

Mark Scheme (Results)

October 2018

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. 'resonance'
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
	The only correct answer is D because an electron is a lepton. A Is not correct because a pion is a type of hadron called a meson, so it is not a fundamental particle, because it is made up of quarks, so it cannot be a lepton B Is not correct because a photon is a massless gauge boson in the electroweak interaction, and therefore not a lepton C Is not correct because a neutron is a type of hadron called a baryon, so it is not a fundamental particle, because it is made up of quarks, so it cannot be a lepton	**1**
2	**The only correct answer is D** because moving the coils further apart decreases their maximum flux linkage and therefore the maximum rate of change of flux linkage and maximum e.m.f. A Is not correct because increasing the frequency increases the maximum rate of change of flux linkage and therefore the maximum e.m.f. B Is not correct because increasing the magnitude of the current increases the maximum magnetic flux density and therefore increases the maximum rate of change of flux linkage and therefore the maximum e.m.f. C Is not correct because increasing the number of turns increases their maximum flux linkage and therefore the maximum rate of change of flux linkage and maximum e.m.f.	**1**
3	**The only correct answer is C** because this is the rate of change of momentum A Is not correct because this represents the weight of the cases B Is not correct because this is the total change in momentum D Is not correct because this is the momentum of one case multiplied by time and divided by the number of cases instead of the momentum of one case multiplied by the number of cases and divided by time	**1**
4	**The only correct answer is A** because this shows the initial momentum in the direction across the page is equal to the sum of the components of momentum in that direction after the collision B Is not correct because the angles used for the components of momentum have been applied to the wrong bodies C Is not correct because the components in the direction up the page have been summed instead of the components across the page D Is not correct because sine would be used to determine the components of momentum in the direction up the page **and** the angles used apply to the opposite bodies	**1**

5	**The only correct answer is C** because this shows that the sum of the kinetic energy of the particles after the collision is equal to the kinetic energy before the collision. A is not correct because this uses components of velocity in kinetic energy calculations B Is not correct because this uses components of velocity in kinetic energy calculations D Is not correct because this uses the sum of the masses and also squares either the sum of the magnitudes of velocity or the vector sum of the velocities (it isn't specified), rather than the individual masses and velocities	**1**
6	**The only correct answer is C** because the deflections observed would be possible for a positively charged particle passing around a negatively charged particle and because protons were not known at that time A is not correct because this conclusion could be made from the deflection of alpha particles through greater than 90° B Is not correct because this conclusion could be made from the low rate of alpha particle deflection D Is not correct because this conclusion could be made from the observation of alpha particle deflection by different angles	**1**
7	**The only correct answer is D** because these are the correct values for $F = BIl\sin\theta$ and, by Fleming's left hand rule, the direction is out of the page A Is not correct because the direction is incorrect and $\sin\theta$ has not been included B Is not correct because the direction is incorrect C Is not correct because $\sin\theta$ has not been included	**1**
8	**The only correct answer is B** because this has been calculated using $4.8 \times 10^6 \times 1.6 \times 10^{-19}$ C $\div (3.0 \times 10^8$ m s$^{-1})^2$ A Is not correct because this has been calculated with eV rather than MeV, i.e. $4.8 \times 10^6 \times 1.6 \times 10^{-19} \div (3.0 \times 10^8$ m s$^{-1})^2$ C Is not correct because the value of c has not been squared, i.e. $4.8 \times 10^6 \times 1.6 \times 10^{-19}$ C $\div 3.0 \times 10^8$ m s^{-1} D Is not correct because 1.6×10^{-19} C has been omitted, i.e. $4.8 \times 10^6 \times 1.6 \times 10^{-19}$ C $\div (3.0 \times 10^8$ m s$^{-1})$	**1**

