Question Number	Scheme		Marks
1.	$H_0: \mu = 30 \quad H_1: \mu < 30$		B1
	$z = \dfrac{29.5 - 30}{\dfrac{2.5}{\sqrt{80}}}$		M1
	$z = -1.7888\ldots$	awrt–1.79	A1
	$-1.7888 < -1.6449$		B1
	Reject H_0 or significant result or in the critical region		
	There is evidence to support the manager's claim.		A1
			(5)
	Notes		**Total 5**

	B1	Both hypotheses correct in terms of μ
	M1	for attempting test statistic, allow $\pm$, Condone $\sqrt{\dfrac{2.5}{80}}$
	A1	awrt -1.79 allow $\lvert z \rvert = 1.7888\ldots$ Allow p value of 0.0367 or awrt 0.0368 or CR $\leqslant 29.54$
	B1	$\lvert CV \rvert = 1.6449$ or better (Ignore any comparisons) Allow CR $\leqslant 29.54$ SC If p value of 0.0367 or awrt 0.0368 award B1 if 2nd A1 is awarded
	A1	For correct conclusion. Allow the manager's claim in words if it includes screws and less (oe)

Question Number	Scheme		Marks
2	H_0: Potassium has no effect on the quality of apple H_1: Potassium has an effect on the quality of apple		B1
	<table><tr><td>Grade</td><td>*A*</td><td>*B*</td><td>*C*</td><td>*D*</td><td>*E*</td></tr><tr><td>Expected values</td><td>9.6</td><td>67.2</td><td>124.8</td><td>24.0</td><td>14.4</td></tr></table>		M1A1
	$\chi^2 = \sum \frac{(O-E)^2}{E} = \frac{(9-"9.6")^2}{"9.6"} + \ldots + \frac{(3-"14.4")^2}{"14.4"}$ or $\chi^2 = \sum \frac{O^2}{E} - N = \frac{9^2}{"9.6"} + \ldots + \frac{3^2}{"14.4"} - 240$		M1
	= 10.657…	awrt 10.7	A1
	Degrees of freedom = 4 $\chi^2_{4,0.05} = 9.488$		B1 B1ft
	[Reject H_0] Data suggests that potassium may affect the distribution of the grades of apples **or** there is evidence that Andy's belief is incorrect		A1ft
			(8)
	Notes		**Total 8**

	B1	Both hypotheses in context. May use other wording eg The grading of apples remains the same.
	M1	A correct method to calculate expected values eg 0.04×240
	A1	At least 3 expected values correct
	M1	A correct method using their expected values to calculate χ^2 At least one correct, ft their expected values with an intention to add
	A1	awrt 10.7
	B1	Degrees of freedom = 4 (may by be implied by 9.488)
	B1ft	9.488 ft their DoF. If no DoF stated then this must be correct for their working.
	A1ft	ft their χ^2 value provided the 2nd M1 is awarded and CV. If no hypotheses or hypotheses wrong way round do not award. Must include the word 'apples' or ' belief' oe

Question Number	Scheme		Marks
3(a)	jam: A, B, C, D, E, F, G, H, I Price: 1, 2, 4, 5, 3, 6, 7, 8, 9 Taste: 1, 2, 8, 9, 4, 3, 6, 5, 7		M1
	$\sum d^2 = [0+0+]16+16+1+9+1+9+4[=56]$		M1A1
	$r_s = 1 - \frac{6(56)}{9(80)}; = \frac{8}{15} = 0.5333..$	awrt 0.533	dM1A1
			(5)
(b)	$H_0 : \rho = 0$, $H_1 : \rho \neq 0$		B1
	Critical Value = 0.7		B1
	There is no evidence of a relationship between <u>price</u> and <u>taste</u> of strawberry jam		B1ft
			(3)
(c)	$r = \frac{16.4943}{\sqrt{2.0455 \times 243.5556}}$		M1
	$= 0.7389...$	awrt 0.739	A1
			(2)
(d)	$H_0 : \rho = 0$, $H_1 : \rho > 0$		B1
	CV = 0.5822		B1
	There is evidence of a <u>positive correlation</u> between <u>price</u> and <u>taste</u> of strawberry jam		B1ft
			(3)
(e)	Spearman's rank as it is unlikely that a joint normal distribution applies.		B1
	or the marks are a judgement or the marks are not a meaningful scale.		
			(1)
	Notes		**Total 14**

