Mark Scheme (Results)

October 2023

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

Question Number	Answer	Mark
1	**A is the correct answer** B is not correct because the number of neutrons N is on the top line C is not correct because Z is on the top line and N is on the bottom line D is not correct because Z is on the top line	**1**
2	**C is the correct answer** because $\Delta(mv) = F\Delta t$	**1**
3	**D is the correct answer** A is not correct because the frequency of the applied p.d. does not change B is not correct because the frequency of the applied p.d. does not change C is not correct because the particles do not experience a force inside the tubes	**1**
4	**A is the correct answer** because $\phi = B.A$	**1**
5	**B is the correct answer** because the scattering is independent of any neutrons	**1**
6	**D is the correct answer** A is not correct because we do not know the sign of the charge on each particle B is not correct because we do not know the direction of the magnetic field C is not correct because we do not know the direction of the magnetic field	**1**
7	**B is the correct answer because $\boldsymbol{r = \frac{mv}{BQ}}$**	**1**
8	**B is the correct answer** because $\omega = 2\pi \times$ (revolutions per second)	**1**
9	**D is the correct answer** because $Q = Q_o e^{-\frac{t}{RC}}$ and RC = 5 s	**1**
10	**C is the correct answer** because $mg - R = \frac{mv^2}{r}$	**1**

Question Number	Answer		Mark
11	Use of $\omega = \frac{2\pi}{T}$	**(1)**	
	Use of $v = \omega r$	**(1)**	
	$v = 1.9 \text{ m s}^{-1}$	**(1)**	**3**
	<u>Example of calculation</u> $\omega = \frac{2\pi}{\left(\frac{12 \text{ s}}{2}\right)} = 1.05 \text{ rad s}^{-1}$ $v = 1.05 \text{ rad s}^{-1} \times 1.8 \text{ m} = 1.89 \text{ m s}^{-1}$		
	Total for question 11		**3**

Question Number	Answer	Mark
12	**EITHER** Use of $E_k = \frac{p^2}{2m}$ **(1)** Use of $\lambda = \frac{h}{p}$ **(1)** $\lambda = 1.8 \times 10^{-11}$ m **(1)** **OR** Use of $E_k = \frac{1}{2}mv^2$ **and** $p = mv$ **(1)** Use of $\lambda = \frac{h}{p}$ **(1)** **(1)** $\lambda = 1.8 \times 10^{-11}$ m <u>Example of calculation</u> $p = \sqrt{2 \times 7.2 \times 10^{-16}\ \text{J} \times 9.11 \times 10^{-31}\ \text{kg}} = 3.62 \times 10^{-23}$ N s ($v = 4.0 \times 10^7$ m s^{-1}) $\lambda = \frac{6.63 \times 10^{-34}\ \text{J s}}{3.62 \times 10^{-23}\ \text{N s}} = 1.83 \times 10^{-11}$ m	3
	Total for question 12	**3**

Question Number	Answer	Mark
13	Use of $W = mg$ **(1)** Use of $F = BIL \sin\theta$ **(1)** $L = 0.064$ m **(1)** <u>Example of calculation</u> $W = 2.8 \times 10^{-3}$ kg $\times$ 9.81 N kg^{-1} = 0.02747 N $L = \frac{0.027 \text{ N}}{120 \times 10^{-3} \text{ T} \times 3.6 \text{ A}} = 0.0636$ m	3
	Total for question 13	**3**

Question Number	Answer		Mark
14	An explanation that makes reference to the following points: Application of Newton's 1st law to the path of the car/passenger, e.g. if no force the car/passenger would continue in a straight line **Or** a force is required to change direction for the car/passenger	**(1)**	
	A force was exerted on the car/passenger towards the centre of the circle **Or** an inwards force was exerted on the car/passenger at right angles to the motion **Or** a centripetal force was exerted on the car/passenger	**(1)**	
	The inward force is exerted by the car on the passenger	**(1)**	
	There is <u>no outward force</u> (on the passenger) so the passenger's claim is incorrect	**(1)**	**4**
	Total for question 14		**4**

