Question 4

(a) (i)	H_0: $\mu = 166500$; H_1: $\mu > 166500$ Where μ denotes the mean selling price in pounds of the population of houses on the large estate	B1 for both correct B1 for definition of μ	**2**
(ii)	n = 6, $\Sigma x = 1018500$, $\bar{x} = £169750$ Test statistic $= \dfrac{169750 - 166500}{14200/\sqrt{6}} = \dfrac{3250}{5797}$ $= 0.5606$ 5% level 1 tailed critical value of z = 1.645 0.5606 < 1.645 so not significant. There is insufficient evidence to reject H_0 It is reasonable to conclude that houses on this estate are not more expensive than in the rest of the suburbs.	B1CAO M1 must include √6 A1FT B1 for 1.645 M1 for comparison leading to a conclusion A1 for conclusion in words in context	**6**

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Question 4

(iv)	H_0: $\mu = 18.3$; H_1: $\mu \neq 18.3$ Where μ denotes the mean travel time by car for the whole population. Test statistic $z = \dfrac{22.4 - 18.3}{8.0/\sqrt{20}} = \dfrac{4.1}{1.789}$ $= 2.292$ 10% level 2 tailed critical value of z is 1.645 2.292 > 1.645 so significant. There is evidence to reject H_0 It is reasonable to conclude that the mean travel time by car is different from that by bus.	B1 for both correct B1 for definition of μ M1 (standardizing sample mean) A1 for test statistic B1 for 1.645 M1 for comparison leading to a conclusion A1 for conclusion in words and context	**7**
(v)	The test suggests that students who travel by bus get to school more quickly. This may be due to their journeys being over a shorter distance. It may be due to bus lanes allowing buses to avoid congestion. It is possible that the test result was incorrect (ie implication of a Type I error). More investigation is needed before any firm conclusion can be reached.	E1, E1 for any two valid comments	**2** **18**

Question 4

(ii)	H_0: $\mu = 67.4$; H_1: $\mu > 67.4$ Where μ denotes the mean score of the population of students taught with the new method. Test statistic = $\frac{68.3 - 67.4}{8.9/\sqrt{12}} = \frac{0.9}{2.57}$ = 0.35 10% level 1 tailed critical value of z = 1.282 0.35 < 1.282 so not significant. There is insufficient evidence to reject H_0 There is insufficient evidence to conclude that the mean score is increased by the new teaching method.	B1 for both correct B1 for definition of μ M1 A1 **cao** B1 for 1.282 M1 for comparison A1 for conclusion in words and in context	**7**
			19

Question 4

(ii)	Test statistic = $\frac{49.2-47}{8.5/\sqrt{50}} = \frac{2.2}{1.202} = 1.830$ 1% level 1 tailed critical value of z = 2.326 1.830 < 2.326 so not significant. There is not sufficient evidence to reject H_0 There is insufficient evidence to conclude that the flowers are larger.	M1 correct denominator A1 B1 for 2.326 M1 (dep on first M1) for sensible comparison leading to a conclusion A1 for fully correct conclusion in words in context	**5**
		TOTAL	**17**

Question 2

(i)	$X \sim N(49.7, 1.6^2)$ (*A*) $P(X > 51.5) = P\left(Z > \frac{51.5 - 49.7}{1.6}\right)$ $= P(Z > 1.125)$ $= 1 - \Phi(1.125) = 1 - 0.8696 = 0.1304$ (*B*) $P(X < 48.0) = P\left(Z < \frac{48.0 - 49.7}{1.6}\right)$ $= P(Z < -1.0625) = 1 - \Phi(1.0625)$ $= 1 - 0.8560 = 0.1440$ $P(48.0 < X < 51.5) = 1 - 0.1304 - 0.1440 = 0.7256$	M1 for standardizing M1 for prob. calc. A1 (at least 2 s.f.) M1 for appropriate prob' calc. A1 (0.725 – 0.726)	**5**
(ii)	P(one over 51.5, three between 48.0 and 51.5) $= \binom{4}{1} \times 0.7256 \times 0.2744^3 = 0.0600$	M1 for coefficient M1 for 0.7256×0.2744^3 A1 FT (at least 2 sf)	**3**
(iii)	From tables, $\Phi^{-1}(0.60) = 0.2533$, $\Phi^{-1}(0.30) = -0.5244$ $49.0 = \mu + 0.2533\,\sigma$ $47.5 = \mu - 0.5244\,\sigma$ $1.5 = 0.7777\,\sigma$ $\sigma = 1.929$, $\mu = 48.51$	B1 for 0.2533 or 0.5244 seen M1 for at least one correct equation μ & σ M1 for attempt to solve two correct equations A1 CAO for both	**4**
(iv)	Where μ denotes the mean circumference of the entire population of organically fed 3-year-old boys. $n = 10$, Test statistic $Z = \frac{50.45 - 49.7}{1.6/\sqrt{10}} = \frac{0.75}{0.5060} = 1.482$ 10% level 1 tailed critical value of z is 1.282 1.482 > 1.282 so significant. There is sufficient evidence to reject H_0 and conclude that organically fed 3-year-old boys have a higher mean head circumference.	E1 M1 A1(at least 3sf) B1 for 1.282 M1 for comparison leading to a conclusion A1 for conclusion in context	**6**
			18

