Question	Answer	Marks	AO	Guidance
15 (a) (i)	337	B1	1.1	
		[1]		
15 (a) (ii)	$\sqrt{\frac{1}{54}(6247066.6 - 55 \times 337^2)}$	B1	1.1	**NB** $\sqrt{14.289} = 3.7800$ ... may see $\sqrt{\frac{6247066.6}{55} - 337^2} \times \sqrt{\frac{55}{54}}$ **or** $\sqrt{\frac{6247066.6}{54} - \frac{55 \times 337^2}{54}}$ **oe;**
	≈ 3.78			**AG** must see substitution of at least three of 6247066.6, 337, 55 and 54
		[1]		

Question			Answer	Marks	AO	Guidance
15	(b)		allow any two reasons eg distribution is (approximately) symmetrical eg distribution is (approximately) bell-shaped eg distribution is unimodal eg data is continuous	E1 E1	2.4 2.2b	
				[2]		
15	(c)		P($X < 330$) found from N(their 337, 3.78^2)	M1	3.3	may be implied by 0.032; allow a more precise value for 3.78 if found in part **(a)(ii)** **NB** eg N(−9E999,330,337,3.78); **NB** may see $\sigma^2 = \frac{643}{45}$ or $z = \frac{330-337}{3.78} (= -1.85 \ldots)$
			100 × their 0.032	M1	3.4	
			awrt 3.2 **www**	A1	1.1	mark the final answer
				[3]		
15	(d)		($z =$) ± 2.3263 ... seen	B1	3.1a	to 2 or more dp
			their $z = \frac{330-\mu}{3.78}$	M1	2.1	
			$338.79 \approx 339$	A1	3.2a	must be correct to 3 sf **A0** for $\mu \geq 339$ or $\mu > 339$
				[3]		

Question			Answer	Marks	AO	Guidance
15	(d)		*Alternatively using calculator* eg cdfNormal(-9.999×10^{999}, 330, 338, 3.78) = 0.017(155…) > 0.01	**M1**		allow slip in calculation if intent is clear; allow for any value between 338 and 338.78 inclusive
			or eg cdfNormal(-9.999×10^{999}, 330, 338.5, 3.78) = 0.012(266…) > 0.01			must see correct distributions if probabilities are wrong
			eg cdfNormal(-9.999×10^{999}, 330, 339, 3.78) = 0.0086(339…) < 0.01	**M1**		allow for any value between 338.8 and 339.5 **NB** critical value is 338.79
			hence minimum value for μ is 339	**A1**		must be correct to 3 sf; **A0** for $\mu \geq 339$ or $\mu > 339$
				3		

15	**(e)**		$H_0: \mu = 340$ $H_1: \mu < 340$	**B1**	**1.1**	do not allow $\bar{X}$ or X, but allow other symbol if defined as [population] mean volume; allow equivalent in words
			μ is the **population mean** (volume of drink in a bottle of Fizzipop)	**B1**	**2.5**	
			$N\left(340, \frac{3.78^2}{100}\right)$ **oe** seen	**M1***	**3.3**	may be implied by $0.0477 - 0.048$ may see $N(340, 0.378^2)$ may see $\sigma^2 = \frac{643}{4500}$
			$[P(\bar{X} < 339.37) =] 0.0477 - 0.048$	**A1**	**3.4**	allow slip such as X for $\bar{X}$ but do not allow μ
			their 0.048 correctly compared with 0.05	**M1dep***	**3.4**	
			do not accept H_0 **or** reject H_0 **or** accept H_1 **or** significant	**A1FT**	**1.1**	
			there is **sufficient evidence** at the 5% level to **suggest** that the **mean volume** of drink in a bottle of Fizzipop is **less than** 340 ml **oe**	**A1**	**3.5a**	dependent on award of all other marks apart from second **B1** do not allow eg conclude / prove / indicate or other assertive statement instead of suggest
				[7]		

15	**(e)**		*Alternatively* H_0: $\mu = 340$ H_1: $\mu < 340$	**B1**	**1.1**	do not allow $\bar{X}$ or X, but allow other symbol if defined as [population] mean volume allow equivalent in words
			μ is the **population mean** (volume of drink in a bottle of Fizzipop)	**B1**	**2.5**	
			$N\left(340, \frac{3.78^2}{100}\right)$ **oe** seen	**M1***	**3.3**	may be implied by $339.378 - 339.38$ may see N(340,0.378²) may see $\sigma^2 = \frac{643}{4500}$
			[critical region is $\bar{X} <$]$339.378 - 339.38$	**A1**	**3.4**	or [critical value is $\bar{X} =$]$339.378 - 339.38$; allow slip such as X for $\bar{X}$ but do not allow μ
			339.37 correctly compared with their 339.378	**M1dep***	**3.4**	allow eg so 339.37 is in the critical region if critical region explicitly identified
			do not accept H_0 **or** reject H_0 **or** accept H_1 **or** significant	**A1FT**	**1.1**	**A0** if 339.37 > their 339.378
			there is **sufficient evidence** at the 5% level to **suggest** that the **mean volume** of drink in a bottle of Fizzipop is **less than** 340 ml **oe**	**A1**	**3.5a**	dependent on award of all other marks apart from second **B1** do not allow eg conclude / prove / indicate or other assertive statement instead of suggest
				[7]		

15	**(e)**		*Alternatively, using standard Normal distribution* H_0: $\mu = 340$ H_1: $\mu < 340$	**B1**		do not allow $\bar{X}$ or X, but allow other symbol if defined as [population] mean volume allow equivalent in words
			μ is the **population mean** (volume of drink in a bottle of Fizzipop)	**B1**		
			$N\left(340, \frac{3.78^2}{100}\right)$ **oe** seen	**M1***		may be implied by $z = -1.667$ may see N(340,0.378^2) may see $\sigma^2 = \frac{643}{4500}$
			$[z =] -1.667$	**A1**		
			their z correctly compared with – 1.64485 to 2 or more dp **oe**; must come from N(340, σ)	**M1dep***		
			do not accept H_0 **or** reject H_0 **or** accept H_1 **or** significant	**A1FT**		**A0** if their $z > -1.64485$
			there is **sufficient evidence** at the 5% level to **suggest** that the **mean volume** of drink in a bottle of Fizzipop is **less than** 340 ml **oe**	**A1**		dependent on award of all other marks apart from second **B1** do not allow eg conclude / prove / indicate or other assertive statement instead of suggest
				[7]		