Question 1

(i)	Faults are detected randomly and independently Uniform (mean) rate of occurrence	B1 B1	**2**
(ii)	(*A*) $P(X = 0) = e^{-0.15}\dfrac{0.15^0}{0!} = 0.8607$ (*B*) $P(X \geq 2) = 1 - 0.8607 - e^{-0.15}\dfrac{0.15^1}{1!}$ $= 1 - 0.8607 - 0.1291 = 0.0102$	M1 for probability calc. M0 for tables unless interpolated A1 M1 A1	**4**
(iii)	$\lambda = 30 \times 0.15 = 4.5$ Using tables: $P(X \leq 3) = 0.3423$	B1 for mean (SOI) M1 attempt to find $P(X \leq 3)$ A1	**3**
(iv)	Poisson distribution with $\lambda = 10 \times (0.15 + 0.05) = 2$ $P(X = 5) = e^{-2}\dfrac{2^5}{5!} = 0.0361$ (3 s.f.) or from tables $= 0.9834 - 0.9473 = 0.0361$	B1 for Poisson stated B1 for $\lambda = 2$ M1 for calculation or use of tables A1 FT	**4**
(v)	Mean no. of items in 200 days = $200 \times 0.2 = 40$ Using Normal approx. to the Poisson, $X \sim N(40,40)$: $P(X \geq 50) = P\left(Z > \dfrac{49.5 - 40}{\sqrt{40}}\right)$ $= P(Z > 1.502) = 1 - \Phi(1.502) = 1 - 0.9334$ $= 0.0666$ (3 s.f.)	B1 for Normal approx. (SOI) B1 for both parameters B1 for continuity corr. M1 for probability using correct tail A1 **cao, (**but FT wrong or omitted CC)	**5**
			18

Question 2

(i) (*A*)	$X \sim N(42,3^2)$ $P(X > 50.0) = P\left(Z > \frac{50.0-42.0}{3.0}\right)$ $= P(Z > 2.667)$ $= 1 - \Phi(2.667) = 1 - 0.9962$ $= 0.0038$	M1 for standardizing M1 for prob. calc. with correct tail A1 **NB answer given**	**3**
(i) (*B*)	P(not positive) = 0.9962 P(At least one is out of 7 is positive) $= 1 - 0.9962^7 = 1 - 0.9737$ $= 0.0263$	B1 for use of 0.9962 in binomial expression M1 for correct method A1 CAO	**3**
(i) (*C*)	If an innocent athlete is tested 7 times in a year there is a reasonable possibility (1 in 40 chance) of testing positive. Thus it is likely that a number of innocent athletes may come under suspicion and suffer a suspension so the penalty could be regarded as unfair. *Or* this is a necessary evil in the fight against performance enhancing drugs in sport.	E1 comment on their probability in (i) B E1 for sensible contextual conclusion consistent with first comment	**2**
(ii) (*A*)	B(1000, 0.0038)	B1 for B(,) or Binomial B1 *dep* for both parameters	**2**
(ii) (*B*)	A suitable approximating distribution is Poisson(3.8) P(at least 10 positive tests) $= P(X \geq 10) = 1 - P(X \leq 9)$ $= 1 - 0.9942$ $= 0.0058$ *NB Do not allow use of Normal approximation.*	B1 for Poisson soi B1FT *dep* for $\lambda = 3.8$ M1 for attempt to use $1 - P(X \leq 9)$ A1 FT	**4**
(iii)	P(not testing positive) = 0.995 From tables $z = \Phi^{-1}(0.995) = 2.576$ $\frac{h-48.0}{2.0} = 2.576$ $h = 48.0 + 2.576 \times 2.0 = 53.15$	B1 for 0.995 seen (or implied by 2.576) B1 for 2.576 (FT their 0.995) M1 for equation in *h* and positive z-value A1 CAO	**4**
			18

Question 3

<table>
<tr><td>(i)</td><td>

Rank x	1	5	4	7	6	8	10	3	9	2
Rank y	2	4	5	8	9	7	10	6	3	1
d	-1	1	-1	-1	-3	1	0	-3	6	1
d^2	1	1	1	1	9	1	0	9	36	1

