Question Number	Scheme	Marks
6(a)	$\log_{10} S = 4.5 - 0.006 \times 2 \Rightarrow S = 10^{4.5-0.006\times 2} = 30800\,\text{km}^2$	M1A1
		(2)
(b)	$\log_{10} S = 4.5 - 0.006t \Rightarrow S = 10^{4.5-0.006t}$ (or $p = 10^{4.5}$ or $q = 10^{-0.006}$)	M1
	$S = 10^{4.5-0.006t} = 10^{4.5} \times \left(10^{-0.006}\right)^t$ (or $p = 10^{4.5}$ and $q = 10^{-0.006}$)	dM1
	$S = 31600 \times (0.986)^t$	A1
		(3)
(c)	E.g. The proportion of area covered by coral reefs retained from year to year.	B1
		(1)
		(6 marks)

Notes

(a)

M1 Substitutes in $t = 2$ and proceeds to find **a value** for *S* via $10^{\cdots}$ May be implied by a correct value for their equation. Note awrt 24000 may arise from a slip with 0.006×2 = 0.12, and is acceptable for M1.

A1: awrt $30800\,\text{km}^2$ including units, from correct work and isw as long as units are included with a correct value. But e.g. 30760 followed by 307 km^2 is A0.

(b)

M1: Writes $S = 10^{4.5-0.006t}$ or award for either $(p =)10^{4.5}$ or $(q =)10^{-0.006}$ even if from an incorrect step. Essentially for knowing they need to raise to base 10. May arise from attempts at solving simultaneous equations using the answer to (a) (allowing for rounding errors).

dM1: Writes $S = 10^{4.5} \times \left(10^{-0.006}\right)^t$ or award for both $p = 10^{4.5}$ and $q = 10^{-0.006}$ (oe forms e.g accept $\left(\frac{1}{10^{0,006}}\right)$ or $\left(\frac{1}{1.01}\right)$ for *q*) Must be fully correct method to this point but allow if all that is wrong is rounding errors from other methods such solving simultaneous equations (e.g. 0.990^t).

A1cso: $S = 31600 \times (0.986)^t$ Must be awrt 3 s.f. values. Must be an equation including the *S*, not just *p* and *q* values, but accept if seen in (c).

(c)

B1: E.g. accept the following or variations of them

- The proportion of area covered by coral reefs retained from year to year.
- The seafloor covered by coral reduces by 1.4% each year.
- The proportional change/decrease in sea floor area covered by coral reefs per year

Do not accept "rate of change" or "decrease in area of reefs per year" or "*q* is the gradient" as the answer as it is an incorrect interpretation. The proportional change should be conveyed.

There must be reference to, or equivalents of, the following:

- sea floor area or sea floor or area or seabed
- coral reefs or coral or reef,
- each year or year to year or per year
- (*q* or its value is) a percentage/proportional decrease/remaining

Some acceptable answers:

- After 1 year the area will reduce to *S* last year times *q*. It shows the speed that coral reefs seafloor reduce.
- The percentage of remaining area of sea floor covered by coral reefs to the area of that covered last year.
- *q* represents the proportion of decreasing of the area of sea floor covered by coral reefs every year.

Some unacceptable answers:

- When there is extra *t*, the *S* will increase one more unit of 0.986
- *q* means the percentage of the part of sea floor covered by coral reefs after *t* years.
- *q* is the amount of coral reefs die/shrink in accordance to time.
- The area of the sea floor is decreasing at almost 0.986 times before.
- For every increase in the value of *t*, the total area of coral reefs will decrease in a rate of 0.986^t

Question Number	Scheme	Marks
7(a)	$\mathrm{f}(0)=(0-3)^2=9$	M1
	$0 \leqslant \mathrm{f}(x) \leqslant 9$	A1
		(2)
(b)	$\mathrm{f}'(x)=-2x\mathrm{e}^{-x^2}(2x^2-3)^2+\mathrm{e}^{-x^2}\times 8x(2x^2-3)$	M1A1
	$=2x(2x^2-3)\mathrm{e}^{-x^2}\left(-(2x^2-3)+4\right)=2x\mathrm{e}^{-x^2}(2x^2-3)\left(7-2x^2\right)$	dM1A1
		(4)
(c)	$x^2=\frac{3}{2},\frac{7}{2}\Rightarrow \mathrm{f}\left(\sqrt{\frac{7}{2}}\right)=\mathrm{e}^{-\frac{7}{2}}\left(2\times\frac{7}{2}-3\right)^2=16\mathrm{e}^{-\frac{7}{2}}$	M1A1
	$16\mathrm{e}^{-\frac{7}{2}}<k<9$	dM1A1
		(4)
		(10 marks)

Notes

(a) Work for part (a) must be seen in part (a) not recovered in part (c).

M1: Substitutes $x=0$ and proceeds to find a value for *y*. Implied by sight of 9.

A1: $0 \leqslant \mathrm{f}(x) \leqslant 9$ Accept with *y* or just f, but not with *x*. Accept interval, [0, 9], or set notation.

(b)

M1: Attempts the product rule and chain rule achieving $\pm Px\mathrm{e}^{-x^2}(2x^2\pm 3)^2+\mathrm{e}^{-x^2}\times Qx(2x^2\pm 3)$ with *P*, *Q* > 0. Alternatively, attempts the quotient rule on $\frac{(2x^2-3)^2}{\mathrm{e}^{x^2}}$ achieving $\frac{Px(2x^2\pm 3)\mathrm{e}^{x^2}-Qx\mathrm{e}^{x^2}(2x^2\pm 3)^2}{\left(\mathrm{e}^{x^2}\right)^2}$ *P*, *Q* > 0

A1: $-2x\mathrm{e}^{-x^2}(2x^2-3)^2+\mathrm{e}^{-x^2}\times 8x(2x^2-3)$ oe (need not be simplified)

dM1: Must have scored previous M. Attempts to takes out a factor of $2x\mathrm{e}^{-x^2}(2x^2-3)$ to obtain a factor $\left(\pm C\pm Dx^2\right)$ which may be unsimplified. Allow if e.g. the *x* or e^{-x^2} is dropped when taking out the factor.

A1: Achieves $2x\mathrm{e}^{-x^2}(2x^2-3)(7-2x^2)$ with no errors seen.

(c) **Note : allow all the marks in (c) from answers which were a constant multiple out in (b) or missing the factor *x*, which lead to the correct answers here.**

M1: Attempts to find a *y* value (which may be zero) for at least one of the valid non-zero roots for f'(*x*)=0. Allow for an attempt at either $\mathrm{f}\left(\pm\sqrt{\frac{3}{2}}\right)$ or $\mathrm{f}\left(\pm\sqrt{\frac{A}{B}}\right)$ leading to a value, where *A* and *B* are their values from (b) with *AB* > 0. Note e.g. $\mathrm{f}\left(\frac{A}{B}\right)$ attempted is M0.

A1: For obtaining $16\mathrm{e}^{-\frac{7}{2}}$ Accept awrt 0.483 for this mark following the award of M.

dM1: Attempts the inside region, allowing $\leqslant$, using their *y* intercept from (a) and their **positive** *y* value, less than their intercept, from an attempt at the at the *y* value of the maxima. Allow a positive *y* value from an attempt at any non-zero root of f'(*x*) as such an attempt. It is dependent on the previous method mark.

A1: $16\mathrm{e}^{-\frac{7}{2}}<k<9$ or in any equivalent form e.g. interval notation $k\in\left(\frac{16}{\mathrm{e}^{7/2}},9\right)$ Allow *y* instead of *k*

Ignore references to "*k* = 0"