Question Number	Answer		Mark
15(a)	Use of conversion factor of 1 eV = 1.6×10^{-19} J Equate kinetic energy to electric potential energy at distance of closest approach **Or** equates potential at point of closest approach to E_k/Q Use of $V = \frac{Q}{4\pi\varepsilon_0 r}$ with $W = QV$ [must be correct values of Q] $r = 4.1 \times 10^{-14}$ m 1 <u>Example of calculation</u> $E_k = 5.52 \times 10^6 \times 1.6 \times 10^{-19}$ J MeV^{-1} $= 8.83 \times 10^{-13}$ J $r = \frac{79 \times 1.6 \times 10^{-19}\text{ C} \times 2 \times 1.6 \times 10^{-19}\text{ C}}{4\pi \times 8.85 \times 10^{-12}\text{ F m}^{-1} \times 8.83 \times 10^{-13}\text{ J}} = 4.12 \times 10^{-14}$ m	**(1)** **(1)** **(1)** **(1)**	**4**
15(b)	Use of $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ **or** $F = \frac{kQ_1 Q_2}{r^2}$ $F = 11$ N <u>Example of calculation</u> $F = \frac{79 \times 1.6 \times 10^{-19}\text{ C} \times 2 \times 1.6 \times 10^{-19}\text{ C}}{4\pi \times 8.85 \times 10^{-12}\text{ F m}^{-1} \times (5.68 \times 10^{-14}\text{ m})^2} = 11.3$ N	**(1)** **(1)**	**2**
	Total for question 15		**6**

Question Number	Answer	Mark
*16	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.	6

IC points	IC mark	Max linkage mark	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

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

Indicative content

IC1 There is a change in flux linkage (with the coil)
Or the wires cut the magnetic field (lines) ignore magnet cuts lines no marks, but doesn't prevent subsequent marks, e.g. for change in flux linkage.

IC2 The greater the rate of change of flux linkage the larger the induced e.m.f.

IC3 After the south pole reaches the coil the flux linkage (starts to) decrease
Or When the south pole reaches the coil, by Lenz's law the polarity of the coil changes to continue to resist the motion of the magnet
Or As the south pole reaches the coil the rate of change of flux linkage is zero
(Not direction of field lines opposite)(reference to wires move along field lines for no change in flux linkage)

IC4 As the south pole of the magnet passes through the coil the (induced) e.m.f. is negative

IC5 The (downwards) speed of the magnet increases

IC6 Emf is zero before magnet enters coil
Or Emf is zero when midpoint of magnet in coil
Or Maximum negative value is greater than maximum positive value
Or Time for which emf is negative is greater than time for which emf is positive
Or emf is zero when magnet totally leaves coil

	Total for question 16	**6**

Question Number	Answer		Mark
17(a)	Use of $\varphi = BA$ with $A = dl$ and $l = vt$	**(1)**	
	Use of $\varepsilon = -\frac{d(N\varphi)}{dt}$	**(1)**	
	$\varepsilon = 3.9 \times 10^{-4}$ V	**(1)**	**3**
	<u>Example of calculation</u> $\varphi = BA = B \times d \times l = B \times d \times v \times t$ $N = 1$ $\varepsilon = \frac{d\varphi}{dt} = \frac{B \times d \times v \times t}{t} = B \times d \times v$ $\varepsilon = 0.15 \text{ T} \times 7.5 \times 10^{-2} \text{ m} \times 3.5 \times 10^{-2} \text{ m s}^{-1} = 3.94 \times 10^{-4} \text{ V}$		
17(b)	(By Lenz's law, if there were a complete circuit) the (direction of the) induced e.m.f. is such as to oppose the change that produces it	**(1)**	
	(With a current) there would be a force to the right (opposing the motion) **Or** There would be a force in the direction opposite to the motion	**(1)**	
	So e.m.f. is from P to Q	**(1)**	**3**
	Total for question 17		**6**

Question Number	Answer		Mark
18(a)	Two corresponding pairs of values of V and t read from graph	(1)	4
	Use of $V = V_0 e^{-\frac{t}{RC}}$ **Or** Use of ln V = ln $V_0 - \frac{t}{CR}$	(1)	
	C= 497 (μF) (Range 463 μF to 520 μF)	(1)	
	Comparison of calculated value to tolerance calculated using 10% and conclusion as to whether it is in tolerance **Or** use of difference between calculated and labelled value to calculate percentage difference and conclusion as to whether it is in tolerance	(1)	
	<u>OR</u> Use of $V = V_0 / e$ (4.4 V) to find time constant (74 s) **Or** intercept with t axis using initial tangent to find time constant	(1)	
	Use of time constant = RC	(1)	
	C= 493 (μF) (Range 463 μF to 520 μF)	(1)	
	Comparison of calculated value to tolerance calculated using 10% and conclusion as to whether it is in tolerance **Or** use of difference between calculated and labelled value to calculate percentage difference and conclusion as to whether it is in tolerance	(1)	
	<u>Example of calculation</u> $\frac{4.1\text{ V}}{12\text{ V}} = \text{e}^{-\frac{80\text{ s}}{150 \times 10^3\ \Omega \times C}}$ $C = -\frac{80\text{ s}}{150 \times 10^3\ \Omega \times \ln\left(\frac{4.1\text{ V}}{12\text{ V}}\right)} = 4.97 \times 10^{-4}\text{ F}$ Largest C = 1.1 × 470 μF = 517 μF The capacitance is 497 μF which is less than the maximum value of 517 μF, so value is within tolerance		

