

Question			Answer	Marks	AO	Guidance
7	(a)		$(k =) 1.5$	B1 [1]	3.3	Allow embedded in equation e.g. $P_{t+1} = \frac{3}{2}P_t$
7	(b)		162	B1 [1]	3.4	cao
7	(c)	(i)	$48e^{0.4} = 71.6 (\approx 72)$ $48e^{0.8} = 106.8 (\approx 107)$ Comment comparing <i>their</i> values with the data e.g. - Reasonably close - Not exactly right	M1 A1 [2]	3.4 3.5a	- Both values – might not round answers - Allow $106.8 \approx 108$ - Condone incorrect values if $48e^{0.4}$ and $48e^{0.8}$ seen - Must have correct values - e.g. 71.6 is close to 72 and 106.8 is close to 108 - Ignore attempts to compare the two models - Condone e.g. ‘close for $t = 1$’ and ‘not close for $t = 2$’
7	(c)	(ii)	$\frac{dQ}{dt} = 19.2e^{0.4t}$ $\frac{dQ}{dt} = 0.4Q$ so the rate of change is proportional to the population	M1 A1 [2]	1.1 2.2a	- Differentiation – might not simplify e.g. $\frac{dQ}{dt} = 19.2e^{0.4t}$ or $\frac{dQ}{dt} = \frac{96}{5}e^{0.4t}$ - Implied by $\frac{dQ}{dt} = ke^{0.4t}$ - Condone poor/no notation - Showing the rate of change is proportional to population e.g. $\frac{dQ}{dt} = 0.4 \times 48e^{0.4t}$ and $Q = 48e^{0.4t}$ so or $\frac{\frac{dQ}{dt}}{48e^{0.4t}} = 0.4$ 0.4 must be exact and not rounded e.g. from numerical trials - Must see $\frac{dQ}{dt}$ or e.g. Q'

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7	(c)	(iii)	Method to find multiplier for Q At time $t + 1$, $Q = 48e^{0.4(t+1)}$ $= 48e^{0.4t} \times e^{0.4}$ $e^{0.4}$ or 1.49 ... (is multiplier for Q) Multiplier for sequence P is 1.5. Both sequences are equal at $t = 0$ or 1 So $\times 1.49$ each month will give smaller answers than $\times 1.5$	M1	3.1b	- Use of exponential equation one month later – may award for correct use of equation for Q to find populations for at least 2 consecutive months (for $t = 2$ onwards) For info: $t = 2, Q = 106.8$; $t = 3, Q = 159.4$; $t = 4, Q = 237.7$ to 3 s.f. or better - This M1 may be implied by finding multiplier of $e^{0.4}$
				B1	1.1	- Finding multiplier for Q - If ‘multiplier’ omitted, then multiplication must be implied by later work
				A1	2.4	Completion with convincing general explanation including consideration of an early value (could be $P > Q$ at $t = 1$ or both sequences start at 48 or at $t = 2$ the values are 107 for Q and 108 for P)
			Alternative 1 for A1 Model P is $48(1.5)^t$ oe $1.49 \dots < 1.5$ So, $48(1.49 \dots)^t < 48(1.5)^t$	A1		Convincing completion, must see ‘48’ or both equal populations at $t = 0$ (or $t = 1$) - oe e.g. showing $\frac{1.5^t}{e^{0.4t}} > 1$ and starting values of 48 soi or writing model for P as $48e^{(\ln 1.5)t} = 48 e^{0.405 \dots t}$
			Alternative 2 for A1 Model P is $48(1.5)^t$ $\frac{dP}{dt} = 48 \times \ln(1.5) \times 1.5^t = \ln(1.5) \times P$ Rate of population growth for P is greater than rate of population growth for Q as $\ln 1.5 > 0.4$ and both equal populations at $t = 0$ (or $t = 1$)	A1		- Differentiates may use $\ln 1.5$ or $0.405 \dots$ Convincing completion

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			Alternative method using inequalities Model for P is 48×1.5^t $(48)e^{0.4t} < (48 \times)1.5^t$ oe $0.4t < \ln 1.5^t$ $0.4t < t \ln 1.5$ True for $t > 1$ since $\ln 1.5 = 0.405... > 0.4$	B1 M1 A1		- B1 for finding correct model for P - Forming inequality for P and Q Convincing completion
				[3]		