Question Number	Scheme	Marks
1(a)	<table><tr><td>**Singer**</td><td>*A*</td><td>*B*</td><td>*C*</td><td>*D*</td><td>*E*</td><td>*F*</td><td>*G*</td><td>*H*</td></tr><tr><td>**Jury rank**</td><td>2</td><td>4</td><td>1</td><td>5</td><td>8</td><td>7</td><td>3</td><td>6</td></tr><tr><td>**Audience rank**</td><td>2</td><td>1</td><td>3</td><td>4</td><td>7</td><td>8</td><td>5</td><td>6</td></tr></table>	M1
	$\left[\sum d^2 =\right] 0+9+4+1+1+1+4+0\ [=20]$	M1
	$\left[r_s =\right] 1-\dfrac{6\times"20"}{8\times(8^2-1)}=0.7619...\left[=\dfrac{16}{21}\right]$ **awrt 0.762**	dM1A1
		(4)
(b)	$H_0:\rho=0,\ H_1:\rho>0$	B1
	CV $r_s=0.6429$ or CR: $r_s>0.6429$	B1
	Reject H_0 or significant or ($r_s=0.762$) lies in the critical region or there is evidence of positive correlation	M1
	There is sufficient evidence of a **positive correlation** between the **rankings** of the **jury** and the **audience**.	A1ft
		(4)
(c)	The rankings for ***E*** and ***F*** would be the same	B1
		(1)

		Notes	Total 9
(a)	**M1**	For an attempt to rank the jury scores (at least four correct). May be implied by $\sum d^2=20$ Condone if ranking is not shown, and we have at least 4 correct differences squared	
	M1	For an attempt to find the difference between each of the ranks (at least 3 correct) and evaluating $\sum d^2$. May be implied by awrt 0.762 or 20 (in formula) NB if no ranks for the jury, then it is M0	
	dM1	**Dependent on 1st M1**. For using $r_s=1-\dfrac{6\times\sum d^2}{8\times(8^2-1)}$ with their $\sum d^2$	
	A1	$\dfrac{16}{21}$ or awrt 0.762	
(b)	**B1**	Both hypotheses correct. Must be in terms of ρ or ρ_s (allow something that looks like rho e.g. *p*). Must be attached to H_0 and H_1. (Do not allow hypotheses in words on their own)	
	B1	CV of ±0.6429 or better. Sign should match their H_1 or r_s	
	M1	For a correct statement comparing their CV ($\lvert CV\rvert<1$) with their r_s ($\lvert r_s\rvert<1$) - no context needed but do not allow contradicting non-contextual comments. If a comparison is made it must be correct e.g. 0.762 > 0.05 is M0) A correct contextual conclusion may imply this mark.	
	A1ft	Correct conclusion in context for their value of r_s from (a) and their stated CV. Conclusion must refer to **positive correlation**, **jury**, **audience** and **rankings** o.e. (Use of "association" is A0)	
	SC	For use of two tailed test: may score B0B1M1A0 (CV of ±0.7381)	
(c)	**B1**	For the idea that both E and F will have the same rank (7.5). If the rank is stated it must be 7.5. Must mention both E and F (or imply) and allow explanations such as 'equal rank', 'average rank', tied 'rank'. If an incorrect rank or letter pairing is given then B0. Accept order for rank	

Question Number	Scheme	Marks
2(a)	$\bar{x} = \frac{4530}{60} = 75.5$	B1
	$s^2 = \frac{350\,761 - 60\times"75.5"^2}{59}$	M1
	$= \frac{8746}{59} = 148.237...$ **awrt 148**	A1
		(3)
(b)	$H_0 : \mu_B - \mu_A = 2, \quad H_1 : \mu_B - \mu_A > 2$	B1
	$\pm\frac{82.3 - "75.5" - 2}{\sqrt{\frac{17.4^2}{80} + \frac{"148"}{60}}} = 1.919...$ **awrt 1.92**	M1 dM1 A1
	Critical value $z = 1.6449$ (p value awrt 0.0274 <0.05)	B1
	Reject H_0 / Significant result	ddM1
	Sufficient evidence to suggest that the mean length of salmon in region *B* is more than 2 cm greater than the **mean length** of salmon in **region** *A* / Sufficient evidence to support the **biologist** claim.	A1ft
		(7)
(c)	Assumed that the sample variance (s^2) is equal to the population variance (σ^2) for both regions	B1
		(1)

