Pearson Edexcel

Mark Scheme (Results)

January 2019

Pearson Edexcel International Advanced Level
In Physics (WPH04)
Paper 01 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:

- 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.

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].

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	**The only correct answer is B because *C = Q/V so* F = C/V** ***A*** *is not correct because this would be a unit Q/W* ***C*** *is not correct because this would be a unit for W/Q* ***D*** *is not correct because would be a unit forV/Q*	1
2	**The only correct answer is A because** **p.d. for each capacitor = $V/2$** **energy for each capacitor = $\frac{1}{2} C (V/2)^2 = C V^2/8$** **energy for pair of capacitors = $C V^2/4$** ***B*** *is not correct because this is the energy stored for a single capacitor with p.d. = V* ***C*** *is not correct because this is calculated without applying V/2* ***D*** *is not correct because this is 8 times the correct energy*	1
3	**The only correct answer is D because $E = V/d$ and $F = EQ$** ***A*** *is not correct because this includes (× d) instead of (÷ d)* ***B*** *is not correct because this is half the correct value, incorrectly using d/2 because Q is hallway between the plates* ***C*** *is not correct because this has reversed Q and d*	1
4	**The only correct answer is D because** **$I = F/Bl = 2 \times 10^{-3}$ N / (0.05 T × 0.1 m)** ***A*** *is not correct because this has been calculated using FBl* ***B*** *is not correct because this has been calculated using FBl with l = 10 (cm) instead of 0.1 (m)* ***C*** *is not correct because l = 10 (cm) has been used instead of 0.1 (m)*	1
5	**The only correct answer is A because mesons are made of quark-antiquark pairs and each quark in the anti-meson column is the antiquark of a quark in the meson column** ***B*** *is not correct because the same quarks have been used and not their respective antiquarks* ***C*** *is not correct because the particles contain more than a single quark and a single antiquark* ***D*** *is not correct because this pair represents a baryon and its corresponding anti-baryon*	1
6	**The only correct answer is D this calculation uses × e/c^2** ***A*** *is not correct because this calculation uses × e/c*	1

	B *is not correct because this calculation uses ÷ ec^2* ***C*** *is not correct because this calculation uses ×ec^2*	
7	**The only correct answer is B this shows pair production from a gamma photon in the presence of a massive particle with no track until X** ***A*** *is not correct because the particles do not move in opposite directions at point X* ***C*** *is not correct because the particles a gamma photon cannot exist at rest* ***D*** *is not correct because the charges of the particles have not been stated*	1
8	**The only correct answer is C because this is calculated using 1200 × 2π /60 s** ***A*** *is not correct because this is calculated using 1200 / 60 s* ***B*** *is not correct because this is calculated using 1200 × π / 60 s* ***D*** *is not correct because this is calculated using 1200 / 2π*	1
9	**The only correct answer is B because $E_K = p^2/2m$ *and doubling mass and momentum doubles* E_K** ***A*** *is not correct because this represents no change and could be concluded by failing to square p* ***C*** *is not correct because this result would be obtained by failing to double m* ***D*** *is not correct because this result would be obtained using $E_K = p^2 \times 2m$*	1
10	**The only correct answer is C because a positively charged particle could be used** ***A*** *is not correct because this is a reason for using electrons* ***B*** *is not correct because this is a reason for using electrons* ***D*** *is not correct because this is a reason for using electrons*	1

Question Number	Answer	Mark
11	Use of $F = \Delta(mv) / \Delta t$ **(1)** With 60 s for time correctly applied **(1)** Use of $v = \Delta v + 252 \text{ m s}^{-1}$ **(1)** $v = 372 \text{ m s}^{-1}$ **(1)** <u>Example of calculation</u> $138\,000 \text{ N} \times 60 \text{ s} = 34\,600 \text{ kg} \times 2 \times \Delta v$ $\Delta v = 120 \text{ m s}^{-1}$ $v = 120 \text{ m s}^{-1} + 252 \text{ m s}^{-1}$ $= 372 \text{ m s}^{-1}$	4
	Total for question 11	**4**

