Rewarding Learning

ADVANCED
General Certificate of Education
2023

Physics

Assessment Unit A2 1

assessing

Deformation of Solids, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

[APH11]

THURSDAY 25 MAY, MORNING

MARK SCHEME

Physics Subject Specific Instructions

It is essential that, before using the mark scheme, markers familiarise themselves with the following guidance.

General

To ensure that all candidates receive the same treatment, the mark scheme must be applied consistently.

The mark scheme for each question shows typical intermediate steps, the answer expected and the marks available for each part of the question.

In cases where a candidate has responded with a seemingly correct response which has not been anticipated in the mark scheme, the marker must make a professional judgement of the correct physics/validity of the response when awarding marks.

Brackets (...) are used to indicate information which is not essential for the mark to be awarded. Alternative answers are indicated by 'or', or the symbol for or, '/'.

Multiple/Cancelled Responses

If a candidate provides multiple responses, the general principle to be followed is that 'right + wrong = wrong'.

Responses considered to be neutral are not penalised. For example, if additional irrelevant information is given in an explanation that does not contradict the correct information given, the mark(s) can be awarded.

In a numerical problem if two different solutions are presented without a definitive answer on the answer line, credit should not be given. If an answer is given on the answer line, then the solution that has led to the answer given should be marked according to the mark scheme.

If a candidate clearly cancels their working by scoring it out, then this should not be marked. It is not the role of the marker to select from the candidate's response what should or should not be marked.

Marking Numerical Problems

In numerical problems, the marks for the intermediate steps shown in the mark scheme are for the benefit of candidates who do not obtain the final correct answer.

A correct answer, if obtained from a valid starting point, gets full credit, even if all the intermediate steps are not shown.

This “correct answer” rule does not apply in situations where candidates have been asked to ‘show your working’ or ‘show that’. These answers must be valid in all stages to obtain full credit.

The answer to a ‘show that’ question should be quoted to one more significant figure than that given in the question.

Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation.

The normal penalty for an arithmetical error is to lose the mark(s) for the answer/unit line. An arithmetic error should be penalised for one mark only. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value of a quantity given in a question.

10^n errors count as arithmetical slips and incur a penalty of one mark.

If a candidate rounds a value incorrectly this should be penalised one mark. However, care must be taken not to penalise a candidate for rounding correctly in parts leading up to their final answer in an unstructured numerical problem.

Answers should be given in decimal form. Fractional answers will not be credited with the answer mark.

Error Carried Forward

An ECF can occur between parts of a question or, in more unstructured numerical problems, within a part.

When an incorrect answer is carried forward from one question to the next, full credit should be awarded in the part where the incorrect answer is used, provided all the working is correct.

Within a part, ECF is applied where a candidate does an incorrect calculation, for example calculates a value for R incorrectly using V/I and then goes on to use their calculated value for R to calculate a resistivity value. The penalty is applied in the V/I calculation but then the value of R can be carried forward so that the remainder of the marks are available to the candidate provided all the remainder of their working is correct.

The ECF within a part will only apply in numerical problems where more than one calculation is required in a part.

Significant Figures

Candidates should show an awareness of using a sensible number of significant figures in their answers, based on the values given in the question. In SPH11, SPH21, APH11 and APH21, unless specifically asked for in the question, candidates will not be penalised for incorrect significant figures.

In SPH31, SPH32, APH31 and APH32, all answers should be given to a suitable number of significant figures and penalties will be applied in these papers unless otherwise stated in the mark schemes.

Units

In the majority of questions, the unit will be stated on the answer line.

When the unit is omitted, candidates will be clearly asked to state an appropriate unit and this will be credited in the mark scheme.

Where there is a final calculation required to get from the unit of the answer calculated to the unit on the answer line the required unit will be stated in the question. For example, if wavelength was calculated and the answer line was in nm a statement ‘Give your answer in nanometres’ would be included.

The unit on the answer line will generally be the SI unit but may in some cases be a more appropriate unit. For example, if values of mass in g and momentum in g cm s^{-1} were given, the unit on the answer line for speed could reasonably be cm s^{-1} without prompt.

