Statistics S3 Mark scheme

Question	Scheme	Marks
1(a)	$\{w\}$ = 018 or 18	B1
		(1)
(b)	$\{x\}$ = 18	B1
		(1)
(c)	{prob} = 0	B1
		(1)
(d)	**Advantage:** Any one of: • Simple or easy to use also allow "quick" or "efficient" (o.e.) • It is suitable for large samples (or populations) • Gives a good spread of the data **Disadvantage:** Any one of: • The alphabetical list is (probably) not random • Biased since the list is not (truly) random • Some combinations of names are not possible	B1 B1
		(2)
		(5 marks)

Notes:

(d) If no labels are given treat the 1st reason as an advantage and the 2nd as a disadvantage

B1: For advantage

B1: For disadvantage – "it requires a sampling frame" is 2nd B0 since the alphabetical list is given.

Note: Do not score both B1 marks for opposing advantages and disadvantages.

Question	Scheme		Marks
2(a)			
	A B C L N R S T Y Judge 1 6 3 4 9 2 8 1 5 7 Judge 2 8 4 5 7 3 9 1 2 6		M1
	or		
	S N B C T A Y R L Judge 1 1 2 3 4 5 6 7 8 9 Judge 2 1 3 4 5 2 8 6 9 7		
	$\sum d^2 = 4+1+1+4+1+1+0+9+1$ or $0+1+1+1+9+4+1+1+4 = 22$		M1
		$\sum d^2 = 22$	A1
	$r_s = 1 - \frac{6(22)}{9(80)}; = 0.8166666...$		M1
		$\frac{49}{60}$ or awrt **0.817**	A1
			(5)
(b)	$H_0 : \rho = 0$, $H_1 : \rho > 0$		B1
	Critical Value = 0.7833 or CR: $r_s \geqslant 0.7833$	**0.7833**	B1
	Since $r_s = 0.8166...$ it lies in the CR , or reject H_0 (o.e.)		M1
	The two judges (or "they") are in agreement or there is a positive correlation between the ranks of the two judges.		A1ft
			(4)
			(9 marks)

Notes:

(a)

M1: For an attempt to rank at least one row (at least 4 correct)

M1: For an attempt at d^2 row (may be implied by sight of $\sum d^2 = 22$ or 221 for reverse ranks)

A1: For $\sum d^2 = 22$ (or 221 if reverse ranking is used) Can be implied by correct answer.

M1: For use of the correct formula with their $\sum d^2$ (if it is clearly stated)

If the answer is not correct then a correct expression is required

False Ranking - e.g. Alphabetic ranking: Gives

Judge 1: 7 5 2 3 8 1 9 6 4

Judge 2: 7 8 5 2 3 9 4 1 6 $\sum d^2 = 162$ and $r_s = -0.35$

Question 2 notes *continued*	
	Scores: M0(for ranking), M1(for attempt at d^2 row), A0, M1 (for use of their $\sum d^2$), A0 i.e. 2 out of 5. Can follow through their r_s in (b)
(b)	
B1:	For both hypotheses stated correctly in terms of ρ (allow ρ_s) H_1 must be compatible with ranking.
B1:	For cv = 0.7833 (independent of their H_1 (no 2-tail value in tables) <u>but</u> compatible sign with their r_s).
M1:	For a correct statement (in words) relating their r_s with their critical value. E.g. "reject H_0 ","in critical region", "significant", "positive correlation". May be implied by a correct contextual comment. **|cv|>1** - If their cv is |cv| > 1 (often from using normal tables) award M0A0 - If |their | > |their cv| then "significant" (o.e.) for M1 and "judges are in - agreement" (o.e.) for A1ft - If |their | < |their cv| then "not significant" (o.e.) for M1 and "judges don't agree" (o.e.) for A1ft
A1ft:	For a correct follow through conclusion in context. "Positive correlation" alone scores M1 A0. For reverse ranking should still say " judges <u>are</u> in agreement"

