Question Number	Scheme		Marks
1 (a)	$P(H=6)=\frac{e^{-4}4^6}{6!}$ or $P(H\le 6)-P(H\le 5)=0.8893-0.7851$		M1
	$=0.10419\ldots$ $=0.1042$	awrt **0.104**	A1
			(2)
(b)	$J\sim Po(8)$		B1
	$P(J\le 7)-P(J\le 2)=0.4530-0.0138$		M1
	$=0.4392$	awrt **0.439**	A1
			(3)
(c)	$K\sim N(28,28)$		M1
	$P(K>30)\approx P\left(Z>\frac{30.5-28}{\sqrt{28}}\right)$		M1M1A1
	$=P(Z>0.4724...)$		
	$=1-0.6808$		
	$=0.3192$ (calc 0.3183)	awrt **0.319/0.318**	A1
			(5)
(d)(i)	The p(robability)/0.97 is not small oe		B1
			(1)
(ii)	$L\sim Po(3)$		B1
	$P(L\le 4)=0.8153$	awrt **0.815**	M1A1
			(3)
	Notes		**Total 14**
	Correct answers imply all marks in each part of this question.		

1(a)	**M1**	Allow any value for lambda $\frac{e^{-\lambda}\lambda^6}{6!}$ or $P(H\le 6)-P(H\le 5)$
	A1	awrt 0.104
(b)	**B1**	Writing Po(8). This may be implied by a correct answer or sight of awrt 0.453 or awrt 0.0138 or awrt 0.0424 or awrt 0.313
	M1	$P(J\le 7)-P(J\le 2)$ oe or (awrt 0.453 – awrt 0.0138)
	A1	awrt 0.439
(c)	**M1**	Using normal approximation with mean = variance = 28 (May be seen in standardisation which takes priority) or writing N(28,28)
	M1	$\pm\left(\frac{30.5 \text{ or } 30 \text{ or } 29.5 \ - \ \text{their mean}}{\text{their sd}}\right)$ If they have not given a mean and a variance, they must be correct here.
	M1	Writing or using a continuity correction 30 ± 0.5
	A1	Correct standardisation with 30.5 or awrt 0.47
	A1	awrt 0.319/0.318
(d)(i)	**B1**	Probability is not small (too large). Allow mean ≠ variance. Do not allow e.g. '*np* too large/*np* > 10' on its own. Ignore extraneous non-contradictory comments.
(ii)	**B1**	Writing or using Po(3)
	M1	Writing or using $P(L\le 4)$ oe
	A1	awrt 0.815

Question	Scheme	Marks
2(a)	$E \sim B(6, 0.35)$	B1
(i)	$P(E = 2) = P(E \leq 2) - P(E \leq 1)$ or $\left({}^6C_2\right)0.35^2(1-0.35)^4$	M1
	$= 0.6471 - 0.3191$	
	$= 0.328$ awrt **0.328**	A1
(ii)	$P(E \geq 4) = 1 - P(E \leq 3)$ or $1 - 0.8826$	M1
	$= 0.1174$ awrt **0.117**	A1
		(5)
(b)	$H_0 : p = 0.35$ $H_1 : p > 0.35$	B1
	$L \sim B(50, 0.35)$ $P(L \geq 25) = 1 - P(L \leq 24)$ $P(L \geq 24) = 0.0396$	M1
	$= 1 - 0.9793$ $P(L \geq 23) = 0.071$	
	$= 0.0207$ CR $L \geq 24$	A1
	Reject H_0 or Significant or 25 does lie in the critical region	dM1
	There is evidence to support Kiyoshi's **belief** oe or that the **proportion/number** oe of **large eggs** has increased after adding the supplement	A1cso
		(5)
(c)	Expected profit before supplement = $"0.1174" \times 1.20 + (1 - "0.1174") \times 0.60$	M1
	$= (£)0.67044$	
	$P(X \geq 4) = 0.2553$ awrt 0.255	B1
	Expected profit per box after supplement = $"0.2553" \times 1.20 + (1 - "0.2533") \times 0.60 - "0.67044"$	M1
	$= (£)0.08274$	A1
	OR Expected profit per box after supplement = $"0.2553" \times 1.20 + (1 - "0.2553") \times 0.60 - 0.10$	(M1)
	$= (£)0.65318$	(A1)
	Kiyoshi should not continue to add the supplement (as 0.0827 < 0.10 or 0.653 < 0.67[0])	A1cso
		(5)
		Total 15

