Question Number	Scheme	Marks
5(i)	$\int x^2 e^x \, dx = x^2 e^x - \int 2x e^x \, dx \left(+c\right)$	M1A1
	$\int x e^x \, dx = x e^x - \int e^x \, dx \left(+c\right)$	M1
	$\int x^2 e^x \, dx = x^2 e^x - 2x e^x + 2e^x \left(+c\right)$ Also allow $\int x^2 e^x \, dx = x^2 e^x - \left(2x e^x - 2e^x\right)\left(+c\right)$	A1
		(4)
(ii)	$u = \left(1-3x\right)^{\frac{1}{2}} \Rightarrow u^2 = 1-3x \Rightarrow 2u\frac{du}{dx} = -3$ or $u = \left(1-3x\right)^{\frac{1}{2}} \Rightarrow \frac{du}{dx} = -\frac{3}{2}\left(1-3x\right)^{-\frac{1}{2}}$	B1
	$\int \frac{27x}{\sqrt{1-3x}} dx = 27\int \frac{\frac{1-u^2}{3}}{u}\left(-\frac{2u}{3}\right) du$ or $\int \frac{27x}{\sqrt{1-3x}} dx = 27\int \frac{\frac{1-u^2}{3}}{\sqrt{1-3x}}\left(-\frac{2}{3}\sqrt{1-3x}\right) du$	M1
	$6\int \left(u^2-1\right) du$ or $-6\int \left(1-u^2\right) du$	A1
	$6\left(\frac{u^3}{3}-u\right)\left(+k\right)$	A1ft
	$6\left(\frac{\left(1-3x\right)^{\frac{3}{2}}}{3}-\left(1-3x\right)^{\frac{1}{2}}\right)\left(+k\right) = 2\left(1-3x\right)^{\frac{1}{2}}\left(1-3x-3\right)\left(+k\right)$	M1
	$= -2\left(1-3x\right)^{\frac{1}{2}}\left(2+3x\right)\left(+k\right)$ or $= -2\left(1-3x\right)^{\frac{1}{2}}\left(3x+2\right)\left(+k\right)$	A1
		(6)
		Total 10

(i) Condone missing dx's here

M1: For applying parts to obtain $x^2 e^x - k\int x e^x \, dx \left(+c\right)$ where $k > 0$

A1: Correct expression. No requirement for + c

M1: Applies parts again to $\int x e^x \, dx$ and obtains $\int x e^x \, dx = x e^x - \alpha \int e^x \, dx \left(+c\right)$ where $\alpha > 0$

Note that if the whole expression is written out then this mark is implied by

$\int x^2 e^x \, dx = x^2 e^x - \alpha x e^x \pm \int \beta e^x \, dx$ or $\int x^2 e^x \, dx = x^2 e^x - \alpha x e^x \pm \beta e^x$ where $\alpha > 0$

A1: Correct answer (+ *c* not required)

Watch for $\int x^2 e^x \, dx = x^2 e^x - \left(2x e^x - 2e^x\right)(+c)$ which scores all 4 marks. ISW after sight of this

Watch for D & I method which may be seen. You will just see the answer here.

D		**I**
x^2	+	e^x
$2x$	−	e^x
2	+	e^x
0		e^x

$= x^2 e^x - 2x e^x + 2e^x$

Score M2 for $x^2 e^x \pm 2x e^x \pm 2e^x$

and then A2 for $x^2 e^x - 2x e^x + 2e^x (+c)$

(ii)

B1: Any correct expression involving $\frac{du}{dx}$ which may be "split" E.g. $du = -\frac{3}{2}(1-3x)^{-\frac{1}{2}} dx$

M1: Substitutes $x = f(u^2)$ to fully change the integrand from $\frac{27x}{\sqrt{1-3x}} dx$ to $k\frac{f(u^2)}{u} u \, du$ o.e.

