Mark Scheme (Results)

Summer 2024

Pearson Edexcel A Level 3 GCE

In Physics (9PH0)

Paper 01: Advanced Physics I

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Mark scheme notes

Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

1. Mark scheme format

1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the MS has specified specific words that must be present. Such words will be indicated by underlining e.g. 'resonance'

1.2 Bold lower case will be used for emphasis e.g. '**and'** when two pieces of information are needed for 1 mark.

1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".

1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.

2.2 This does not apply in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.3 The mark will not be awarded for the same missing or incorrect unit only once within one clip in epen.

2.4 Occasionally, it may be decided not to insist on a unit e.g the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.

2.5 The mark scheme will indicate if no unit error is to be applied by means of [no ue].

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not be prevent a mark being awarded if the answer given rounds to the answer in the MS.

3.2 Too few significant figures will mean that the final mark cannot be awarded in 'show that' questions where one more significant figure than the value in the question is needed for the candidate to demonstrate the validity of the given answer.

3.3 The use of one significant figure might be inappropriate in the context of the question e.g. reading a value off a graph. If this is the case, there will be a clear indication in the MS.

3.4 The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will mean that one mark will not be awarded. (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

3.5 In questions assessing practical skills, a specific number of significant figures will be required e.g. determining a constant from the gradient of a graph or in uncertainty calculations. The MS will clearly identify the number of significant figures required.

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks. then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

1. **Graphs**

1.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

1.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

1.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

1.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

  For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Acceptable answers	Additional guidance	Mark
1	**The only correct answer is A** B is not the correct answer, as C is not a base unit. C is not the correct answer, as J and V are not base units. D is not the correct answer, as Q is not a unit.		1
2	**The only correct answer is B** A is not the correct answer, as it is charged so could be accelerated. C is not the correct answer, as it is charged so could be accelerated. D is not the correct answer, as it is charged so could be accelerated.		1
3	**The only correct answer is B** A is not the correct answer, as it equals (power of motor×time) −g.p.e. C is not the correct answer, as it equals (power of motor×time) −g.p.e. D is not the correct answer, as it equals (power of motor×time) −g.p.e.		1
4	**The only correct answer is A** B is not the correct answer, as force on sphere is repulsion. C is not the correct answer, as tension in thread direction is incorrect. D is not the correct answer, as force on sphere is repulsion and tension direction is incorrect.		1
5	**The only correct answer is B** A is not the correct answer, as $2Q/(2d)^2$ simplifies to $F/2$. C is not the correct answer, as $2Q/(2d)^2$ simplifies to $F/2$. D is not the correct answer, as $2Q/(2d)^2$ simplifies to $F/2$.		1
6	**The only correct answer is C** A is not the correct answer, as force is downwards. B is not the correct answer, as there is no force. D is not the correct answer, as there is no force.		1
7	**The only correct answer is C** A is not the correct answer, as I, n and e all constant. B is not the correct answer, as I, n and e all constant. D is not the correct answer, as I, n and e all constant.		1
8	**The only correct answer is A** B is not the correct answer, as angular velocity = $5 \times 2\pi/20$ C is not the correct answer, as angular velocity = $5 \times 2\pi/20$		1

	D is not the correct answer, as angular velocity = $5 \times 2\pi/20$		
9	**The only correct answer is D** A is not the correct answer, as $mg - R = ma$ B is not the correct answer, as $mg - R = ma$ C is not the correct answer, as $mg - R = ma$		**1**
10	**The only correct answer is B** A is not the correct answer, as this is a correct equation of motion in the vertical plane. C is not the correct answer, as this is a correct equation of motion in the vertical plane. D is not the correct answer, as this is a correct equation of motion in the vertical plane. .		**1**

(Total for Multiple Choice Questions = 10 marks)

Question Number	Acceptable answers	Additional guidance	Mark
11(a)	• Moment of a force (around a point) = force × perpendicular distance (to line of action of the force from the point) **Or** Moment of a force (around a point) = distance (to the point) × perpendicular component of force **(1)**	need to see "perpendicular" or equivalent	**1**
11(b)	• Takes one moment around pivot **(1)** • Equates a clockwise and anticlockwise moment **(1)** • Correct distance to gold or people **(1)** • $y = 1.2$ m **(1)** Alternative • Resolves vertical forces • Takes one moment around CoG • Equates a clockwise and anticlockwise moment • $y = 1.2$ m	<u>Example of calculation</u> $32000 \text{ N} \times y + 8700 \text{ N} \times (y + 4.5) = 31000 \text{ N} \times (4.0 - y)$ $71700\, y = 124000 - 39150 = 84850$ $y = 1.18$ m Alternative: $R = 31000 + 32000 + 8700 = 71700$ N Moments about CoG $71700 \text{ N} \times y + 8700 \text{ N} \times 4.5 = 31000 \text{ N} \times 4.0$ $y = 1.18$ m	**4**