Notes

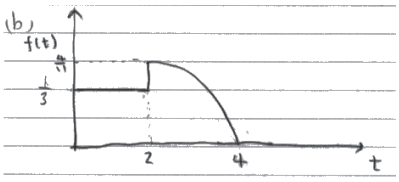
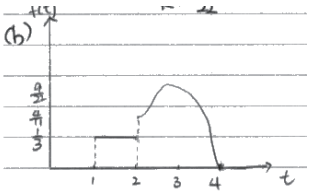
2(a)	**B1**	Using or writing B(6,0.35) in either part
(i)	**M1**	Using or writing $P(E \leq 2) - P(E \leq 1)$ oe or writing $\left({}^6C_2\right)0.35^2(1-0.35)^4$ oe
	A1	awrt 0.328
(ii)	**M1**	Either writing or using $P(E \geq 4)$ or $1 - P(E \leq 3)$ or P(*E* = 4) + P(*E* = 5) + P(*E* = 6) oe
	A1	awrt 0.117 (Correct answers imply all previous marks in part (a))
(b)	**B1**	Both hypotheses correct with *p* or π
	M1	Writing or using $L \sim B(50, 0.35)$ **and** $1 - P(L \leq 24)$ **or** writing P(*L* ≥ 24) = 0.0396 or P(*L* ≥ 23) = 0.071 **leading to a CR**. Condone use of normal approx *M*~N(17.5, awrt 11.4) **and** 1 – P(*M* < 24.5) for the M1
	A1	awrt 0.0207 or $L \geq 24$ allow any letter
	dM1	dep on previous M being awarded for a correct statement (condone Accept H_1) ft their probability or CR Do not allow contradicting non-contextual comments.
	A1cso	All previous marks must be awarded. A correct statement in context. Need **bold words. NB** award M1A1 for a correct contextual statement on its own.
(c)	**Note:**	Some candidates may multiply by *n* or an integer so allow these multiples throughout.
	M1	$"\text{their (ii)} \times 1.20 + (1 - "\text{their(ii)}") \times 0.60$
Allow £ or pence in part (c)	**B1**	awrt 0.255
	M1	$"p" \times 1.20 + (1 - "p") \times 0.60 - "\text{their } 0.67044"$ or $"p" \times 1.20 + (1 - "p") \times 0.60 - 0.10$ oe where $p > 0.1174$ (do not allow $p = 0.45$ for this mark)
	A1	awrt (£)0.083 or awrt (£)0.65
	A1cso	Dep on all previous marks in (c). Correct conclusion with correct supporting figures.

Question Number	Scheme	Marks
3(a)	$\frac{3}{4}$	B1
		(1)
(b)	$\mathrm{E}(T)=\dfrac{50+2k}{2}[=25+k]$	B1
	$\mathrm{Var}(T)=\dfrac{(4k)^2}{12}\left[=\dfrac{4k^2}{3}\right]$	B1
	$\mathrm{E}\left(T^2\right)=\dfrac{4k^2}{3}+\left(25+k\right)^2$	M1
	$\dfrac{7k^2}{3}+625+50k=918.76$	
	$7k^2+150k-881.28=0$	dM1
	$k=\frac{-150\pm\sqrt{150^2+4\times7\times881.28}}{14}$	dM1
	$k=4.8$ oe only	A1
		(6)
(c)	$\mathrm{P}(T<25)=\frac{1}{4}$	B1
	B(50, 0.25)	
	$\mathrm{P}\left(X\geq20\right)=1-\mathrm{P}\left(X\leq19\right)$	M1
	$=1-0.9861$	
	$=0.0139$ awrt 0.0139	A1
		(3)
		Total 10