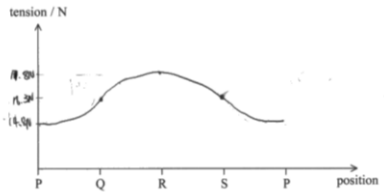
9	**The only correct answer is C** because the nucleus the element contains 7 neutrons and 7 protons, making 14 nucleons A Is not correct because this nucleus would contain 5 protons and 8 neutrons for a total of 13 nucleons B Is not correct because this nucleus would contain 6 protons and 9 neutrons for a total of 13 nucleons D Is not correct because this nucleus would contain 7 protons but 8 neutrons for a total of 15 nucleons	**1**
10	**The only correct answer is A** because the lambda particle is neutral but the products would have a charge of +1, violating conservation of charge, so the process is disallowed B Is not correct because the products are neutral and other conservation laws are obeyed so the process is not disallowed C Is not correct because the products are neutral and other conservation laws are obeyed so the process is not disallowed D Is not correct because the products are neutral and other conservation laws are obeyed so the process is not disallowed	**1**

Question Number	Answer		Mark
11(a)	Baryons have 3 quarks	**(1)**	
	sss, ssu, ssd, sdd, suu, sdu are the only possibilities	**(1)**	**2**
11(b)	Symmetry of the model **Or** There were believed to be the same number of types of quarks as the number of types of leptons **Or** There were believed to be the same number of generations of quarks as the number of generations of leptons	**(1)**	
	There were 6 types of leptons so there should be 6 types of quarks **Or** top and bottom were paired with the tau and tau neutrino **Or** There were 3 generations of leptons so there should be 3 generations of quarks	**(1)**	**2**
	Total for question 11		**4**

Question Number	Answer		Mark
12(a)	Use of $F = kQ_1Q_2 / r^2$ $F = 4.53 \times 10^{-10}$ N <u>Example of calculation</u> $F = 8.99 \times 10^9$ N m^2 C^{-2} $\times$ $(2.85 \times 10^{-20}$ C$)^2$ / $(1.27 \times 10^{-10}$ m$)^2$ $F = 4.53 \times 10^{-10}$ N	**(1)** **(1)**	**2**
12 (b)	Use of $E = kQ / r^2$ Correct calculation of field Correct use of Pythagoras **Or** Correct use of trigonometry $E_R = 4.49 \times 10^{10}$ N C^{-1} <u>Example of calculation</u> For one charge, $E = 8.99 \times 10^9$ N m^2 C^{-2} $\times$ 2.85×10^{-20} C / $(8.98 \times 10^{-11}$ m$)^2$ $E = 3.18 \times 10^{10}$ N C^{-1} $(E_R)^2 = (3.18 \times 10^{10}$ N C$^{-1})^2 + (3.18 \times 10^{10}$ N C$^{-1})^2$ $E_R = 4.49 \times 10^{10}$ N C^{-1}	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 12		**6**

Question Number	Answer	Mark
***13(a)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 3 from** Speed of particles is near the speed of light **Or** particles at relativistic speeds **(1)** Additional energy increases mass (not speed) **Or** $E_K = ½ mv^2$ no longer applies **(1)** The idea that the alternating accelerating p.d. is synchronised with the passage of the electrons from one tube to the next, e.g. reference to tubes switching polarity at fixed time intervals **(1)** Time spent in each drift tube is constant and speed is constant (so length must be constant) **(1)**	**3**
***13(b)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 4** For the colliding particles the total momentum before collision is zero **Or** For the stationary target the total momentum before collision is non-zero **(1)** Momentum is conserved **(1)** So, for the colliding particles, the total momentum after collision is zero **Or** So, for the stationary target, the total momentum after collision is non-zero **(1)** For the colliding particles this allows all of the energy to be used to create new particles **Or** For the stationary target this means some of the energy is required for the kinetic energy of the particles created **(1)** For the colliding particles higher available energy means particles of greater mass can be created **Or** For the stationary target, less energy is available for particle creation so only lower mass particles can be created **(1)**	**4**
	Total for question 13	**7**

