A2 UNIT 3 – Oscillations and Nuclei

MARK SCHEME

GENERAL INSTRUCTIONS

The mark scheme should be applied precisely and no departure made from it.

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response questions).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statement.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*	(i)		N = number of molecules **and** m = mass of molecule	1			1		
		(ii)		Use of $\rho = \frac{Nm}{V}$ or equivalent clearly distinguishable (1) Statement that Nm is mass of gas or that ρ is density (1)	2			2	1	
		(iii)		$\sqrt{c^2}$ should be α $\sqrt{\frac{1}{\rho}}$ **or** equivalent e.g. ρc^2 calculated **or** $p = \frac{1}{3}\rho\overline{c^2}$ = 53 000 [Pa] (1) Quoting of data points e.g. (1,400) and (4,200) (1) When ρ is 4×, $\sqrt{c^2}$ is halved **or** ρc^2 constant **or** ρ = constant (1)			3	3	2	
	(b)	(i)		Substitution of $\overline{c^2} = \frac{3\text{x}3.0\text{x}10^5}{0.5}$ (1) c_{rms} = 1.34 × 10^3 [m s^{-1}] (1)	1	1		2	2	
		(ii)		**Either:** Use of $n = \frac{0.025}{4\text{x}10^{-3}} = 6.25$ (1) N = 6.25 × 6.02 × 10^{23} = 3.76 × 10^{24} (1) Mass of molecule = $\frac{0.025}{3.76\text{x}10^{24}}$ = 6.6 × 10^{-27} [kg] (1) Mean KE per molecule = ½ × 6.6 × 10^{-27} × (1.34 × 10^3)^2 = 5.9 × 10^{-21} [J] (1) **Or:** Use of $pV = nRT$ (1) $T = \frac{3\text{x}10^5\text{x}0.05\text{x}4\text{x}10^{-3}}{0.025\text{x}8.3}$ (1) = 289 [K] (1) Mean KE per molecule = $\frac{3}{2}$ × 1.38 × 10^{-23} × 289 = 5.9 × 10^{-21} [J] (1)	1	1 1 1		4	4	
				Question 1 total	**5**	**4**	**3**	**12**	**9**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*			Attempt to use: Electrical energy supplied = power × time (e.g. 2 × 7) (1) 50.4 [MJ] (1) Use of $\Delta U = mc\Delta T$. Tolerate mistakes such as ΔT = 320, 573 (1) ΔU = 40.3 [MJ] (1) Statement or clear implication that 10.1 [MJ] **(ecf)** has escaped from the bricks as heat (1) Clear conclusion that statement is true **(ecf)** available, but if electrical energy < ΔU a comment on its impossibility is needed (1)			6	6	2	
	(b)	(i)		Calculation of one pV **or** T (1) Calculation of second pV **or** T (1) Correct value of T obtained 289 [± 5K] (1) Calculation of third pV **or** T (1) Correct conclusion regarding agreement of values (their data) (1)		1 1 1 1	1	5	4	
		(ii)		Work done = area (1) Method clear (e.g. rectangle + triangle, counting squares) (1) W between 135 [J] and 225 [J] if correct from method used (1) W in range 166 ± 20 [J], **or** if outside, comment on whether likely to be too high or too low (1)	1	1 1 1		4	2	
		(iii)		ΔU = increase (accept *change*) in internal energy **and** Q = heat *in* **and** W = work *out* (**or** work done by system)	1			1		
		(iv)		ΔU = 0 [since gas is ideal and ΔT = 0] (1) Q = answer to *(b)*(ii) so in range 166 ± 20 [J] (1)		2		2		
				Question 2 total	**2**	**9**	**7**	**18**	**8**	**0**