	Notes	Total 11
(a)	**B1**	75.5 cao
	M1	A correct expression for either s or s^2 (ft their mean)
	A1	$\frac{8746}{59}$ or awrt 148
(b)	**B1**	Both hypotheses stated correctly, must be in terms of μ. Allow equivalent hypotheses. Condone the use of X and Y for A and B
	M1	Attempt at the SE using their part (a). e.g. $\sqrt{\frac{17.4^2}{80} + \frac{"148"}{60}}$. May be in their standardisation. (Implied by awrt ± 1.92 seen or awrt 0.0274)
	dM1	**Dependent on 1st M1** for standardising correctly. Allow $\pm$. Must be in the form $\frac{82.3 - "75.5" - 2}{\sqrt{\frac{p}{q} + \frac{r}{s}}}$ or equivalent. (Implied by awrt ± 1.92 seen or awrt 0.0274)
	A1	awrt 1.92 or awrt -1.92 or awrt 0.0274
	B1	Critical value of ± 1.6449 or better (seen). Allow for a p value of awrt 0.0274 <0.05 using tables)
	ddM1	**Dependent on both previous M marks**. A correct non-contextual statement based on their normal CV and their test statistic. – Do not allow contradicting non contextual comments.
	A1ft	Correct comment in context rejecting the null hypothesis. Must mention **mean, length, region** Allow sufficient evidence to support the **biologists** claim (o.e)

(c)	**B1**	Suitable comment assuming $s^2 = \sigma^2$ for both regions (o.e) (Allow ${s_x}^2 = {\sigma_x}^2$ and ${s_y}^2 = {\sigma_y}^2$ (o.e))

Question Number	Scheme	Marks
3(a)	It involves an **unknown** (population) **parameter** σ	B1
		(1)
(b)	$\left[\mathrm{E}(S)=\mathrm{E}\left(\frac{2}{5}X_1+X_2-\frac{1}{3}X_3\right)\right]=\frac{2}{5}\mathrm{E}(X_1)+\mathrm{E}(X_2)-\frac{1}{3}\mathrm{E}(X_3)=\frac{2}{5}\mu+\mu-\frac{1}{3}\mu$	M1
	$\frac{2}{5}\mu+\mu-\frac{1}{3}\mu=\frac{16}{15}\mu\neq\mu$ (so S is a biased estimator of μ)	A1
		(2)
(c)	Bias $E(S)-\mu=\text{"}\frac{16}{15}\mu\text{"}-\mu=\frac{1}{15}\mu$	B1ft
		(1)
(d)	$\mathrm{E}(Y)=a\mathrm{E}(X_1)+b\mathrm{E}(X_2)-3\mathrm{E}(X_3)=\mu$ $\Rightarrow(a+b-3)\mu=\mu$	M1
	$a+b=4$	A1
		(2)
(e)	$\mathrm{Var}(Y)=a^2\mathrm{Var}(X_1)+b^2\mathrm{Var}(X_2)+(-3)^2\mathrm{Var}(X_3)=\left(a^2+b^2+9\right)\sigma^2$	M1
	$\mathrm{Var}(Y)=\left(a^2+(4-a)^2+9\right)\sigma^2$	M1
	$\mathrm{Var}(Y)=\left(2a^2-8a+25\right)\sigma^2$	A1
		(3)
(f)	$\mathrm{Var}(Y)=\left(2(a-2)^2+17\right)\sigma^2$	M1
	Smallest value of $\mathrm{Var}(Y)=17\sigma^2$	A1ft
		(2)

