



Mark Scheme (Results)

Summer 2023

Pearson Edexcel International Advanced
Subsidiary Level In Physics (WPH14)

Paper 01

Unit 4: Physics Further Mechanics, Fields and
Particles

Question Number	Answer	Mark
1	<p>The only correct answer is D because the emission of electrons from a heated filament is called thermionic emission.</p> <p>A is not correct because the emission of electrons from a heated filament is not called annihilation</p> <p>B is not correct because the emission of electrons from a heated filament is not called ionisation</p> <p>C is not correct because the emission of electrons from a heated filament is not called photoelectric effect</p>	1
2	<p>The only correct answer is B because the charge stored on the capacitor in coulomb is given by $2.2 \times 10^{-4} \times 6$</p> <p>A is not correct because the charge stored on the capacitor in coulomb is not given by $0.5 \times 2.2 \times 10^{-4} \times 6$</p> <p>C is not correct because the charge stored on the capacitor in coulomb is not given by $\frac{0.5 \times 2.2 \times 10^{-4}}{6}$</p> <p>D is not correct because the charge stored on the capacitor in coulomb is not given by $\frac{2.2 \times 10^{-4}}{6}$</p>	1
3	<p>The only correct answer is B because after emission the proton number is 18 and the nucleon number is 38</p> <p>A is not correct because after emission the proton number is 18 and the nucleon number is 38</p> <p>C is not correct because after emission the proton number is 18 and the nucleon number is 38</p> <p>D is not correct because after emission the proton number is 18 and the nucleon number is 38</p>	1
4	<p>The only correct answer is A because impulse has the units of mass \times velocity</p> <p>B is not correct because this is not units of mass \times velocity</p> <p>C is not correct because N is not a base unit</p> <p>D is not correct because N is not a base unit</p>	1
5	<p>The only correct answer is D because this is a requirement for creating new particles rather than investigating structure</p> <p>A is not correct because this is a reason why particles with high energy are required</p> <p>B is not correct because this is a reason why particles with high energy are required</p> <p>C is not correct because this is a reason why particles with high energy are required</p>	1
6	<p>The only correct answer is A because a neutrino is a fundamental particle</p> <p>B is not correct because a neutron is not a fundamental particle</p> <p>C is not correct because a pion is not a fundamental particle</p> <p>D is not correct because a proton is not a fundamental particle</p>	1
7	<p>The only correct answer is B because the mass in kg is given by $\frac{6.5 \times 1.6 \times 10^{-13}}{(3 \times 10^8)^2}$</p> <p>A is not correct because this does not take account of the M in MeV</p> <p>C is not correct because multiplication and division are reversed</p> <p>D is not correct because multiplication and division are reversed</p>	1
8	<p>The only correct answer is C because there is insufficient evidence to draw this conclusion</p> <p>A is not correct because this is a valid conclusion</p> <p>B is not correct because this is a valid conclusion</p> <p>D is not correct because this is a valid conclusion</p>	1

9	<p>The only correct answer is B</p> <p>A is not correct because there should be an antineutrino and not a neutrino</p> <p>C is not correct because charge is not conserved</p> <p>D is not correct because charge is not conserved</p>	1
10	<p>The only correct answer is A</p> <p>B is not correct because the length of the magnet is the length of wire perpendicular to the field</p> <p>C is not correct because the force is into the page</p> <p>D is not correct because the force is into the page</p>	1

Question Number	Answer	Mark
11	Meson	
	\bar{c} and one quark from cdsu	(1)
	Charge correct for quark-antiquark combination	(1)
	Baryon	
	3 quarks from cdsu	(1)
	Charge correct for three-quark combination	(1)
	Correct 5 quarks used once each such that meson and baryon charges are equal and opposite (\bar{c} d and csu or \bar{c} s and cdu) (MP5 dependent on MP1, 2, 3 and 4)	(1)
	Total for question 11	5