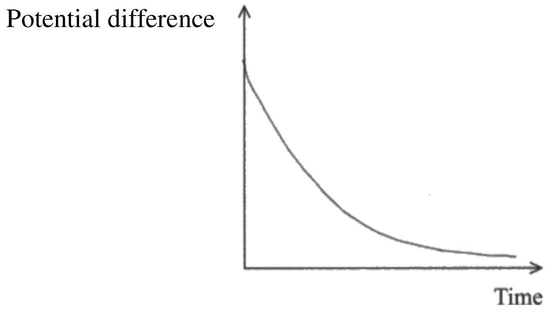
Question Number	Answer	Mark
12(a)	Electron is a <u>lepton</u> **(1)** Proton is a <u>baryon</u> **Or** Neutron is a <u>baryon</u> **(1)** Baryons made of 3 <u>quarks</u> **Or** Neutron made of 3 <u>quarks</u> **Or** Proton made of 3 <u>quarks</u> **(1)**	**3**
12(b)	Use of $\Delta E = c^2 \Delta m$ **(1)** $\Delta E = 1.20 \times 10^{-9}$ J **(1)** (Accept $\Delta E = 7.47 \times 10^9$ eV) <u>Example of calculation</u> $\Delta E = (3.00 \times 10^8 \text{ m s}^{-1})^2 \times 2 \times 6.64 \times 10^{-27}$ kg $= 1.20 \times 10^{-9}$ J	**2**
	Total for question 12	**5**

Question Number	Answer	Mark
13(a)	Use of $r = p/BQ$ **(1)** Use of $p = mv$ **(1)** Use of $v = 2\pi r/T$ and $f = 1/T$ **Or** Use of $\omega = v/r$ and $\omega = 2\pi r/T$ and $T = 1/f$ **(1)** $f = 190$ (kHz) **(1)** **Or** Use of $F = Bqv$ **(1)** Use of $F = mv^2/r$ **(1)** Use of $v = 2\pi r/T$ and $f = 1/T$ **Or** Use of $\omega = v/r$ and $\omega = 2\pi r/T$ and $T = 1/f$ **(1)** $f = 190$ (kHz) **(1)** <u>Example of calculation</u> $r = 4 \times 10^5 \text{ m s}^{-1} \times 9.11 \times 10^{-31} \text{ kg} / 6.8 \times 10^{-6} \text{ T} \times 1.60 \times 10^{-19} \text{ C}$ $= 0.335 \text{ m}$ $T = 2\pi \times 0.335 \text{ m} / 4 \times 10^5 \text{ m s}^{-1} = 5.26 \times 10^{-6} \text{ s}$ $f = 1/ 5.26 \times 10^{-6} \text{ s}$ $f = 190 \text{ kHz}$	**4**
13(b)	(According to FLHR) horizontal force on electron (into the page) (as horizontal component perpendicular to field) **Or** force on electron into the page **(1)** Force perpendicular to path results in circular motion **Or** Force perpendicular to path acts as centripetal force **(1)** Component of motion downwards is unaffected as it is parallel to field lines **Or** There are no downward forces so vertical motion is unaffected **(1)**	**3**
	Total for question 13	**7**

Question Number	Answer	Mark
14(a)	Use of $E_P = mg\Delta h$ **(1)** Use of $E_K = ½\, mv^2$ **(1)** v = 1.1 (m s^{-1}) **(1)** <u>Example of calculation</u> E_P = 0.15 kg × 9.81 N kg^{-1} × 0.060 m = 0.088 J 0.088 J = ½ × 0.15 kg × v^2 v = 1.08 m s^{-1}	**3**
14(b)	Use of $p = mv$ **(1)** Use of conservation of momentum **(1)** v = 174 m s^{-1} so legal (ecf from (a)) **(1)** <u>Example of calculation</u> p = 0.15 kg × 1.08 m s^{-1} = 0.162 kg m s^{-1} v = 0.162 kg m s^{-1} / 0.00093 kg = 174.2 m s^{-1}	**3**
14(c)	For pellet, E_K = 14 J **(1)** Comparison of their values and concludes that collision not elastic **(1)** (Allow ecf from (a) and (b)) <u>Example of calculation</u> For pellet, E_K = ½ × 0.00093 kg × (174 m s^{-1})^2 = 14 J 14 J > 0.088 J	**2**
	Total for question 14	**8**