<table>
<tr><th>Question</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>3(a)</td><td>$\widehat{\lambda} = \dfrac{0(47)+1(57)+2(46)+3(35)+4(9)+5(6)}{200} = \dfrac{320}{200} = 1.6$ * Full exp' or at least 2 products and 320/200 seen</td><td>B1 *</td></tr>
<tr><td></td><td></td><td>(1)</td></tr>
<tr><td>(b)</td><td>$r = 200 \times \dfrac{e^{-1.6}(1.6)^2}{2!}$ $\{= 51.68550861...\}$ Using $r = 200 \times \dfrac{e^{-1.6}(1.6)^2}{2!}$</td><td>M1</td></tr>
<tr><td></td><td>$s = 200 - (40.38 + 64.61 + \text{their } r + 27.57 + 11.03)$ $\{= 4.72449139...\}$ <u>or</u> their $r + s = 56.41$</td><td>M1</td></tr>
<tr><td></td><td>$r =$ 51.68550861... and $s =$ 4.72449139... $r =$ awrt 51.69 and $s =$ awrt 4.72</td><td>A1</td></tr>
<tr><td></td><td></td><td>(3)</td></tr>
<tr><td>(c)</td><td>H_0 : Poisson (distribution) is a suitable/ sensible (model)
H_1 : Poisson (distribution)is not a suitable/ sensible (model).</td><td>B1</td></tr>
<tr><td></td><td>
<table>
<tr><th>Number of accidents</th><th>Observed</th><th>Expected</th><th>Combined Observed</th><th>Combined Expected</th><th>$\frac{(O-E)^2}{E}$</th><th>$\frac{O^2}{E}$</th></tr>
<tr><td>0</td><td>47</td><td>40.38</td><td>47</td><td>40.38</td><td>1.0853</td><td>54.7053</td></tr>
<tr><td>1</td><td>57</td><td>64.61</td><td>57</td><td>64.61</td><td>0.8963</td><td>50.2863</td></tr>
<tr><td>2</td><td>46</td><td>51.69</td><td>46</td><td>51.69</td><td>0.6264</td><td>40.9364</td></tr>
<tr><td>3</td><td>35</td><td>27.57</td><td>35</td><td>27.57</td><td>2.0024</td><td>44.4324</td></tr>
<tr><td>4</td><td>9</td><td>11.03</td><td rowspan="2">15</td><td rowspan="2">15.75</td><td rowspan="2">0.0357</td><td rowspan="2">14.2857</td></tr>
<tr><td>$\geqslant 5$</td><td>6</td><td>4.72</td></tr>
<tr><td colspan="5">Totals</td><td>4.6461</td><td>204.6461</td></tr>
</table>
</td><td>M1</td></tr>
<tr><td></td><td>$X^2 = \sum \dfrac{(O-E)^2}{E}$ or $\sum \dfrac{O^2}{E} - 200$;$= 4.6461$</td><td>M1
A1 awrt 4.65</td></tr>
<tr><td></td><td>$\nu = 5 - 1 - 1 = 3$ 3</td><td>B1 ft</td></tr>
<tr><td></td><td>$\chi^2_3(0.10) = 6.251 \Rightarrow$ CR: $X^2 \geqslant 6.251$ 6.251</td><td>B1 ft</td></tr>
<tr><td></td><td>[Since $X^2 = 4.6461$ does not lie in the CR, then there is insufficient evidence to reject H_0]</td><td></td></tr>
<tr><td></td><td>The number of accidents per day can be modelled by a Poisson distribution <u>or</u> the supervisor's belief is correct.</td><td>A1 ft</td></tr>
<tr><td></td><td></td><td>(7)</td></tr>
<tr><td colspan="3">(11 marks)</td></tr>
<tr><td colspan="3">Notes:</td></tr>
<tr><td colspan="3">(b)
Note: Allow A1 for $s =$ awrt 4.74 (fou as a result of using expected values to full accuracy.)</td></tr>
</table>

Question 3 notes *continued*

(c)

B1: For both hypotheses and mentioning Poisson at least once. Allow Poisson is a "good fit/model" but not "good method". Inclusion of 1.6 for mean in hypotheses is B0 but condone in conclusion.

M1: For an attempt to pool 4 accidents and $\geqslant 5$ accidents or pool when $E_i < 5$ No pooling is M0

M1: For an attempt at the test statistic, at least 2 correct expressions/values (to awrt 2 d.p.)