(Total for Question 11 = 5 marks)

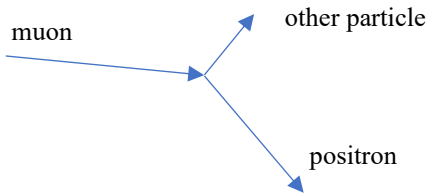
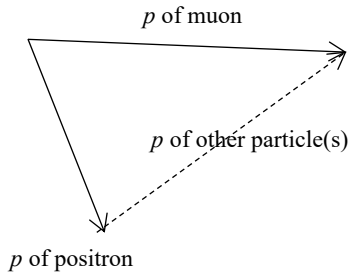
Question Number	Acceptable answers	Additional guidance	Mark
12	• Use of $P = VI$ **(1)** • Use of $A = \pi r^2$ **(1)** • Use of $R = \rho l / A$ **(1)** • Use of $P = I^2 R$ **(1)** • Use of efficiency = power out/power in **(1)** • 100% and consistent conclusion **(1)** (MP6 dependent on fully correct method)	Accept for MP5 power loss/power in Example of calculation 1400×10^6 W = 1100×10^3 V × I I = 1273 A radius = 0.15 m /2 = 0.075 m $A = \pi(0.075)^2$= 0.0177 m^2 R = 1.7 ×10^{-8} Ω m ×720 000 m / π (0.075 m)^2 R = 0.693 Ω P_{lost} = (1273 A)^2 × 0.693 Ω = 1.12 MW Efficiency calculation (1400−1.12) MW / 1400 MW or 1.12 MW / 1400 W Efficiency = 99.9 % OR 1 – 0.0008 = 99.9 %	**6**

(Total for Question 12 = 6 marks)

Question Number	Acceptable answers		Additional guidance	Mark
13(a)	• Identifies mass of antiproton is the same as proton	(1)	MP1: use of 1.67×10^{-27} kg	4
	• Convert kg to J	(1)	Example of calculation $m = \frac{1.67 \times 10^{-27}\ \text{kg} \times (3.0 \times 10^{8})^{2} (\text{m s}^{-1})^{2}}{1.6 \times 10^{-13}\ \text{J MeV}^{-1}}$	
	• Convert J to eV	(1)		
	• Mass = 940 (MeV/c^2)	(1)	m = 939 MeV/c^2	
13(b)	Maximum 4 out of 5			4
	• Applies conservation of charge number	(1)	eg +1 +1 = +1 +1 +1 −1	
	• Applies conservation of baryon number	(1)	eg +1 +1 = +1 +1 +1 −1	
	• The momentum is conserved if the products have zero (total) momentum	(1)		
	• Energy required to create the extra mass of the two particles **Or** calculates Δm = 1880 MeV/c^2	(1)	"show that" value gives 1800 MeV/c^2	
	• So possible if the protons can be given the energy by accelerating each beam through (at least) 940 MeV **Or** This can come from (a loss of) kinetic energy of protons	(1)	Accept Each beam needs an energy of (at least) 940 MeV **Or** 900 MeV if using "show that" value	

(Total for Question 13 = 8 marks)

Question Number	Acceptable answers	Additional guidance	Mark
14(a)	Any **two** from: • Each lepton has an antiparticle **(1)** • Baryon number = 0 **(1)** • Leptons are fundamental particles **(1)** • Leptons interact via the weak force **(1)** • Leptons have a lepton number which isn't zero **(1)**		**2**
14(b)	• Correct symbols for positive muon and positron **(1)** • Correct symbols for neutrino and antineutrino **(1)**	μ^+ e^+ $(\mu^+ \rightarrow e^+) + \nu_e + \bar{\nu}_\mu$	**2**
14(c)	• Magnetic field is used to curve the track **Or** Magnetic field exerts a centripetal force **(1)** • The direction of curvature indicates whether the charge is positive or negative **(1)** • It enables the momentum of particles to be determined **(1)**		**3**