Question Number	Answer	Mark
12(a)	<p>Equates $F = \frac{mv^2}{r}$ and $F = BQv$ (1)</p> <p>Substitutes $p = mv$ with suitable algebra to arrive at $r = \frac{p}{BQ}$ (1)</p> <p><u>Example of derivation</u></p> $\frac{mv^2}{r} = BQv$ $\frac{mv}{r} = BQ$ $\frac{p}{r} = BQ$ $r = \frac{p}{BQ}$	2
12(b)	<p>Use of conversion factor from eV to J (1)</p> <p>Use of $E_k = \frac{p^2}{2m}$</p> <p>Or</p> <p>Use of $E_k = \frac{1}{2} mv^2$ and $p = mv$ (1)</p> <p>Use of $r = \frac{p}{BQ}$ (1)</p> <p>$B = 3.5 \text{ T}$ (1)</p> <p><u>Example of calculation</u></p> $E = 5.4 \text{ MeV} \times 10^6 \times 1.6 \times 10^{-19} \text{ C}$ $= 8.64 \times 10^{-13} \text{ J}$ $8.64 \times 10^{-13} \text{ J} = \frac{p^2}{2 \times 6.64 \times 10^{-27} \text{ kg}}$ $p = 1.07 \times 10^{-19} \text{ Ns}$ $0.096 \text{ m} = 1.07 \times 10^{-19} \text{ Ns} / B \times 2 \times 1.6 \times 10^{-19} \text{ C}$ $B = 3.48 \text{ T}$	4
Total for question 12		6

Question Number	Answer	Mark
13(a)	The particles are accelerated by an electric field in the gaps (1)	4
	The a.c. frequency is constant so the particles spend the same time in the tubes/gaps (1)	
	(This is achieved by) increasing length of drift tubes Or (This is achieved by) increasing length of gaps (1)	
	The (a.c) polarity changes so the (electric) field is in the same direction when the particle is in the gaps Or The (a.c.) polarity changes so it is always accelerating the particles (1)	
13(b)	The particles experience a force at right angles to their motion/path/velocity. (1)	2
	Which causes centripetal acceleration/force Or Which causes circular motion (1)	
Total for question 13		6

Question Number	Answer	Mark
14(a)	<p>Use of trigonometrical function for x component of alpha momentum after collision Or Use of trigonometrical function for y component of alpha momentum after collision (1)</p> <p>Applies conservation of momentum in x direction Or Applies conservation of momentum in y direction (1)</p> <p>Applies trigonometry to calculate final angle for proton (1)</p> <p>Applies trigonometry or Pythagoras to calculate magnitude (1)</p> <p>Angle = $17.0(^{\circ})$ (1)</p> <p>Magnitude = 4.9×10^{-20} (N s) (1)</p> <p><u>Example of calculation</u> x component of alpha after = 8.06×10^{-20} Ns $\times \cos 10.2^{\circ} = 7.93 \times 10^{-20}$ Ns y component of alpha after = 8.06×10^{-20} Ns $\times \sin 10.2^{\circ} = 1.43 \times 10^{-20}$ Ns x component of proton = 1.26×10^{-19} Ns $- 7.93 \times 10^{-20}$ Ns = 4.67×10^{-20} Ns y component of proton = 1.43×10^{-20} Ns $\tan \theta = 1.43 \times 10^{-20}$ Ns $\div 4.67 \times 10^{-20}$ Ns = 0.31 $\theta = 17.0^{\circ}$ $p^2 = (4.67 \times 10^{-20} \text{ Ns})^2 + (1.43 \times 10^{-20} \text{ Ns})^2$ $p = 4.88 \times 10^{-20}$ N s</p>	6
14(b)	<p>Use of $E_k = \frac{p^2}{2m}$ Or Use of $E_k = \frac{1}{2} mv^2$ and $p = mv$ (1)</p> <p>Correct calculation of one kinetic energy (e.c.f from (a)) (1)</p> <p>Correct calculation of all kinetic energies (e.c.f from (a)) (1)</p> <p>Conclusion consistent with correctly calculated values of kinetic energy (1)</p> <p><u>Example of calculation</u> $E_k = \frac{(4.88 \times 10^{-20} \text{ N s})^2}{2 \times 1.67 \times 10^{-27} \text{ kg}} = 7.13 \times 10^{-13} \text{ J}$ (proton after) $E_k = \frac{(8.06 \times 10^{-20} \text{ N s})^2}{2 \times 6.64 \times 10^{-27} \text{ kg}} = 4.89 \times 10^{-13} \text{ J}$ (alpha after) $E_k = \frac{(1.26 \times 10^{-19} \text{ N s})^2}{2 \times 6.64 \times 10^{-27} \text{ kg}} = 1.20 \times 10^{-12} \text{ J}$ (initial alpha) $7.13 \times 10^{-13} \text{ J} + 4.89 \times 10^{-13} \text{ J} = 1.2 \times 10^{-12} \text{ J} = \text{initial alpha kinetic energy, so it is elastic}$</p>	4
Total for question 14		10

