Mock Exam 2

PHYSICS **9702**

Paper 4 A Level Structured Questions **2 hours**

MARK SCHEME

Maximum Mark: 84

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2022 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

1

(a) energy $= \frac{1}{2}m\omega^2a^2$ and $\omega = 2\pi f$ — C1
$= \frac{1}{2} \times 37 \times 10^{-3} \times (2\pi \times 3.5)^2 \times (2.8 \times 10^{-2})^2$ — M1
$= 7.0 \times 10^{-3}$ J — A0 [2]
(allow $2\pi \times 3.5$ shown as 7π)

Energy $= \frac{1}{2} mv^2$ and $v = r\omega$ — (C1)
Correct substitution — (M1)
Energy $= 7.0 \times 10^{-3}$ J — (A0)

(b) $E_K = E_P$
$\frac{1}{2}m\omega^2 (a^2 - x^2) = \frac{1}{2}m\omega^2x^2$ *or* E_K or $E_P = 3.5$ mJ — C1
$x = a/\sqrt{2} = 2.8/\sqrt{2}$ *or* $E_K = \frac{1}{2}m\omega^2 (a^2 - x^2)$ *or* $E_P = \frac{1}{2}m\omega^2x^2$ — C1
$= 2.0$ cm — A1 [3]
(E_K or $E_P = 7.0$ mJ scores 0/3)

Allow: $k = 17.9$ — (C1)
$E = \frac{1}{2} kx^2$ — (C1)
$x = 2.0$ cm — (A1)

(c) **(i)** graph: horizontal line, *y*-intercept = 7.0 mJ with end-points of line at +2.8 cm and –2.8 cm — B1 [1]

(ii) graph: reasonable curve — B1
with maximum at (0,7.0) end-points of line at (–2.8, 0) and (+2.8, 0) — B1 [2]

(iii) graph: inverted version of **(ii)** — M1
with intersections at (–2.0, 3.5) and (+2.0, 3.5) — A1 [2]
(Allow marks in **(iii)**, but not in **(ii)**, if graphs K & P are not labelled)

(d) gravitational potential energy — B1 [1]

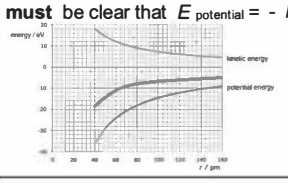
2

Question			Answer	Marks	Guidance
6	(a)		(Gravitational) potential energy is converted to kinetic energy which is then converted to thermal energy/heat Statement that KE to thermal takes place on impact	B1 B1	Not 'GPE to KE and thermal'
	(b)		GPE converted in one inversion = 0.025 x 9.8 x 1.2 (= 0.294) GPE converted in 50 inversions = 0.294 x 50 = 14.7 (J) (Use of Q =mcΔθ to give) 14.7 = 0.025 x c x 4.5 c = 130 (J kg^{-1} K^{-1})	C1 A1 C1 A1	**Allow** follow through from their total GPE converted **Note** answer to 3 sf = 131 (J kg^{-1} K^{-1})
	(c)		• No heat is absorbed by the tube/ lost (by conduction) through the tube/all heat goes to pellets • All the lead falls through the same height or length of tube/ Lead does not bounce on impact	B1 B1	**Ignore** 'heat lost to surroundings/air'
	(d)		Temperature change is the same (Since mass is doubled) (max) GPE/KE/total energy is doubled **AND** Q is doubled	M1 A1	**Allow** mgh = mcΔθ and m is same **or** m cancels **Alternative answer** **Allow** 2 marks for any sensible practical suggestions why T is **not** the same eg double mass means more lead which will **not** fall full length of tube.
			Total	**10**	

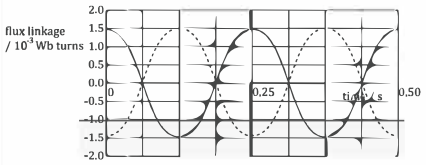
3

Question			Answer	Marks	Guidance
2	a	i	$V = 9.0 \times e^{-3.5/(4700 \times 10\text{^}-6 \times 1400)}$ ✓ = 5.29 V ✓	2	Must give own value.
	a	ii	$\Delta E = ½ C (9.0^2 - 5.3^2) = 0.124$ J ✓ Power = 0.036 W ✓ Current through/ p.d. across component not constant ✓	3	3rd mark independent
	b		p.d. across capacitor when E = 300 J, $V_{300\,J} = \sqrt{(2E/C)} = \sqrt{(2 \times 300\ J/120\ F)} = \sqrt{5}$ V = 2.24 V ✓ p.d. across capacitor when E = 50 J, $V_{50\,J}$ = 0.91 V ✓ time = $-\ln(0.91/2.24) \times 30 \times 10^{-3} \times 120$ = 3.2 s ✓ minimum value because no external load ✓	3	Other routes may be used. Bald correct answer gains all three marks for the calculation.