A1: For awrt 4.65 (score M1M1A1 if awrt 4.65 seen).

No pooling: If no pooling can allow 2nd M1 if $X^2 = 5.33$ is seen

B1ft: For $n-1-1$ i.e. subtracting 2 from their n.

B1ft: For a correct ft for their $\chi^2_k(0.10)$, where $k = n - 1 - 1$ from their n.

(B1B1 may be implied by 6.251 (if pooling) or 7.779 for no pooling)

A1ft: **(*Dep. on the* 2nd M1)** For correct comment in context based on their test statistic and their critical value that mentions ***accidents*** or ***supervisor***. Condone mention of Po(1.6) in conclusion. Score A0 for inconsistencies e.g. "significant" followed by "supervisor's belief is justified"

Note: Full accuracy gives a combined expected frequency of 15.76, $\frac{(O-E)^2}{E} = 0.0366$,

$\frac{O^2}{E} = 14.2766$, $X^2 = 4.64855...$ and p-value 0.199.

Question	Scheme		Marks
4(a)	Let X = weight of a sack of potatoes, $X \sim \mathrm{N}(25.6\ ,\ 0.24^2)$		
	So $D = X_1 - X_2 \sim \mathrm{N}(0\ ,\ 2(0.24)^2)$ or $D \sim \mathrm{N}(0\ ,\ 0.1152)$	Attempt at D and $D \sim \mathrm{N}(0, ..)$	M1
		$(0.24)^2 + (0.24)^2$; **0.1152**	A1 A1
	$\{\mathrm{P}(\lvert D\rvert > 0.5) =\} \ 2\mathrm{P}(D > 0.5)$	$2 \times \mathrm{P}(D > 0.5)$ can be implied	dM1
	$= 2 \times \mathrm{P}\left(Z > \dfrac{0.5}{\sqrt{0.1152}}\right)$		dM1
	$= 2 \times \mathrm{P}(Z > 1.4731...)$ or $= 2(1 - 0.9292)$		
	$= 0.1416$	**awrt 0.141** or **awrt 0.142**	A1
			(6)
(b)	Let Y = weight of an empty pallet, $Y \sim \mathrm{N}(20.0\ ,\ 0.32^2)$		
	So $T = X_1 + X_2 + ... + X_{30} + Y$		
	$T \sim \mathrm{N}(30(25.6) + 20,\ 30(0.24)^2 + 0.32^2)$	$30(25.6) + 20$ or **788**	B1
		$30(0.24)^2 + 0.32^2$	M1
	$T \sim \mathrm{N}(788, 1.8304)$	N and 1.8304 or awrt **1.83**	A1
	$\{\mathrm{P}(T > 785) =\}\ \mathrm{P}\left(Z > \dfrac{785 - 788}{\sqrt{1.8304}}\right)$		M1
	$= \mathrm{P}(Z > -2.2174...)$		
	$= 0.9868$	**awrt 0.987**	A1
			(5)
			(Total 11)

Notes:

(a)

M1: For clear definition of D and normal distribution with mean of 0 (Can be implied by 3rd M1).

A1: For correct use of Var($X_1 - X_2$) formula.

A1: For 0.1152

dM1: For realising need $2 \times \mathrm{P}(D > 0.5)$ (Dependent on 1st M1 i.e. must be using suitable D).

dM1: Dep on 1st M1 for standardising with 0.5, 0 and their s.d.($\neq 0.24$)Must lead to P($Z >$ +ve) (o.e.). P($Z > 1.47$) implies 1st M1 1st A1 2nd A1 and 3rd M1. Correct answer only will score 6 out of 6.

Question 4 notes *continued*

(b)

B1: For a mean of $30(25.6) + 20$. Can be implied by 788.

M1: For $30(0.24)^2 + 0.32^2$. Can be implied by 1.8304 or awrt 1.83

Allow M1 for swapping error i.e. $30 \times 0.32^2 + 0.24^2$ if the expression is seen

A1: For normal and correct variance of 1.8304 or awrt 1.83. Normality may be implied by standardisation

M1: For standardising with 785 with their mean and st. dev..($\neq 0.24$) Must lead to $P(Z > -ve)$ o.e.

