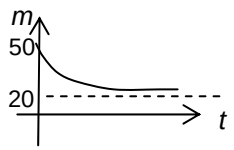
1 $e^{2x} - 5e^x = 0$ $\Rightarrow$ $e^x (e^x - 5) = 0$ $\Rightarrow$ $e^x = 5$ $\Rightarrow$ $x = \ln 5$ or 1.6094	M1 M1 A1 A1 [4]	factoring out e^x or dividing $e^{2x} = 5e^x$ by e^x $e^{2x} / e^x = e^x$ ln 5 or 1.61 or better, mark final answer –1 for additional solutions, e.g. $x = 0$
or $\ln(e^{2x}) = \ln(5e^x)$ $\Rightarrow$ $2x = \ln 5 + x$ $\Rightarrow$ $x = \ln 5$ or 1.6094	M1 A1 A1 A1 [4]	taking lns on $e^{2x} = 5e^x$ $2x$, $\ln 5 + x$ ln 5 or 1.61 or better, mark final answer –1 for additional solutions, e.g. $x = 0$

2 (i) When $t = 0$, $T = 100$ $\Rightarrow$ $100 = 20 + b$ $\Rightarrow$ $b = 80$ When $t = 5$, $T = 60$ $\Rightarrow$ $60 = 20 + 80\, e^{-5k}$ $\Rightarrow$ $e^{-5k} = ½$ $\Rightarrow$ $k = \ln 2 / 5 = 0.139$	M1 A1 M1 A1 [4]	substituting $t = 0$, $T = 100$ cao substituting $t = 5$, $T = 60$ 1/5 ln 2 or 0.14 or better
(ii) $50 = 20 + 80\, e^{-kt}$ $\Rightarrow$ $e^{-kt} = 3/8$ $\Rightarrow$ $t = \ln(8/3) / k = 7.075$ mins	M1 A1 [2]	Re-arranging and taking lns correctly – ft their b and k answers in range 7 to 7.1

3 $p = 100/x = 100\,x^{-1}$ $\Rightarrow$ $dp/dx = -100x^{-2} = -100/x^2$ $dp/dt = dp/dx \times dx/dt$ $dx/dt = 10$ When $x = 50$, $dp/dx = (-100/50^2)$ $\Rightarrow dp/dt = 10 \times -0.04 = -0.4$	M1 A1 M1 B1 M1dep A1cao [6]	attempt to differentiate $-100x^{-2}$ o.e. o.e. soi soi substituting $x = 50$ into their dp/dx dep 2nd M1 o.e. e.g. decreasing at 0.4	condone poor notation if chain rule correct *or* $x = 50 + 10\,t$ B1 $\Rightarrow P = 100/x = 100/(50 + 10\,t)$ $\Rightarrow dP/dt = -100(50 + 10\,t)^{-2} \times 10 = -1000/(50 + 10t)^{-2}$ M1 A1 When $t = 0$, $dP/dt = -1000/50^2 = -0.4$ A1

4(i) $100 = Ae^0 = A \Rightarrow A = 100$	M1A1	
$50 = 100\,e^{-1500k}$	M1	$50 = A\,e^{-1500k}$ ft their 'A' if used
$\Rightarrow$ $e^{-1500k} = 0.5$ $\Rightarrow$ $-1500k = \ln 0.5$ $\Rightarrow$ $k = -\ln 0.5 / 1500 = 4.62 \times 10^{-4}$	M1 A1 [5]	taking lns correctly 0.00046 or better
(ii) $1 = 100e^{-kt}$	M1	ft their A and k
$\Rightarrow$ $-kt = \ln 0.01$ $\Rightarrow$ $t = -\ln 0.01 / k$ $= 9966$ years	M1 A1 [3]	taking lns correctly art 9970

5 (i) When $n = 1$, $10\,000 = A\,e^{b}$ when $n = 2$, $16\,000 = A\,e^{2b}$ $\Rightarrow \quad \frac{16000}{10000} = \frac{Ae^{2b}}{Ae^{b}} = e^{b}$ $\Rightarrow \quad e^{b} = 1.6$ $\Rightarrow \quad b = \ln 1.6 = 0.470$ $A = 10000/1.6 = 6250.$	B1 B1 M1 E1 B1 B1 [6]	soi soi eliminating A (do not allow verification) SCB2 if initial 'B's are missing, and ratio of years = 1.6 $= e^{b}$ ln 1.6 or 0.47 or better (mark final answer) cao – allow recovery from inexact b's
(ii) When $n = 20$, $P = 6250 \times e^{0.470 \times 20}$ $= £75{,}550{,}000$	M1 A1 [2]	substituting $n = 20$ into their equation with their A and b Allow answers from £75 000 000 to £76 000 000.

6(i) Initial mass = $20 + 30\,e^{0} = 50$ grams Long term mass = 20 grams	M1A1 B1 [3]	
(ii) $30 = 20 + 30\,e^{-0.1t}$ $\Rightarrow \quad e^{-0.1t} = 1/3$ $\Rightarrow \quad -0.1t = \ln(1/3) = -1.0986\ldots$ $\Rightarrow \quad t = 11.0$ mins	M1 M1 A1 [3]	 anti-logging correctly 11, 11.0, 10.99, 10.986 (not more than 3 d.p)
(**iii**) 	B1 B1 [2]	correct shape through (0, 50) – ignore negative values of t $\rightarrow 20$ as $t \rightarrow \infty$

7 (i) When $t = 0$, $V = 10\,000$ $\Rightarrow$ $10\,000 = Ae^0 = A$ When $t = 3$, $V = 6000$ $\Rightarrow$ $6000 = 10\,000\,e^{-3k}$ $\Rightarrow$ $-3k = \ln(0.6) = -0.5108\ldots$ $\Rightarrow$ $k = 0.17(02\ldots)$	M1 A1 M1 M1 A1 [5]	$10\,000 = Ae^0$ $A = 10\,000$ taking lns (correctly) on their exponential equation - not logs unless to base 10 art 0.17 or $-(\ln 0.6)/3$ oe
(ii) $2000 = 10\,000e^{-kt}$ $\Rightarrow$ $-kt = \ln 0.2$ $\Rightarrow$ $t = -\ln 0.2 / k = 9.45$ (years)	 M1 A1 [2]	 taking lns on correct equation (consistent with their k) allow art 9.5, but not 9.