Mark Scheme (Results)

January 2017

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.

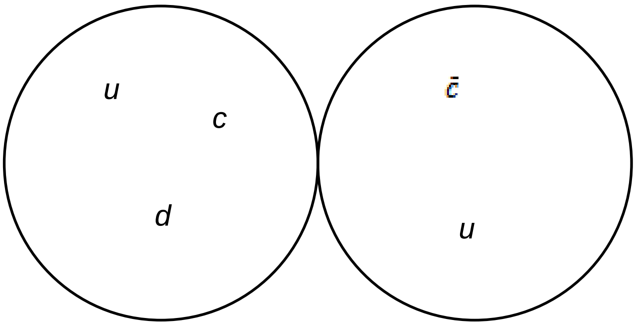
Question Number	Answer	Mark
1	**C is the correct answer** A, B and D are fundamental particles	1
2	**C is the correct answer** A, B and D are other combinations of units involving quantities in F = BIl	1
3	**C is the correct answer** A, B and D are the other possible changes involving decreasing tension	1
4	**B is the correct answer** A, C and D are incorrect combinations of the values given	1
5	**B is the correct answer** A, C and D are all true but not conclusions from the experiment	1
6	**A is the correct answer** B charges don't balance, C wrong neutrino for the muon, D wrong neutrino for the electron	1
7	**C is the correct answer** There are 8 neutrons and 6 protons and A, B and D do not match both	1
8	**B is the correct answer** A time the same so C energy the same so D frequency constant	1
9	**D is the correct answer** A, B, C all based on mv/t but with or without factor 2 and some not negative	1
10	**C is the correct answer** All of A, B, C, D use the same traces, but only C has the electron deflected most AND electron deflected to the right and proton to the left. A wrong directions and amounts of deflection, B wrong directions, D wrong amounts of deflection	1

Question Number	Answer		Mark
11	Use of $W = mg$	**(1)**	
	Use of $F = \frac{kQ_1Q_2}{r^2}$ **Or** Use of $F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$	**(1)**	
	F = 8990 N and W = 9810 N **Or** r = 957 m for Q = 1 C and m = 1 tonne **Or** Q = 1.05 C for r = 1 km and m = 1 tonne **Or** m = 916 kg for Q = 1 C and r = 1 km	**(1)**	
	Correct comparison and conclusion using their calculated values E.g. The statement isn't true because the force is less than the weight at that distance.	**(1)**	4
	<u>Example of calculation</u> $W = 1000 \text{ kg} \times 9.81 \text{ N kg}^{-1}$ $9810 \text{ N} = 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2} \times 1 \text{ C} \times 1 \text{ C} \div r^2$ $r = 957 \text{ m}$		
	Total for question 11		**4**

Question Number	Answer		Mark
12(a)	Evidence of $E_k = ½\ mv^2$ **and** $p = mv$ Correct algebraic link to $E_k = p^2/2m$	**(1)** **(1)**	 **2**
12(b)	Use of eV conversion Use of $E_k = p^2/2m$ Use of $\lambda = h/p$ $\lambda = 2.09 \times 10^{-13}$ m <u>Example of calculation</u> $E_k = 18\ 800$ eV $\times 1.6 \times 10^{-19}$ C $= 3.01 \times 10^{-15}$ J 3.01×10^{-15} J $= p^2/2 \times 1.67 \times 10^{-27}$ kg $p = 3.17 \times 10^{-21}$ N s $\lambda = 6.63 \times 10^{-34}$ J s $\div 3.17 \times 10^{-21}$ N s $\lambda = 2.09 \times 10^{-13}$ m	**(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) (Alternating current in charger coil produces) alternating/varying magnetic field **(1)** Idea that magnetic flux in charger coil linked to coil in watch **Or** Lines of flux cutting coil in watch **Or** varying flux in coil in watch **(1)** e.m.f. <u>induced</u> in watch circuit **(1)** current since complete/closed circuit **(1)**	**4**
13(b)	direct current required/produced **Or** otherwise it would be alternating current **(1)** (accept dc for direct current or ac for alternating current)	**1**
	Total for question 13	**5**