A1: Awrt 0.987. Correct answer only will score 5 out of 5

Note: Calculator answers are (a) 0.14071... , (b) 0.98670...

Question	Scheme		Marks
5	H_0 : Grades and gender are independent (or not associated) H_1 : Grades and gender are dependent (or associated)	"grades" and "gender" mentioned at least once.	B1
	Observed / Male / Female Distinction: 37 / 44 Merit: 127 / 96 Unsatisfactory: 36 / 20	An attempt to convert percentages to observed frequencies.	M1
		All observed frequencies are correct.	A1
	Expected / Male / Female / Totals Distinction: 45 / 36 / 81 Merit: 123.889 / 99.111 / 223 Unsatisfactory: 31.111 / 24.889 / 56 Totals: 200 / 160 / 360	Some attempt at $\frac{(\text{Row Total})(\text{Column Total})}{(\text{Grand Total})}$ Can be implied by a correct E_i	M1
		All expected frequencies are correct to nearest integer.	A1
	Observed / Expected / $\frac{(O-E)^2}{E}$ / $\frac{O^2}{E}$ 37 / 45 / 1.422 / 30.422 44 / 36 / 1.778 / 53.778 127 / 123.889 / 0.078 / 130.189 96 / 99.111 / 0.098 / 92.987 36 / 31.111 / 0.768 / 41.657 20 / 24.889 / 0.960 / 16.071 Totals / 5.104 / 365.104	At least 2 correct terms for $\frac{(O-E)^2}{E}$ or $\frac{O^2}{E}$ or correct expressions with their E_i. Accept 2 sf accuracy for the M1 mark.	M1
		All correct $\frac{(O-E)^2}{E}$ or $\frac{O^2}{E}$ terms to either 2 dp or better. Allow truncation. ($\Rightarrow$ by awrt 5.1 if 3rd M1 seen)	A1
	$X^2 = \sum \frac{(O-E)^2}{E}$ or $\sum \frac{O^2}{E} - 360$;= awrt 5.1	awrt **5.1**	A1
	$\nu = (3-1)(2-1) = 2$	($\nu =$) **2** (Can be implied by 5.991)	B1
	$\chi^2_2(0.05) = 5.991 \Rightarrow$ CR: $X^2 \geqslant 5.991$	For **5.991** only	B1
	Since $X^2 = 5.1$ does not lie in the CR, then there is insufficient evidence to reject H_0		M1

Question	Scheme	Marks
5 ***continued***	Business Studies grades and gender are independent or There is no association between Business Studies grades and gender or Head of department's (belief) is correct	A1ft
		(4)
		(12 marks)

Notes:

Final M1:	For a correct statement linking their test statistic and their critical value (> 3.8) Note: Contradictory statements score M0. E.g. "significant, do not reject H_0 ".
Final A1ft:	For a correct ft statement in context – must mention "grades" and "gender" or "sex" or "head of department" Condone "relationship" or "connection" here but **not** "correlation". e.g. "There is no evidence of a relationship between grades and gender"
5.10 only	Just seeing 5.10... only can imply 1st 3 Ms but loses 1st 3 As so can score 4 out of 7 (Qu says show..")