Question Number	Answer		Mark
14(a)	First part is charging, second part is discharging	**(1)**	
	As V approaches the final value, the current decreases, so V changes more slowly **Or** When charging $V = V - V_0 e^{-t/RC}$ **and** when discharging $V = V_0 e^{-t/RC}$	**(1)**	**2**
14(b)(i)	Use of $V = V_0/e$ (1.48 V) to find time constant (range 0.18 s to 0.22 s) **Or** intercept with t axis using initial tangent to find time constant (range 0.18 s to 0.22 s)	**(1)**	
	Use of time constant = RC	**(1)**	
	$C = 1.2 \times 10^{-5}$ (F) to $C = 1.5 \times 10^{-5}$ (F)	**(1)**	
	Or		
	Attempts a pair of readings of V and t from graph	**(1)**	
	Use of $V = V_0 e^{-t/RC}$	**(1)**	
	$C = 1.2 \times 10^{-5}$ (F) to $C = 1.5 \times 10^{-5}$ (F)	**(1)**	
	Or		
	Attempts to obtain 'half-life' from graph	**(1)**	
	Use of $t_{½} = RC \ln 2$	**(1)**	
	$C = 1.2 \times 10^{-5}$ (F) to $C = 1.5 \times 10^{-5}$ (F)	**(1)**	
	Or		
	States time to fully charge/discharge $\approx 5RC$	**(1)**	
	Use of time constant = RC	**(1)**	
	$C = 1.3 \times 10^{-5}$ (F)	**(1)**	**3**
	Example of calculation 0.2 s = 15 000 Ω × C $C = 1.3 \times 10^{-5}$ F		
14(b)(ii)	Use of $Q = CV$ (ecf for C from (b)(i))	**(1)**	
	Use of $W = ½ QV$ (accept use of $W = ½ CV^2$ for MP1 and MP2)	**(1)**	
	$W = 1.0 \times 10^{-4}$ J	**(1)**	**3**
	Example of calculation $Q = 1.3 \times 10^{-5}$ F × 4.0 V = 5.2×10^{-5} C $W = ½ \times 5.2 \times 10^{-5}$ C × 4.0 V $W = 1.04 \times 10^{-4}$ J (Use of $C = 1 \times 10^{-5}$ F → 0.8×10^{-4} J)		
***14(c)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 3**		
	Time for the process is 2 s **or** Time for the process is short	**(1)**	
	Change too fast for humans to observe and take simultaneous readings	**(1)**	
	Insufficient time for a human to take multiple readings	**(1)**	
	Change too fast for voltmeter to respond	**(1)**	**3**
	Total for question 13		**11**

Question Number	Answer		Mark
15(a)	The moving wire would cut through lines of magnetic flux (Allow references to change in flux linkage) This induces an e.m.f. (across the ends of the wire)	**(1)** **(1)**	**2**
15(b)(i)	**Either** Use of $v = 2\pi r / T$ Use of $F = mv^2/r$ $F = 16$ N **Or** Use of $\omega = 2\pi / T$ **Or** Use of $\omega = 2\pi f$ Use of $F = m\omega^2 r$ $F = 16$ N Example of calculation $v = 2\pi \times 0.85$ m $\times$ 27 / 15 s = 9.61 m s^{-1} $F =$ 0.150 kg $\times$ (9.61 m s^{-1})^2 / 0.85 m = 16.3 N	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
15(b)(ii)	Use of $W = mg$ Max tension = 17.8 N **and** Min tension = 14.8 N (ecf from b(ii)) Graph shows min at P, max at R, min at P Smooth curve, able to join continuously with next cycle Example of calculation and graph $W = 0.15$ kg $\times$ 9.81 N kg^{-1} = 1.47 N Max = 16.3 N + 1.47 N = 17.8 N Min = 16.3 N − 1.47 N = 14.8 N  	**(1)** **(1)** **(1)** **(1)**	**4**
15(b)(iii)	Use of area of circle Application of flux = BA Use of e.m.f. = change in flux / time e.m.f. = 9.0 $\times$ 10^{-5} V Example of calculation Area = $\pi \times$ (0.85 m)^2 =2.27 m^2 Change of flux in one rotation = 2.2 $\times$ 10^{-5} T $\times$ 2.27 m^2 = 5.0 $\times$ 10^{-5} Wb Rate of change of flux = 5.0 $\times$ 10^{-5} Wb $\times$ 27 ÷ 15 s e.m.f. = 9.0 $\times$ 10^{-5} V	**(1)** **(1)** **(1)** **(1)**	**4**
15(c)	There would be an identical e.m.f. across the second wire The total e.m.f. in the circuit would therefore be zero (and there would be no current through the buzzer)	**(1)** **(1)**	**2**
	Total for question 15		**15**