1 (a)

Symbol	Quantity
r_0	Radius of a nucleon/proton/neutron
A	Number of nucleons/mass number/nucleon number

[1]
[1] [2]

(b) $V = \frac{4}{3}\pi r^3$

$7.46 \times 10^{-43} = \frac{4}{3}\pi A \times (1.2 \times 10^{-15})^3$ [1]

A = 103 [1]

Number of neutrons = 103 – 45 = 58 ECF from A [1] [3]

AVAILABLE MARKS: 5

2 (a)

$^{236}_{92}U = {}^{144}_{\boxed{56}}Ba + {}^{90}_{36}Kr + \boxed{2}{}^{1}_{0}n + {}^{\boxed{0}}_{\boxed{0}}\gamma$

[1] [1] [1] [4]

(b) (i) The neutrons (produced in a reaction) need to be slowed before they can be absorbed by (another U-235)/produce other fissions/continue a chain reaction [1] [1] [2]

(ii) Smallest amount of fuel [1]
For a/capable of sustaining a chain reaction [1] [2]

(iii) Capture of (excess) neutrons/absorb neutrons [1]
Using control rods [1] [2]

(c) No carbon dioxide produced during fission reactions [1]
Burning coal, carbon dioxide is produced [1]
Both produce CO_2 in mining/transport/construction [1] [3]

(d) (i) 0.7% of 1 kg = 7 g or 0.007 kg [1]
number of moles of U-235 = 7/235 [1]
No. of atoms = 1.8×10^{22} [1] [3]

alternative methods

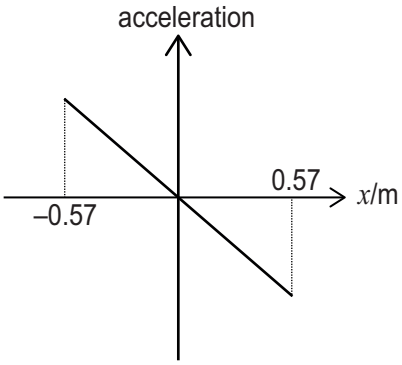
Mass of 1 atom = 235 x 1.66 x 10^ -27 = 3.9 x 10^-25 kg [1]
1/3.9 x 10^-25 = 2.56 x 10^24 atoms [1]
0.7% = 1.79 x 10^22 [1]

or

0.007 kg [1]
Number of nucleons = 7 x 10^-3/1.66 x 10^-27 [1]
4.22 x 10^24/235 = 1.79 x 10^-22 [1]

(ii) 200×10^6 [1]
$1.8 \times 10^{22} \times 200 \times 10^6 = 3.6 \times 10^{30}$ eV ecf [1]
$3.6 \times 10^{30} \times 1.6 \times 10^{-19} = 5.8 \times 10^{11}$ J [1] [3]

AVAILABLE MARKS: 19

						AVAILABLE MARKS
3	**(a)**	**(i)**	Decreasing curve which doesn't cross x-axis	[1]		
			Curve in correct sense	[1]	[2]	
		(ii)	T = 0.38s No ECF for wong T	[1]		
			$f = \frac{1}{T}$	[1]		
			f = 2.64 Hz	[1]	[3]	
		(iii)	Increases to a max at f_0/natural frequency/2.64 Hz	[1]		
			Decreases again after f_0	[1]	[2]	
	(b)	**(i)**	nodes – positions of zero amplitude/no oscillations or vibrations take place (zero displacement at all times)	[1]		
			Antinodes – positions of maximum amplitude/periodic maximum displacement	[1]	[2]	
		(ii)	$8.2 = 3\lambda/4$	[1]		
			λ = 10.9 cm	[1]	[2]	11
4	**(a)**					
			Straight line through the origin	[1]		
			negative gradient	[1]		
			Max and min values on x-axis = –0.57 and +0.57	[1]	[3]	
	(b)		Max acceleration = $\omega^2 A$	[1]		
			Max acceleration = $(\pi/4)^2 \times 0.57$	[1]		
			Max value of acceleration = 0.35 ms^{-2}	[1]	[3]	6