18(b)	Use of $W = \frac{1}{2}.\frac{Q^2}{C}$ Use of $W = \frac{1}{2}CV^2$ Calculates ratio of energies stored and makes comparison to 1000 and suitable conclusion **Or** Applies factor of 1000 to one calculated energy and makes comparison to the other energy and suitable conclusion <u>Example of calculation</u> $W = \frac{1}{2}.\frac{(56\text{ C})^2}{47\text{ F}} = 33.4\text{ J}$ $W = \frac{1}{2} \times 470 \times 10^{-6} \times (12\text{ V})^2 = 0.0338\text{ J}$ $\text{Ratio} = \frac{33.4\text{ J}}{0.0338\text{ J}} = 987$ Ratio of energies stored is 990 which is close to 1000, so claim is accurate	**(1)** **(1)** **(1)**	**3**
	Total for question 18		**7**

Question Number	Answer		Mark
19(a)	Use of $p = mv$	(1)	
	Use of trigonometrical function for *x* or *y* component of momentum for either stone	(1)	
	Applies conservation of momentum in *x* direction or *y* direction	(1)	
	v = 1.32 (m s^{-1}) (3 sf reqd) if *x* components considered Or v = 1.33 (m s^{-1}) (3 sf reqd) if *y* components considered	(1)	4
	<u>Example of calculation</u> $p = 19.1 \text{ kg} \times 0.87 \text{ m s}^{-1} = 16.6 \text{ kg m s}^{-1}$ y component for upper stone $= 16.6 \text{ kg m s}^{-1} \times \sin 50^{o} = 12.7 \text{ kg m s}^{-1}$ y component for lower stone $= 12.7 \text{ kg m s}^{-1} = 19.1 \text{ kg} \times v \sin 30^{o}$ $v = \frac{12.7 \text{ kg m s}^{-1}}{0.5 \times 19.1 \text{ kg}} = 1.33 \text{ m s}^{-1}$		
19(b)	Use of $E_k = \frac{1}{2}mv^2$ **Or** use of $E_k = \frac{p^2}{2m}$	(1)	
	Correct calculation of one kinetic energy (e.c.f from (a))	(1)	
	Comparison and conclusion consistent with correctly calculated values of kinetic energy	(1)	3
	<u>Example of calculation</u> $E_{\text{k}} = \frac{1}{2} \times 19.1 \text{ kg} \times (1.7 \text{ m s}^{-1})^2 = 27.6 \text{ J}$ before $E_{\text{k}} = \frac{1}{2} \times 19.1 \text{ kg} \times (0.87 \text{ m s}^{-1})^2 + \frac{1}{2} \times 19.1 \text{ kg} \times (1.33 \text{ m s}^{-1})^2$ $\therefore E_k = 7.2 \text{ J} + 16.9 \text{ J} = 24.1 \text{ J}$ after Initial E_{k} = 28 J so kinetic energy is not the same and collision is not elastic		
	Total for question 19		**7**

Question Number	Answer		Mark
20(a)	Use of $C = 4\pi\varepsilon_0 r$	**(1)**	
	Use of $Q = CV$	**(1)**	
	Use of $E = \frac{V}{d}$	**(1)**	
	Use of $F = EQ$	**(1)**	
	$F = 1.6 \times 10^{-3}$ N	**(1)**	**5**
	<u>Example of calculation</u> $C = 4\pi \times 8.85 \times 10^{-12}$ F m^{-1} $\times 3.5 \times 10^{-2}$ m $= 3.89 \times 10^{-12}$ F $Q = 3.89 \times 10^{-12}$F $\times 4500$ V $= 1.75 \times 10^{-8}$ C $E = \frac{4500 \text{ V}}{5.0 \times 10^{-2} \text{ m}} = 9.0 \times 10^4$ V m^{-1} $F = 9.0 \times 10^4$ N C^{-1} $\times 1.75 \times 10^{-8}$ C $= 1.58 \times 10^{-3}$ N		
20(b)	When the sphere touches the plate it is charged with the same polarity	**(1)**	
	The force on the sphere due to the electric field is away from that plate so it moves towards the opposite plate **Or** the sphere is repelled from the plate with the charge of the same sign **Or** the sphere is attracted towards the plate with opposite charge	**(1)**	
	When the sphere touches the charged plate opposite the first it becomes oppositely charged and is repelled from that charged plate (and so on) **Or** When the sphere touches the oppositely charged plate it becomes oppositely charged and is attracted to the first plate (and so on)	**(1)**	**3**
20(c)	(The bell connected to the lightning conductor becomes positively charged so) <u>electrons</u> are attracted to the right-hand side of the sphere	**(1)**	
	The sphere is attracted to the positively charged bell [MP2 dependent on award of MP1]	**(1)**	**2**
	Total for question 20		**10**

