Q	Scheme	Marks	AOs	Pearson Progression Step and Progress Descriptor
1ai	If a T statistic is used as an estimator for a population parameter θ	B1	1.2	6th Explain what is meant by an unbiased estimator
	Then T is an unbiased estimator for θ when $\mathrm{E}(T)=\theta$	B1	1.2	
		(2)		
1aii	bias $=\mathrm{E}(T)-\theta$	B1	1.2	6th Explain what is meant by bias in an estimator
		(1)		
1b	$(\mu=\bar{x}=)\dfrac{2718}{75}=36.24$	M1	1.1b	5th Understand how a sample statistic may be used to estimate a population parameter
	$(\sigma^2=s^2=)\dfrac{1}{74}\left(98984-\dfrac{2718^2}{75}\right)=6.536\ldots$	M1 A1	1.1b 1.1b	
		(3)		
				(6 marks)

Notes

1ai **B1:** for 'if a T statistic is used as an estimator for a population parameter θ' o.e (may be seen in (i) or (ii)

B1: for $\mathrm{E}(T)=\theta$

1aii **B1:** for $\mathrm{E}(T)-\theta$

1b **M1:** for $\dfrac{2718}{75}$

M1: for use of $\dfrac{1}{n-1}\left(\sum x^2-\dfrac{\sum x^2}{n}\right)$

A1: awrt 6.54

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress Descriptor
2a	$\bar{x} = \frac{38.8}{4} = 9.7$	**M1**	1.1b	6th Find a confidence interval for the mean of a normal distribution with known variance
	Z value = 1.96	**B1**	1.1 b	
	$9.7 \pm 1.96 \times \frac{0.36}{\sqrt{4}}$	**M1**	1.1b	
	(9.3472, 10.0528)	**A1** **A1**	1.1b 1.1b	
		(5)		
2b	$2 \times 1.96 \times \frac{0.36}{\sqrt{4}} = 0.7056$	**M1** **A1**	1.1b 1.1b	7th Explain the relationship between the width of a confidence interval and its size used
		(2)		
2c	$2 \times z_{\text{value}} \times \frac{0.36}{2} = 0.3$	**M1**	1.1b	7th Explain the relationship between the width of a confidence interval and its size used
	$z = 0.833$	**A1**	1.1b	
	$2\Phi(0.833) - 1 = 2(0.7967) - 1$	**M1**	2.1	
	= 0.5934 So confidence interval associated with width 0.3 is 59.34%	**A1**	1.1b	
		(4)		

2d	$2\times1.96\times\dfrac{0.36}{\sqrt{n}}\leq0.3$	**M1**	1.1b	7th Explain the relationship between the width of a confidence interval and the sample size
	$\sqrt{n}\dots4.704$	**M1**	1.1b	
	$n\geqslant22.127\dots$	**A1**	1.1b	
	So the sack would need to be weighed 23 times.	**A1**	2.2a	
		(4)		
				(15 marks)

Notes

2a **M1:** for $\dfrac{38.8}{4}$

B1: for 1.96

M1: for use of $\bar{x}\pm z_{\text{value}}\times\dfrac{s}{\sqrt{n}}$

A1: awrt 9.35

A1: awrt 10.1

2b **M1:** for use of $2\times z_{\text{value}}\times\dfrac{s}{\sqrt{n}}$

A1: for 0.7056

2c **M1:** for $2\times z_{\text{value}}\times\dfrac{s}{\sqrt{n}}=0.3$

A1: awrt 0.83

M1: for either $2\Phi(0.833)-1$ or $2(0.7967)-1$

A1: awrt 59.3(%)

2d **M1:** for $2\times1.96\times\dfrac{0.36}{\sqrt{n}}$ „ 0.3

M1: for solving as far as $\sqrt{n}\dots\cdots$

A1: $n\geqslant$ awrt 22.1

A1: $n=23$

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress Descriptor
3a	Z value = 1.96	B1	1.1b	6th Find a confidence interval for the mean of a normal distribution with known variance
	$44.2 \pm 1.96 \times \frac{8}{\sqrt{25}}$	M1	1.1b	
	(41.064, 47.336)	A1 A1	1.1b 1.1b	
		(4)		
3b	$H_0 : \mu_1 = \mu_2 \qquad H_1 : \mu_1 > \mu_2$	B1	2.5	6th Carry out a hypothesis test for the difference between the means of two normal distributions with known variances
	Z value = 1.6449	B1	1.1b	
	$z = \frac{44.2 - 40.9}{\sqrt{\frac{64}{25} + \frac{64}{20}}} = 1.375$	M1 A1	2.1 1.1b	
	Do not reject H_0. There is not sufficient evidence for the mathematics teacher's conclusion that the mean for school *B* is less than that of school *A*	A1	2.2b	
		(5)		
				(9 marks)