Question 2

(a) (i)	$X \sim N(28,16)$ $P(24 < X < 33) = P\left(\frac{24-28}{4} < Z < \frac{33-28}{4}\right)$ $= P(-1 < Z < 1.25)$ $= \Phi(1.25) - (1 - \Phi(1))$ $= 0.8944 - (1 - 0.8413)$ $= 0.8944 - 0.1587$ $= 0.7357$ (4 s.f.) *or* 0.736 (to 3 s.f.)	M1 for standardizing A1 for 1. 25 and -1 M1 for prob. with tables and correct structure A1 CAO (min 3 s.f., to include use of difference column)	**4**
(ii)	$25000 \times 0.7357 \times 0.1 = £1839$ $25000 \times 0.1587 \times 0.05 = £198$ Total = £1839 + £198 = £2037	M1 for either product, (with or without price) M1 for sum of both products with price A1 CAO awrt £2040	**3**
(iii)	$X \sim N(k, 16)$ From tables $\Phi^{-1}(0.95) = 1.645$ $\frac{33-k}{4} = 1.645$ $33 - k = 1.645 \times 4$ $k = 33 - 6.58$ $k = 26.42$ (4 s.f.) *or* 26.4 (to 3 s.f.)	B1 for ±1.645 seen M1 for correct equation in k with positive z-value A1 *CAO*	**3**
(b) (i)	H_0: $\mu = 0.155$; H_1: $\mu > 0.155$ Where μ denotes the mean weight in kilograms of the population of onions of the new variety	B1 for both correct & ito μ B1 for definition of μ	**2**
(ii)	Mean weight = 4.77/25 = 0.1908 Test statistic = $\frac{0.1908-0.155}{\sqrt{0.005}/\sqrt{25}} = \frac{0.0358}{0.01414}$ = 2.531 1% level 1-tailed critical value of z = 2.326 2.531 > 2.236 so significant. There is sufficient evidence to reject H_0 It is reasonable to conclude that the new variety has a higher mean weight.	B1 M1 must include √25 A1FT B1 for 2.326 M1 For sensible comparison leading to a conclusion A1 for correct, consistent conclusion in words and in context	**6**
			18

Question 1

(i)	$X \sim N(11,3^2)$ $P(X < 10) = P\left(Z < \frac{10-11}{3}\right)$ $= P(Z < -0.333)$ $= \Phi(-0.333) = 1 - \Phi(0.333)$ $= 1 - 0.6304 = 0.3696$	M1 for standardizing M1 for use of tables with their z-value M1 *dep* for correct tail A1CAO (must include use of differences)	**4**
(ii)	P(3 of 8 less than ten) $= \binom{8}{3} \times 0.3696^3 \times 0.6304^5 = 0.2815$	M1 for coefficient M1 for $0.3696^3 \times 0.6304^5$ A1 FT (min 2sf)	**3**
(iii)	$\mu = np = 100 \times 0.3696 = 36.96$ $\sigma^2 = npq = 100 \times 0.3696 \times 0.6304 = 23.30$ $Y \sim N(36.96,23.30)$ $P(Y \geq 50) = P\left(Z > \frac{49.5-36.96}{\sqrt{23.30}}\right)$ $= P(Z > 2.598) = 1 - \Phi(2.598) = 1 - 0.9953$ $= 0.0047$	M1 for Normal approximation with correct (FT) parameters B1 for continuity corr. M1 for standardizing and using correct tail A1 **CAO (**FT 50.5 or omitted CC)	**4**
(iv)	H_0: $\mu = 11$; H_1: $\mu > 11$ Where μ denotes the mean time taken by the new hairdresser	B1 for H_0, as seen. B1 for H_1, as seen. B1 for definition of μ	**3**
(v)	Test statistic $= \frac{12.34-11}{3/\sqrt{25}} = \frac{1.34}{0.6}$ $= 2.23$ 5% level 1 tailed critical value of z = 1.645 2.23 > 1.645, so significant. There is sufficient evidence to reject H_0 It is reasonable to conclude that the new hairdresser does take longer on average than other staff.	M1 must include $\sqrt{25}$ A1 (FT their μ) B1 for 1.645 M1 for sensible comparison leading to a conclusion A1 for conclusion in words in context (FT their μ)	**5**
			19