Note that the *u*'s may have been cancelled.
Condone the d*u* not being present but it cannot appear as d*x*

A1: Correct simplified integral. Look for the *u*'s being cancelled and some simplification/collection of the constant terms

Look for, for example. integrals such as $6\int (u^2 - 1) du$, $\int 6u^2 - 6 \, du$, $-6\int (1-u^2) du$ or even

$-\frac{2}{3}\int (9 - 9u^2) du$ The brackets may be implied by subsequent work

Condone the d*u* not being present as long as it is implied by subsequent integration

A1ft: Correct follow through integration on their simplified integral.

It is dependent upon having achieved an integral of the form above

E.g. $\alpha\int (u^2 - 1) du$ or $\beta\int (1-u^2) du$ $\alpha, \beta > 0$. No requirement for + *k*

M1: Achieves an integral of $Pu^3 + Qu$ and

- "correctly" takes out a common factor of u or $(1-3x)^{\frac{1}{2}}$ for their $Pu^3 + Qu$ or $\alpha(1-3x)^{\frac{3}{2}} + \beta(1-3x)^{\frac{1}{2}}$ AND proceeds to the form $(1-3x)^{\frac{1}{2}}(\delta(1-3x) + \varepsilon)$ or better. Condone slips on coefficients
- substitutes $u = (1-3x)^{\frac{1}{2}}$

A1: CAO. No requirement for + *k*

Question Number	Scheme	Marks
6(a)	$\frac{\mathrm{d}\theta}{\mathrm{d}t} = -k(\theta - 15)^2 \Rightarrow \int \frac{\mathrm{d}\theta}{(\theta-15)^2} = \int -k\,\mathrm{d}t$	B1
	$\int \frac{\mathrm{d}\theta}{(\theta-15)^2} = -(\theta-15)^{-1}$	M1
	$-\frac{1}{\theta-15} = -kt + c$	A1
	$t = 0, \theta = 85 \Rightarrow -\frac{1}{70} = c$	M1
	$t = 10, \theta = 40 \Rightarrow \frac{1}{25} = 10k + \frac{1}{70} \Rightarrow k = ...\left(\frac{9}{3500}\right)$	M1
	$\frac{1}{\theta-15} = \frac{9t}{3500} + \frac{1}{70} \Rightarrow \theta = ...$	M1
	$\theta = \frac{135t + 4250}{9t + 50}$	A1
		(7)
(b)	$20 = \frac{135t + 4250}{9t + 50} \Rightarrow t = ...$	M1
	$t =$ awrt 72	A1
		(2)
		Total 9

(a) **Note that candidates cannot work backwards from the answer using differentiation**

B1: Correct separation of variables.
The integral signs do not have to be present, but the $\mathrm{d}\theta$ and $\mathrm{d}t$ do, and be in the correct positions

M1: Integrates $\int \frac{1}{(\theta-15)^2}\,\mathrm{d}\theta$ to $\frac{\alpha}{\theta-15}$

A1: Correct equation including a *k* and another **different** constant.

M1: Uses $t = 0, \theta = 85$ to find "*c*". May be awarded after incorrect integration. May be also awarded if the constant *k* had been assigned a value using given values of θ and t.
Their initial equation may have been (incorrectly) adapted but it must be solvable with $t = 0, \theta = 85$ used leading to c =...

M1: Uses t = 10 and θ = 40 with their value of "c" to find k.
May be awarded after incorrect integration but there must have been two constants. Their initial equation may have been adapted but it must be solvable with t = 10, θ = 40 AND their c =...

M1: Rearranges using correct algebra to obtain θ in terms of *t*.
For this to be awarded the integral must be in the correct form and both constants found using a correct method . Condone slips in working but the overall process should be sound.
Look for $\frac{1}{\theta-15} = \alpha t + \beta \Rightarrow \theta = \frac{ct + d}{et + f}$

A1: Correct expression. Allow integer multiples of the given answer E.g. $\theta = \frac{297500 + 9450t}{3500 + 630t}$