Question Number	Scheme	Marks
7(a)	$\frac{1}{2}mU^2-\frac{1}{2}mv^2=\frac{2mgx^2}{2l}$	M1 A1A1
	$v^2=U^2-\frac{2gx^2}{l}$ *	A1* (4)
7(b)	$2v\frac{\mathrm{d}v}{\mathrm{d}x}=-\frac{4gx}{l}$	M1A1
	$\ddot{x}=-\frac{2g}{l}x$, SHM ($\omega=\sqrt{\frac{2g}{l}}$)	A1
	Period = $\frac{2\pi}{\omega}=\pi\sqrt{\frac{2l}{g}}$ *	DM1A1* (5)
7(c)	$\sqrt{\frac{gl}{2}}=a\sqrt{\frac{2g}{l}}$ **OR** $0=\frac{gl}{2}-\frac{2ga^2}{l}$	M1
	$a=\frac{1}{2}l$	A1
	time from $x=a$ to $x=\frac{1}{4}l$, t given by: $\frac{1}{4}l=\frac{1}{2}l\cos\sqrt{\frac{2g}{l}}t$	M1
	$t=\frac{\pi}{3}\sqrt{\frac{l}{2g}}$	A1
	Time = $\frac{1}{4}$period + time from $x=a$ to $x=\frac{1}{4}l$	M1
	$=\frac{5\pi}{6}\sqrt{\frac{l}{2g}}$	A1 (6)
		(15)
	Notes for question 7	
7(a)		
M1	Use conservation of energy equation with 2KE terms and 1EPE term. Note there are rearrangements. Dimensionally correct, terms of the correct structure, condone sign errors. EPE of the form $\frac{1}{2}k\,x^2$	
A1	For an unsimplified equation with at most one error	
A1	For a correct unsimplified equation	
A1*	Given answer obtained from complete and correct working. Must include a line of working before reaching the given answer.	
7(b)	Note: In (b) it is possible to score M1A1A0 DM1A1*	
M1	For differentiating wrt x. Powers of v and x to reduce by 1 and $\frac{dv}{dx}$ seen. M0 for an approach that does not involve differentiating with respect to x eg N2L	
A1	A correct differentiated equation	
A1	Correct SHM equation. Must use $\ddot{x}$ for acceleration **and** conclude SHM.	
DM1	Dependent on previous M. Correct use of period = $\frac{2\pi}{\omega}$	

Question Number	Scheme	Marks
A1*	Given answer correctly obtained. Must include a line of working between $\ddot{x} = -\omega^2 x$ and the given answer. Eg period = $\frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{2g}{l}}} = \pi\sqrt{\frac{2l}{g}}$ Or $\omega = \sqrt{\frac{2g}{l}}$, period = $2\pi\sqrt{\frac{l}{2g}} = \pi\sqrt{\frac{2l}{g}}$	
7(c)		
M1	For use of $U = a\omega$ OR energy equation with $v = 0$ and $x = a$ to find the amplitude.	
A1	For correct amplitude, $\frac{l}{2}$	
M1	For a complete method to find the partial time with their calculated a and their ω • Use of $x = a\cos(\omega t)$ where $\frac{1}{4}l = \frac{1}{2}l\cos\sqrt{\frac{2g}{l}}t$ to give a partial time. • Use of $x = a\sin(\omega t)$ where $\frac{1}{4}l = \frac{1}{2}l\sin\sqrt{\frac{2g}{l}}t$ to give a partial time.	
A1	For a correct partial time • Use of $x = a\cos(\omega t) \Rightarrow t = \frac{1}{\omega}\frac{\pi}{3}$ • Use of $x = a\sin(\omega t) \Rightarrow t = \frac{1}{\omega}\frac{\pi}{6}$ or $\frac{1}{\omega}\frac{5\pi}{6}$	
M1	For a complete method to find the total time • Using $x = a\cos(\omega t)$ Total time = $\frac{1}{4}$period + time from $x = a$ to $x = \frac{1}{4}l$ $= \frac{1}{4}\pi\sqrt{\frac{2l}{g}} + \frac{\pi}{3}\sqrt{\frac{l}{2g}}$ • Using $x = a\sin(\omega t)$ with $\frac{1}{\omega}\frac{5\pi}{6}$ Total time = $\frac{1}{\omega}\frac{5\pi}{6}$ • Using $x = a\sin(\omega t)$ with $\frac{1}{\omega}\frac{\pi}{6}$ Total time = $\frac{1}{2}$period $-$ time from $x = 0$ to $x = \frac{1}{4}l$ Total time = $\frac{1}{2}\pi\sqrt{\frac{2l}{g}} - \frac{\pi}{6}\sqrt{\frac{l}{2g}}$	
A1	Correct answer of $\frac{5\pi}{6}\sqrt{\frac{l}{2g}} = \frac{5\pi}{3}\sqrt{\frac{l}{8g}} = \pi\sqrt{\frac{25l}{72g}}$ o.e	

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