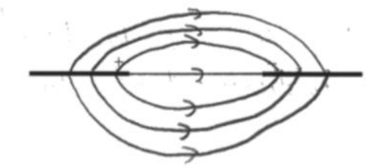
Question Number	Answer		Mark
*15(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Current in primary produces a magnetic field When switch opened (the current in primary falls) and there is a change in magnetic flux linkage in the secondary **Or** When switch opened (the current in primary falls) and lines of flux cut the secondary coils <u>E.m.f.</u> is <u>induced</u>	 **(1)** **(1)** **(1)**	**3**
15(b)	Use of $\varphi = BA$ **Or** Use of $N\varphi = NBA$ Use of e.m.f. = $(-)N\Delta\varphi/\Delta t$ $\Delta t = 4.0 \times 10^{-3}$ s <u>Example of calculation</u> $\varphi = 7.4 \text{ T} \times 1.4 \times 10^{-3} \text{ m}^2$ e.m.f. = $(42\,000 \times 7.4 \text{ T} \times 1.4 \times 10^{-3} \text{ m}^2) / \Delta t$ $\Delta t = 3.96 \times 10^{-3}$ s	**(1)** **(1)** **(1)**	**3**
15 (c)(i)	Use of (E =) V/d for values from table Answer less than $3 \times 10^6 \text{ V m}^{-1}$, (so cannot be uniform) **Or** Values not constant, (so cannot be uniform) **OR** V is not proportional to d an example comparing data from two rows in the table <u>Example of calculation</u> $E = 110 \times 10^3 \text{ V} / 0.1 \text{ m}$ $= 1.1 \times 10^6 \text{ V m}^{-1}$ Other values from table: $7.5 \times 10^5 \text{ V m}^{-1}$, $6.3 \times 10^5 \text{ V m}^{-1}$, $5.8 \times 10^5 \text{ V m}^{-1}$	**(1)** **(1)** **(1)** **(1)**	**2**
15(c)(ii)	Shape as for opposite point charges, at least three lines, at least one above and one below the midline Direction of arrows (plus to minus) <u>Example of diagram</u> 	**(1)** **(1)**	**2**
	Total for question 15		**10**

Question Number	Answer	Mark
16 (a)	To prevent alpha particles interacting with air molecules/particles **(1)** Which could have: **Or** resulted in alpha particles striking the foil from a different angle **Or** stopped alpha particles from reaching the foil or reaching the screen **(1)**	**2**
16(b)	Alpha particles need a large (electrostatic) force/field to deflect them through angles greater than 90° **(1)** (very) few were close enough to the charge so the space occupied must be very small **Or** a strong enough (electrostatic) field can only be formed by a high concentration of charge **Or** a strong enough (electrostatic) force can only be exerted by a high concentration of charge **(1)**	**2**
*16 (c)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Greater angle/deflection with greater proton number **(1)** Greater proton number means a greater charge **(1)** More charge means a greater repulsive/deflecting force, so more deflection **(1)**	**3**
16(d)	Use of $F = kQ_1Q_2 / r^2$ **(1)** Equates to $F = mv^2/r$ with substitution **(1)** Use of $\lambda = h/p$ **and** $p = mv$ **(1)** $\lambda = 3.33 \times 10^{-10}$ m **(1)** $C = 2\pi r = 3.32 \times 10^{-10}$ m **(1)** <u>Example of calculation</u> $F = 8.99 \times 10^{9}$ N m^2 C^{-2} $\times (1.60 \times 10^{-19}$ C$)^2$ / $(5.29 \times 10^{-11}$ m$)^2$ $F = 8.22 \times 10^{-8}$ N $= 9.11 \times 10^{-31}$ kg v^2/ 5.29×10^{-11} m $v = 2.19 \times 10^{6}$ m s^{-1} $p = 9.11 \times 10^{-31}$ kg $\times 2.19 \times 10^{6}$ m s^{-1} $= 1.99 \times 10^{-24}$ N s $\lambda = 3.33 \times 10^{-10}$ m $C = 2\pi r = 3.32 \times 10^{-10}$ m	**5**
	Total for question 16	**12**

