Simple Harmonic Motion - Mark Scheme

Q1.

Question Number	Answer	Mark
	The only correct answer is D *A is not correct, as the inverse ratio has been calculated.* *B is not correct as the inverse ratio has been calculated but the amplitude ratio hasn't been squared.* *C is not correct, as the amplitude ratio hasn't been squared*	(1)

Q2.

Question Number	Answer	Mark
	The only correct answer is **D** A is not correct because the energy is proportional to the amplitude squared B is not correct because the energy is proportional to the amplitude squared C is not correct because the energy is proportional to the amplitude squared	**1**

Q3.

Question Number	Answer	Mark
	C	**1**

Q4.

Question Number	Answer	Mark
(a)	Use of $T = 2\pi\sqrt{\frac{m}{k}}$ and $f = \frac{1}{T}$ **(1)** Correct use of factor 4 in spring constant or mass **(1)** f = 3.3 Hz (accept unit s^{-1}) **(1)** Example of calculation: $k = 4 \times 450\ Nm^{-1} = 18\ 00\ Nm^{-1}$ $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{4.3\,kg}{1800\,N\,m^{-1}}} = 0.307\,s$ $f = \frac{1}{T} = \frac{1}{0.307\,s} = 3.26\,Hz$	**3**
(b)	**Either** Acceleration is: • (directly) proportional to displacement from equilibrium position **(1)** • (always) acting towards the equilibrium position **Or** idea that acceleration is in the opposite direction to displacement **(1)** **Or** (Resultant) force is: • (directly) proportional to displacement from equilibrium position **(1)** • (always) acting towards the equilibrium position **Or** idea that force is a restoring force e.g. "in the opposite direction" **(1)** [accept towards undisplaced point/fixed point/central point for equilibrium position] [An equation with symbols defined correctly is a valid response for both marks. e.g $a \propto -x$ or $F \propto -x$] **And** (The box undergoes simple harmonic motion because) the springs obey Hooke's law **(1)**	**3**
	Total for Question	**6**

Q5.

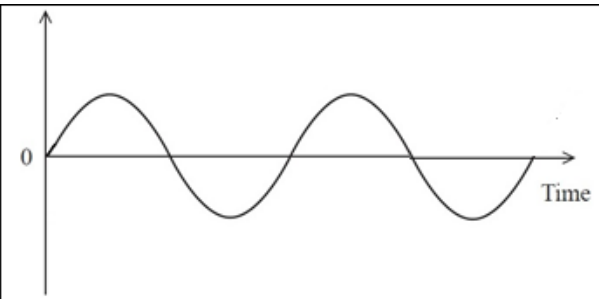
Question Number	Answer		Mark
(a)	**EITHER** Acceleration is: (directly) proportional to displacement from the equilibrium position	(1)	
	(always) acting towards the equilibrium position **Or** idea that acceleration is in the opposite direction to displacement	(1)	
	OR Force is: (directly) proportional to displacement from the equilibrium position	(1)	
	(always) acting towards the equilibrium position **Or** idea that force is a restoring force e.g. "in the opposite direction"	(1)	
	[Accept undisplaced point, fixed point, central point, centre for equilibrium position] [An equation with all symbols defined correctly is a valid response for both marks. e.g $a \propto -x$ or $F \propto -x$]		**2**
(b)(i)	Mean time period calculated [see 19.07 (s) or working]	(1)	
	Use of $f = \frac{1}{T}$	(1)	
	$f = 2.62$ (Hz)	(1)	**3**
	Example of calculation $T = \frac{(18.9+19.2+19.1)\text{s}}{3\times 50} = 0.381\text{s}$ $f = \frac{1}{0.381\text{s}} = 2.62\ \text{Hz}$		
(b)(ii)	Use of $\omega = 2\pi f$	(1)	
	Use of $v = \omega A$	(1)	
	$v = 6.2\times10^{-2}\ \text{m s}^{-1}$ (ecf candidate's value of f from (i))	(1)	**3**
	Example of calculation $\omega = 2\pi\,\text{rad}\times 2.62\,\text{s}^{-1} = 16.5\,\text{rad s}^{-1}$ $v = 16.5\,\text{rad s}^{-1}\times 0.375\times10^{-2}\,\text{m} = 6.17\times10^{-2}\,\text{m s}^{-1}$ [Use of 'show that' value gives $6.13\times10^{-2}\ \text{m s}^{-1}$] [Using $A = 0.75$ cm could score MP1 and MP2]		
	Total for question		**8**

Q6.

Question Number	Answer	Mark
	D is correct because $T \propto \frac{1}{f}$	**1**

Q7.

Question Number	Answer		Mark
(a)	The acceleration of an object is proportional to the displacement from the equilibrium position	(1)	2
	and (always) directed towards the equilibrium position **Or** (always) in the opposite direction to displacement	(1)	
	[Accept answers given in terms of force] [Answers using defined equations acceptable (as long as symbols are identified).] [Accept equilibrium point, centre point, undisplaced position instead of equilibrium position; do not accept mean position]		
(b)(i)	Time multiple (complete) oscillations [Accept measure nT, accept a number ≥ 3]	(1)	3
	Repeat timing and calculate a mean time period	(1)	
	Use a (fiducial) marker to indicate the centre/timing position **Or** Time the oscillations from centre (position)	(1)	
	[Accept equilibrium or undisplaced instead of centre]		
(b)(ii)	Use of $\omega = \frac{2\pi}{T}$	(1)	3
	Use of $v_{max} = \omega A$	(1)	
	$v_{max} = 0.22\ \text{m s}^{-1}$	(1)	
	Example of calculation: $\omega = \frac{2\pi}{T} = \frac{2\pi}{0.57\ \text{s}} = 11.0\ \text{rad s}^{-1}$ $v_{max} = \omega A = 11.0\ \text{s}^{-1} \times 2.0 \times 10^{-2}\ \text{m} = 0.22\ \text{m s}^{-1}$		

(b)(iii)	 Sinusoidal graph with $a = 0$ at $t = 0$ of any constant amplitude (1) Acceleration graph leading velocity graph by one quarter of a cycle [$\pi/2$ rad] and with same period as velocity graph (1)	2
(b)(iv)	The oscillation is damped (1) Viscous/resistive/frictional forces dissipate energy **Or** Viscous/resistive/frictional forces cause energy to be transferred to the water (1)	2
		12

Q8.

	Answer	Mark
	D	1

Q9.

	Answer	Mark
	B	1

Q10.

Question Number	Answer	Mark
	The only correct answer is C ***A*** *is not correct because the maximum velocity is given by* ωA ***B*** *is not correct because the maximum velocity is given by* ωA ***D*** *is not correct because the maximum velocity is given by* ωA	(1)

Q11.

Question Number	Answer	Amplification	Mark
	C	The only correct answer is **C** A is not correct because $a = \omega^2 r$ has been used incorrectly B is not correct because $a = \omega^2 r$ has been used incorrectly D is not correct because $a = \omega^2 r$ has been used incorrectly	**1**