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

Question Number	Scheme	Marks
7(a)	$\mathrm{E}(D) = x + 2$	M1
	$\mathrm{Var}(D) = \frac{((x+5)-(x-1))^2}{12} [= 3]$	M1
	$\bar{D} \sim N\left(x+2, \frac{3}{n} \right)$	A1
		(3)
(b)	$\text{"}x+2\text{"} = 22.101 + \text{"2"}\ (= 24.101)$ or $\text{"}x+2\text{"} = 24.6 \Rightarrow 24.6 - \text{"2"}\ (= 22.6)$	M1
	$24.6 - \text{"2.5758"}\sqrt{\frac{\text{"3"}}{n}} = \text{"24.101"}$ oe	B1M1 dM1
	$n = 80$	A1cao
		(5)
	Notes	Total 8

Question Number	Scheme	Marks
2(a)	$H_0 : \mu_{year7} = \mu_{year8}$ $\quad$ $H_1 : \mu_{year7} \neq \mu_{year8}$	B1
	$SE = \sqrt{\frac{38}{240} + \frac{42}{240}}$	M1
	$z = \frac{103 - 101}{SE}$	M1
	$= (\pm)3.464....$ $\quad$ $(2\sqrt{3})$ $\quad$ awrt $(\pm)$ 3.46	A1
	$Z_{critical} = 2.5758$	B1
	In CR/Significant/Reject H_0	M1
	There is sufficient evidence to suggest that the regional education officer's claim is not correct/ There is a difference between the mean scores of the two year groups.	A1
		(7)
(b)	CLT allows us to use sample means (oe) being normally distributed	B1
		(1)
	Notes	**Total 8**

(a)	**B1**	both hypotheses correct. Allow equivalent rearrangements. Must be in terms of μ If using e.g. $\mu_A = \mu_B$ A and B must be clearly identified with year groups
	M1	for use of SE with 38 and 42 (may be implied by SE = awrt 0.577)
	M1	for a correct standardisation expression using 103, 101 (in either order) and SE = awrt.0577 or ft their stated SE or if not stated (i.e. only seen in standardisation) only allow $\sqrt{\frac{38^2}{240} + \frac{42^2}{240}}$ or $\sqrt{\frac{\sqrt{38}}{240} + \frac{\sqrt{42}}{240}}$
	A1	awrt 3.46 or awrt −3.46 allow p value of awrt 0.000266
	B1	|CV| = 2.5758 or better (seen)
	M1	a correct statement linking their test statistic and their CV – need not be contextual but do not allow contradicting non contextual comments.
	A1	do not allow a ft conclusion here. a correct contextual statement (dependent on 2nd M1) which must be consistent with their test statistics and CV and which also must reject H_0. It must mention the officer or mean scores.
(b)	**B1**	a correct explanation which must mention sample means oe (population means are normally distributed is B0) ignore extraneous non-contradictory comments

Question Number	Scheme	Marks
5(a)	$H_0 : \mu_p - \mu_f = 1$ oe	B1
	$H_1 : \mu_p - \mu_f > 1$ oe	B1
	s.e. $= \sqrt{\frac{9}{605}+\frac{4}{45}} = \left[\sqrt{0.10376...}\right] = [0.322…]$	M1
	$z = \pm \frac{7.0-5.6-1}{"\sqrt{\frac{9}{605}+\frac{4}{45}}"}$	dM1
	$= 1.24175...$ awrt 1.24	A1
	CV 5% one tailed $= \pm 1.6449$ (see notes)	B1
	Not significant, do not reject H_0	dM1
	Insufficient evidence that **full-time** staff are more than **one minute** faster than **part-time** staff or manager's **claim** is not supported	A1ft
		(8)
(b)	Assume **both** samples are **normal** or **both** large enough for **CLT** oe	B1
	Assume $s^2 = \sigma^2$ for **both** samples	B1
	Assume individual results are independent	
		(2)
(c)	$\bar{a} = \frac{45\times 7+8}{46}[= 7.0217...]$	M1
	$\sum a^2 = 44\times 4 + 45\times 7^2 + 8^2 [= 2445]$	M1
	$s^2 = \frac{"2445" - 46\times "7.0217..."^2}{45}$	M1
	$= 3.93285…$ awrt 3.93	A1
		(4)
	Notes	Total 14