Notes

(a)	**B1**	0.75 oe
(b)	**B1**	$\mathrm{E}(T)=\dfrac{50+2k}{2}[=25+k]$ allow equivalent unsimplified expressions
	B1	$\mathrm{Var}(T)=\dfrac{(4k)^2}{12}\left[=\dfrac{4k^2}{3}\right]$ allow equivalent unsimplified expressions
	M1	Using Var(T) + [E(T)]^2 oe e.g. $"\frac{4k^2}{3}"=\mathrm{E}(T^2)-"(25+k)"^2$
	dM1	Dependent on previous M being awarded. Substituting E(T^2) = 918.76, multiplying out and combining like terms leading to a 3TQ = 0
	dM1	Dependent on previous M being awarded. A correct method for solving their quadratic – use of formula (allow one slip), completing the square, factorising.
	A1	Must have 4.8 oe on its own as answer (must reject k = –26.2 if seen) 4.8 on its own scores 6 out of 6.
	ALT	**For first 4 marks in (b)** $\int_{25-k}^{25+3k} t^2(\frac{1}{4k})\mathrm{d}t=\left[\dfrac{t^3}{12k}\right]_{25-k}^{25+3k}\rightarrow\dfrac{(25+3k)^3}{12k}-\dfrac{(25-k)^3}{12k}=918.76$ B2 for correct integral (ignore limits), M1 for attempt at integration $t^2\rightarrow t^3$, dM1 for use of limits and = 918.76, then follow main scheme
(c)	**B1**	0.25
	M1	Writing or using $1-\mathrm{P}\left(X\leq19\right)$
	A1	awrt 0.0139

Question Number	Scheme		Marks
4(a)	$\int_1^2 \frac{1}{3}\,\mathrm{d}t + \int_2^4 k(4t^2 - t^3)\,\mathrm{d}t = 1$		M1
	$\left[\frac{1}{3}t\right]_1^2 + \left[k\left(\frac{4t^3}{3} - \frac{t^4}{4}\right)\right]_2^4 = 1$		A1
	$\frac{1}{3} + k\left(\frac{64}{3} - \frac{20}{3}\right) = 1$ or $\frac{44}{3}k = \frac{2}{3}$ leading to $k = \frac{1}{22}$		A1cso
			(3)
(b)	[f(t)] [4/11] [1/3] 1 2 4 [t]		B1(shape) dB1 (labels)
			(2)
(c)	$\frac{\mathrm{d}f(t)}{\mathrm{d}t} = k\left(8t - 3t^2\right)$		B1
	$8t - 3t^2 = 0$		M1
	$t = \frac{8}{3}$ only	awrt 2.67	A1
			(3)
(d)	$\int_1^t \frac{1}{3}\,\mathrm{d}x = \left[\frac{x}{3}\right]_1^t$		M1
	$\mathrm{F}(2) + \int_2^t \frac{1}{22}\left(4x^2 - x^3\right)\mathrm{d}t = \frac{1}{3} + \left[\frac{4x^3}{66} - \frac{x^4}{88}\right]_2^t$ Or $\int \frac{1}{22}\left(4t^2 - t^3\right)\mathrm{d}t = \frac{2t^3}{33} - \frac{t^4}{88} + C$ and $\mathrm{F}(4) = 1$		M1
	$\mathrm{F}(t) = \begin{cases} 0 & t<1 \\ \frac{1}{3}t - \frac{1}{3} & 1 \le t < 2 \\ \frac{2t^3}{33} - \frac{t^4}{88} + \frac{1}{33} & 2 \le t \le 4 \\ 1 & \text{otherwise} \end{cases}$		A1 A1 A1
			(5)
(e)	$\mathrm{P}(T > 3) = 1 - \mathrm{F}(3)$		
	$= 1 - \left[\frac{4\times 3^3}{66} - \frac{3^4}{88} + \frac{1}{33}\right]$		M1
	$= \frac{67}{264}$ or 0.2537…	awrt 0.254	A1
			(2)
			Total 15

