Mark Scheme (Results)

October 2020

Pearson Edexcel GCE
In Physics (WPH04/01)
Paper 4: Physics On The Move

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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.

Quality of Written Communication

- Questions which involve the writing of continuous prose will expect candidates to:
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- • write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- • select and use a form and style of writing appropriate to purpose and to complex subject matter
- • organise information clearly and coherently, using specialist vocabulary when appropriate.
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- Full marks will be awarded if the candidate has demonstrated the above abilities.
- Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

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. '<u>resonance</u>'
- 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].
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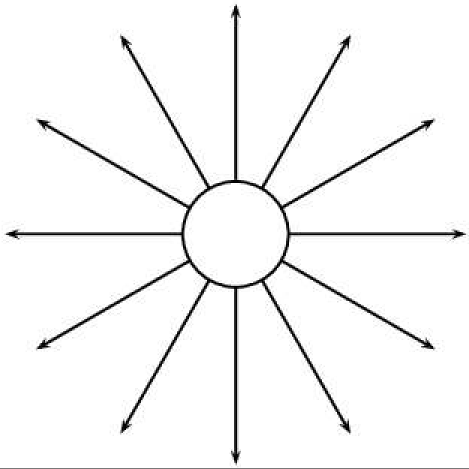
- **3. Significant figures**
- 3.1 Use of too many significant figures in the theory questions will not be prevent a mark being awarded if the answer given rounds to the answer in the MS.
- 3.2 Too few significant figures will mean that the final mark cannot be awarded in 'show that' questions where 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.

Question Number	Answer	Mark
1	C	**1**
2	A	**1**
3	A	**1**
4	A	**1**
5	B	**1**
6	C	**1**
7	D	**1**
8	C	**1**
9	B	**1**
10	D	**1**

Question Number	Answer	Mark
11(a)(i)	Arrow pointing radially away from nucleus starting on the path at closest point to the nucleus **(1)**	**1**
11(a)(ii)	Deflection starts earlier **(1)** Final deflection is greater (paths should diverge) **(1)**	**2**
11(b)	Charge is conserved **(1)** The proton and positron are both positively charged and the neutron uncharged **(1)** [Allow 1 = 0 + 1 + 0 for MP2, dependent upon MP1]	**2**
	Total for question 11	**5**

Question Number	Answer	Mark
12(a)	So that charge does not flow through it **(1)** **Or** So that sphere does not discharge **(1)** **Or** So that sphere's charge does not change **(1)**	**1**
12(b)	Equally spaced radial field lines pointing away from sphere [at least 4 lines] **(1)** Field lines start at surface [no lines within sphere] **(1)** Example of diagram: 	**2**
12(c)	Use of $C = 4\pi\varepsilon_0 r$ **(1)** Use of $C = \frac{Q}{V}$ **(1)** Use of $E = kQ / r^2$ **(1)** E =4500 N C^{-1} **(1)** <u>Example of calculation</u> $C = 4\pi \times 8.85 \times 10^{-12}$ F $m^{-1} \times 0.03$ m $=3.34\times10^{-12}$ F $Q = 3.34 \times 10^{-12}\ F \times 1500\ V = 5.01 \times 10^{-9}$C $E = 8.99 \times 10^9$ N m^2 $C^{-2} \times 5.0 \times 10^{-9}$ C $\div$ $(0.1\ m)^2$ = 4495 N C^{-1}	**4**
	Total for question 12	**7**

Question Number	Answer		Mark
13(a)	To reduce the effect of random errors	**(1)**	**1**
13(b)(i)	Use of $E_k = \frac{1}{2}mv^2$ and $\Delta E_{grav} = mg\Delta h$ v = 1.8 (m s^{-1}) <u>Example of calculation</u> $v = \sqrt{2 \times 9.81 \text{ N kg}^{-1} \times 0.16 \text{ m}} = 1.77 \text{ m s}^{-1}$	**(1)** **(1)**	**2**
13(b)(ii)	Use of $p = mv$ Apply conservation of momentum v = 120 m s^{-1} [allow ECF from (b)(i)] <u>Example of calculation</u> $1.88 \times 10^{-3}\text{kg} \times v = (0.125 + 1.88 \times 10^{-3})\text{ kg} \times 1.77 \text{ m s}^{-1}$ $v = \frac{(0.125 + 1.88 \times 10^{-3})\text{ kg} \times 1.77 \text{ m s}^{-1}}{1.88 \times 10^{-3}\text{kg}} = 119 \text{ m s}^{-1}$	**(1)** **(1)** **(1)**	**3**
13 (b)(iii)	Use of $E_k = \frac{1}{2}mv^2$ E_k calculated before and after collision E_k values not the same, so not an elastic collision [allow use of values from (b)(ii)] [13.1 J is difference in energy] <u>Example of calculation</u> $E_{ki} = \frac{1}{2} \times 1.88 \times 10^{-3}\text{kg} \times (119 \text{ m s}^{-1})^2 = 13.3 \text{ J}$ $E_{kf} = \frac{1}{2} \times (0.125 + 1.88 \times 10^{-3})\text{kg} \times (1.77 \text{ m s}^{-1})^2 = 0.199 \text{ J}$	**(1)** **(1)** **(1)**	**3**
	Total for question 13		**9**

