Pearson Edexcel

Mark Scheme (Results)

January 2022

Pearson Edexcel International Advanced Level in Physics (WPH14) Paper 01 Physics Further Mechanics, Fields and Particles

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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.

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Question Number	Answer	Mark
1	The only correct answer is **D** *A is not correct because 8 is the number of protons* *B is not correct because 8 is the number of protons* *C is not correct because 8 is the number of protons*	**1**
2	The only correct answer is **D** *A is not correct because this is the mass of an electron* *B is not correct because this is the mass of an electron* *C is not correct because this is the charge of a proton*	**1**
3	The only correct answer is **A** *B is not correct because* $p^2/_{2m}$ *= 0.5 J* *C is not correct because* $p^2/_{2m}$ *= 0.5 J* *D is not correct because* $p^2/_{2m}$ *= 0.5 J*	**1**
4	The only correct answer is **B** *A is not correct because momentum is conserved and* E_k *decreases* *C is not correct because momentum is conserved and* E_k *decreases* *D is not correct because momentum is conserved and* E_k *decreases*	**1**
5	The only correct answer is **D** *A is not correct because the process described is thermionic emission* *B is not correct because the process described is thermionic emission* *C is not correct because the process described is thermionic emission*	**1**
6	The only correct answer is **B** *A is not correct because this would have no effect on the deflection* *C is not correct because this would increase the deflection* *D is not correct because this would increase the deflection*	**1**
7	The only correct answer is **A** *B is not correct because force is out of page on QR* *C is not correct because force is zero on RS* *D is not correct because force is into page on SP*	**1**
8	The only correct answer is **C** *A is not correct because this was a correct conclusion* *B is not correct because this was a correct conclusion* *D is not correct because this was a correct conclusion*	**1**
9	The only correct answer is **D** *A is not correct because this would not change the energy* *B is not correct because this would not change the energy for one revolution* *C is not correct because this would not change the energy*	**1**
10	The only correct answer is **B** *A is not correct because if the time of orbit stays constant and the radius of orbit increases then the speed must increase* *C is not correct because if the time of orbit stays constant and the radius of orbit increases then the speed must increase* *D is not correct because the angular velocity stays constant*	**1**

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Question Number	Answer	Mark
11	at least 4 radial straight lines (1) distributed equally (1) arrow on at least one line pointing towards centre (1)	**3**
	Total for question 11	**3**

Question Number	Answer	Mark
12	The blades exert a downward force on the air (1) The air exerts an equal upwards force on the blades/helicopter **Or** By Newton's 3rd law there is an equal upwards force (1) This upwards force equals the weight of helicopter (1) The resultant force is zero, so (by Newton's 1st or 2nd law) there is no acceleration (and the helicopter maintains a constant height) (1)	**4**
	Total for question 12	**4**

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Question Number	Answer	Mark
13ai	Use of trigonometry appropriate for determination of angle (1) Use of $W = mg$ (1) Resolves tension in thread vertically or horizontally (1) **Or** draw triangle of forces Force of repulsion = 1.2×10^{-3} (N) (1) <u>Example of calculation</u> $\sin\theta = 13/122$ Angle of thread to vertical $\theta = 6.12°$ $T\cos 6.12° = 1.1 \times 10^{-3}\text{kg} \times 9.81\text{N kg}^{-1}$ Tension in thread = 0.0109 N Force of repulsion = 0.0109 sin 6.12° = 1.16×10^{-3} N	**4**
13aii	Use of $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ (accept use of $F = \frac{k\,Q_1 Q_2}{r^2}$) (1) $Q = 1.7 \times 10^{-7}$ (C) (allow ecf from ai) (1) <u>Example of calculation</u> $1.16 \times 10^{-3}\text{N} = 8.99 \times 10^{9}\ \text{Nm}^2\text{C}^{-2}\frac{Q^2}{0.47^2\text{m}^2}$ $Q = 1.69 \times 10^{-7}$ C	**2**
13b	Use of $V = \frac{Q}{4\pi\varepsilon_0 r}$ (accept use of $V = \frac{kQ}{r}$) (1) V = 5100 V (allow ecf from aii) (1) <u>Example of calculation</u> $V = 8.99 \times 10^{9}\ \text{Nm}^2\text{C}^{-2}\frac{(-)1.7\times10^{-7}\text{C}}{0.30\ \text{m}}$ = (−)5094 V	**2**
	Total for question 13	**8**