Note: Full accuracy gives $X^2 = 5.104356...$ and p-value 0.0779

<table>
<tr><th>Question</th><th>Scheme</th><th></th><th>Marks</th></tr>
<tr><td rowspan="11">5</td><td colspan="2"><u>Mark Scheme for candidates who use percentages instead of observed values.</u></td><td></td></tr>
<tr><td>H_0 : Grades and gender are independent (or not associated)
H_1 : Grades and gender are dependent (or associated)</td><td>“grades” and “gender” mentioned at least once.</td><td>B1</td></tr>
<tr><td><table><tr><td>Observed</td><td>Male</td><td>Female</td></tr><tr><td>Distinction</td><td>18.5</td><td>27.5</td></tr><tr><td>Merit</td><td>63.5</td><td>60.0</td></tr><tr><td>Unsatisfactory</td><td>18.0</td><td>12.5</td></tr></table></td><td>These marks cannot be obtained.</td><td>M0 A0</td></tr>
<tr><td rowspan="2"><table><tr><td>Expected</td><td>Male</td><td>Female</td><td>Totals</td></tr><tr><td>Distinction</td><td>23</td><td>23</td><td>46</td></tr><tr><td>Merit</td><td>61.75</td><td>61.75</td><td>123.5</td></tr><tr><td>Unsatisfactory</td><td>15.25</td><td>15.25</td><td>30.5</td></tr><tr><td>Totals</td><td>100</td><td>100</td><td>200</td></tr></table></td><td>Some attempt at $\frac{(\text{Row Total})(\text{Column Total})}{(\text{Grand Total})}$
Can be implied by one of these E_i ’s</td><td>M1</td></tr>
<tr><td>Expected frequencies are not correct.</td><td>A0</td></tr>
<tr><td rowspan="2"><table><tr><td>Observed</td><td>Expected</td><td>$\frac{(O-E)^2}{E}$</td><td>$\frac{O^2}{E}$</td></tr><tr><td>18.5</td><td>23</td><td>0.8804</td><td>14.8804</td></tr><tr><td>27.5</td><td>23</td><td>0.8804</td><td>32.8804</td></tr><tr><td>63.5</td><td>61.75</td><td>0.0496</td><td>65.2996</td></tr><tr><td>60.0</td><td>61.75</td><td>0.0496</td><td>58.2996</td></tr><tr><td>18.0</td><td>15.25</td><td>0.4959</td><td>21.2459</td></tr><tr><td>12.5</td><td>15.25</td><td>0.4959</td><td>10.2459</td></tr><tr><td colspan="2">Totals</td><td>2.8518</td><td>202.8518</td></tr></table></td><td>At least 2 “correct” terms for $\frac{(O-E)^2}{E}$ or $\frac{O^2}{E}$ or correct expressions with their E_i .
Accept 2 sf accuracy for the M1 mark.</td><td>M1</td></tr>
<tr><td>This mark cannot be obtained.</td><td>A0</td></tr>
<tr><td>$X^2 = \sum \frac{(O-E)^2}{E}$ or $\sum \frac{O^2}{E} - 360 ;= 2.8518$</td><td>This mark cannot be obtained.</td><td>A0</td></tr>
<tr><td>$\nu = (3-1)(2-1) = 2$</td><td>($\nu =$) 2 (Can be implied by 5.991)</td><td>B1</td></tr>
<tr><td>$\chi^2_2(0.05) = 5.991 \Rightarrow$ CR: $X^2 \geqslant 5.991$</td><td>For 5.991 only</td><td>B1</td></tr>
</table>

Question	Scheme		Marks
5 ***continued***	Since $X^2 = 2.86$ does not lie in the CR, then there is insufficient evidence to reject H_0		M1
		Not available since comes from incorrect	A0
			(12)
			(12 marks)
Notes:			
If a candidate uses percentages rather than observed values then they can obtain a maximum of **6 marks**. They can get B1 M0A0 M1A0 M1A0A0 B1B1M1A0.			

Question	Scheme		Marks
6(a)	$\left\{\hat{\mu} = \dfrac{\sum x}{n} = \dfrac{1570}{50} = \right\}\ \bar{x} = 31.4$	$\bar{x} =$ **31.4**	B1 cao
	$\left\{\hat{\sigma}^2 = \dfrac{\sum x^2 - n\bar{x}^2}{n-1} = \right\}\ s_x^2 = \dfrac{49467.58 - 50(31.4)^2}{50-1}$		M1 A1ft
	$= 3.460816...$	awrt **3.46**	A1
			(4)
(b)	[Let Y = time taken to complete obstacle course in the afternoon.]		
	$H_0 : \mu_x = \mu_y$, $H_1 : \mu_x > \mu_y$		B1
	$(z =) \dfrac{"31.4" - 30.9}{\sqrt{\dfrac{"3.46"}{50} + \dfrac{3.03}{50}}}$		M1 A1ft
	$= 1.38781...$	awrt **1.39**	A1
	CR: $Z \geqslant 1.6449$ or probability = awrt 0.082 or awrt 0.083	**1.6449** or better	B1
	Since $z = 1.38781...$ does not lie in the CR, then there is insufficient evidence to reject H_0		M1
	Conclude that the <u>mean time</u> to complete the obstacle course is the same for the early <u>morning</u> and late <u>afternoon</u>.		A1
			(7)
(c)	$\bar{X}$ <u>and</u> $\bar{Y}$ are both approx. <u>normal</u>ly distributed <u>or</u> $\bar{X} - \bar{Y}$ normal (Condone $\bar{x}$ and $\bar{y}$)		B1
			(1)
(d)	Have assumed $s^2 \simeq \sigma^2$ or variance of sample $\simeq$ variance of population		B1
			(1)
			(13 marks)

