$P(X \leq 2) = 0.1117$ or $CR X \leq 1$	B1
(b)	Do not reject H_0 /Not in the critical region	M1
	There is insufficient evidence to suggest that this result supports the managing <u>director's</u> <u>claim</u> /not enough evidence to suggest a <u>reduction</u> in the probability of a tennis ball <u>failing</u> the bounce test	A1
		(4)
	$X \sim B(n, 0.1)$ and we reject H_0 if $P(X=0) < 0.01$	
	$P(X=0) = \left[{}^nC_0 \times 0.1^0 \right] \times 0.9^n < 0.01$	M1
(c)	$0.9^{44} = 0.00969... < 0.01$	$n > \frac{\ln 0.01}{\ln 0.9} \Rightarrow n > 43.7$
	$n = 44$	M1
		A1
		(3)
Notes		Total 11

(a) (i)	M1	for writing or using $P(X \geq 4) = 1 - P(X \leq 3)$
	A1	awrt 0.0128
(ii)	M1	for writing or using $P(X \leq 4) - P(X \leq 1)$
	A1	or for writing or using $P(X=2) + P(X=3) + P(X=4)$
(b)	A1	awrt 0.262
	B1	Both hypotheses correct. Must be in terms of p or π Must be attached to H_0 and H_1
(c)	B1	awrt 0.112 or $CR \leq 1$
	M1	A correct ft statement consistent with their p -value and 0.05 or their CR and 2- no context needed but do not allow contradicting non contextual comments. The comparison of their p -value and the significance level is not counted as a non contextual statement. May be implied by a correct ft conclusion in context. Must have a p -value or CR to access this mark.
(d)	A1	Correct conclusion in context which must be not rejecting H_0 . Must use underlined words (oe). No hypotheses then A0
	M1	For recognising $P(X=0) = 0.9^n$
(e)	M1	For $0.9^{44} (= 0.00969...)$ or $0.9^{43} (= 0.01077...)$ or rearranging to $n > \frac{\ln 0.01}{\ln 0.9} \dots$ (Allow =)
	A1	$n > \text{awrt } 43.7$ implies M1M1 (Allow $n = \text{awrt } 43.7$ for M1M1)
(f)	A1	Cao
	SC	Use of tables only, $n = 40, p = 0.0148$ and $n = 50, p = 0.0052$ scores M1M0A0

5.Oct 2023-5

5 (a)	Complaints received are independent or occurring at a constant rate or singly	B1
		(1)
(b)(i)	$P(X < 3 X \sim \text{Po}(6)) = 0.0620$ awrt 0.062	B1
(ii)	$P(X \geq 6) = 1 - P(X \leq 5) \text{ or } 1 - 0.4457 = 0.5543$ awrt 0.554	M1A1
		(3)
(c)	$H_0 : \lambda = 6 \quad H_1 : \lambda > 6$	B1
	$P(X \geq 12) = 1 - P(X \leq 11) = [1 - 0.9799] \text{ or } P(X \geq 11) = 1 - P(X \leq 10) = [1 - 0.9574]$	M1
	$= 0.0201 \text{ or } CR \geq 11$	A1
	Reject H_0 /In the CR/Significant	M1
	There is sufficient evidence to suggest that the mean number of complaints received is greater than 6 per week	A1ft
		(5)
(d)	$H_0 : \lambda = 6 \quad H_1 : \lambda < 6$	B1
	6 week period is $\text{Po}(36) \Rightarrow N(36, 36)$	B1
	$P(Y \leq 26) \approx P(Y < 26.5) = P\left(Z < \frac{26.5 - 36}{\sqrt{36}}\right) \text{ or } \frac{x + 0.5 - 36}{\sqrt{36}} < -1.6449$	M1 M1
	$[P(Z < -1.583...)] = 0.0571 \text{ (Calculator } 0.05667... \text{) or } x < 25.63...$	A1
	awrt 0.057 awrt 25.6	
	Do not reject H_0 /Not in the CR/Not significant	M1
	There is insufficient evidence to suggest that the mean number of complaints received after the changes made is less than 6 per week	A1ft
		(7)