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Question Number	Answer		Mark
14a	Use of $I = V / R$	(1)	**2**
	I = 0.15 mA which is consistent (with the value on the graph)	(1)	
	<u>Example of calculation</u> I = 5.0 V / 33 kΩ = 1.5 ×10^{-4} A = 0.15 mA		
14b	The current would vary with time in the same way as on ammeter A_1	(1)	**2**
	Because (current is same everywhere) in a series circuit	(1)	
14c	**Either**		**3**
	Takes two corresponding values of I and t from graph	(1)	
	Use of $\ln I = \ln I_0 - t/RC$	(1)	
	C = 2.27 ×10^{-4} F (2.0 ×10^{-4} F - 2.3 ×10^{-4} F)	(1)	
	Or		
	Draws initial tangent to curve and determines t intercept: T (0.65-0.75 s)	(1)	
	Use of $T = RC$	(1)	
	C = 2.2 ×10^{-4} F (2.0 ×10^{-4} F - 2.3 ×10^{-4} F)	(1)	
	Or		
	Read value of t at which $I = I_o / e$ (0.56 A, 0.7 s)	(1)	
	Use of $T = RC$	(1)	
	C = 2.1 ×10^{-4} F (2.0 ×10^{-4} F - 2.3 ×10^{-4} F)	(1)	
	<u>Example of calculation</u> eg I = 0.04 mA and t = 10 s $\ln 0.04 = \ln 0.152 - \frac{10\text{s}}{C \times 33\text{k}}$ C = 2.27 ×10^{-4} F range: 2.0 ×10^{-4} F - 2.3 ×10^{-4} F		
14d	Attempt to determine an area under the curve	(1)	**2**
	Q = 1.1 ×10^{-3} C (1.0 ×10^{-3} C to 1.2 ×10^{-3} C)	(1)	
	Or		
	Use of $Q = CV$ with 5.0 V	(1)	
	Q = 1.1 ×10^{-3} C (allow ecf from (c))	(1)	
14e	Use of $W = \frac{QV}{2}$ or $W = \frac{1}{2}CV^2$ or $W = Q^2/2C$	(1)	**2**
	W = 2.8 ×10^{-3} J (allow ecf from 14c and 14d)	(1)	
	<u>Example of calculation</u> W = 1.1 ×10^{-3} C × 5 V / 2 = 2.8 ×10^{-3} J		
	Total for question 14		**11**

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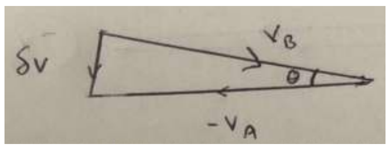
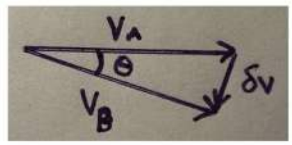
Question Number	Answer		Mark
15a	Correct vector diagram showing velocity change (Small angle, so) $\delta\theta = \delta v / v$ Use of $\delta\theta / \delta t = \omega$ and $v = r\omega$ Use of $\delta v / \delta t = a$ Algebra to show $a = v^2 / r$ Example of derivation   Small angle, so $\delta\theta = \delta v / v$ $\delta\theta = \omega\delta t$ $\delta\theta = v\delta t / r$ $v\delta t / r = \delta v / v$ $\delta v / \delta t = v^2 / r$	(1) (1) (1) (1) (1)	**5**
15b	Use of velocity = $f \times 2\pi r$ Use of $a = v^2 / r$ $a = 39$ m s^{-2} **Or** Use of $\omega = 2\pi f$ Use of $a = \omega^2 / r$ $a = 39$ m s^{-2} Example of calculation $v = 1.3$ s$^{-1} \times 2\pi \times 0.58$ m $= 4.74$ m s^{-1} $a = 4.74^2$ (m s^{-1})^2/0.58 m $= 38.7$ m s^{-2}	(1) (1) (1)	**3**
15c	Tension in cord is force on hand Centripetal force is constant Weight of ball is added to tension at top Weight is subtracted from tension at bottom so force on hand varies and child correct	(1) (1) (1) (1)	**4**

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	OR Tension in cord is force on hand (1) Centripetal force is constant (1) Weight of ball is subtracted from tension at bottom (1) Weight is added to tension at top so force on hand varies and child correct (1) <u>Example of discussion</u> At top of motion $W + T$ = centripetal force **Or** at bottom of motion $T - W$ = centripetal force So T varies from (centripetal force − W) to (centripetal force + W)	
	Total for question 15	**12**

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<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>16a</td><td>(the particle is) ionising
Or
it knocks electrons out of atoms in its path (1)

A track is formed by the ionised particles produced (1)</td><td>2</td></tr>
<tr><td>16bi</td><td>A baryon is three quarks (or three antiquarks) (1)

A meson is an anti-quark and a quark (1)</td><td>2</td></tr>
<tr><td>16bii</td><td>into the page/paper (1)</td><td>1</td></tr>
<tr><td>16biii</td><td>charge:
applies charge conservation (1)

omega baryon charge −1 (1)

baryon number:
before = 1 identified as the proton so the omega particle = 1 (1)</td><td>3</td></tr>
<tr><td>*16c</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.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</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></td><td>6</td></tr>
</table>