Notes:

(a)

B1: 31.4 cao. Allow 31 minutes, 24 seconds.

M1: A correct expression for either s or s^2 (ignore label)

A1ft: A correct expression for s^2 with their ft $\bar{x}$.

A1: Awrt 3.46 (Correct answer scores 3 out of 3)

(b)

B1: Both hypotheses stated correctly, with some indication of which μ is which. E.g: μ_M , μ_A

Question 6 notes *continued*

M1: For an attempt at $\dfrac{a-b}{\sqrt{\dfrac{c}{50}+\dfrac{d}{50}}}$ with at least 3 of *a, b, c* or *d* correct. Allow $\pm$

A1ft: For $\pm\dfrac{\text{their } 31.4 - 30.9}{\sqrt{\dfrac{\text{their } 3.46}{50}+\dfrac{3.03}{50}}}$

Allow $D = \bar{x} - \bar{y}$ $\quad 1.64 \sim 1.65 = \dfrac{D-0}{\sqrt{\dfrac{"3.46"}{50}+\dfrac{3.03}{50}}}$ [SE = 0.360277..]

A1: For awrt 1.39 (possibly $\pm$)(Allow for CV *D* = awrt 0.593) (NB *d* = 0.5)

Correct answer scores M1A1ftA1 but $0-(31.4-30.9)\rightarrow -1.39$ loses this 2nd A mark

B1: Critical value of 1.6449 or better (seen). Allow for probability = awrt 0.082 or awrt 0.083.

Note: p-values are 0.0823 (tables) and 0.0826 (calculator).

M1: For a correct statement linking their test statistic and their critical value.

Note: Contradictory statements score M0. E.g. "significant, do not reject H_0 ".

A1: For a correct statement in context that accepts H_0 (no ft) Condone "no difference in mean times". Must mention "mean time", "morning" and "afternoon" or "both times of day"

(c)

B1: E.g. $\bar{X} \sim$ N(...) need both. Allow in words e.g "sample means are normally distributed".

(d)

B1: Condone only mentioning "*x*" or "*y*" but watch out for $s_x = s_y$ or $\sigma_x = \sigma_y$ which scores B0.

Question	Scheme		Marks
7(a)	Let X = score on a die		
	$\mathrm{E}(S) = 3.5$, $\mathrm{Var}(S) = \frac{35}{12}$	$\mathrm{E}(S) =$ **3.5**	B1
		$\mathrm{Var}(S) = \frac{35}{12}$ or awrt **2.92**	B1
			(2)
(b)	So, $\overline{S} \sim \mathrm{N}\left("3.5", \frac{"\left(\frac{35}{12}\right)"}{40}\right)$ or $\overline{S} \sim \mathrm{N}\left("3.5", \frac{7}{96}\right)$		B1ft
	$\mathrm{P}\left(\overline{S} < 3\right) = \mathrm{P}\left(Z < \frac{3 - "3.5"}{\sqrt{\frac{7}{96}}}\right)$ $\{= \mathrm{P}(Z < -1.85164...)\}$		M1
	$\{= 1 - 0.9678\} = 0.0322$	**0.032 to 0.0322**	A1
			(3)
			(5 marks)

Notes:

(a)

B1: (2^{nd}) allow awrt 2.92

(b)