Question Number	Answer		Mark
14(a)	**Either** Use of Pythagoras to find length of wire perpendicular to field [6.1 cm] Use of $F = B \times I \times$length of wire perpendicular to field using F = 0.0037 N **Or** Use of cosθ = a/h **Or** use of sinθ = o/h **Or** measures an angle from diagram as 73°± 1° **Or** measures an angle from diagram as 17°± 1° Use of $F = BIl\sin\theta$ using correct angle F = 0.0037 N (accept F = 0.0040 N if measured angle of 73° used) Example of calculation cos θ = 3.2 cm / 6.9 cm θ = 62.4° F = 0.074 T × 0.82 A × 0.069 m × sin 62.4° = 0.074 T × 0.82 A × 0.069 m × 0.89 F = 0.0037 N Using measured angle: θ = 73° F = 0.074 T × 0.82 A × 0.069 m × sin 73° = 0.074 T × 0.82 A × 0.069 m × 0.96 F = 0.0040 N	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	 **3**
14(b)	Direction into page Using (Fleming) LHR	**(1)** **(1)**	 **2**
	Total for question 14		**5**

Question Number	Answer		Mark
15(a)	Baryon - 3 quarks Meson - quark-antiquark baryon - *ucd*; meson - $\bar{c}u$ **Or** baryon - *uud*; meson - $\bar{c}c$  baryon meson	**(1)** **(1)** **(1)**	 **3**
15(b)	Use of eV conversion using 1.6×10^{-19} C Use of $\Delta E = c^2 \Delta m$ $m = 7.79 \times 10^{-27}$ (kg) <u>Example of calculation</u> 4.38×10^9 eV $\times 1.6 \times 10^{-19}$ C = 7.01×10^{-10} J $m = 7.01 \times 10^{-10}$ J ÷ $(3 \times 10^8$ m s$^{-1})^2$ = 7.79×10^{-27} kg	**(1)** **(1)** **(1)**	 **3**
15(c)(i)	Use of $v = s/t$ Calculated speed = 2.64×10^{10} m s^{-1} Comparison with speed of light **and** relevant comment (e.g. this is impossible or relativistic effects apply) (Accept correct reference to specific relativistic effect.) <u>Example of calculation</u> $v = 3.9 \times 10^{-2}$ m ÷ 1.48×10^{-12} s = 2.64×10^{10} m s^{-1}	**(1)** **(1)** **(1)**	 **3**
***15(c)(ii)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Any 4: <u>Particle creation</u> Mass-energy is conserved (High energy required) to create <u>particles</u> with large/larger mass because $\Delta E = c^2 \Delta m$ and c^2 is a large multiplying factor <u>Overcoming repulsive forces</u> There are (electrostatic) repulsive forces between protons (and high energies are required) so repulsive force can be overcome to allow protons to get close to each other	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	 **4**
	Total for question 15		**13**

Question Number	Answer		Mark
16(a)(i)	Use of $I = I_0 /e$ (I_0 from 2.35 mA to 2.4 mA) to find time constant **Or** intercept with t axis using initial tangent to find time constant (range 125 s to 135 s) Use of time constant = RC C = 0.015 (F) to 0.017 (F) **Or** Attempts a pair of readings of I and t from graph Use of $I = I_0 e^{-t/RC}$ C = 0.015 (F) to 0.017 (F) **Or** Attempts to obtain 'half-life' from graph Use of $t_{½} = RC \ln 2$ C = 0.015 (F) to 0.017 (F) <u>Example of calculation</u> 131 s = 8200 Ω × C $C = 1.60 \times 10^{-2}$ F	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
16(a)(ii)	Use of $V = IR$ for initial p.d. using initial current Use of $C = Q/V$ ecf from (i) Q = 0.32 C <u>Example of calculation</u> V = 0.0024 A × 8200 Ω = 19.7 V $\Delta Q = 1.60 \times 10^{-2}$ F × 19.7 V = 0.316 C	**(1)** **(1)** **(1)**	**3**
16(a)(iii)	Use of suitable equation, e.g. $W = ½\, QV$ ecf from (i) and (ii) W = 3.1 J <u>Example of calculation</u> W = ½ × 0.316 C × 19.7 V W = 3.08 J	**(1)** **(1)**	**2**
16(b)	Use of $V = V_0 e^{\frac{-t}{RC}}$ Correct use of 15% R = 240 kΩ <u>Example of calculation</u> $0.15 V_0 = V_0 e^{\frac{-t}{RC}}$ $\ln 0.15 + \ln V_0 = \ln V_0 - \frac{t}{RC}$ $\ln 0.15 = \frac{-210\ s}{R \times 470 \times 10^{-6}\ F}$ $R = 2.36 \times 10^5\ \Omega$	**(1)** **(1)** **(1)**	**3**
	Total for question 16		**11**