		Notes
4(a)	**M1**	Adding the two integrals together with correct limits and setting = 1 (may be done in stages) Allow $\frac{1}{3}$ instead of first integral
	A1	Correct integration (again allow $\frac{1}{3}$ instead of first integration)
	A1cso	Must have at least one line of working before the given answer and no errors
(b)	**B1**	Correct shape with correct curvature Horizontal line, then quadratic (increasing then decreasing as t increases) starting above horizontal line and finishing on horizontal axis. The sketch is not continuous. There should be no **solid** vertical lines.
	dB1	Fully correct with 1, 2 and 4 each labelled at appropriate place on horizontal axis (Ignore vertical labelling). e.g.  B0B0 (solid vertical line)  B1B1Condone curvature
(c)	**B1**	For $k\left(8t-3t^2\right)$
	M1	Putting their differential = 0 ignore missing k
	A1	Allow awrt 2.67 only
(d)	**M1**	For $\int_1^t \frac{1}{3}\mathrm{d}x$ with attempt to integrate. Must have correct limits. Or for integration with +C and use of F(1) = 0
	M1	For $\mathrm{F}(2)+\int_2^t \frac{1}{22}\left(4x^2-x^3\right)\mathrm{d}x$ and attempt to integrate or $\int \frac{1}{22}\left(4t^2-t^3\right)\mathrm{d}t=\frac{4t^3}{66}-\frac{t^4}{88}+C$ and using F(4) =1 or F(2) = $\frac{1}{3}$ – must attempt to integrate, have + C
	A1	For 2nd line of cdf oe (allow < instead of ≤ and vice versa ditto > and ≥) (allow any letter to be used for this A1 mark)
	A1	For 3rd line of cdf oe (allow < instead of ≤ and vice versa ditto > and ≥) (allow any letter to be used for this A1 mark)
	A1	All correct and in terms of t including F(t). Allow the otherwise to be for any of the parts but there must be only one. (allow < instead of ≤ and vice versa ditto > and ≥)
(e)	**M1**	Attempting to find 1 – F(3) with attempt to use 3rd line of their F(t) or $\int_3^4 k(4t^2-t^3)\mathrm{d}t$
	A1	$\frac{67}{264}$ oe or awrt 0.254

Question Number	Scheme	Marks
5(a)	$X \sim \text{Po}(4)$	M1
	$P(X = 0) = 0.0183$ $P(X \geq 8) = 0.0511$	
	$P(X \leq 1) = 0.0916$ $P(X \geq 9) = 0.0214$	
	CR $X = 0$ oe $X \geq 9$ oe	A1A1
		(3)
(b)	3.97%	B1
		(1)
(c)	6 is not in the critical region – the data collected are consistent with Chris's claim	B1ft
		(1)
(d)	$\lambda = \frac{2n}{9}$	B1
	$1 - P(Y = 0) > 0.9$	M1
	$1 - e^{-\frac{2n}{9}} > 0.9$	
	$e^{-\frac{2n}{9}} < 0.1$	
	$n = 10$ and $e^{-\frac{2n}{9}} = 0.1083...$ or $-\frac{2n}{9} < \ln 0.1$	dM1
	$n = 11$ $e^{-\frac{2n}{9}} = 0.08677...$	
	Therefore $n = 11$	A1 cao
		(4)
(e)	$H_0 : \lambda = 10$ $H_1 : \lambda < 10$	B1
	$[W \sim \text{Po}(10)$ $P(W \leq 5) =] 0.0671$ or CR $W \leq 4$	B1
	Do not reject H_0 or insignificant or 5 does not lie in the critical region	M1
	There is no significant evidence that the **mean** number/**rate** of **whales** has decreased.	A1cso
		(4)
		Total 13

Notes

(a)	**M1**	Writing or using Po(4) (may be implied by one correct CR)
	A1	**Either tail** $X = 0$ (allow $X \leq 0$) **or** $[18 \geq] X \geq 9$ (allow $X > 8$) Allow any letters in place of X
	A1	**Both tails** $X = 0$ oe , $[18 \geq] X \geq 9$ oe Allow any letters in place of X
		SC: $P(X = 0)$ and $P(X \geq 9)$ as final answer to score M1A1A0.
(b)	**B1**	awrt 3.97% or awrt 0.0397
(c)	**B1ft**	Supports this claim **and** correct reason. Allow a correct f.t. statement and reason based on their CR
(d)	**B1**	writing or using $\frac{2n}{9}$
	M1	May be implied by $P(Y = 0) < 0.1$ (Allow = in place of <)
	dM1	Dep on previous M mark for solving $e^{-\lambda} < 0.1$. This may be implied by n = awrt 10.4
		Allow for a trial of any n value or $"-\frac{2n}{9}" < \ln 0.1$ (condone $\frac{2n}{9} = 2.5$) (Allow = in place of <)
	A1	11 cao (Do not allow $n \geq 11$)
(e)	**B1**	Both hypotheses with λ or μ (Allow $H_0 : \lambda = 2$ $H_1 : \lambda < 2$)
	B1	awrt 0.0671 or $W \leq 4$
	M1	Correct statement – ft their probability or CR Do not allow contradicting non-contextual comments
	A1cso	Fully correct solution with conclusion in context must have mean/rate with whales.
		NB award M1A1 for a correct contextual statement on its own provided previous marks scored