Question Number	Answer	Mark																																								
15(a)(i)	States $T = 0.16 \text{ s}$	(1)																																								
	Use of $\omega = 2\pi / T$	(1)																																								
	$\omega = 39 \text{ (radian s}^{-1}\text{)}$	(1)																																								
	<u>Example of calculation</u>																																									
	$T = 0.16 \text{ s}$ $\omega = 2\pi / 0.16 \text{ s}$ $\omega = 39.3 \text{ radian s}^{-1}$																																									
15(a)(ii)	Maximum force read from graph ($F = 0.63 \text{ N}$) (accept 0.62 N to 0.64 N)	(1)																																								
	Use of $F = m \omega^2 r$	(1)																																								
	$r = 0.044 \text{ (m)}$ (e.c.f from (a)(i))	(1)																																								
	86 mm is $2 \times 0.043 \text{ m}$, so 0.086 m was the diameter in mm	(1)																																								
	<u>Example of calculation</u> $0.63 \text{ N} = 0.0095 \text{ g} \times (39 \text{ radian s}^{-1})^2 \times r$ $r = 0.044 \text{ m}$ (Show that value gives 0.041)																																									
15(b)*	<p>This question assesses a student’s ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.</p> <p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p>The following table shows how the marks should be awarded for indicative content.</p> <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> <p>The following table shows how the marks should be awarded for structure and lines of reasoning.</p> <table><tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr><tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr></table> <p>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).</p>	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	Max linkage mark available	Max final mark	6	4	2	6	5	3	2	5	4	3	1	4	3	2	1	3	2	2	0	2	1	1	0	1	0	0	0	0		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	
Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	Max linkage mark available	Max final mark																																							
6	4	2	6																																							
5	3	2	5																																							
4	3	1	4																																							
3	2	1	3																																							
2	2	0	2																																							
1	1	0	1																																							
0	0	0	0																																							
	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																																									

	<p>Indicative content:</p> <p>IC1: Magnitude of centripetal force is constant since speed is constant</p> <p>IC2: Centripetal force on car at bottom is normal contact force minus weight $(F = N - W \text{ or } N = F + W)$</p> <p>IC3: When car is at bottom force is maximum</p> <p>IC4: Centripetal force on car at top is normal contact force plus weight $(F = N + W \text{ or } N = F - W)$</p> <p>IC5: When car is at top force is minimum</p> <p>IC6: At 0.04 s it is at the bottom and at 0.12 s it's at the top</p>	6
	Total for question 15	13

Question Number	Answer	Mark
16(a)	(Wires) cut lines of magnetic flux Or flux <u>linkage</u> (with coil) changing (1) <u>Induces emf</u> (1)	2
16(b)	Use of $A = \pi(d/2)^2$ (1) Applies knowledge of flux = flux density \times area (1) Flux = 8.8×10^{-5} (Wb) (at least 2 s.f) (1) <u>Example of calculation</u> $A = \pi \times (0.025 \text{ m} / 2)^2$ $= 4.9 \times 10^{-4} \text{ m}^2$ $\phi = 0.18 \text{ T} \times 4.9 \times 10^{-4} \text{ m}^2$ $= 8.84 \times 10^{-5} \text{ Wb}$	3
16(c)	Determine maximum gradient of graph (1) Use of flux linkage = $N \phi$ (1) Use of $\varepsilon = dN\phi / dt$ (1) $V = 2.3 \text{ V}$ (range rounds – 2.2 V to 2.6 V) (1) <u>Example of calculation</u> max gradient = $4.62 \times 10^{-4} \text{ Wb s}^{-1}$ max $V = 5000 \times 4.62 \times 10^{-4} \text{ Wb s}^{-1} = 2.3 \text{ V}$	4
16(d)	By Lenz's law, current/e.m.f./field/force produced is so as to oppose the cause of the current/e.m.f. (1) Force on wire due to interaction of induced current and field (1) Force to left, so, by (Fleming) LHR... (1) ... current into page and student is correct (dependent on MP3) (1)	4
Total for question 16		13