Question Number	Scheme		Marks
1.	H_0: $\mu = 30$ H_1: $\mu < 30$		B1
	$z = \frac{29.5-30}{\frac{2.5}{\sqrt{80}}}$		M1
	$z = -1.7888...$	awrt–1.79	A1
	$-1.7888 < -1.6449$		B1
	Reject H_0 or significant result or in the critical region		
	There is evidence to support the manager's claim.		A1
			(5)
	Notes		**Total 5**

	B1	Both hypotheses correct in terms of μ
	M1	for attempting test statistic, allow $\pm$, Condone $\sqrt{\frac{2.5}{80}}$
	A1	awrt –1.79 allow $\|z\| = 1.7888...$ Allow p value of 0.0367 or awrt 0.0368 or CR $\leqslant 29.54$
	B1	$\|CV\| = 1.6449$ or better (Ignore any comparisons) Allow CR $\leqslant 29.54$ SC If p value of 0.0367 or awrt 0.0368 award B1 if 2nd A1 is awarded
	A1	For correct conclusion. Allow the manager's claim in words if it includes screws and less (oe)

Question Number	Scheme	Marks
3 (a)	$\left[p = \frac{118}{40} = \right] 2.95$	B1
	$[q =] \frac{350.05 - 40('2.95')^2}{39} = 0.05$	M1 A1
		(3)
(b)	$H_0 : \mu_A = \mu_B \quad H_1 : \mu_A < \mu_B$	B1
	$z = \pm \frac{2.65 - '2.95'}{\sqrt{\frac{0.07}{50} + \frac{'0.05'}{40}}}$	M1 M1
	$= 5.827...$ or $= -5.827...$ awrt ± 5.83	A1
	CV = 1.6449	B1
	Reject H_0 There is significant evidence to support the biologist's **belief**	M1 A1ft
		(7)
(c)	Large sample sizes so …	
	both sample means are normally distributed (CLT)	B1
	$s_A^2 = \sigma_A^2$ **and** $s_B^2 = \sigma_B^2$	B1
		(2)
	Notes	**Total 12**

Question Number	Scheme	Marks
8.	X follows a continuous unform distribution over $[a+3, 2a+9]$; $Y = \frac{2\bar{X}}{3} + k$	
(a)	$\{E(\bar{X}) = m\} = \frac{2a+9+a+3}{2}$	M1
	$= \frac{3a}{2} + 6$ or $\frac{3a+12}{2} \neq a$. {So $\bar{X}$ is a biased estimator.}	A1
		[2]
(b)	bias $\left\{= \frac{3a}{2} + 6 - a\right\} = \frac{1}{2}a + 6$ or $\frac{a+12}{2}$ (allow ±)	B1ft
		[1]
(c)	$\left\{E(Y) = \frac{2}{3}E(\bar{X}) + k = a \Rightarrow\right\} \frac{2}{3}\left(\frac{3a}{2} + 6\right) + k = a$	M1
	$\{a + 4 + k = a \Rightarrow\}$ $k = -4$ $k = -4$	A1
		[2]
(d)	$\left\{\hat{a} = \frac{2}{3}\bar{X} - 4 \Rightarrow\right\}$ $\hat{a} = \frac{2}{3}(7.8) - 4$ $\{= 1.2\}$	M1
	Max value $= 2(1.2) + 9$	M1
	$= 11.4$ 11.4 or $11\frac{2}{5}$ or $\frac{57}{5}$	A1
		[3]
		8