		Notes	Total 16
(a)	B1	A correct assumption. Must be in context so need 'complaints' and then independent/random or constant rate or singly	
(b)(i)	B1	awrt 0.062	
(ii)	M1	For writing or using $1 - P(X \leq 5)$ May be implied by awrt 0.554	
	A1	awrt 0.554	
(c)	B1	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of λ or μ	
	M1	For writing or using $1 - P(X \leq 11)$ or $1 - P(X \leq 10)$	
	A1	For 0.0201 or $CR \geq 11$	
	M1	A correct statement – no context needed but do not allow contradicting non contextual comments	
	A1ft	Correct conclusion in context with the words highlighted in bold	
(d)	B1	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of λ or μ Allow use of 36 rather than 6	
	B1	For writing or using $N(36, 36)$	
	M1	For standardising using 25.5/26/26.5, their mean and their standard deviation or standardising using $x - 0.5/x + 0.5$, their mean and their standard deviation and setting equal to -1.6449	
	M1	For a correct continuity correction written or used e.g. 26.5 or $x + 0.5$	
	A1	awrt 0.057 (NB Poisson used gives 0.0512685... and scores M0M0A0) or $CR < \text{awrt } 25.6$ (Allow $\leq$)	
	M1	A correct statement – no context needed but do not allow contradicting non contextual comments	
	A1ft	Correct conclusion in context with the words in bold (Allow The mean number of complaints has stayed the same/not changed oe)	

6.Jan 2022-3

3 (a)	We can assume breakdowns are [rare], independent events occurring at a constant rate.	B1
		(1)
(b)	$H_0 : \lambda = 8$ $H_1 : \lambda \neq 8$	B1
		(1)
(c)	$X \sim \text{Po}(8)$	
	$P(X \leq 2) = 0.0138$ oe $P(X \leq 3) = 0.0424$ oe	M1
	$P(X \geq 14) = 0.0342$ oe $P(X \geq 15) = 0.0173$ oe	M1
	$X \leq 2 \cup X \geq 15$ oe	A1
		(3)
(d)	“0.0138” + “0.0173”	M1
	=“0.0311”	A1ft
		(2)
(e)	“[4 is] not in the critical region”	M1
	So there is insufficient evidence that refurbishment has changed the mean breakdown rate	A1
		(2)

		Notes	Total 9
3 (a)	B1	A correct statement which include the words independent or constant rate or singly. No context needed	
(b)	B1	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of λ or μ .	
(c)	M1	Use of Po(8) to find the lower critical value. May be implied by either 0.0138 or 0.0424 or $X \leq 2$ if no probabilities shown (Calculator values: 0.01375... and 0.04238...)	
	M1	Use of Po(8) to find the upper critical value. May be implied by 0.0342 or 0.0173 or 0.9658 or 0.9827 or $X \geq 15$ if no probabilities shown (Calculator values: 0.03418... and 0.01725... and 0.96581... and 0.98274...)	
	A1	$X \leq 2$ oe $[\cup] X \geq 15$ oe Condone the use of and/or Do not allow as probability statements Allow $[0, 2]$ or $[0, 3]$ and $[15, \infty]$ or $[15, \infty)$ or $(14, \infty]$ or $(14, \infty)$	
(d)	M1	Adding the two probabilities for their critical region	
	A1ft	0.0311 Allow 3.11 or awrt 3.1[0] or awrt 0.031[0] ft their critical region	
		NB 3.11 or 0.0311 or awrt 3.1[0] or awrt 0.031[0] will score 2/2	
(e)	M1	A correct statement ft their critical region e.g. Do not reject H_0 /Accept H_0 /not significant – no context needed but do not allow contradicting non contextual comments	
	A1	Correct conclusion in context. Must include rate/number of breakdown (Allow decreased for changed)	
		NB Award M1 A1 for a correct contextual statement on its own	

7.June 2022-4

4. (a)	$[P(Y = 0) < 0.05]$	
	$(1 - 0.07)^n < 0.05$	M1
	$n \log(0.93) < \log(0.05)$	M1
	$n > 41.28 \dots \quad n = 42$	A1
(b)		(3)
	$H_0: p = 0.08 \quad H_1: p \neq 0.08$	B1
	$X \sim B(75, 0.08) \rightarrow \text{Po}(6)$	M1
	$P(X \leq 11) = 1 - P(X \geq 10)$	M1
	$= 1 - 0.9574 = 0.0426 [> 0.025]$	A1
	Do not Reject H_0 or not significant or 11 does not lie in the CR	dM1
	There is not significant evidence to suggest that the proportion of pears weighing more than 180g has changed	A1
		(6)
		[9 marks]