B1ft: For $\overline{S} \sim \mathrm{N}\left("3.5", \frac{"\left(\frac{35}{12}\right)"}{40}\right)$ seen or implied. Follow through their E(S) and their Var(S)

N.B $\frac{7}{96} = 0.072916\dot{}$ accept awrt 0.0729

M1: For an attempt to standardise with 3, their mean (>3) and $\sqrt{\frac{\text{their Var}(S)}{40}}$. Must lead to P($Z <$ −ve)

A1: For 0.032 ~ 0.0322

Alternative ΣS

B1ft: For $\sum S \sim \mathrm{N}\left(140, \frac{350}{3}\right)$ where 140 is 40×their E(S) and variance is 40×their Var(S).

Question 7 notes *continued*

M1: For $\mathrm{P}\left(Z < \dfrac{120 - "140"}{\sqrt{\dfrac{350}{3}}}\right)$ or $\mathrm{P}\left(Z < \dfrac{119.5 - "140"}{\sqrt{\dfrac{350}{3}}}\right)$ $\{= \mathrm{P}(Z < -1.8979...)\}$

A1: for 0.032~0.0322 or (with continuity correction) 0.0287 (tables) or 0.0289 (calculator).

Question	Scheme		Marks
8(a)	$\left\{\bar{x} = \frac{29.74 + 31.86}{2}\right\} \Rightarrow \bar{x} = 30.8$	$\bar{x} = 30.8$ This can be implied. See note.	B1
	$"1.96"\left(\frac{\sigma}{\sqrt{n}}\right) = 31.86 - 30.8$ or $2("1.96")\left(\frac{\sigma}{\sqrt{n}}\right) = 31.86 - 29.74$		M1
	$SE_{\bar{x}} = \frac{31.86 - 30.8}{1.96} = 0.540816... = 0.54\,(2\text{dp})$	awrt **0.54**	A1
			(3)
(b)	A 90% CI for μ is $\bar{x} \pm 1.6449\left(\frac{\sigma}{\sqrt{n}}\right)$		B1
	$= 30.8 \pm 1.6449(0.54)$	$(\text{their } \bar{x}) \pm (\text{their } z)(\text{their } SE_{\bar{x}} \text{ from (a)})$	M1
	$= (29.91,\ 31.69)$	(awrt **29.9**, awrt **31.7**)	A1
			(3)
(c)	Let X = number of confidence intervals containing μ		
	or Y = number of confidence intervals not containing μ		
	So $X \sim \text{Bin}(4, 0.9)$ or $Y \sim \text{Bin}(4, 0.1)$		M1
	$P(X \geqslant 3)$ or $P(Y \leqslant 1) = {}^4C_3(0.9)^3(0.1) + (0.9)^4$	${}^4C_3(0.9)^3(0.1) + (0.9)^4$ oe	A1
	$= 0.2916 + 0.6561 = 0.9477$	**0.9477** or **0.948**	A1
			(3)
			(9 marls)

Notes:

(a)

B1: $\bar{x} = 30.8$ may be implied by $1.96\left(\frac{\sigma}{\sqrt{n}}\right) = [31.86 - 30.8] = 1.06$ or

$2(1.96)\left(\frac{\sigma}{\sqrt{n}}\right) = 31.86 - 29.74$

M1: A correct equation for either a width or a half-width involving a z-value $1.5 \leqslant z \leqslant 2$

Eg: $"\text{their } z"\left(\frac{\sigma}{\sqrt{n}}\right) = 31.86 - "30.8"$ ft their $\bar{x}$ or $2("\text{their } z")\left(\frac{\sigma}{\sqrt{n}}\right) = 31.86 - 29.74$

or $"\text{their } z"(SE_{\bar{x}}) = 31.86 - "30.8"$ or $2("\text{their } z")(SE_{\bar{x}}) = 31.86 - 29.74$ are fine for M1.

A1: 0.54 or awrt 0.54 Must be seen as final answer to (a) NB $\frac{53}{98}$ as final answer is A0

Condone $\bar{x} \pm 1.96\sigma = ...$ for B1 and M1 but A0 even if they say "σ = standard error = 0.54". Otherwise answer only of 0.54 scores 3 out of 3