Question			Answer	Marks	AO	Guidance
5	(a)		(The rate of change with respect to time is $\frac{\mathrm{d}P}{\mathrm{d}t}$), which is $-\frac{1}{80}P^2$ because the population is in **decline**.	**B1** **[1]**	**3.3**	Must see use of **decrease/decline** linked to the negative sign. Condone answers that do not refer to $\frac{\mathrm{d}P}{\mathrm{d}t}$ Examples: • "it's $-\frac{1}{80}P^2$ because decreasing" B1 • "decreasing" [and nothing further] B0 • "decline implies negative sign" B1

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5	(b)		$\frac{dP}{P^2} = -\frac{dt}{80}$ oe	M1*	3.4	Attempt to separate variables, must see P and dP on the same side May see $\frac{dt}{dP} = \frac{-80}{P^2}$ as a first step. In this case M1 is implied by a subsequent attempt to integrate the RHS w.r.t. P (so do not give M1 for this statement alone).
			$-\frac{1}{P} = -\frac{t}{80}(+c)$ oe	A1	1.1	May see $\frac{1}{P} = \frac{t}{80}(+c)$ etc. Allow without $+c$
			$c = -\frac{1}{120}$ oe $\left(\frac{1}{P} = \frac{3t+2}{240}\right)$	M1 dep*	2.1	Substitute (0, 120) and attempt to find c (which may not be this value). Must reach a value of c for this mark.
			$P = \frac{240}{3t+2}$ oe	A1 [4]	1.1	Must be in terms of P (P=…) but need not be simplified. isw incorrect attempts to simplify following P=…
5	(c)		$10 = \frac{240}{3t+2}$ or $t = \frac{80}{P} - \frac{2}{3}$	M1	3.4	Either substitute P = 10 into their equation from (b) or rearrange to make t the subject.
			$t = 7\frac{1}{3}$ (years) oe	A1 [2]	1.1	Accept 7.33 (3sf), ignore units.
5	(d)		‘for large t, P is small’ or $t \geq 160 \Rightarrow P < 1$ (P is modelled as continuous but in fact the number of animals is discrete), at this time the **actual population** would be 0.	B1 [1]	3.5a	Allow $t = 160 \Rightarrow P = 0.5$ (Use of the value t=160 not required) Any correct statement in context relating to the model predicting non-integer values between 0 and 1. (Note that the statement ‘will never reach zero’ is given in the question so gains no credit). Acceptable examples (for a comment, in combination with the statement that P is small for large t): • “cannot have part of an animal” • “the actual population has reached 0” • “not possible to have a population of 0.49(8)” • “the population will go extinct when less than 1”