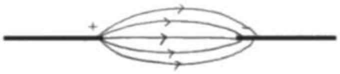
Question Number	Answer	Mark
***17(a)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Capacitor charges when S_1 moves to position 1 **(1)** Capacitor starts to discharge when S_1 moves to position 2 **(1)** Capacitor stops discharging when S_2 is opened **Or** Final V used with $V = V_o e^{-t/RC}$ **(1)**	**3**
17(b)(i)	Use of $V = V_o e^{-t/RC}$ **Or** Use of $\ln V = \ln V_0 - t/RC$ **(1)** $t = 0.21$ (s) **(1)** <u>Example of calculation:</u> $V = V_o e^{-t/RC}$ $0.7 \text{ V} = 6.0 \text{ V } e^{-t/370\ \Omega \times 0.00027\ \text{F}}$ $t = 0.21$ s	**2**
17(b)(ii)	Non-zero intercept on y axis and p.d. decreasing **(1)** Exponential curve i.e. decreasing gradient, but not reaching x-axis **(1)** <u>Example of graph:</u>  	**2**
17b(iii)	More sensitive means a bigger change in p.d. for a given change in time **(1)** Requires the gradient (at that time) to be greater **(1)** This requires the time constant to be close(r) to the approximate reaction time **Or** If time constant too small it will be nearly discharged **Or** If time constant too large the p.d. will be changing too slowly **(1)** Increase the resistance/capacitance **(1)** **Or** More sensitive means a bigger change in p.d. for a given change in time **(1)** Requires the gradient (at that time) to be greater **(1)** Because the gradient at a given time is proportional to the initial p.d. **(1)** Increase the initial p.d. **(1)**	**4**
	Total for question 17	**11**

Question Number	Answer	Mark
18(a)	Mass numbers correct with 4 neutrons **(1)** Atomic numbers correct **(1)** $^{1}_{1}p + ^{85}_{37}Rb \rightarrow ^{82}_{38}Sr + 4 \times ^{1}_{0}n$	**2**
18(b)(i)	Adjacent drift tubes have opposite potentials/polarity/charge **(1)** There is an electric field between drift tubes **Or** There is an electric field in the gaps **(1)** This exerts a force on protons (and causes acceleration) **(1)** Idea that while the protons are traveling through a particular drift tube, the polarity reverses (so that once they reach the next gap they are again accelerated down the linac) **(1)**	**4**
18(b)(ii)	Conversion from MeV to J **(1)** Use of $E_K = ½ mv^2$ **Or** Use of $E_K = p^2/2m$ **and** $p = mv$ **(1)** Use of time = 1/frequency **(1)** Use of $s = vt$ **(1)** $s = 4.9$ cm **(1)** Example of calculation $E_K = 3.2 \times 10^{-13}$ J $v = \sqrt{(2 \times 3.2 \times 10^{-13} \text{ J} / 1.67 \times 10^{-27} \text{ kg})} =$ $v = 1.96 \times 10^{7}$ m s^{-1} $T = 1/ 198$ MHz $= 5.1 \times 10^{-9}$ s From A to B is half a cycle of the a.c., so $t = 5.1 \times 10^{-9}$ s / 2 $s = 1.96 \times 10^{7}$ m s^{-1} $\times 5.1 \times 10^{-9}$ s / 2 = 4.9 cm	**5**
18(b)(iii)	The time between accelerating sections is shorter (with a higher frequency) **Or** The time in the drift tubes is shorter **(1)** So it is possible to reach high speed/acceleration with a shorter linac **Or** So it is possible to reach greater speed/acceleration with the same length **Or** It is possible to use greater electric field strength between tubes **(1)**	**2**
	Total for question 18	**13**

15cii examples



2 (allow touching along the rods)



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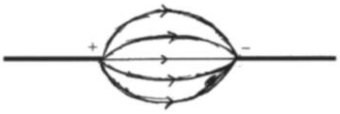
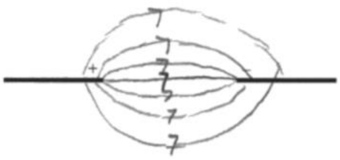


2

1 (only one line)

2



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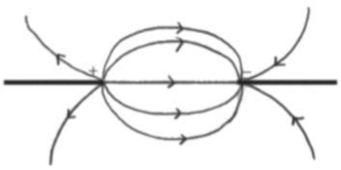

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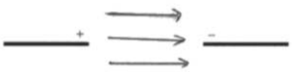
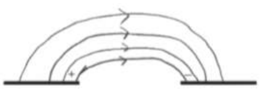
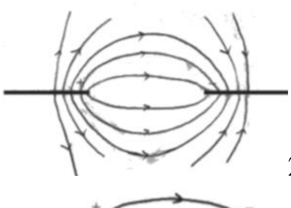


1 (only straight lines, not touching rods)



1 (only on one side of the centre line)



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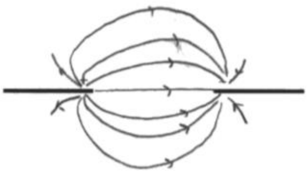
2



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