4

Question			Answer	Marks	Guidance
	(a)	(i)	$E = ke/r^2 = 8.98 \times 10^9 \times 1.6 \times 10^{-19} / [40 \times 10^{-12}]^2$ ✓	L	**Allow** just $E = ke/r^2$ OR correct substitution for method mark
			$= 0.90 \times 10^{12}$ (V m^{-1}) ✓	L	**allow** use of $k = 9 \times 10^9$ leading to 0.9×10^{12} evaluation of show that : **allow** 0.898×10^{12}
	(a)	(ii)	**expect** two valid checks with 2 approx = numerical values ✓✓ OR 0.9 TV m^{-1} @ 40 pm becomes $0.9/2^2 = 0.22$ TV m^{-1} @ 80 pm two values here ✓✓	MM	check: Er^2 = sensibly constant in range [1.4 to 1.5] $\times 10^{-9}$ **Max 1** mark if one value just outside range **Max 1 mark only for general statement :** as r doubles E becomes x ¼ OR for 1 value of Er^2 **Allow** full credit for correct calculation without units
	(a)	(iii)	area represents p.d. OR potential difference OR ΔV ✓ 1 big sq ≡ $0.2 \times 10^{12} \times 20 \times 10^{-12} = 4$ V and about 5 ± ½ big squares ≈ 20 ± 2 V ✓ OR $= \Delta ke/r = 9 \times 10^9 \times 1.6 \times 10^{-19} \times [1/52 \times 10^{-12} - 1/160 \times 10^{-12}]$ ✓ $= [27.7 - 9] = 18.7$ V ✓	H S&C	**not** unit of V **evaluation** by counting squares **allow** units not needed here if area ≡ voltage given already
	(b)	(i)	method: $mv^2/r = ke^2/r^2 \rightarrow ½ mv^2 = ke^2/2r$ ✓	H	**requires** algebraic argument
	(b)	(ii)	$E_{total} = ½ ke^2/r - ke^2/r = -½ ke^2/r$ ✓ graph is mirror image i.e. $-E_{kinetic}$ ✓	M M	**must** be clear that $E_{potential} = -ke^2/r$ 
	(b)	(iii)	otherwise orbits would decay by (radiative emission) / electron would spiral into proton ✓	M	any valid point: **Allow** without quantisation any energy or orbit radius would be allowed and there would be no specific energy levels OR no typical line spectrum
	(b)	(iv)	r = 53 pm ✓ requires 14 eV so 14 V is ionization potential ✓	S&C S&C	evaluation 5.3×10^{-11} m on total energy graph (to remove electron to ∞)
			Total	12	

5

	$N = \frac{\Phi}{AB}$ Or $N = \frac{1.5 \times 10^{-3}}{2.5 \times 10^{-2} \times 5.0 \times 10^{-4}}$ ✓$_1$ N = 120 (turns) ✓$_2$	✓$_1$ N must be the subject of the equation for the mark. ✓$_2$ A correct answer gains both marks. If no mark is awarded a single mark can be given for $\Phi = BAN\cos 30^o$ being used to find N =139.	2
	$\Phi (= NAB\cos\theta = 1.5 \times 10^{-3} \cos 30^o)$ Flux linkage = 1.3×10^{-3} (Wb turns) ✓		1
	$f = \frac{1}{T} = \frac{1}{0.25}$ = 4.0 (Hz) or ω = 25.1 or 8π (rad s^{-1}) ✓$_1$ Peak emf (= $BAN\frac{2\pi}{T} = 1.5 \times 10^{-3} \times \frac{2\pi}{0.25}$) = 0.038 (volt) ✓$_2$ (0.0377 volt)	✓$_1$ Condone using 1 sig fig for f but not ω or T. The mark can be gained from seeing f or ω or T given explicitly or from a substitution in the peak emf equation in the second mark. ✓$_2$ A correct answer gains both marks.	2
	 Either solid or dashed line gains mark ✓	The mark is dependent on the exact crossing of the time axis which has a tolerance of ± 1 small square. The vertical axis figures is not expected. Also ignore errors in height and the exact positions of the peaks. Only a rough sinusoidal shape is expected. A	1

6

Question			Answer	Marks	Guidance
	(a)		recessional speed / velocity of galaxy is proportional to its distance (from us)	B1	**Allow**: recessional speed of galaxy = Hubble constant × distance
	(b)	(i)	v = 1010 (10^3 m s^{-1}) d in the range 4.47 to 4.54 (10^{23} m)	B1 B1	**Note**: Answer to 4 sf is 1014 (10^3 m s^{-1})
		(ii)	(Straight line drawn through the points gradient = Hubble constant, H_0) gradient = 2.24×10^{-18} (s^{-1}) age = $(2.24 \times 10^{-18})^{-1}$ age = 4.46×10^{17} (s) age = 1.4×10^{10} (y)	 C1 C1 A1	 **Allow**: gradient in the range 2.21 to 2.27 $\times 10^{-18}$ **Allow** ecf from incorrect value of the gradient **Allow**: A maximum of 2 marks if values from the table are used instead of the gradient of the line drawn on Fig. 11.2 **Note**: No marks for a bald 14 billion years
	(c)		Big bang: Creation / birth / expansion / evolution of the universe or The universe was very hot / very dense / singularity (at the start) Evidence: Any **one** from: • Microwave / background radiation / 3 K (or 2.7 K) • Existence of (primordial) helium / lithium / lighter elements • Tiny variation (or ripples) in (background) temperature	B1 B1	 **Not**: More matter than antimatter / baryonic asymmetry
			Total	**9**	