Question Number	Answer		Mark
21(a)	$u\bar{d}$ **Or** $d\bar{u}$ **Or** $u\bar{u}$ **Or** $d\bar{d}$	**(1)**	**1**
21(b)	MAX 2 conservation laws (Conservation of) charge $-1 \rightarrow -1 + 0$ Dependent on MP1 (Conservation of) lepton number $0 \rightarrow 1 + -1$ Dependent on MP3 (Conservation of) baryon number $0 \rightarrow 0 + 0$ Dependent on MP5	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
21(c)	Conversion of eV to J Use of $\Delta E = c^2 \Delta m$ $m = 1.9 \times 10^{-28}$ (kg) <u>Example of calculation</u> $m = 106 \text{ MeV} \times 10^6 \times 1.6 \times 10^{-19} \text{J eV}^{-1} = 1.70 \times 10^{-11} \text{ J}$ $m = \frac{1.70 \times 10^{-11} \text{ J}}{(3.0 \times 10^8)^2} = 1.88 \times 10^{-28} \text{ kg}$	**(1)** **(1)** **(1)**	**3**
21(d)	(When $v = 0.99c$) relativistic effects will be significant **Or** (When $v = 0.99c$) time dilation occurs The lifetime (of high energy pions) would be longer (than for pions at rest) MP2 dependent on MP1	**(1)** **(1)**	**2**
	Total for question 21		**10**

Question Number	Answer		Mark
22(a)	There is a (resultant) force on the electrons in the vertical direction	**(1)**	
	So the electrons are accelerated vertically	**(1)**	
	But in the horizontal direction the electrons have a constant speed	**(1)**	**3**
22(b)(i)	Use of $W = QV$	**(1)**	
	Use of $E_K = \frac{1}{2}mv^2$	**(1)**	
	$v = 1.73 \times 10^7$ (m s^{-1})(minimum 3 sf required)	**(1)**	**3**
	<u>Example of calculation</u> $E_K = 1.6 \times 10^{-19}\ \text{C} \times 850\ \text{V} = 1.36 \times 10^{-16}\ \text{J}$ $v = \sqrt{\frac{2 \times 1.6 \times 10^{-19}\ \text{C} \times 850\ \text{V}}{9.11 \times 10^{-31}\ \text{kg}}} = 1.73 \times 10^7\ \text{m s}^{-1}$		
22(b)(ii)	Use of $s = ut$	**(1)**	
	Use of $F = EQ$	**(1)**	
	Use of $F = ma$	**(1)**	
	Use of $s = ut + \frac{1}{2}at^2$	**(1)**	
	$s = 0.028$ m (Allow ecf from (b)(i))	**(1)**	**5**
	<u>Example of calculation</u> $t = \frac{7.5 \times 10^{-2}\ \text{m}}{1.73 \times 10^7\ \text{m s}^{-1}} = 4.34 \times 10^{-9}\ \text{s}$ $F = 1.7 \times 10^4\ \text{V m}^{-1} \times 1.6 \times 10^{-19}\ \text{C} = 2.72 \times 10^{-15}\ \text{N}$ $a = \frac{2.72 \times 10^{-15}\ \text{N}}{9.11 \times 10^{-31}\ \text{kg}} = 2.99 \times 10^{15}\ \text{m s}^{-2}$ $s = \frac{1}{2} \times 2.99 \times 10^{15}\ \text{m s}^{-2}\ (4.34 \times 10^{-9}\ \text{s})^2 = 0.028\ \text{m}$		

22(b)(iii)	Use of $F = BQv \sin\theta$ with $F = \frac{mv^2}{r}$ to obtain $\frac{e}{m} = \frac{v}{Br}$ **Or** Use of $p = mv$ with $r = \frac{p}{BQ}$ to obtain $\frac{e}{m} = \frac{v}{Br}$ **(1)** $\frac{e}{m} = 1.65 \times 10^{11}$ C kg^{-1} (ecf from (b)(i)) **(1)** Substitutes standard values into $\frac{e}{m}$ **(1)** Standard value of $\frac{e}{m} = 1.76 \times 10^{11}$ C kg^{-1} calculated **and** comparison with experimental value **and** clear conclusion **(1)** <u>Example of calculation</u> $\frac{e}{m} = \frac{1.73 \times 10^{7} \text{ m s}^{-1}}{3.0 \times 10^{-3} \text{ T} \times 3.5 \times 10^{-2} \text{ m}} = 1.65 \times 10^{11} \text{ C kg}^{-1}$ $\frac{e}{m} = \frac{1.6 \times 10^{-19} \text{ C}}{9.11 \times 10^{-31} \text{ kg}} = 1.76 \times 10^{11} \text{ C kg}^{-1}$	4
	Total for question 22	**15**