Question Number	Answer	Mark
17(a)	At least 4 radial straight lines, from surface of sphere	(1)
	Equal spacing	(1)
	Arrows outward	(1) 3
17(b)(i)	Use of $V = \frac{Q}{4\pi\epsilon_0 r}$	(1)
	$Q = 1.1 \times 10^{-8} \text{ (C)}$	(1) 2
	<u>Example of calculation</u> $5000 \text{ V} = 8.99 \times 10^9 \text{ Nm}^2\text{C}^{-2} \times \frac{Q}{0.02 \text{ m}}$ $Q = 1.1 \times 10^{-8} \text{ C}$	
17(b)(ii)	Use of $E = V/d$	(1)
	Use of $F = EQ$	(1)
	$F = 5.2 \times 10^{-4} \text{ N}$ (e.c.f from (b)(i)) <u>Example of calculation</u> $E = 5000 \text{ V} \div 0.105 \text{ m} = 47\,600 \text{ V m}^{-1}$ $F = 47\,600 \text{ V m}^{-1} \times 1.1 \times 10^{-8} \text{ C}$ $F = 5.24 \times 10^{-4} \text{ N}$	(1) 3
17(b)(iii)	Use of $W = mg$	(1)
	Use of suitable trigonometry, such as $\tan \theta = F/W$	(1)
	$\theta = 1.1(^{\circ})$ (e.c.f from (b)(i) and (b)(ii)) <u>Example of calculation</u> $W = 0.0027 \text{ kg} \times 9.81 \text{ N kg}^{-1} = 0.0265 \text{ N}$ $\tan \theta = 5.24 \times 10^{-4} \text{ N} / 0.0265 \text{ N} = 0.0198$ $\theta = 1.13^{\circ}$	(1) 3
17(c)	Use of $F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$	(1)
	with $Q_1 = Q_2 = 1.2 \times 10^{-8} \text{ C}$	(1)
	$r = 0.051 \text{ m}$ <u>Example of calculation</u> $5.0 \times 10^{-4} \text{ N}$ $= \frac{8.99 \times 10^9 \text{ Nm}^2\text{C}^{-2} \times 1.2 \times 10^{-8} \text{ C} \times 1.2 \times 10^{-8} \text{ C}}{r^2}$ $r = 0.051 \text{ m}$	(1) 3
Total for question 17		14

Question Number	Answer	Mark
18(a)	<p>Draws best fit straight line on graph (1)</p> <p>Use of two corresponding pairs of values of I and t (1)</p> <p>Use of gradient $= -1 / CR$ (1)</p> <p>$C = 2.17 \times 10^{-5}$ (F) (rounds to 2.2×10^{-5}) (1)</p> <p>Or</p> <p>Draws best fit straight line on graph (1)</p> <p>Use of two corresponding pairs of values of I and t (1)</p> <p>Use of $\ln I = \ln I_0 - t / CR$ (1)</p> <p>$C = 2.17 \times 10^{-5}$ (F) (rounds to 2.2×10^{-5}) (1)</p> <p><u>Example of calculation</u> Gradient $= -0.189 \text{ s}^{-1}$ $0.191 \text{ s}^{-1} = 1 / C \times 240\,000 \, \Omega$ $C = 2.17 \times 10^{-5} \text{ F}$</p>	4
18(b)(i)	<p>Use of $\Delta E_{\text{grav}} = mg\Delta h$ (1)</p> <p>Use of $E_k = \frac{1}{2} mv^2$ and conservation of energy (1)</p> <p>$v = 0.46 \text{ m s}^{-1}$ (1)</p> <p><u>Example of calculation</u> $E_{\text{grav}} = 0.028 \text{ kg} \times 9.81 \text{ N kg}^{-1} \times 0.011 \text{ m} = 3.02 \times 10^{-3} \text{ J}$ $3.02 \times 10^{-3} \text{ J} = \frac{1}{2} \times 0.028 \text{ kg} \times v^2$ $v = 0.464 \text{ m s}^{-1}$</p>	3
18(b)(ii)	<p>Use of $V = V_0 e^{-t/CR}$ (1)</p> <p>Or</p> <p>Use of $\ln V = \ln V_0 - t / CR$</p> <p>$t = 1.4 \times 10^{-4} \text{ s}$ (1)</p> <p><u>Example of calculation</u> $\ln (5.43 \text{ V} / 6.18 \text{ V}) = -t / 2.2 \times 10^{-5} \text{ F} \times 49 \, \Omega$ $t = 1.39 \times 10^{-4} \text{ s}$</p>	2
18(b)(iii)	<p>Use of $W = mg$ (1)</p> <p>Use of $p = mv$ (1)</p> <p>Use of $F \Delta t = \Delta p$ (1)</p> <p>$F = 93 \text{ N}$ which is (much) more than the weight of sphere A, so the suggestion is incorrect (e.c.f from (b)(i) and (b)(ii)) (1)</p> <p><u>Example of calculation</u> $W = mg$ $= 0.028 \text{ kg} \times 9.81 \text{ N kg}^{-1}$</p>	4

	$= 0.275 \text{ N}$ $p = 0.028 \text{ kg} \times 0.464 \text{ m s}^{-1}$ $= 0.013 \text{ N s}$ $F = 0.013 \text{ N s} / 1.39 \times 10^{-4} \text{ s}$ $= 93 \text{ N}$	
	Total for question 18	13