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
3	*(a)*			Use of $\omega = 2\pi f$ tolerate mistakes over units but not attempts to incorporate 0.45 m or omission of 2π (1) 251 [rad s^{-1}] (1)	1	1		2	2	
	(b)	(i)		Use of $mr\omega^2$ **or** $\frac{mv^2}{r}$ with $v = \omega r$ (1) 2 270 [N] **(ecf)** from *(a)* (1)	1	1		2	2	
		(ii)		For the sock, mg = 0.8 [N] (1) Comment that mg << [resultant] force or equivalent (1)			2	2		
	(c)	(i)		Towards cylinder axis (accept circle centre)	1			1		
		(ii)		Straight line towards top of page	1			1		
				Question 3 total	**4**	**2**	**2**	**8**	**4**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*	(i)		0.3 [s]		1		1		
		(ii)		0.9 [s]		1		1		
	(b)	(i)		0.045 [m]	1			1		
		(ii)		T = 0.80 s **or** by implication (1) ω = 7.85 [rad s^{-1}] tolerate error due to misreading of T (1)		2		2	1	
		(iii)		0 **or** zero		1		1		
	(c)	(i)		Reasonable attempt at sinusoid with period of 0.8 s (1) Inverted displacement-time graph (1)	2			2	2	
		(ii)		Acceleration = $\omega^2 A$ at lowest point (1) So a = (7.85)^2 × 0.045 (1) a = 2.77 [m s^{-2}] (1) **(ecf)** on A and ω $a < g$ so therefore it will not separate (1) **(ecf)**			4	4	2	
				Question 4 total	**3**	**5**	**4**	**12**	**5**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*			System [capable of oscillation] subjected to ['driving'] force (1) Maximum amplitude of oscillation [accept maximum response] at one frequency [of driving force] (1)	2			2		
	(b)			Natural frequency = 2.0 [Hz] (1) Substitution into $T = 2\pi\sqrt{\frac{m}{k}}$ (1) $k = 4\pi^2 m f^2$ **or** $k = \frac{4\pi^2 m}{T^2}$ **or** equivalent re-arrangement of equation at any stage (1) k = 15.8 N m^{-1} **unit mark** (1)	1 1	1 1		4	3	
	(c)			Peak lower and at same frequency or lower (1) Low frequency amplitude unaffected, high frequency amplitude lower or unaltered, so curve blunter (1)	2			2		
				Question 5 total	**6**	**2**	**0**	**8**	**3**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*	(i)		Mass number = 206 (1) Atomic number = 82 (1)		2		2		
		(ii)		**Any 3 × (1) from:** • More data on radon dosage • More data on types of cancer • Safe dosage known • Measurable life of lab rate • Killing animals to get data • Encourages animal terrorism	3			3		
	(b)			Use of $\lambda = \frac{\ln 2}{T_{\frac{1}{2}}}$ e.g. λ = 0.182 day^{-1} (2.11 × 10^{-6} s^{-1}) or $t = nT_{\frac{1}{2}}$ (1) Logs taken correctly e.g. $\ln A = \ln A_0 - \lambda t$ **or** $\ln A = \ln A_0 - n\ln 2$ (1) Algebra correct e.g. $t = \frac{1}{\lambda}\ln\frac{A_0}{A}$ **or** $n = \frac{1}{\ln 2}\ln\frac{A_0}{A}$ **or** implied (1) Correct answer 13.2 days **unit mark** (1.14 × 10^{6} s) (1)	1	1 1 1		4	4	
	(c)			Product nuclei give added activity		1		1		
	(d)			Current = rate of flow of charge **or** equivalent (1) 250 × 1.15 × 10^{6} × 1.6 × 10^{-19} = 4.6 × 10^{-11} [A] (1) Assumption – all charges contribute to the current **or** all ions are single charges (1)	1	1 1		3	1	
	(e)			Subtraction of masses (221.9773 – 4.0015 = 217.9758) (1) Conversion of 5.59 MeV to mass (i.e. 0.0060 u **o**r 9.9671 × 10^{-31} kg) (1) Answer = 217.9698 [u] (**or** 3.618299 × 10^{-25} kg depends on u) (1)	1	1 1		3	2	
				Question 6 total	**6**	**10**	**0**	**16**	**7**	**0**

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
7	*(a)*			Alpha present because significant drop after paper (1) Beta not present because no **additional** drop after Al (1) Gamma present because significant **after** Al **or** Pb (1) Absorbers **explained** e.g. paper stops alpha, beta stopped by ~1 mm of Al, 15 cm of Pb for gamma (1)	1		1 1 1	4		4
	(b)			As a check/ensure fair test **or** equivalent (1) In case source activity changing/distance changed/apparatus disturbed etc (1)			2	2		2
				Question 7 total	**1**	**0**	**5**	**6**	**0**	**6**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*			**Factor explanations** F0 – Energy required α mass or $E = mc\Delta T$. F1 – Heat in α surface area. F2 – Increasing thickness – heat must travel further or smaller temperature gradient. **Time** T0 – Energy α time or energy = power × time (of oven). T1 – Time α mass. T2 – Time α 1/area. T3 - Time increases as thickness increases. **5-6 marks** All of F0 – F2 are present. At least 3 from T0 – T3 are present. There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. **3-4 marks** Expect 2 from F0 – F2. Expect 2 from T0 – T3. There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. **1-2 marks** 1 from F0 – F2 is present. 1 from T0 – T3 is present. There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure. **0 marks** No attempt made or no response worthy of credit.		6		6		

	(b)			Per unit mass is missing	1			1		
	(c)			22 × 1·26 = 27·7 [cm]		1		1		
	(d)			$\frac{0.46}{1.59} = 0.29\,[\text{m}^2]$		1		1		
	(e)	(i)		$E = mc\Delta T$ used e.g. = 9 × 3 200 × 90 (1) Answer = 9 × 3 200 × 90 = 2·59 [MJ] (1)	1 1			2	2	
		(ii)		$P = \frac{E}{t}$ [or by implication] (1) $t = \frac{2\,590\,000}{2200} = 1200\,\text{s}$ (1)	1 1			2	2	
		(iii)		Some detailed account of the 'lost' energy (1) e.g. All the oven and air also need rise in temperature Heat escapes from the oven to the kitchen/room/surroundings Energy goes to change of state of fat/water Clear statement that most of the energy is lost (1)			1 1	2		
		(iv)		Electrical energy used: 2 200 × 6.4 × 60^2 (1) [=50 688 000 J] Efficiency = 2 590 000 / 50 688 000 **(ecf)** = 0.051 **or** 5.1% (1)		1 1		2	2	
		(v)		Less than (1) Thermal energy required is only ½ that of 9.0 kg turkey (1) But cooking time >½ that required (1)			1 1 1	3		
				Question 8 total	**3**	**12**	**5**	**20**	**6**	**0**

A2 UNIT 3: Oscillations and Nuclei - SUMMARY OF ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	5	4	3	12	9	0
2	2	9	7	18	8	0
3	4	2	2	8	4	0
4	3	5	4	12	5	0
5	6	2	0	8	3	0
6	6	10	0	16	7	0
7	1	0	5	6	0	6
8	3	12	5	20	6	0
TOTAL	**30**	**44**	**26**	**100**	**42**	**6**