Question Number	Answer		Mark
16(a)	Electrons gain energy from the heater	**(1)**	
	So electrons have enough energy to be released from the surface of the metal	**(1)**	**2**
	If neither MP1 nor MP2 awarded, allow 1 mark for - Electrons are produced by thermionic emission		
16(b)(i)	Use of $E_K = ½ mv^2$	**(1)**	
	Use of $W = QV$	**(1)**	
	$V = 1030$ V	**(1)**	**3**
	Example of calculation ke = ½ × 9.11 × 10^{-31} kg × (1.9 × 10^7 m s^{-1})^2 = 1.64 × 10^{-16} J V = 1.64 × 10^{-16} J / 1.60 × 10^{-19} C V = 1030 V		
16(b)(ii)	Use of correct trigonometrical function(s)	**(1)**	
	$v_v = 7.3 \times 10^6$ (m s^{-1})	**(1)**	**2**
	Example of calculation v_v = 1.9 × 10^7 m s^{-1} × tan 21° = 7.3 × 10^6 m s^{-1}		
16(b)(iii)	Use of $v = s/t$ to determine time an electron is between the plates	**(1)**	
	Use of $v = u + at$ to determine vertical acceleration (ecf from part (ii))	**(1)**	
	Use of $F = ma$ to determine accelerating force	**(1)**	
	Use of $E = F/q$ to determine electric field strength	**(1)**	
	Use of $E = V/d$	**(1)**	
	$V = 300$ V	**(1)**	**6**
	Example of calculation t = 0.012 m / 1.9 × 10^7 m s^{-1} = 6.32 × 10^{-10} s a = 7.3 × 10^6 m s^{-1} / 6.32 × 10^{-10} s = 1.16 × 10^{16} m s^{-2} F = 9.11 × 10^{-31} kg × 1.16 × 10^{16} m s^{-2} = 1.06 × 10^{-14} N E = 1.06 × 10^{-14} N / 1.60 × 10^{-19} C = 66 300 V m^{-1} V = 66 300 V m^{-1} × 0.0046 m V = 300 V		
	Total for question 16		**13**

Question Number	Answer		Mark
17(a)(i)	Only charged particles leave tracks **Or** gamma has no charge	**(1)**	**1**
17(a)(ii)	As the particles cause ionisation they lose energy/speed (accept reference to energy radiated) Since $r = p/BQ$, lower $p \rightarrow$ lower radius	**(1)** **(1)**	**2**
17(b)	Use of $\Delta E = c^2 \Delta m$ With use of $\Delta m = 2 \times 9.11 \times 10^{-31}$ kg Use of $E = hf$ $f = 2.47 \times 10^{20}$ Hz Example of calculation $\Delta E = (3.00 \times 10^8 \text{ m s}^{-1})^2 \times 2 \times 9.11 \times 10^{-31}$ kg $= 1.64 \times 10^{-13}$ J 1.64×10^{-13} J $= 6.63 \times 10^{-34}$ J s $\times f$ $f = 2.47 \times 10^{20}$ Hz	**(1)** **(1)** **(1)** **(1)**	**4**
17(c)(i)	Quotes $E = hf$ **and** $p = h/\lambda$ ***Or*** Quotes $E = hc/\lambda$ **and** $p = h/\lambda$ Correct algebra to arrive at $E = pc$ (Accept quoting $E^2 = p^2c^2 + m^2c^4$ and stating $m = 0$ for both marks) Example $p = h/\lambda$ $c = f\lambda$ so $\lambda = c/f$ Therefore $p = hf/c$ So $pc = hf$ $E = hf$ So $E = pc$	**(1)** **(1)**	**2**
17(c)(ii)	Use of $E = p^2/2m$ p for one electron $= 2.01 \times 10^{-23}$ kg m s^{-1} Use of $E = pc$ p for photon $= 5.5 \times 10^{-22}$ kg m s^{-1} Momentum for photon not equal to momentum for the two electrons combined Example of calculation $p = \sqrt{(2 \times 9.11 \times 10^{-31} \text{ kg} \times 2.22 \times 10^{-16} \text{ J})}$ $= 2.01 \times 10^{-23}$ kg m s^{-1} $p = 1.64 \times 10^{-13}$ J / 3.00×10^8 m s^{-1} p for photon $= 5.5 \times 10^{-22}$ kg m s^{-1}	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question 17		**14**

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