

Question		Answer	Marks	AO	Guidance	
11	(i)	When $t = 0, M = 300$	B1	2.2a	Identify that the initial mass is 300g	Could be implied by eg $e^{-0.05t} = 0.5$
		$300e^{-0.05t} = 150$ $e^{-0.05t} = 0.5$ $-0.05t = \ln 0.5$	M1	3.1a	Equate to 150 and attempt to solve	Correct order of operations as far as attempting $t$ If using logs on $300e^{-0.05t} = 150$ then the LHS must be dealt with correctly
		$t = 13.9$ (minutes)	A1	1.1	Obtain 13.86, or better	Allow 14 minutes www Or 13 minutes and 52 seconds
			[3]			
	(ii)	$M_2 = 400e^{kt}$	B1	2.2a	State or imply $400e^{kt}$	Could be implied by stating general form of $Ae^{kt}$ with $A = 400$ Any unknowns permitted
		$320 = 400e^{10k}$ $k = 0.1 \ln 0.8$	M1	1.1a	Attempt to find $k$	Substitute $M = 320, t = 10$ and attempt $k$ Must be using valid method
		$M_2 = 400e^{-0.02223t}$	A1	1.1	Obtain correct expression for mass of second substance	Allow exact or decimal $k$ (2sf or better) Must be seen or used as a complete term, not just implied by stated values of $A$ and $k$
		Substance 1: $\frac{dM_1}{dt} = -15e^{-0.05t}$ Substance 2: $\frac{dM_2}{dt} = -8.93e^{-0.0223t}$	M1	3.1a	Attempt differentiation at least once	To obtain $ae^{-0.05t}$ or $be^{-0.0223t}$ , where $a$ and $b$ are non-zero constants not 300 and 400 respectively
			A1ft	1.1	Both derivatives correct	Following their equation for substance 2

Question			Answer	Marks	AO	Guidance
			$-15e^{-0.05t} = -8.93e^{-0.0223t}$ $e^{0.0277t} = 1.681$	<b>M1</b>	<b>3.1a</b>	Equate derivatives and rearrange as far as $e^{f(t)} = c$  Equation must be of the form $ae^{-0.05t} = be^{-0.0223t}$ Combining like terms to result in a two term equation – not necessarily on opposite sides If logs are introduced earlier then allow M1 only if the products are correctly split so eg $\ln(15) \times (-0.05t)$ is M0 M0 if attempting to take a log of a term that is negative
			$0.0277t = 0.519$	<b>M1</b>	<b>1.1</b>	Attempt to solve equation of form $e^{f(t)} = c$  As far as attempting $t$ Or equiv if logs have been taken earlier
			time = 18.75 minutes	<b>A1</b>	<b>3.2a</b>	Obtain correct value for $t$ Allow 18.7, 18.8 or 19 mins  Units required Could be 18 minutes and 45 seconds Must have been working with 3sf or better throughout
				<b>[8]</b>		
<b>12</b>			<b>DR</b>			
			$\frac{dy}{dx} = \frac{(-8 \sin 2x)(3 - \sin 2x) - (4 \cos 2x)(-2 \cos 2x)}{(3 - \sin 2x)^2}$	<b>M1</b>	<b>3.1a</b>	Attempt use of quotient rule  Correct structure, including subtraction in numerator Could be equivalent using the product rule
				<b>A1</b>	<b>1.1</b>	Obtain correct derivative  Award A1 once correct derivative seen even subsequently spoiled by simplification attempt