Notes

3a **B1:** for 1.96

M1: for use of $\bar{x} \pm z_{\text{value}} \times \frac{s}{\sqrt{n}}$

A1: awrt 41.1

A1: awrt 47.3

3b **B1:** both hypotheses

B1: for 1.6449

M1: for use of $\frac{\bar{x}_A - \bar{x}_B}{\sqrt{\frac{\sigma_A^2}{n_A} + \frac{\sigma_B^2}{n_B}}}$

A1: for 1.375

A1: Drawing a correct inference, follow through their CV and test statistic

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress Descriptor
4a	$H_0 : \mu_B = \mu_G \qquad H_1 : \mu_B \neq \mu_G$	B1	2.5	6th Carry out a hypothesis test for the difference between the means of two normal distributions with known variances
	$z = \dfrac{70-65}{\sqrt{\frac{14^2}{50}+\frac{14^2}{50}}} = 1.7857\ldots$	M1 A1	2.1 1.1b	
	Z value = 1.96	B1	1.1b	
	Do not reject H_0. There is insufficient evidence to suggest that there is a difference between the mean scores of the boys and girls.	A1	2.2b	
		(5)		
4b	$H_0 : \mu_B = \mu_G \qquad H_1 : \mu_B < \mu_G$	B1	2.5	6th Carry out a hypothesis test for the difference between the means of two normal distributions with known variances
	$z = \dfrac{78-73}{\sqrt{\frac{7^2}{50}+\frac{7^2}{50}}} = 3.751\ldots$	M1 A1	2.1 1.1b	
	Z value = 1.6449	B1	1.1b	
	Reject H_0. There is sufficient evidence to suggest that the mean mark for boys is less than the mean mark for girls.	A1	2.2b	
		(5)		
4c	Girls have improved more than boys or girls have performed better than boys after one year.	B1	2.2a	8th Comment on claims made in the context of the question
		(1)		
				(11 marks)

Notes

4a **B1:** for both hypotheses

M1: for use of $\frac{\overline{x}_G - \overline{x}_B}{\sqrt{\frac{\sigma_G^2}{n_G} + \frac{\sigma_B^2}{n_B}}}$

A1: awrt 1.79

B1: Z value = 1.96

A1: Drawing a correct inference, follow through their CV and test statistic

4b **B1:** for both hypotheses

M1: for use of $\frac{\overline{x}_G - \overline{x}_B}{\sqrt{\frac{\sigma_G^2}{n_G} + \frac{\sigma_B^2}{n_B}}}$

A1: awrt 3.75

B1: Z value = 1.6449

A1: Drawing a correct inference, follow through their CV and test statistic

4c **B1:** Correct interpretation follow through parts **a** and **b**

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress Descriptor
5a	$\bar{x} = \frac{315}{70} = 4.5$	M1	1.1b	5th Understand how a sample statistic may be used to estimate a population parameter
	$s^2 = \frac{1}{69}\left(1521 - \frac{315^2}{70}\right) = 1.5$	M1 A1	1.1b 1.1b	
		(3)		
5b	$H_0 : \mu_A = \mu_B \qquad H_1 : \mu_A > \mu_B$	B1	2.5	7th Use large sample results to carry out the test with unknown population variances
	$z = \frac{4.5 - 4.04}{\sqrt{\frac{1.5}{70} + \frac{2.35}{60}}} = 1.8686\ldots$	M1 A1	2.1 1.1b	
	Z value = 1.6449	B1	1.1b	
	Reject H_0. There is sufficient evidence to suggest that the mean weight loss after the first month using training programme *A* is greater than that using training programme *B*	A1	2.2b	
		(5)		
5c	The central limit theorem allows you to assume that the sample means of *A* and *B* follow a normal distribution.	B1	3.5b	7th Use large sample results to carry out the test with unknown population variances
		(1)		
				(9 marks)

Notes

5a **M1:** for $\frac{315}{70}$

M1: for use of $\frac{1}{n-1}\left(\sum x^2 - \frac{\sum x^2}{n}\right)$

A1: for 1.5

5b **B1:** both hypothese

M1: for use of $\frac{\overline{x}_A - \overline{x}_B}{\sqrt{\frac{\sigma_A^2}{n_A} + \frac{\sigma_B^2}{n_B}}}$

A1: awrt 1.87

B1: Z value = 1.6449

A1: Drawing a correct inference, follow through their CV and test statistic

5c **B1:** for stating that the sample means of A **and** B follow a normal distribution