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The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

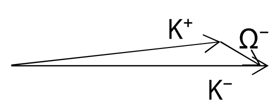
Indicative content:
Energy:
IC1 As (Rest) mass-energy of proton and kaon + Initial E_k = (rest) mass-energy of omega and kaon + kinetic energies of both particles
Or (Total) mass-energy conserved

IC2 Incoming K^- had **high** kinetic energy

IC3 some of this initial kinetic energy converted to mass of the omega particle (– mass of proton)

IC4 $\Delta E = \Delta mc^2$

momentum:
IC5 momentum of K^- = sum of x components of $K^+ + \Omega^-$
Or vector sum of momentum of $K^+ + \Omega^-$ = momentum of K^-
Or an attempt to sketch a triangle of vectors
eg



IC6 y component of K^+ equals y component Ω^-
Or
all vectors correctly labelled

	Total for question 16	14

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Question Number	Answer	Mark
17a	It is a lepton (1) It is a fundamental particle **Or** second generation (1)	**2**
17b	negative pion (1) muon anti-neutrino (1)	**2**
17c	Use of $\Delta E = c^2 \Delta m$ (1) Divide mass of muon by mass of electron **Or** multiplies the mass of an electron by 200 (1) Mass of muon is 207 times that of an electron so true statement **Or** 200 times electron mass is 1.82×10^{-28} kg which is just under 1.88×10^{-28} kg so it is correct (1) <u>Example of calculation</u> $\text{mass} = \frac{106\ \text{MeV/c}^2 \times 10^6 \times 1.6 \times 10^{-19}\ \text{JeV}^{-1}}{(3 \times 10^8)^2\ (\text{m s}^{-1})^2} = 1.88 \times 10^{-28}\ \text{kg}$ $\text{mass} = \frac{1.88 \times 10^{-28}\ \text{kg}}{9.11 \times 10^{-31}\ \text{kg}}$ mass = 207 times that of an electron	**3**
17di	A unit of energy is GeV **Or** a unit of mass is GeV/c^2 (1) The unit of momentum is the same as the unit of energy/velocity so GeV divided by c = GeV/c **Or** The unit of momentum is the same as the unit of mass × velocity so $\text{GeV/c}^2 \times \text{c} = \text{GeV/c}$ (1)	**2**
17dii	Use of Circumference = $2\pi r$ (1) Use of $r = p / BQ$ (1) Show that a momentum of 1.65×10^{-18} N s is consistent with the correct radius (7.11 m) by determination of *p, r, B* or *Q* and statement that it is correct (1) <u>Example of calculation</u> $r = 44.7\ \text{m} / 2\pi = 7.11\ \text{m}$ $r = \frac{1.65 \times 10^{-18}\ \text{N s}}{1.45\ \text{T} \times 1.6 \times 10^{-19}\ \text{C}} = 7.11\ \text{m}$	**3**
17diii	muons travelling close to speed of light (1) relativistic effect on particle lifetime (1)	**2**
	Total for question 17	**14**

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Question Number	Answer		Mark
18a	Flux linkage weber / Wb	(1) (1)	**2**
18b	Evidence of attempt to determine maximum gradient of graph Use of ΔB / Δt use of area of coil = πr^2 use of $\emptyset = BA$ Use of $\varepsilon = \frac{d(N\emptyset)}{dt}$ $\mathcal{E}$= 1.4 V range 1.2 to 1.6 V <u>Example of calculation</u> gradient = 0.6 T / 0.006 s = 100 T s^{-1} Area of coil $= \pi(0.003 \text{ m})^2 = 2.83 \times 10^{-5} \text{ m}^2$ $\varepsilon = 500 \times 100 \text{ T s}^{-1} \times 2.83 \times 10^{-5} \text{ m}^2$ $\mathcal{E}$= 1.4 V	(1) (1) (1) (1) (1) (1)	**6**
18c	There is a change in the magnetic flux (linkage with aluminium disc) **Or** disc is cutting magnetic field/flux So an <u>e.m.f.</u> is <u>induced</u> Leads to a current (in the disc) (accept eddy current) Force acts on the disc, as there is a current in a magnetic field (accept reference to motor effect, FLHR or *F* = *BIl* if current in disc has been mentioned) **Or** field due to current in disc interacting with field due to magnet to cause force on disc According to Lenz's law **Or** the direction of e.m.f./current is such to oppose (the cause of) the change in flux The disc moves to reduce this change (the same direction as the magnet) so correct suggestion	(1) (1) (1) (1) (1) (1)	**6**
	Total for question 18		**14**

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