Question 3

(i)	$X \sim N(27500, 4000^2)$ $P(X > 25000) = P\left(Z > \frac{25000-27500}{4000}\right)$ $= P(Z > -0.625)$ $= \Phi(0.625) = 0.7340$ (3 s.f.)	M1 for standardising A1 for -0.625 M1 *dep* for correct tail A1CAO (must include use of differences)	**4**
(ii)	P(7 of 10 last more than 25000) $= \binom{10}{7} \times 0.7340^7 \times 0.2660^3 = 0.2592$	M1 for coefficient M1 for $0.7340^7 \times 0.2660^3$ A1 FT (min 2sf)	**3**
(iii)	From tables $\Phi^{-1}(0.99) = 2.326$ $\frac{k-27500}{4000} = -2.326$ $x = 27500 - 2.326 \times 4000 = 18200$	B1 for 2.326 seen M1 for equation in *k* and negative z-value A1 CAO for awrt 18200	**3**
(iv)	H_0: $\mu = 27500$; H_1: $\mu > 27500$ Where μ denotes the mean lifetime of the new tyres.	B1 for use of 27500 B1 for both correct B1 for definition of μ	**3**
(v)	Test statistic $= \frac{28630-27500}{4000/\sqrt{15}} = \frac{1130}{1032.8}$ $= 1.094$ 5% level 1 tailed critical value of $z = 1.645$ $1.094 < 1.645$ so not significant. There is not sufficient evidence to reject H_0 There is insufficient evidence to conclude that the new tyres last longer.	M1 must include $\sqrt{15}$ A1 FT B1 for 1.645 M1 *dep* for a sensible comparison leading to a conclusion A1 for conclusion in words in context	**5**
			18

Question 3

(i)	$X \sim N(1720, 90^2)$ $P(X < 1700) = P\left(Z < \frac{1700-1720}{90}\right)$ $= P(Z < -0.2222)$ $= \Phi(-0.2222) = 1 - \Phi(0.2222)$ $= 1 - 0.5879$ $= 0.4121$	M1 for standardising A1 M1 use of tables (correct tail) A1CAO **NB ANSWER GIVEN**	**4**
(ii)	P(2 of 4 below 1700) $= \binom{4}{2} \times 0.4121^2 \times 0.5879^2 = 0.3522$	M1 for coefficient M1 for $0.4121^2 \times 0.5879^2$ A1 FT (min 2sf)	**3**
(iii)	Normal approx with $\mu = np = 40 \times 0.4121 = 16.48$ $\sigma^2 = npq = 40 \times 0.4121 \times 0.5879 = 9.691$ $P(X \geq 20) = P\left(Z \geq \frac{19.5-16.48}{\sqrt{9.691}}\right)$ $= P(Z \geq 0.9701) = 1 - \Phi(0.9701)$ $= 1 - 0.8340 = 0.1660$	B1 B1 B1 for correct continuity corr. M1 for correct Normal probability calculation using correct tail A1 CAO, **(**but FT wrong or omitted CC)	**5**
(iv)	H_0: $\mu = 1720$; H_1 is of this form since the consumer organisation suspects that the mean is below 1720 μ denotes the mean intensity of 25 Watt low energy bulbs made by this manufacturer.	B1 E1 B1 for definition of μ	**3**
(v)	Test statistic $= \frac{1703-1720}{90/\sqrt{20}} = \frac{-17}{20.12}$ $= -0.8447$ Lower 5% level 1 tailed critical value of $z = -1.645$ $-0.8447 > -1.645$ so not significant. There is not sufficient evidence to reject H_0 There is insufficient evidence to conclude that the mean intensity of bulbs made by this manufacturer is less than 1720	M1 must include $\sqrt{20}$ A1FT B1 for –1.645 No FT from here if wrong. Must be –1.645 unless it is clear that absolute values are being used. M1 for sensible comparison leading to a conclusion. FT only candidate's test statistic A1 for conclusion in words in context	**5**
		TOTAL	**20**

	(iv)	H_0: $\mu = 32.8$; H_1: $\mu < 32.8$ Where μ denotes the population mean weight of rubbish in the bins. Test statistic = $\frac{30.9-32.8}{3.4/\sqrt{50}} = -\frac{1.9}{0.4808} = -3.951$ 5% level 1 tailed critical value of z = –1.645 –3.951 < –1.645 so significant. There is sufficient evidence to reject H_0 There is evidence to suggest that the weight of rubbish in dustbins has been reduced.	B1 for use of 32.8 B1 for both correct B1 for definition of μ M1 must include √50 A1 B1 for ±1.645 M1 for sensible comparison leading to a conclusion A1 for conclusion in words in context **TOTAL**	**[8]** **[18]**