14(d)	• The path of the positron has a different direction to that of the muon **Or** radius of curvature of each path is different **(1)** • Momentum of positron is different to that of muon **(1)** • Momentum is conserved **(1)** • So a further particle(s) must be produced **(1)** MP4 depends on MP3	MP1 and 4 accept a sketch showing other particle direction eg  The labelled sketch below would gain 4 marks  	**4**

(Total for Question 14 = 11 marks)

Question Number	Acceptable answers		Additional guidance	Mark
15(a)(i)	• At least three straight horizontal parallel lines	**(1)**		**3**
	• Equispaced	**(1)**		
	• Arrow to indicate direction to the right	**(1)**		
15(a)(ii)	• As no current drawn from supply	**(1)**		**2**
	• Terminal potential difference is equal to e.m.f. **Or** no potential difference across internal resistance	**(1)**	Accept no "lost volts"	
15(b)(i)	• Use of $E = V / d$	**(1)**	Example of calculation 3×10^6 V m^{-1} = V / 0.002 m	**2**
	• V = 6000 V	**(1)**	V = 6000 V	
15(b)(ii)	• (A spark is) a current (drawn from the supply)	**(1)**		**3**
	• A potential difference is produced across the internal resistance of the supply	**(1)**	Accept "lost volts" are present/increases	
	• According to $V = E - Ir$ V decreases **Or** (the decrease in V) is large because the internal resistance is large	**(1)**	Accept reduces the terminal potential difference which is shown on the voltmeter	

(Total for Question 15 = 10 marks)

<table>
<tr><th>Question Number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>16(a)</td><td>• Use of $P = V^2/R$ (1)

• R = 4.5 (Ω) (1)</td><td><u>Example of calculation</u>
0.50 W = (1.5 V)^2 / R
R = 4.5 Ω</td><td>2</td></tr>
<tr><td>*16(b)</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

Indicative content:

IC1 When slider is at A bulb not lit Or when slider is at A p.d. (across bulb) is zero

IC2 When slider is at B bulb will be lit normally / maximum

IC3 When slider is at B p.d. (across bulb) is 1.5 V

IC4 The brightness of the bulb will increase as slider moves towards B

IC5 The potential difference/current in bulb increases as the slider is moved towards B

IC6 Resistance to right of slider decreases Or resistance of section of potential divider in series with bulb decreases Or bulb lights just before B</td><td><table><tr><th>IC points</th><th>IC mark</th><th>Max linkage mark available</th><th>Max final mark</th></tr><tr><td>6</td><td>4</td><td>2</td><td>6</td></tr><tr><td>5</td><td>3</td><td>2</td><td>5</td></tr><tr><td>4</td><td>3</td><td>1</td><td>4</td></tr><tr><td>3</td><td>2</td><td>1</td><td>3</td></tr><tr><td>2</td><td>2</td><td>0</td><td>2</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td></tr></table>
Accept "supply voltage" for 1.5 V

Accept resistance to left of slider increases Or resistance of section of potential divider in series with bulb is large</td><td>6</td></tr>
</table>

16(c)	• Initial p.d. across the capacitor is zero **Or** Initial p.d. across bulb will be 1.5 V/maximum **Or** initial current is maximum **(1)** • Bulb will be bright/lit initially **(1)** • As capacitor charges the brightness of bulb decreases **(1)** • Exponential decrease **Or** The time constant is 6.0 s (so the process will be of the order of 25 − 35 s) **(1)**	Accept pd across capacitor increasing so brightness of bulb decreases MP4 for correct calculation of time constant Example of calculation $RC = 5.0\ \Omega \times 1.2\ \text{F} = 6.0\ \text{s}$	**4**

(Total for Question 16 = 12 marks)