Question Number	Scheme		Marks
6(a)	$\mathrm{E}(X^2)=\int_{-1}^{1}\frac{1}{8}\left(x^4+2x^3+x^2\right)\mathrm{d}x+\int_{1}^{\frac{11}{3}}\frac{1}{4}x^2\mathrm{d}x$		M1
	$=\left[\frac{1}{8}\left(\frac{x^5}{5}+\frac{2x^4}{4}+\frac{x^3}{3}\right)\right]_{-1}^{1}+\left[\frac{x^3}{12}\right]_{1}^{\frac{11}{3}}$		A1
	$=\frac{1684}{405}$		
	$\mathrm{Var}(X)=\text{"}\frac{1684}{405}\text{"}-\left(\frac{31}{18}\right)^2$		dM1
	$=\frac{1931}{1620}$ or 1.1919…	awrt **1.19**	A1
			(4)
(b)	$\mathrm{P}\left(X<-\frac{1}{2}\right)=\int_{-1}^{-0.5}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ **or** $1-\int_{-0.5}^{0.5}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ (gets M2)		M1
	$\mathrm{P}\left(X>\frac{1}{2}\right)=\frac{2}{3}+\int_{0.5}^{1}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$		M1
	$\mathrm{P}\left(X<-\frac{1}{2}\right)=\left[\frac{x^3}{24}+\frac{x^2}{8}+\frac{x}{8}\right]_{-1}^{-0.5}$ **or** $\mathrm{P}\left(X>\frac{1}{2}\right)=\frac{2}{3}+\left[\frac{x^3}{24}+\frac{x^2}{8}+\frac{x}{8}\right]_{0.5}^{1}$ **or** $1-\left[\frac{x^3}{24}+\frac{x^2}{8}+\frac{x}{8}\right]_{-0.5}^{0.5}$		A1
	$=\frac{83}{96}$ or 0.8645…	awrt **0.865**	A1
			(4)
			Total 8

Notes

In parts (a) and (b) a correct answer does NOT imply all marks.

(a)

M1 For attempt at $\int x^2\mathrm{f}(x)\mathrm{d}x$ for both parts of f(x) added **and** attempt to integrate $x^n \to x^{n+1}$

A1 Correct algebraic integration (ignore limits). This mark cannot be implied.

dM1 dep on previous M1 for "an expression for their E(X^2)" – [E(X)]^2
Values must be substituted here

A1 awrt 1.19

(b)

	Main scheme method	Alternative method using F(x)
M1	$\int_{-1}^{-0.5}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ oe	$\int_{-1}^{x}\frac{1}{8}\left(t^2+2t+1\right)\mathrm{d}t$ or $\int\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ with + C
M1	$\frac{2}{3}+\int_{0.5}^{1}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ oe	Use of F(–0.5) + (1 – F(0.5)) oe
NB	$1-\int_{-0.5}^{0.5}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ gets M2	**Note:** $\mathrm{F}(-0.5)=\frac{1}{192}$ and $\mathrm{F}(0.5)=\frac{9}{64}$
A1	One correct integration (may be implied by $\frac{1}{192}$, $\frac{9}{64}$ or $\frac{55}{64}$)	$\mathrm{F}(x)=\frac{1}{8}\left(\frac{x^3}{3}+x^2+x+\frac{1}{3}\right)$ (from $-1<x<1$)
A1	$\frac{83}{96}$ or awrt 0.865 must come from correct working and dependent on all previous marks.	