

13	(i)	(a)	$\frac{dN}{dt} = \frac{k}{N}$	B1	3.3	State correct differential equation	Or $\frac{dN}{dt} = \frac{1}{k'N}$ or equiv with k on LHS
				[1]			
		(b)	$kt = \int NdN$ $kt = \frac{1}{2}N^2 + c$	M1*	2.1	Attempt integration	Obtain equation of form $at = bN^2 + c$ Condone no $+ c$
			$0 = 80000 + c \Rightarrow c = -80000$	M1d*	3.4	Attempt c from (0, 400)	Substitute (0, 400) into their equation containing c and k Could give value for c , or could result in an equation involving both c and k depending on structure
			$k = 96800 - 80000 = 16800$	M1d*	3.4	Attempt k from (1, 440)	Substitute (1, 440) into their equation containing c (possibly now numerical) and k If c is numerical then value of k must be attempted If this gives second equation in c and k then the equations need to be solved simultaneously for c and k to award M1
			$N = \sqrt{(33600t + 160000)}$	A1	1.1	Correct equation for N	N must be the subject of the equation

Question			Answer	Marks	AO	Guidance
				[4]		
	(ii)		$\int 3988N^{-2}dN = \int e^{-0.2t} dt$	M1	3.1a	Separate variables and attempt integration Must be valid method to separate variables so allow coefficient slips only Some attempt to integrate, but may not be correct BOD if no integral signs, as long as integration is actually attempted
			$-3988N^{-1} = -5e^{-0.2t} + c$ OR	M1*	1.1a	Integrate to obtain answer of correct form Obtain integral of the form $aN^{-1} = be^{-0.2t} + c$ or equiv
			$-N^{-1} = -\frac{5}{3988}e^{-0.2t} + c$	A1	1.1	Obtain correct integral Condone no + c Any equivalent form
			$-9.97 = -5 + c \Rightarrow c = -4.97$ OR $-\frac{1}{400} = -\frac{5}{3988} + c \Rightarrow c = -\frac{497}{398800}$	M1d*	2.2a	Attempt c from (0, 400) or (1, 440) As far as attempting numerical value for c NB (0, 400) gives -4.97 , (1, 440) gives an answer which rounds to -4.97 Equation may no longer be correct
			$\frac{3988}{N} = 5e^{-0.2t} + 4.97$ OR $\frac{1}{N} = \frac{5}{3988}e^{-0.2t} + \frac{497}{398800}$	M1d*	1.1	Attempt to make N the subject Using correct algebraic processes throughout, but allow sign slips – this includes any rearrangement attempt made prior to attempting c Must involve a c , either numerical or still as c
			$N = \frac{3988}{5e^{-0.2t} + 4.97}$	A1	1.1	Correct equation for N Any correct equation of form $N = \dots$
				[6]		

Question		Answer	Marks	AO	Guidance	
	(iii)	Model in (i) predicts that population will continue to increase	E1	3.5a	Comment about continuing to increase	Allow comments such as tending to infinity Any additional comments must also be correct so E0 for eg 'will always increase at a steady rate' but E1 for 'will always increase but the rate of increase will decrease'
		Model in (ii) predicts that population will tend towards a limit of 802	E1	3.5a	Comment about tending towards a limit of 802	Allow a limit of 803 or 802.4 Must come from a fully correct function Any additional comments must also be correct
			[2]			