(a)	**M1**	Attempt to rank each jar for taste and price. At least 4 pairs of ranks correct
	M1	For an attempt at d^2 row for their ranks (may be implied by $\sum d^2 = 56$)
	A1	$\sum d^2 = 56$
	dM1	Dependent on the previous M being awarded. Using $1 - \frac{6\sum d^2}{9(80)}$
	A1	$\frac{8}{15}$ or awrt 0.533
(b)	**B1**	Both hypotheses stated in terms of ρ. Must be two- tail.
	B1	0.7 for CV. Allow 0.6 if a one tail test is used
	B1ft	For a correct contextualised comment which has price and taste Follow through their r_s with their 0.7 (provided $\lvert$their $r_s\rvert < 1$)
(c)	**M1**	Correct method used
	A1	awrt 0.739
(d)	**B1**	Both hypotheses stated in terms of ρ. Must be one-tail. If B0 awarded in part (b) then allow any letter instead of ρ that is consistent with part (b)
	B1	0.5822 Allow 0.6664 if a two-tail test is used.
	B1ft	Correct conclusion in context which has positive correlation (this may be implied by a correct description of positive correlation), price and taste. Follow through their 0.5822 and 0.739
(e)	**B1**	Selecting Spearman's with a suitable reason. Do not allow 'because it is ranked' as a suitable reason

Question Number	Scheme		Marks
4(a)	Label the houses in area A 1- 41, area B 1 – 164, area C 1 – 123 and area D 1 - 82		M1
	Use random numbers to select a ...		M1
	Simple random sample of 20 area A, 80 area B, 60 area C and 40 area D		A1
			(3)
(b)	$\frac{357\times260}{595}$ or $\frac{238\times260}{595}$		M1
	156 and 104		A1
			(2)
(c)	Observed / Expected / $\frac{(O-E)^2}{E}$: 162, "156", $\frac{(162-\text{"156"})^2}{\text{"156"}}=\frac{3}{13}=0.2307\ldots$; 98, "104", $\frac{(98-\text{"104"})^2}{\text{"104"}}=\frac{9}{26}=0.3461\ldots$		M1
	$\chi^2=4.657+\text{"0.2307..."}+\text{"0.346..."}$		M1
	$=5.234\ldots.$	awrt 5.23	A1
	$\nu=(2-1)(3-1)=2$		B1
	$\chi^2_2(0.05)=5.991\Rightarrow$ CR: $\chi^2>5.991$		B1ft
	There is no evidence to suggest that there is an association between age and listening to *LSB*		dA1
			(6)
	Notes		**Total 11**

(a)	**M1**	For suitable labelling of all four areas. E.g. for area A: 1 – 41 or 0 - 40
	M1	For use of random numbers to select houses in each area.
	A1	For 20 A, 80B, 60C and 40 D (dependent on 2nd M1 only) NB A simple random sample of 20 A, 80B, 60C and 40 D scores M0M1A1. Allow M1 : allocate random numbers to each house M1 : arrange the numbers in order A1 : select the 1st 20 for area A, 80 for area B, 60 for area C and 40 for area D SC If M0M0 scored then award B1 for 20 area A, 80 area B, 60 area C and 40 area D
(b)	**M1**	A correct method for finding one expected value.
	A1	Correct answer for both values
(c)	**M1**	A correct method for finding both contributions to the χ^2 value
	M1	Adding the two values to 4.657 (may be implied by a full χ^2 calculation, do not ISW)
	A1	awrt 5.23
	B1	2
	B1ft	5.991 or better ft their DoF
	dA1	A correct contextual conclusion, which has the words age and listening dependent on both M marks being awarded. **NB** if they give a *p* value of 0.0730… rather than the CV they can get M1M1B1B0A1

Question Number	Scheme	Marks
5(a)	$2.977 \pm 2.5758 \times \frac{0.015}{3}$	M1,B1
	$= (2.9641\ldots, 2.9898\ldots)$ awrt (2.964, 2.990)	A1
		(3)
(b)	The CI does not contain the stated weight.	B1
		(1)
(c)	$2.995 - 1.96 \times \frac{0.015}{\sqrt{n}} < 2.991$	M1
	$\sqrt{n} < \frac{1.96 \times 0.015}{2.995 - 2.991}$	M1d
	$\sqrt{n} <$ awrt 7.35	A1
	$n = 54$	A1cao
		(4)
	Notes	**Total 8**

(a)	**M1**	$2.977 \pm (z \text{ value}) \times \frac{0.015}{3}$
	B1	awrt 2.5758
	A1	awrt (2.964, 2.990 (condone 2.99))
(b)	**B1**	cao this must be consistent with their confidence interval
(c)	**M1**	Setting up an inequality using z value > 1.5 Condone =
	M1d	Dep on previous M mark. Correct rearranging to get $\sqrt{n} < \ldots$ or $n < \ldots$ Condone = or >
	A1	awrt 7.35 may be implied by awrt 54
	A1cao	54