					AVAILABLE MARKS
5	**(a)**	A force towards the centre of a circle	[1]		
	(b)	**(i)** $Rcos20 - Fsin20 = \frac{mv^2}{r}$ [1] [1] [1]			
		$v = 9.79\ ms^{-1}$	[1]	[4]	
		(ii) $v = 2\pi r/T$	[1]		
		$T = 2\pi \times 6.6/9.79 = 4.24\,s$ or $f = 0.236\,Hz$ ECF for v	[1]		
		$0.236 \times 60 = 14.1\,rpm$ ECF for f or T	[1]	[3]	8
6	**(a)**	**(i)** Young modulus is the (ratio) of stress over strain	[1]		
		up to the limit of proportionality	[1]	[2]	
		(ii) Elastic limit is the maximum load/stress (a specimen can experience)	[1]		
		without permanent deformation/becoming plastic/ Will return to original shape/dimensions (when unloaded)	[1]	[2]	
	(b)	**(i)** Polyester	[1]		
		extension inversely proportional to the Young modulus	[1]	[2]	
		(ii) $E = \frac{Fl}{Ax}$	[1], [1]		
		$A = \frac{\pi d^2}{4} = \frac{\pi(1.3 \times 10^{-3})^2}{4} = 1.33 \times 10^{-6}$	[1]		
		Giga conversion	[1]		
		$2.7 \times 10^9 = \frac{50 \times 12}{1.33 \times 10^{-6} x}$ ECF for wrong A calc	[1]		
		$x = 0.167\,m$	[1]	[6]	
		(iii) Strain energy $= \frac{1}{2} \times 50 \times 5.93 \times 10^{-3}$	[1]		
		Strain energy = 0.148 J	[1]	[2]	14

						AVAILABLE MARKS
7	**(a)**	**(i)**	For a fixed mass of gas	[1]		
			Constant volume	[1]		
			The pressure of the gas is proportional to the temperature in kelvin/absolute temperature/thermodynamic temperature	[1]	[3]	
		(ii)	Diagram to show trapped air in a flask	[1]		
			Pressure gauge attached to top of flask	[1]		
			Thermometer in the water bath	[1]		
			Water bath with flask of air inside water bath	[1]	[4]	

(iii) Measure the pressure of the gas
Measure the temperature of the water
Change the water temperature
Record 5 × different readings
Plot pressure vs temperature in kelvin
Graph should be straight line through the origin

Response	Marks
Candidates identify clearly **5 or 6** of the points above. There is widespread and accurate use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are excellent. They use the most appropriate form and style of writing. Relevant material is organised with clarity and coherence.	[5]–[6]
Candidates identify clearly **3 or 4** of the points above. Presentation, spelling, punctuation and grammar are sufficiently competent to make meaning clear. They use appropriate form and style of writing. There is good reference to scientific terminology.	[3]–[4]
Candidates identify clearly **1 or 2** of the points above. There may be some errors in their spelling, punctuation and grammar but form and style are of a satisfactory standard. They have made some reference to specialist terms.	[1]–[2]
Response is not worthy of credit.	[0]

[6]

(b) $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ [1]

temperatures 338 K and 296 K [1]

new $V = \frac{5}{6}V$ [1]

$\frac{P_1V}{338} = \left(\frac{\frac{5}{6}VP_2}{296}\right)$ for correct subs [1]

$P_2 = 1.0509P$ [1]
Percentage change = 5.09 % [1] [6] 19

						AVAILABLE MARKS
8	**(a)**	**(i)**	The internal energy of a real gas is the sum of the kinetic and potential energy (of the atoms in the gas)		[1]	
		(ii)	In an ideal gas there is only KE or there is no PE		[1]	
	(b)	**(i)**	$pV = nRT$	[1]		
			50×10^{-6} conversion of volume to m^3	[1]		
			$15 \times 50 \times 10^{-6} = n \times 8.31 \times 373$ subs ECF for V	[1]		
			$n = 2.42 \times 10^{-7}$	[1]	[4]	
			Alternative answer			
			PV = Nkt	[1]		
			v conversion	[1]		
			15 x 50 x 10^-6 = N x 1.38 x 10^-23 x 373	[1]		
			n = 2.42 x 10^-7	[1]		
		(ii)	$5.30 \times 10^{-26} \times \langle c^2 \rangle = 3 \times 1.38 \times 10^{-23} \times 373$	[1]		
			$\langle c^2 \rangle = 291362$	[1]		
			Root mean square speed = 540 m s^{-1} ECF for mean square speed	[1]	[3]	9
9	**(a)**		Spontaneous – not affected by external factors	[1]		
			Random – the exact nuclei which will decay cannot be predicted	[1]	[2]	
	(b)	**(i)**	A = number of nuclei decaying per second/unit time	[1]		
			λ = fraction of nuclei decaying per second/ probability of a nucleus decaying per second	[1]	[2]	
		(ii)	Intercept = 11.3	[1]		
			Half-life = 14.4 × 24 × 60 × 60 = 1244160	[1]		
			λ = 0.693/1244160 ECF for t	[1]		
			Gradient = 5.57×10^{-7} ECF for wrong t	[1]		
			Gradient s^{-1}, intercept no unit	[1]	[5]	9
					Total	**100**