	Notes
(a)	1st M1 For 0.93^n or 0.93^{42} or 0.93^{41} 2nd M1 for $n \log(0.93) < \log(0.05)$ or $\log_{0.93} 0.05$, n Allow = or „ condone > or ... or $0.93^{42} = 0.0474 \dots$ or 0.0475 (min 4 dp) Implied by 41.28... or awrt 41.3 A1 42 cao NB An answer of 42 gains 3/3 SC condone for M1 M0 A0 ($[e^{-3} =] 0.04978 \dots$ (min 4dp) and $-0.07n = -3$)
(b)	B1 both hypotheses correct (may use p or π but do not allow $p(x)$) Allow 8% connected to H_0 and H_1 correctly 1st M1 writing or using Poisson approximation with mean 6. 2nd M1 for writing or using $1 - P(X \geq 10)$ or for a CR method (must give a CR) giving $P(X \geq 11) = 0.9799$ or $P(X \leq 12) = 0.0201$ Implied by awrt 0.0426 or correct CR 1st A1 for 0.0426 or CR: $X \leq 12$ ignore lower CR. NB M1A1 for $P(X \geq 10) = 0.9574$ on its own 3rd dM1 Independent of their hypotheses dependent on 2nd M1 but A correct statement i.e. not significant/do not reject H_0/Not in CR/reject H_1 Do not allow non-contextual conflicting statements. 2nd A1 For a correct contextual statement. Need proportion oe and changed oe Allow the farmers belief (oe) is not supported (bold words) Do not accept contradicting statements. No hypotheses is A0 NB Award d M1A1 for a correct contextual statement on its own SC1: Use of one-tailed test may score B0M1M1A1M1A0 for rejecting H_0 SC2: Use of Binomial throughout max (3/6) B1M0M1A0dM1A0 SC3: normal approximation prob = 0.0277 (maximum 3 out of 6) B1 M0 M1 for writing or using $1 - P(X \geq 10.5)$ allow < implied by awrt 0.027/0.028 A0 dM1A0

8.Oct 2022-3

3(a)	$H_0: p = 0.35 \quad H_1: p \neq 0.35$	B1
	$P(X, 8) = \text{awrt } 0.0303 \text{ or } P(X \dots 21) = \text{awrt } 0.0173 \text{ or } P(X, 20) = \text{awrt } 0.9827$	M1
	$[P(X, 8) =] \text{awrt } 0.0303 \text{ and } [P(X \dots 21) =] \text{awrt } 0.0173$	A1
	CR $X, 8$ and $X \dots 21$	A1
		(4)
(b)	0.0476	B1ft
		(1)
(c)	$H_0: p = 0.028 \quad H_1: p > 0.028$	B1
	$Y \square B(250, 0.028) \Rightarrow Y \square \text{Po}(7)$	M1
	$P(Y \dots 11) = 1 - P(Y, 10) \text{ or } P(Y \dots 13) = 1 - 0.973$	M1
	$= 0.0985 \text{ or Critical region } Y \dots 13$	A1
	There is insufficient evidence to suggest that the <u>proportion</u> of sunflower seeds that grow to a height of more than 3 metres is now <u>greater</u> than 0.028	A1
		(5)
Notes		Total 10

Notes		Total 10
(a)	B1	Both hypotheses in terms of p or π
	M1	One of the correct probability statements. Implied by a correct critical region
	A1	awrt 0.0303 and awrt 0.0173
	A1	Both parts of the critical region given. Allow alternative notation e.g. $X < 9$ and $X > 20$ Do not allow as probability statements.
(b)	B1	For 0.0476 Allow awrt 0.0475 (calculator) or ft their two critical regions provided probabilities are seen in part (a) Common ft is for $X, 7$ and $X \dots 21$ gives 0.0297
(c)	B1	Both hypotheses in terms of p or π – If already lost the mark in (a) for incorrect letter allow any letter
	M1	Po(7) written or used
	M1	Writing or using $1 - P(Y, 10)$ or $1 - 0.9015$ or $1 - 0.973$ (May be implied by 0.0985) or may be implied by $Y \dots 13$ provided Po(7) seen or used If using N(7, 6.804) or N(7, 7) allow use of $1 - P(Y, 10)$ or $1 - P(Y, 10.5)$ B(250, 0.028) gives 0.09549... and implies M1 N(7, 6.804) gives awrt 0.09 (Calc gives 0.08983...) or awrt 0.13 (Calc gives 0.125...) and implies M1 N(7, 7) gives awrt 0.09 (Calc gives 0.09293...) or awrt 0.13 (Calc gives 0.1284...) and implies M1
	A1	awrt 0.0985 or CR: $Y \dots 13$ provided Po(7) seen or used (Allow any letter for the CR)
	A1	Independent of the hypotheses but dependent on the previous M1A1 being awarded. A correct conclusion in context. Allow amount/number for proportion, sunflowers for seeds and increased oe for greater. Ignore any non-contextual statements