Question Number	Scheme	Marks
6(a)	$\bar{h} = 65.4$	B1
	$s^2 = \dfrac{214676 - 50\times("65.4")^2}{49}$	M1
	$= 16.693...$ awrt 16.7	A1
		(3)
(b)	$H_0: \mu_{\text{do}} = \mu_{\text{do not}}$ $H_1: \mu_{\text{do}} < \mu_{\text{do not}}$	B1
	$z = \pm\dfrac{"65.4" - 70.8}{\sqrt{\dfrac{"16.693..."}{50} + \dfrac{29.6}{40}}}$	M1M1
	$= \pm 5.21...$ awrt 5.21	A1
	CV 1.6449	B1
	Amala's belief is supported	A1 ft
		(6)
(c)	CLT enables you to assume that (the sampling distribution of the sample mean of) resting heart rate is normally distributed for both groups	B1
		(1)
(d)	Each population/sample is independent **or** each male is independent of the other males.	B1
	Assume the $\sigma_{\text{do}}^2 = s_{\text{do}}^2$ and $\sigma_{\text{do not}}^2 = s_{\text{do not}}^2$	B1
		(2)
	Notes	**Total 12**

(a)	**B1**	65.4 only
	M1	Correct method to find s^2 using their $\bar{h}$
	A1	awrt 16.7
(b)	**B1**	Both hypotheses correct - must be clear which is exercise and which is not
	M1	For the denominator. Ft their 16.693…
	M1	Correct ft their 65.4 and 16.693…
	A1	awrt 5.21 allow $\lvert z\rvert = 5.21…$
	B1	$\lvert CV\rvert$ =1.6449 or better
	A1	ft their z value and CV if the hypotheses are the correct way round. Correct conclusion in context need belief. May be in words with heart and exercise e.g. resting heart rate is lower in men who exercise regularly
(c)	**B1**	For the idea both groups normally distributed
(d)	**B1**	For identifying the need for the groups **or** males to be independent.
	B1	Realising the $\sigma^2 = s^2$ Allow sample sizes big enough for CLT to hold

Question Number	Scheme	Marks
7(a)	$\mathrm{E}(B_1 - B_2) = 0$	B1
	$\mathrm{Var}(B_1 - B_2) = 0.006$	B1
	$\mathrm{P}(\lvert B_1 - B_2\rvert > 0.1) = 2\mathrm{P}(B_1 - B_2 > 0.1)$	M1
	$= 2\times\mathrm{P}\left(Z > \frac{0.1}{\sqrt{"0.006"}}\right)\left[= 2\times\mathrm{P}(Z > 1.2909...)\right]$	M1
	$= 0.1967\ldots$ awrt 0.197	A1
		(5)
(b)	$\bar{B} \sim \mathrm{N}\left(1.96, \frac{0.003}{n}\right)$	B1
	$\mathrm{P}(\bar{B} > 2) = \mathrm{P}\left(Z > \frac{2-1.96}{\sqrt{0.003/n}}\right)$ $[< 0.01]$	M1
	$\frac{2-1.96}{\sqrt{\frac{0.003}{n}}} > 2.3263$	B1 dM1
	$n = 11$	A1
		(5)
(c)	$\mu_M = 21.8 + 500\times1.96[= 1001.8]$; $\sigma_M{}^2 = 0.6 + 500\times0.003[= 2.1]$	M1 ; M1
	Let $X = 4T - 3M$	M1
	$\mu_X = 4\times774 - 3\times"1001.8"[= 90.6]$; $\sigma_X{}^2 = 16\times1.8 + 9\times"2.1"[= 47.7]$	M1 ; M1
	$\mathrm{P}(4T - 3M > 100) = \mathrm{P}\left(Z > \frac{100 - "90.6"}{\sqrt{"47.7"}}\right)\left[= \mathrm{P}(Z > 1.361...)\right]$	M1
	$= 0.0869$ (table) or $0.08675\ldots$ (calc)	A1
		(7)
		Total 17

(a)	**B1**	For expected value being 0 written or used
	B1	For 0.006 being written or used for Variance
	M1	Realising they need to consider both
	M1	Correct standardisation using their 0.1 and 0.006 If the expected value and/or standard deviation not stated then they must be correct
	A1	awrt 0.197
(b)	**B1**	The correct distribution written or used
	M1	Correct standardisation. Allow using their distribution if stated but must contain $\sqrt{n}$ for sd
	B1	Using awrt 2.3263
	dM1	Dep on previous M being awarded using a z value, $2 < z < 3$
	A1	11
(c)	**M1**	Correct method for finding the mean of M
	M1	Correct method for finding the var of M
	M1	Realising the need to find $4T - 3M$ or $4T - 3M - 100$ or $100 + 3M - 4T$
	M1	Correct method for finding the mean of X (using $4T - 3M - 100 = -9.4$ or $100 + 3M - 4T = 9.4$)
	M1	Correct method for finding the var of X
	M1	Correct standardisation using their mean of X and their standard deviation of X If these are not stated then they must be correct
	A1	awrt 0.0869 or 0.0868