		Notes	Total 11
(a)	**B1**	Suitable comment referring to the bold words and including σ Ignore any references to μ	
(b)	**M1**	Writing or using $\mathrm{E}(S)=\frac{2}{5}\mathrm{E}(X_1)+\mathrm{E}(X_2)-\frac{1}{3}\mathrm{E}(X_3)$. Must be in terms of E(X) or μ. Implied by correct expression $\frac{2}{5}\mu+\mu-\frac{1}{3}\mu$ (o.e). Condone missing subscripts.	
	A1	cao Must see $\frac{16}{15}\mu$ or awrt 1.07μ and showing that is does not equal μ (e.g. $\frac{16}{15}\mu\neq\mu$)	
(c)	**B1ft**	$\frac{1}{15}\mu$ (awrt 0.07μ) or follow through their part (b) $-\mu$	
(d)	**M1**	For writing or using $\mathrm{E}(Y)=a\mathrm{E}(X_1)+b\mathrm{E}(X_2)-3\mathrm{E}(X_3)=\mu$. Implied by $a+b=4$. Condone missing subscripts.	
	A1	cao	
	SC	If they state, $a=b=2$ then score **M1A1**	
(e)	**M1**	Writing or using $\mathrm{Var}(Y)=a^2\mathrm{Var}(X_1)+b^2\mathrm{Var}(X_2)+(-3)^2\mathrm{Var}(X_3)$. Condone missing subscripts.	
	M1	For substituting of $b=4-a$ ft their part (d) into their expression for $\mathrm{Var}(Y)$	
	A1	$\mathrm{Var}(Y)=\left(2a^2-8a+25\right)\sigma^2$ (o.e)	
	SC	Using -9 $\mathrm{Var}(X_3)$ instead of (-3)^2 $\mathrm{Var}(X_3)$ leads to $\left(2a^2-8a+7\right)\sigma^2$ **M1M1A0**	

(f)	**M1**	For a valid method to find minimum e.g. differentiation, complete the square. Implied by 17 seen if their values of p, q and r are correct.
	A1ft	$17\sigma^2$ or ft their a and using the correct expression $\left(2a^2-8a+25\right)\sigma^2$. $\text{Var}(Y)<0$ A0

Question Number	Scheme	Marks
4(a)	Use of $\frac{335.6}{28} \pm 2.3263 \times \frac{0.9}{\sqrt{28}}$	M1B1
	$= (11.590..., 12.381...)$ **awrt (11.6, 12.4)**	A1A1
		(4)
(b)	The **weights** are normally distributed	B1
		(1)
(c)	As 12 is in the CI there is insufficient evidence against the manufacturer's claim	B1ft
		(1)
(d)	$\frac{5.07-5}{\frac{0.3}{\sqrt{n}}} = 1.19$	M1B1
	$\sqrt{n} = \frac{"1.19" \times 0.3}{0.07}$ (o.e)	dM1
	$[n =] 26$	A1
		(4)

		Notes	Total 10
(a)	**M1**	For use of correct expression with 0.9, 28 and $1 < z < 3$ Ignore their value for $\bar{x}$	
	B1	For $z = 2.3263$ or better (calc: 2.326347931)	
	1st A1	For awrt 11.6 or awrt 12.4 (must come from awrt 2.33)	
	2nd A1	For awrt 11.6 and awrt 12.4 (must come from awrt 2.33)	
	Note	M1B0A1A1 is possible	
(b)	**B1**	For a suitable comment referring **weights** being normally distributed. It is a normal distribution – B0 Any comments implying not being normally distributed – B0	
(c)	**B1ft**	Comment suggesting claim is accepted / true (o.e) and that **12** is in the CI ft on their confidence interval. 12 needs to be seen. It is in the confidence interval and claim is accepted / rejected (o.e) B0. "awrt 11.6 < 12 < awrt 12.4" is equivalent to 12 is in the confidence interval.	
(d)	**M1**	For correct standardisation using 5.07, 5 and $\frac{0.3}{\sqrt{n}}$ (o.e) set equal to $1 < z < 3$. Allow $\pm$ provided the signs are compatible.	
	B1	awrt 1.19	
	dM1	Dependent on 1st method mark. For rearranging to and equation in which n can be found e.g. $\sqrt{n} = \frac{"1.19" \times 0.3}{0.07}$, $\frac{0.3}{n} = "\frac{1}{289}"$ or equivalents. Implied by $n = 26$	
	A1	cao (Correct answer with no incorrect work seen 4/4)	