9.June 2021-1

1.	(a)	[$X \sim$ the number of pansy seeds that do not germinate or $Y =$ the number...that <u>do</u> germinate] $X \sim B(20,0.05)$ or $Y \sim B(20, 0.95)$		B1								
	(i)	$P(X \leq 4) - P(X \leq 2) = 0.9974 - 0.9245$ or $\binom{20}{3} 0.05^3 \times 0.95^{17} + \binom{20}{4} 0.05^4 \times 0.95^{16} = 0.05958... + 0.01332...$ $= 0.072909...$ awrt 0.0729		M1 A1								
	(ii)	$P(X \leq 1)$ or $P(Y \geq 19) = 20 \times (0.95)^{19} (0.05) + (0.95)^{20}$ $= 0.7358$ or $= 0.735839...$ awrt 0.736		M1 A1 (5)								
	(b)	[Let $W =$ no. of packets where $Y > 18$] $P(W = 5) = ("0.7358...")^5$ $= 0.21573...$ awrt 0.216		M1 A1 (2)								
	(c)	$H_0 : p = 0.05$ $H_1 : p > 0.05$		B1 (1)								
	(d)	[$V =$ no. of seeds that do not germinate $V \sim B(100, 0.05)$ approximates to] $V \sim Po(5)$		M1A1								
		$P(V \geq 8) = 1 - P(V \leq 7)$ $= 1 - 0.8666$ $= 0.1334$	<table><tr><th>CR for 1-tail in (c)</th><th>CR for 2-tail in (c)</th></tr><tr><td>$P(V \geq 9) = 0.0681$</td><td>$P(V \geq 10) = 0.0318$</td></tr><tr><td>$P(V \geq 10) = 0.0318$</td><td>$P(V \geq 11) = 0.0137$</td></tr><tr><td>CR $V \geq 10$ oe</td><td>CR $V \geq 11$ oe</td></tr></table>	CR for 1-tail in (c)	CR for 2-tail in (c)	$P(V \geq 9) = 0.0681$	$P(V \geq 10) = 0.0318$	$P(V \geq 10) = 0.0318$	$P(V \geq 11) = 0.0137$	CR $V \geq 10$ oe	CR $V \geq 11$ oe	M1 A1
CR for 1-tail in (c)	CR for 2-tail in (c)											
$P(V \geq 9) = 0.0681$	$P(V \geq 10) = 0.0318$											
$P(V \geq 10) = 0.0318$	$P(V \geq 11) = 0.0137$											
CR $V \geq 10$ oe	CR $V \geq 11$ oe											
		Accept H_0 or not significant or 8 does not lie in the critical region Data consistent with <i>Spany's claim</i> or Insufficient evidence for <i>Jem's belief</i> or insufficient evidence that percentage of seeds not germinating is more than 5% (o.e.)		dM1 A1cso (6)								
				Total 14								

		Notes
(a)	B1: writing or using $B(20, 0.05)$ [Allow $Y \sim B(20, 0.95)$ if Y is clearly defined]. Implied by 1 correct prob.	
(i)	M1: for $P(X \leq 4) - P(X \leq 2)$ and one correct prob. or $P(X = 3) + P(X = 4)$ and 1 correct prob.	
(ii)	M1: for $P(X \leq 1)$ or $[20] \times (0.95)^{19} (0.05) + (0.95)^{20}$ - condone missing 20	
(b)	M1: for $(\text{their(a)(ii)})^5$	
(c)	B1: both hypotheses correct with p or π	
(d)	1st M1: for realising a Poisson approximation is appropriate. NB $Po(95)$ is M0A0 1st A1: writing or using $V \sim Po(5)$ i.e correct mean for the Poisson. 2nd M1: for writing or using $1 - P(V \leq 7)$ or $P(V \leq 7) = 0.8666$ or writing $P(V \geq 10) = 0.0318$ or $P(V \geq 9) = 0.0681$ or $P(V \geq 11) = 0.0137$ leading to a CR. Implied by correct CR or probability = awrt 0.133 2nd A1: for awrt 0.133 or $V \geq 10$ oe (e.g. $V > 9$) or $V \geq 11$ oe allow any letter but CR must match part(c) 3rd dM1: dep on 2 nd M1. ft their CR or probability. A correct statement based on comparing 8 with their CR or their prob with 0.05 or 0.025 [condone $0.866 < 0.95$]—contradicting non-contextual comments M0 3rd A1 cso: all previous marks must be awarded. A correct statement in context. Need Bold words . NB award M1A1 for a correct contextual statement on its own. If there are no hypotheses or they are the wrong way around, then 3 rd M0 3 rd A0 Normal approximation: Award marks in pairs with 2, 4 or 6 marks available Sight of $N(5 \text{ or } 95, \sqrt{4.75})$ M1A1; probability awrt 0.125/6 M1A1; Correct contextual concl' dM1A1 No approximation: Use of $B(100, 0.05)$ M0A0; probability awrt 0.128 or CR ≥ 10 M1A1; then M0A0	
SC1		
SC2		