Question Number	Answer		Mark
17(a)	Electrons emitted from hot metal (surface) **Or** states thermionic emission Idea that electrons accelerated by electric field produced by charge on the anode (e.g. Electrons accelerated by anode; electrons attracted to positive charge; electrons attracted to anode)	 **(1)** **(1)**	**2**
17(b)	Use of $W = QV$ Use of $E_k = ½ mv^2$ $v = 2.72 \times 10^7$ m s^{-1} <u>Example of calculation</u> $W = 1.6 \times 10^{-19}$ C × 2100 V = 3.36×10^{-16} J 3.36×10^{-16} J = ½ × 9.11×10^{-31} kg × v^2 $v = 2.72 \times 10^7$ m s^{-1}	**(1)** **(1)** **(1)**	**3**
17 (c)	Straight vertical lines, at least 3, equally spaced, touching both plates Downward direction	**(1)** **(1)**	**2**
17(d)(i)	Use of $E = V/d$ Use of $F = EQ$ $F = 1.8 \times 10^{-15}$ (N) <u>Example of calculation</u> E = 550 V / 0.05 m = 11 000 V m^{-1} F = 11 000 V m^{-1} × 1.6×10^{-19} C $F = 1.76 \times 10^{-15}$ N	**(1)** **(1)** **(1)**	**3**
17(d)(ii)	Use of $F = ma$ (ecf from (d)(i)) Use of $v = s/t$ Use of $s = ut + ½ at^2$ with $u = 0$ s = 0.020 m <u>Example of calculation</u> $a = F/m = 1.76 \times 10^{-15}$ N / 9.11×10^{-31} kg = 1.93×10^{15} m s^{-2} t = 0.1 m / 2.2×10^7 m s^{-1} = 4.55×10^{-9} s $s = ½ \times 1.93 \times 10^{15}$ m s^{-2} × $(4.55 \times 10^{-9}$ s$)^2$ s = 0.020 m	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 17		**14**

Question Number	Answer		Mark
18(a)(i)	Use of $p = mv$ (mass may be left as m or justify ignoring mass, e.g. by cancelling) See either × cos 29° or × cos 61° A correct value of momentum for at least one ball, or total, after collision (see 0.036 N s **Or** 0.55 (m) **Or** 0.011 (N s) **Or** 0.17 (m) **Or** 0.048 (N s) **Or** 0.72(m)) Calculated momentum before = calculated momentum after **and** states that momentum is conserved **Or** Calculated momentum before = calculated momentum after **and** states that momentum before = momentum after <u>Example of calculation</u> p_1 = 0.066 kg × 0.72 m s^{-1} = 0.0475 N s = 0.048 N s (2 sf) Components in direction of u_1 = (0.066 kg × 0.63 m s^{-1} × cos 29°) + (0.066 kg × 0.35 m s^{-1} × cos 61°) = 0.0364 N s + 0.0112 N s = 0.0476 N s = 0.048 N s (2 sf) Momentum before = momentum after, so satisfies principle of conservation of momentum	**(1)** **(1)** **(1)** **(1)**	**4**
18(a)(ii)	Use of $E_k = ½\, mv^2$ **Or** E_k α v^2 Initial E_k = 0.017 (J) (v^2 = 0.52 (m^2 s^{-2})) Calculation of final E_k = 0.017 (J) and statement that E_k conserved (final v^2 = 0.52 (m^2 s^{-2})) <u>Example of calculation</u> $E_k = ½\, mv^2$ Before: Ball 1, E_k = ½ × 0.066 kg × (0.72 m s^{-1})^2 = 0.0171 J After: Ball 1, E_k = ½ × 0.066 kg × (0.63 m s^{-1})^2 = 00131 J Ball 2, E_k = ½ × 0.066 kg × (0.35 m s^{-1})^2 = 0.0040 J Total = 0.0171 J, so kinetic energy conserved	**(1)** **(1)** **(1)**	**3**
18(b)(i)	The time intervals between images The scale of the photograph (accept the diameter of the balls)	**(1)** **(1)**	**2**
18(b)(ii)	φ = 45° to 52° Use of graph with their angle to determine total kinetic energy after the collision Statement that it is an inelastic collision **Or** Statement that kinetic energy is not conserved (dependent on candidate attempting MP1 and MP2)	**(1)** **(1)** **(1)**	**3**
	Total for question 18		**14**

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