Question Number	Acceptable answers	Additional guidance	Mark
17(a)	• The atom is mainly empty space **(1)** • All/most of mass of the atom is in a nucleus/centre which is charged **(1)** • The nucleus is small compared to the atom **(1)**	Accept dense and charged	**3**
17(b)(i)	• Use of $V = {}^{Q}/_{4\pi\varepsilon_0 r}$ **(1)** • Identifies number of (positive) charges for alpha or gold nucleus **(1)** • Use of $W = VQ$ **(1)** • $r = 5 \times 10^{-14}$ m so textbook statement is correct **Or** $V = 7.27 \times 10^{-13}$ J so textbook statement is correct **(1)** (MP4 dependent on MP1)	Example of calculation 7.30×10^{-13} J = $\left(\frac{8.99\times10^{9}\text{Nm}^2\text{C}^{-2}\times79\times1.6\times10^{-19}\text{C}}{r}\right)\times2\times1.6\times10^{-19}\text{C}$ $r = 4.98 \times 10^{-14}$ m	**4**
17(b)(ii)	• Use of $E_k = \frac{p^2}{2m}$ **(1)** • Converts atomic mass to kg **(1)** • $p = 9.9 \times 10^{-20}$ kg m s^{-1} **(1)**	Accept Use of $Ek = \frac{1}{2}mv^2$ and $p = mv$ Example of calculation 7.30×10^{-13} J $= p^2/2 \times 4 \times 1.66 \times 10^{-27}$kg $p = 9.9 \times 10^{-20}$ kg m s^{-1}	**3**
17(c)(i)	• (Total) kinetic energy conserved **(1)**		**1**
17(c)(ii)	• The gold atom/nuclei recoil **(1)** **Or** the gold atoms/nuclei gain kinetic energy **Or** the gold atoms/nuclei are displaced/move	Accept Small/negligible increase in thermal energy (in the gold foil)	**1**

(Total for Question 17 = 12 marks)

Question Number	Acceptable answers		Additional guidance	Mark
18(a)	• There is a (rate of) change of flux (linkage)/field with the (moving coil) • Induces an emf (and current) • To oppose the change that created (the induced current) • Wheels will slow down/not turn as fast MP4 dependent on MP3	**(1)** **(1)** **(1)** **(1)**	Accept magnetic field (due to induced current) will oppose original field	**4**
18(b)(i)	• Converts speed to m s^{-1} **Or** converts time to hours • Determines gradient of graph **Or** uses appropriate equation of motion • Acceleration = 0.22 m s^{-2} **Or** 2800 km h^{-2} range 2800-2900 km h^{-2}	**(1)** **(1)** **(1)**	Example of calculation 360 km/h = 360000 m / 3600 s = 100 m s^{-1} $a = \frac{100\ \text{m s}^{-1}}{450\ \text{s}} = 0.222\ \text{m s}^{-2}$	**3**
18(b)(ii)	• Determines area under graph for a time of 450 s. **Or** use of appropriate equation of motion • Distance = 22.5 km • 22.5 km is less than 40 km so meets specification **Or** • Use of appropriate equation of motion to calculate v • velocity = 130 m s^{-1} • 130 m s^{-1} is more than 100 m s^{-1} so meets specification **Or** • Use of appropriate equation of motion to calculate a	**(1)** **(1)** **(1)**	Example of calculation $s = \frac{(0+100\ \text{m s}^{-1})}{2} \times 450\ \text{s} = 22.5\ \text{km}$ **Or** $v^2 = 2 \times 0.22\ \text{m s}^{-2} \times 40000\ \text{m}$ $v = 133\ \text{m s}^{-1}$ **Or** $(3600\ \text{km h}^{-1})^2 = 2 \times a \times 40\ \text{km}$ $a = 1620\ \text{km h}^{-2}$	**3**

	• a = 1620 km h^{-2} • 1620 km h^{-2} is less than 2800 km h^{-2} so meets specification		
18(c)(i)	• If the track is curved then a centripetal force is required **(1)** • This force provided by reaction force between wheel and rails **(1)** • The centripetal force is given by $F = mv^2/r$ **(1)** • There will be a maximum speed at which the train will leave the track (and the train must travel at less than this speed) as there is a maximum value of reaction/friction (between wheels and rails) **(1)**	Accept Force towards the centre Accept This force is provided by friction (between rail and wheels) Accept Train slips off track if centripetal force is larger than reaction/friction can provide	**4**
18(c)(ii)	• Use of constant = v^2/r **(1)** • r = 5800 m **(1)**	Example of calculation As v^2/r = constant (k) k = 200^2 (km h^{-1})^2/ 1800 m = 22.22 r = 360^2 (km h^{-1})^2 / 22.22 m (km h^{-1})$^{-2}$ r = 5840 m	**2**

(Total for Question 18 = 16 marks)

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