Question Number	Answer		Mark
14(a)	The capacitor discharges over a very short time so recording the p.d. variation manually would be inaccurate A data logger has a high sample rate (allow takes readings at a higher frequency) **Or** a data logger allows a large number of readings to be taken in a short space of time Also the data logger allows simultaneous readings (of p.d. and time) to be taken	**(1)** **(1)** **(1)**	**3**
14(b)(i)	R has units V A^{-1} and C has units C V^{-1} A has units C $s^{-1}$and substitution to show RC has units s (Allow use of base units. Allow working in quantities leading to t which is measured in seconds) <u>Example of calculation</u> RC has units V A^{-1} C V^{-1} = A^{-1} C = A^{-1} A s = s	**(1)** **(1)**	**2**
14(b)(ii)	Pair of values of V and t read from graph [e.g. V = 2.8 V, t = 1.5 s] Use of $V = V_0 e^{-t/RC}$ RC = 1.0 s **Or** State $V = V_0$/e after one time constant Use of $V = V_0$/e (for MP1 & MP2) RC = 1.0 s **Or** State $V = V_o/2$ after one half life Use of $T_{1/2}$ = ln2RC = 0.7 s (for MP1 & MP2) RC = 1.0 s **Or** Draw tangent to line at t = 0 s Read x intercept from graph RC = 1.0 s <u>Example of calculation</u> $2.8\text{ V} = 12\text{ V}e^{-1.5\text{ s}/RC}$ $\therefore \ln\frac{2.8\text{ V}}{12\text{ V}} = -\frac{1.5\text{ s}}{RC}$ $\therefore RC = \frac{-1.5\text{ s}}{-1.46} = 1.03\text{ s}$ [Range of times 1.00 to 1.10]	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
14(b)(iii)	Use of $T = RC$ $C = 4.6 \times 10^{-6}$ F (ECF from 14(b)(ii)) <u>Example of calculation</u> $C = \frac{T}{R} = \frac{1.0\text{ s}}{220 \times 10^3\ \Omega} = 4.55 \times 10^{-6}$ F [Range from 4.54 to 4.70]	**(1)** **(1)**	**2**
14 (b)(iv)	Use of $W = \frac{1}{2}QV$ and $Q = CV$ to calculate energy Use of $W = \frac{1}{2}QV$ and $Q = CV$ to calculate p.d. when energy is 50% Time for p.d. when energy is 50% (read from graph) t = 0.35 s	**(1)** **(1)** **(1)**	**3**

	Example of calculation $W = \frac{1}{2}QV = \frac{1}{2}CV^2$ $W \rightarrow \frac{W}{2} \therefore V^2 \rightarrow \frac{V^2}{2} \therefore V \rightarrow \frac{V}{\sqrt{2}} \therefore V = \frac{12}{\sqrt{2}} = 8.49\ V$	
	Total for question 14	**13**
Question Number	Answer	Mark
15(a)	Thermionic emission **(1)** **Or** electrons emitted from cathode/filament Electrons accelerated by potential difference between anode and cathode **Or** Electrons accelerated by electric field between anode and cathode **(1)** [Accept idea of electrons attracted to anode]	**2**
15(b)	Use of $qV = ½\ mv^2$ **(1)** $v = 8.9 \times 10^6$ (m s^{-1}) **(1)** Example of calculation 1.60×10^{-19} C × 225 V = ½ × 9.11 × 10^{-31} kg × v^2 $v = 8.89 \times 10^6$ m s^{-1}	**2**
15(c)(i)	Equates $F = mv^2/r$ and $F = BQv$ **(1)** Substitution of $p = mv$ and $q = e$ with algebra leading to conclusion **(1)** Example of derivation $F = mv^2/r$ and $F = BQv$ $mv^2/r = Bev$ $mv/r = Be$ $r = mv/Be$ so $r = p/Be$	**2**
15 (c)(ii)	Use of $r=p/BQ$ **(1)** $B = 6.5 \times 10^{-4}$ T (ecf of v from (b)) **(1)** Example of calculation $B = \frac{p}{er} = \frac{9.11\times10^{-31}\ \text{kg} \times 8.9\times10^{6}\ \text{m s}^{-1}}{1.6\times10^{-19}\ \text{C} \times 0.155\ \text{m}/2} = 6.53 \times 10^{-4}\ \text{T}$	**2**
15(c)(iii)	The magnetic force is much greater than the weight **(1)** **Or** Weight is insignificant compared to magnetic force **(1)**	**1**
	Total for question 15	**9**