7

Question			Answer	Marks	Guidance
	(a)		curves path / slows velocity ✓	L	**allow** accelerates the α / changes direction / changes velocity / slows down
	(b)		(most) has been stored as / converted to electrical potential energy OR $k Q_1 Q_2 / R$ ✓	L	**allow** (small) fraction converted to k.e. of recoiling nucleus (which carries original momentum of alpha at closest approach)
	(c)	(i)	low Z and high k.e. i.e. bottom left of table ✓	M	
	(c)	(ii)	method: $R = k \times 2 \times 13 \times e^2/[7.7.\text{MeV}]$ ✓ OR = $9 \times 10^9 \times 2 \times 13 \times 1.6 \times 10^{-19} / [7.7 \times 10^6]$ evaluation: = 4.9×10^{-15} m ✓	M H	**allow** 5.7×10^{-15} m as 15% alpha k.e. in Al nucleus at closest approach (due to momentum transfer) for 2 marks **allow** 4.85×10^{-15} as a result of using k=8.98 for 2 marks
			Total	**5**	

8

Question			Answer	Marks	Guidance
	(a)	(i)	Δm = [1.008665 - {1.007276+0.000549}] = 0.00084 u ✓ = 0.78(2) (MeV) ✓	L L	find mass defect in u convert to MeV
	(a)	(ii)	"missing" energy / momentum was carried by an (anti)neutrino / a particle of tiny rest mass and zero charge ✓	M	**Allow** Energy (of beta particle) is shared with (anti)neutrino / a particle of tiny rest mass and zero charge
	(a)	(iii)	$A = \lambda N = \ln 2 / t_{1/2} \times 10^4$ ✓ = 10 or 11 (10.7 s^{-1}) ✓	M M	Allow alternative method – e.g. calculate N remaining after 1 s (for 1 mark) and subtract from 10^4 (for second mark) evaluation do **not** penalise non-integer values
	(a)	(iv)	d quark changes → u quark ✓	L	**Allow** udd → uud

9

Question	Answer	Marks	Guidance
(a)	The patient is surrounded by (gamma) detectors or Increased activity is where F-18 accumulates (AW)	B1	**Allow** 'diametrically opposite detectors'
	The positrons (from the F-18) annihilate electrons (inside the patient)	B1	
	Each annihilation produces two gamma photons travelling in opposite directions	B1	**Not** gamma rays / radiation
	The arrival times are used to locate position (of increased activity)	B1	**Allow** 'delay time'
(b)	$\lambda = \ln 2/110$ or 6.3×10^{-3} (min^{-1})	C1	**Allow** 1.05×10^{-4} (s^{-1})
	$0.30 = e^{-6.3\times10^{-3}t}$		This is the same as $0.30 = e^{-1.05\times10^{-4}t}$
	$t = \frac{\ln(0.30)}{-6.3\times10^{-3}}$	C1	**Note**: This mark is for a **ln** expression (any subject)
	t = 190 (minutes)	A1	**Allow** 2 marks for 1.15×10^4 (s) as the final answer

10

(a) obeys the law pV/T = constant or any two named gas laws **M1**
at all values of p, V and T **A1** **[2]**
or two correct assumptions of kinetic theory of ideal gas **(B1)**
third correct assumption **(B1)**

(b) (i) mean square speed **B1** **[1]**

(ii) mean kinetic energy = $\frac{1}{2}m\langle c^2\rangle$ **M1**
$\rho = Nm/V$ and algebra leading to [do not allow if takes $N = 1$] **M1**
$\frac{1}{2}m\langle c^2\rangle = 3/2\ kT$ **A0** **[2]**

(c) (i) $\frac{1}{2} \times 6.6 \times 10^{-27} \times (1.1 \times 10^4)^2 = 3/2 \times 1.38 \times 10^{-23} \times T$ **C1**
$T = 1.9 \times 10^4$ K **A1** **[2]**

(ii) Not all atoms have same speed/kinetic energy **B1** **[1]**

11

Question	Answer	Marks	Guidance
	brighter star could be closer	B1	**Allow** reverse argument if clear
	brighter star could have a greater luminosity in the visible wavelengths	B1	**Allow** reverse argument if clear **Allow** 'emit more power' for 'have a greater luminosity' **Allow** brighter star is hotter
(b)	object with known luminosity	B1	**Allow** 'star' or 'galaxy' for 'object'
(c)(i)	$\frac{660.9-656.3}{656.3} \approx \frac{v}{3.0\times10^8}$ leading to 2.1×10^6 m s^{-1}	B1	
(c)(ii)	$v = H_o d$	C1	
	$d = 2.1 \times 10^6 / 2.3 \times 10^{-18}$		
	= **9.1×10^{23} m**	A1	Correct to at least 2 s.f. (9.13) AFC applies.
(c)(iii)	wavelength has increased / light is redshifted	B1	
	galaxy is moving away (from Earth)	B1	
	universe is expanding	B1	