Question Number	Scheme	Marks
5(a)(i)	Quota (sampling)	B1
(ii)	e.g. May not reach the quota of customers.	dB1
		(2)
(b)	$\frac{65\times 60}{200}$ or $\frac{57\times 60}{200}$	M1
	19.5 and 17.1	A1
		(2)
(c)	H_0: The type of **products** bought, and customer **age** are independent (not associated) H_1: The type of **products** bought, and customer **age** are not independent (are associated)	B1
	Observed / Expected / $\frac{(O-E)^2}{E}$ 29 / "19.5" / $\frac{(29-"19.5")^2}{"19.5"}=4.628...$ 8 / "17.1" / $\frac{(8-"17.1")^2}{"17.1"}=4.84...$	M1
	$\sum\frac{(O-E)^2}{E}=6.456+"4.628..."+"4.84..."$	M1
	$=15.926...$ **awrt 15.9**	A1
	$\nu=(3-1)(3-1)=4$ $\quad\chi^2_4(0.01)=13.277\Rightarrow \text{CR}: X^2\geqslant 13.277$	B1 B1ft
	[In the CR / Significant / Reject H_0] Sufficient evidence to suggest there is evidence of an association between the range of **products** bought and customer **age**	dA1
		(7)

	Notes	Total 11
(a)(i)	**B1**	Correct sampling method
(a)(ii)	**dB1**	**Dependent on B mark awarded in a(i).** For a suitable contextual comment e.g., customers divided into groups which may not be appropriate or customers who do not want to participate are not recorded. Allow e.g. not all people may want to say what their age is or may give a different age. No reason that this would give a sample representative of the customers, (Condone introduces bias, it is not random so can introduce bias (o.e)) Random on its own is not enough . eg. It is not random\ non-random sampling)– B0,
(b)	**M1**	A correct method for finding one expected value. Implied by one correct value.
	A1	Both answers correct
(c)	**B1**	For both hypotheses and attached to H_0 and H_1 Must mention **product** and **age** at least once. Use of "relationship" or "correlation" or "connection" is B0.
	M1	A correct method for finding **both** missing values for the χ^2 value or awrt 4.63 or awrt 4.84 Allow truncated answers. May be implied by awrt 15.9. May be seen by the table.
	M1	For adding their two values to 6.456 (may be implied by a full χ^2 calculation, with at least 3 correct expressions or values. May be seen by the table.
	A1	awrt 15.9 (Correct answer only with no incorrect working seen M1 M1 A1)
	B1	$\nu=4$ This mark can be implied by a correct critical value of 13.27[7] or better
	B1ft	13.277 or better, ft their degrees of freedom and using a 1% significance level. e.g. $\nu=2$ 9.21[0] or better, $\nu=3$ 11.34[5] or better, $\nu=9$ 21.66[6].or better, $\nu=8$ 20.09[0] or better
	dA1	**Independent of the hypotheses mark but dependent on all other previous marks.**

		A correct contextual conclusion compatible with their values, which has the words **product** and **age**. Contradictory statements score A0. Condone 'relationship' or 'connection' here but do not allow correlation. Ignore their hypotheses

Question Number	Scheme	Marks
6(a)	$D = F - M$	M1
	$D \sim \text{N}(5,\ 23)$	A1A1
	$\left[\text{P}(D > 2)\right] = \text{P}\left(Z > \frac{2 - '5'}{\sqrt{'23'}}\right)\left[= 1 - \text{P}(Z < -0.6255..)\right]$ or $\left[\text{P}(D < -2)\right] = \text{P}\left(Z > \frac{-2 + '5'}{\sqrt{'23'}}\right)\left[= 1 - \text{P}(Z < -0.6255..)\right]$	M1
	$= 0.7357$ **awrt 0.736**	A1
		(5)
(b)	$X = M_1 - M_2$	M1
	$X \sim \text{N}(0,\ 18)$	A1A1
	$\left[\text{P}(X > 1)\right] = \text{P}\left(Z > \frac{1 - '0'}{\sqrt{'18'}}\right)\left[= \text{P}(Z > 0.2357...)\right]$ $\left(\text{or } \left[\text{P}(X < -1)\right] = \text{P}\left(Z < \frac{-1 - '0'}{\sqrt{'18'}}\right)\right)$	dM1
	$\text{P}(\lvert X \rvert > 1) = 2 \times \text{P}(X > 1) = 2 \times '0.4052'$	M1
	$= 0.8104$ **awrt 0.810**	A1
		(6)
(c)	$T = F_1 + F_2 - 2M_1$	M1
	$T \sim \text{N}(\pm 10,\ 64)$	A1A1
	$\text{P}(T > 0) = \text{P}\left(Z > \frac{0 - '10'}{\sqrt{'64'}}\right)\ \left[= \text{P}(Z > -1.25)\right]$	dM1
	$= 0.8944$ **awrt 0.894**	A1
		(5)
	Notes	**Total 16**

Parts a), b) and c)

If they have not written down the **correct** model ($D \sim \text{N}(5,\ 23)$, $X \sim \text{N}(0,\ 18)$ or $T \sim \text{N}(\pm 10,\ 64)$) but you see the **correct** values (simplified or un-simplified) for the E(X) and Var (X) in their standardisation, then award first 4 marks (In b) award the M for seeing 2 x) and then the final A mark for a correct answer.