10.Oct 2020-4

4(a)	Common Spotted-orchids occur singly/randomly/independently	B1
		(1)
(b)(i)	$S \sim \text{Po}(4.5)$	
	$P(S=6) = \frac{e^{-4.5} 4.5^6}{6!}$ or $P(S \leq 6) - P(S \leq 5)$	M1
	$= 0.1281 \dots$ awrt 0.128	A1
(ii)	$P(4 < S < 10) = P(S \leq 9) - P(S \leq 4)$ or $0.9829 - 0.5321$	M1
	$= 0.4508$ awrt 0.451	A1
		(4)
(c)	$H_0: \lambda = 9$ $H_1: \lambda > 9$	B1
	$M \sim \text{Po}(9)$ $P(M \geq 11) = 1 - P(M \leq 10)$ or $P(M \geq 15) = 0.0415$	M1
	$= 0.294$ or CR $M \geq 15$	A1
	Accept H_0 or insignificant or 11 does not lie in the critical region	dM1
	There is insufficient evidence to support Juan's belief	A1
		(5)
(d)	$T \sim N(90, 90)$	B1
	$P(T < 70) = P\left(Z < \pm \left(\frac{69.5 - 90}{\sqrt{90}}\right)\right)$ or $P(Z < \pm 2.160 \dots)$ awrt 2.16	M1
	$= 0.0154$ awrt 0.0154	A1
		(3)
(e)	$V \sim \text{Po}(200 \times 0.012) = \text{Po}(2.4)$ $V \sim \text{Po}(2.4)$	M1
	$P(V=0) + P(V=1) = e^{-2.4}(1 + 2.4)$	dM1
	$= 0.30844 \dots$ awrt 0.308	A1
		(3)

	Notes		Total 16
4(a)	B1	One of the given reasons. No context needed	
(b)(i)	M1	For $\frac{e^{-\lambda} \lambda^6}{6!}$ with any value for λ or writing or using $P(S \leq 6) - P(S \leq 5)$	
	A1	awrt 0.128	
(ii)	M1	Writing or using $P(S \leq 9) - P(S \leq 4)$	
	A1	awrt 0.451	
(c)	B1	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of λ or μ . Allow 4.5 instead of 9.	
	M1	Writing or using $\text{Po}(9)$ and $1 - P(M \leq 10)$ or $P(M \geq 15) = 0.0415$ oe Implied by correct CR or awrt 0.3 or 0.29... or better (0.2940...)	
	A1	0.3 or 0.29... or better (0.2940...) or $M \geq 15$ oe SC: Condone $P(X \leq 10) = 0.7$ or better (0.705988...) for M1A1	
	dM1	Dep on M1 A1. A correct statement– no context needed but do not allow contradicting non contextual comments. Allow opposite conclusion if 2-tail hypotheses given.	
	A1	Correct conclusion. If H_0 is 2- tail the opposite conclusion must be given. No hypotheses or H_0 $\lambda < 9$ gets A0. Allow claim instead of belief. Alternative: There is insufficient evidence to support hat the number of Common Spotted-orchids has increased/ /is not 9/has changed oe (with the bold words included).	
(d)	B1	Writing or using $N(90, 90)$	
	M1	Standardising with 68.5 or 69.5 or 70.5 and their mean and sd	
	A1	awrt 0.0154 NB Poisson gives 0.01275...	
(e)	M1	Writing or using $\text{Po}(200 \times 0.012)$ Allow $\text{Po}(200 \times \text{"their d"})$	
	dM1	Dependent on using Poisson. For using / writing $P(V=0) + P(V=1)$ or $e^{-\lambda}(1 + \lambda)$ or $P(V \leq 1)$ oe	
	A1	awrt 0.308 NB Binomial gives 0.3066	