Question Number	Answer	Mark
***16 (a)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) The varying current in the **charger coil** produces varying magnetic field **(1)** So there is a changing flux linkage with **toothbrush coil** **(1)** An <u>e.m.f.</u> is <u>induced</u> across the toothbrush coil **(1)** This produces a current in the **battery circuit** **(1)**	**4**
***16(b)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) There is a current in the coil **(1)** A force is exerted on the coil as it is in a magnetic field **(1)** The forces on the sides of the coil are in opposite directions **(1)** The force on the LHS of the coil is upwards and that on the RHS downwards, (hence the forces cause a turning action on the coil) **Or** The forces cause the coil to rotate clockwise **(1)**	**4**
16 (c)	Use of $\omega = \frac{2\pi}{T}$ **(1)** Use of $v = \omega r$ **(1)** v = 1.9 m s^{-1} **(1)** <u>Example of calculation</u> $\omega = \frac{5.5 \times 10^3 \times 2\pi \text{ rad}}{60 \text{ s}} = 576 \text{ rad s}^{-1}$ $v = 576 \text{ rad s}^{-1} \times 3.25 \times 10^{-3} \text{m} = 1.87 \text{ m s}^{-1}$	**3**
	Total for question 16	**11**

Question Number	Answer	Mark
17(a)	Charge on Σ_{b1} = (+) e **(1)** Charge on Σ_{b2} = $-e$ **(1)** (Max 1 mark if charge not in terms of e) <u>Example of calculation</u> Charge on $\Sigma_{b1} = -\frac{e}{3} + \frac{e}{3} + \frac{e}{3} = +e$ Charge on $\Sigma_{b2} = -\frac{e}{3} - \frac{e}{3} - \frac{e}{3} = -e$	**2**
17 (b)(i)	Use of $\Delta E = c^2 \Delta m$ **(1)** Conversion of (G)eV to J **(1)** $m = 1.08 \times 10^{-26}$ (kg) **(1)** <u>Example of calculation</u> $m = \frac{6.097 \times 10^{9}\ \text{eV} \times 1.6 \times 10^{-19}\ \text{J eV}^{-1}}{(3.00 \times 10^{8}\ \text{m s}^{-1})^2} = 1.084 \times 10^{-26}$ kg	**3**
17 (b)(ii)	Energy available for each photon = 6.097 GeV **Or** Use of $\Delta E = c^2 \Delta m$ **(1)** Use of $E = hf$ $f = 1.47 \times 10^{24}$ Hz **(1)** **(1)** <u>Example of calculation</u> $f = \frac{6.097 \times 10^{9}\ \text{eV} \times 1.6 \times 10^{-19}\ \text{J eV}^{-1}}{6.63 \times 10^{-34}\ \text{J s}} = 1.471 \times 10^{24}$ Hz	**3**
17(b)(iii)	Use of $c = f\lambda$ **(1)** Use of $\lambda = \frac{h}{p}$ **(1)** $p = 3.3 \times 10^{-18}$ N s (allow ecf from 17bii) **(1)** <u>Example of calculation</u> $\lambda = \frac{3.00 \times 10^{8}\ \text{m s}^{-1}}{1.47 \times 10^{24}\ \text{Hz}} = 2.04 \times 10^{-16}$ m $p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}\ \text{J s}}{2.04 \times 10^{-16}\ \text{m}} = 3.25 \times 10^{-18}$ N s	**3**
17(c)(i)	(Perpendicularly) out of the page **(1)**	**1**
17(c)(ii)	Proton has the same magnitude/size charge (as electron) **(1)** Proton has larger momentum, $r = \frac{p}{BQ}$ so r is larger for the proton **(1)**	**2**
17(c)(iii)	The <u>kinetic</u> energy of the electron decreases as it collides with atoms in the bubble chamber **(1)** Hence the speed and/or momentum of the electron decreases. **(1)**	**2**
	Total for question 17	**16**

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