(a)	**M1**	States or uses a correct model $D = F - M$ or $D = M - F$. May be implied by a correct E(D) of 5 or -5. Condone the use of different letters.
	A1	Correct E(D) = 5 or 29-24 If they use $M - F$ you should see E(D)= –5 or 24-29
	A1	Correct Var(D) =23 or 9 +14
	M1	Attempts standardising ($\pm$), with their mean and variance. (Implied by $\pm$ awrt 0.626)
	A1	awrt 0.736 or 0.734 (calc: 0.73419…)
(b)	**M1**	States or uses a correct model. $X = M_1 - M_2$ or $X = M_2 - M_1$ Implied by E(X) = 0. Condone the use of different letters.
	A1	Correct E(X) =0 or 24-24
	A1	Correct Var(X) = 18 or 9 + 9
	dM1	**Dependent on 1st M1** for standardising ($\pm$) with their mean and variance (Implied by $\pm$ awrt 0.236). Condone a missing 0 in their standardisation.

	M1	For 2 x seen or implied (calc: 0.4068….)
	A1	awrt 0.810 or 0.814 (calc: 0.81366…)
(c)	**M1**	States or uses a correct model $T = F_1 + F_2 - 2M_1$ or $T = 2M_1 - F_1 - F_2$ Implied a correct Var(T). Condone the use of different letters and missing subscripts
	A1	Correct E(T) of 10 (29+29-2 x 24) or -10 (2 x 24 – 29 – 29)
	A1	Correct Var(T) = 64 or 14 + 14 + 2^2 x 9
	dM1	**Dependent on 1st M1** for standardising ($\pm$) with their mean and variance (Implied by $\pm$ 1.25). Condone a missing 0 in their standardisation.
	A1	awrt 0.894 (calc: 0.89435…)

Question Number	Scheme	Marks
7 (a)	$\left[\mathrm{E}(X)=\right]\dfrac{k-6+k+10}{2} \quad \left[=k+2\right]$	M1
	$\left[\mathrm{Var}(X)=\right]\dfrac{(k+10-k+6)^2}{12} \quad \left[=\dfrac{64}{3}\right]$	M1
	$\overline{X} \sim \mathrm{N}\left(k+2, \dfrac{4}{15}\right)$	A1ft
		(3)
(b)	$17.5-2.5758\sqrt{"\dfrac{4}{15}"} < \mu < 17.5+2.5758\sqrt{"\dfrac{4}{15}"}$	M1 B1
	$17.5-2.5758\sqrt{"\dfrac{4}{15}"}-4 < k-2 < 17.5+2.5758\sqrt{"\dfrac{4}{15}"}-4$	M1
	$12.2 < \mathrm{Q}_1 < 14.8$ **awrt (12.2, 14.8)**	A1
		(4)

	Notes		Total 7
(a)	**M1**	For attempting to find the mean of X	
	M1	For attempting to find the variance of X	
	A1ft	For a correct distribution. Condone awrt 0.267, $\dfrac{64/3}{80}$ for $\dfrac{4}{15}$. They must have divided their Var(X) by 80.	
(b)	**M1**	For attempting at least one tail of confidence interval $17.5 \pm "z"(\text{their } \mathrm{SE}_{\overline{X}})$. Follow their z value, $1 < z < 3$ Alternatively, may estimate the lower quartile as 13.5 and attempt at least one tail of confidence interval for the lower quartile . Dividing by 80 again is M0 Follow through the $\sqrt{\mathrm{Var}(\overline{X})}$ Implied by the 2nd M mark	
	B1	For either awrt $+2.5758$ or -2.5758	
	M1	For attempting both tails of $17.5 \pm "z"(\text{their } \mathrm{SE}_{\overline{X}}) - 4$. Follow their z value, $1 < z < 3$	
	A1	$12.2 < \mathrm{Q}_1 < 14.8$ or awrt (12.2, 14.8)	