$r_s = 1 - \frac{6\Sigma d^2}{n(n^2-1)} = 1 - \frac{6\times 60}{10\times 99}$
= 0.636 (to 3 s.f.) [*allow* 0.64 to 2 s.f.]</td><td>M1 for ranking (allow all ranks reversed)
M1 for d^2
A1 CAO for Σd^2
M1 for structure of r_s using their Σd^2
A1 f.t. for $|r_s| < 1$
NB No ranking scores zero</td><td>5</td></tr>
<tr><td>(ii)</td><td>H_0: no association between x and y
H_1: positive association between x and y
Looking for positive association (one-tail test):
Critical value at 5% level is 0.5636
Since 0.636 > 0.5636, there is sufficient evidence to reject H_0,
i.e. conclude that there appears to be positive association between temperature and nitrous oxide level.</td><td>B1 for H_0
B1 for H_1
NB H_0 H_1 <u>not</u> ito rho
B1 for ± 0.5636
(FT their H_1)
M1 for comparison with c.v., provided $|r_s| < 1$
A1 for conclusion in words f.t. their r_s and sensible cv</td><td>5</td></tr>
<tr><td>(iii)</td><td>Underlying distribution must be bivariate normal.
If the distribution is bivariate normal then the scatter diagram will have an elliptical shape.
This scatter diagram is not elliptical and so a PMCC test would not be valid.
(Allow comment indicating that the sample is too small to draw a firm conclusion on ellipticity and so on validity)</td><td>B1 CAO for bivariate normal
B1 indep for elliptical shape
E1 dep for conclusion</td><td>3</td></tr>
<tr><td>(iv)</td><td>n=60, PMCC critical value is r = 0.2997
So the critical region is $r \geq 0.2997$</td><td>B1
B1 FT their sensible c.v.</td><td>2</td></tr>
<tr><td>(v)</td><td>Any three of the following:
• Correlation does not imply causation;
• There could be a third factor (causing the correlation between temperature and ozone level);
• the claim could be true;
• increased ozone could cause higher temperatures.</td><td>E1
E1
E1</td><td>3</td></tr>
<tr><td></td><td></td><td></td><td>18</td></tr>
</table>

Question 4

(i)	H_0: no association between method of travel and type of school; H_1: some association between method of travel and type of school;..	B1 for both	**1**
(ii)	Expected frequency = 120/200 × 70 = 42 Contribution = $(21 - 42)^2$ / 42 = 10.5	M1 A1 M1 for valid attempt at $(O\text{-}E)^2/E$ A1 FT their 42 provided O = 21 (at least 1 dp)	**4**
(iii)	X^2 = 42.64 Refer to $\mathcal{X}_2^2$ Critical value at 5% level = 5.991 Result is significant There appears to be some association between method of travel and year group. NB if H_0 H_1 reversed, or 'correlation' mentioned, do not award first B1or final E1	B1 for 2 deg of f(seen) B1 CAO for cv B1 for significant (FT their c.v. provided consistent with their d.o.f. E1	**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 chi squared calculations

H_0: no association between method of travel and type of school;
H_1: some association between method of travel and type of school;

Observed		Type of school		**Row totals**
		Year 6	Year 11	
Method of travel	Bus	21	49	**70**
	Car	65	15	**80**
	Cycle/Walk	34	16	**50**
Column totals		**120**	**80**	**200**

Expected		Type of school		**Row totals**
		Year 6	Year 11	
Method of travel	Bus	42	28	**70**
	Car	48	32	**80**
	Cycle/Walk	30	20	**50**
Column totals		**120**	**80**	**200**

Chi Squared Contribution		Type of school		**Row totals**
		Year 6	Year 11	
Method of travel	Bus	10.50	15.75	**26.25**
	Car	6.02	9.03	**15.05**
	Cycle/Walk	0.53	0.80	**1.33**
Column totals		**17.05**	**25.58**	**42.64**