Mark Scheme (Results)

Summer 2016

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	**1**
2	B	**1**
3	A	**1**
4	D	**1**
5	B	**1**
6	D	**1**
7	B	**1**
8	B	**1**
9	C	**1**
10	C	**1**

Question Number	Answer		Mark
11(a)	Use of $\omega = \frac{2\pi}{T}$	(1)	
	$\omega = 1.2 \times 10^{-3}$ (rad s^{-1})	(1)	**2**
	<u>Example of calculation</u> $\omega = \frac{2\pi \times 16 \text{ rad}}{(24 \times 60 \times 60 \text{ s})} = 1.16 \times 10^{-3}$ rad s^{-1}		
11(b)	Use of $a = r\omega^2$ **Or** use of $v = r\omega$ **and** $a = v^2/r$ (ecf from (a))	(1)	
	$a = 9.7$ m s^{-2} ("show that" answer gives 6.7 m s^{-2}) (using $\omega = 1.16 \times 10^{-3}$ gives 9.1 m s^{-2})	(1)	**2**
	<u>Example of calculation</u> $a = (330 + 6400) \times 10^3 \text{ m} \times (1.2 \times 10^{-3} \text{rad s}^{-1})^2 = 9.7$ m s^{-2}		
	Total for question 11		**4**

Question Number	Answer	Mark
12(a)	Quark and an anti-quark **Or** q + $\bar{q}$ (1)	**1**
12(b)	Anti-proton: $\bar{u}\bar{u}\bar{d}$ (1) Anti-neutron: $\bar{u}\bar{d}\bar{d}$ (1)	**2**
12(c)	Adds the 3 energies (2034 MeV) (1) Conversion of MeV to J (1) Use of E = hf **and** use of λ = c/f (1) $\lambda = 1.2 \times 10^{-15}$m (1) (Use of de Broglie equation can only score MP1 & 2) <u>Example of calculation</u> total energy $= ((1876 + 158) \times 10^{6}\text{eV}) \times 1.6 \times 10^{-19}\text{C}$ $= 3.25 \times 10^{-10}$ J $\lambda = \frac{(6.63\times10^{-34}\text{ J s} \times 3\times10^{8}\text{ m s}^{-1})}{(3.25\times10^{-10}\text{ J} / 2)} = 1.22 \times 10^{-15}$ m	**4**
	Total for question 12	**7**

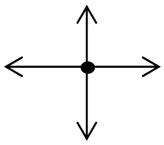
Question Number	Answer	Mark
13(a)	Use of $p = mv$ to determine momentum before **and** after collision (1) Resolves velocities horizontally (1) v = 3.4 m s^{-1} (1) **Or** Resolves velocities vertically (1) States that momentum before is zero (1) v = 3.5 m s^{-1} (1) <u>Example of calculation</u> (m)6.9 = (m) 6 cos 30 + (m) v cos 60 $v = \frac{6.9\ \mathrm{m\ s^{-1}} - (6\cos 30)\ \mathrm{m\ s^{-1}}}{\cos 60°} = 3.4\ \mathrm{m\ s^{-1}}$	3
13(b)	E_k before = 24 m (J) (1) E_k after = 24 m (J) therefore elastic (1) (ecf from (a) and conclusion consistent with their values for kinetic energy) [a statement that because the masses are identical and move apart at 90° means the collision is elastic scores 2 marks] <u>Example of calculation</u> Before $E_k = \frac{1}{2}m(6.9\ \mathrm{m\ s^{-1}})^2 = 24m$ (J) After $E_k = \frac{1}{2}m(6\ \mathrm{m\ s^{-1}})^2 + \frac{1}{2}m(3.4\ \mathrm{m\ s^{-1}})^2 = 24m$ (J)	2
	Total for question 13	**5**

Question Number	Answer	Mark
***14(a)**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** Links the magnitude of (induced) e.m.f. to rate of change/cutting of flux (linkage) (accept equation) (1) Indication that magnet's speed increases as it falls (1) Positive (max) value > negative (max) value **Or** Time for second pulse shorter (this mark is dependent on awarding MP2) (1) The areas of the two parts of the graph will be the same (since $N\varphi$ constant) (1) Links Lenz's law to the change in polarity of e.m.f. (1)	**5**
14(b)	**Any two** High sampling rate Different quantities to be taken at the same time measurements to be taken remotely experiments can be carried out over a long period of time. (2)	**2**
	Total for question 14	**7**

Question Number	Answer	Mark
15(a)	Direction changing **Or** the velocity changes (1) Therefore (cyclist) accelerates (1)	**2**
15(b)	The horizontal component of reaction force acts towards centre of rotation **Or** The horizontal component of R provides/contributes to the centripetal force (1) The cyclist can go faster (1)	**2**
15(c)	Graph drawn: has a smaller maximum force (1) the change is over a longer time (1) Justification: With airbag the rate of change of momentum is smaller **Or** acceleration is smaller **Or** Area(s) under graph(s) the same (accept impulse the same) (1)	**3**
	Total for question 15	**7**

Question Number	Answer	Mark
16(a)	Photon causes no ionisation (1)	**1**
16(b)	Track A by (Fleming's) left hand rule (1)	**1**
***16(c)**	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) Charges are opposite so spiral in opposite directions (1) Both particles have same mass/charge so same curvature/radius (1) Circular motion is due to magnetic field/force being at right angles to (direction of) motion (1) They have decreasing E_k/speed/momentum (1) Uses $Bqv=mv^2/r$ or $r=mv/Bq$ to justify decreasing radius (1)	**5**
	Total for question 16	**7**

Question Number	Answer		Mark
17(a)	Initially p.d. across C = 0V (producing maximum current) **Or** initially p.d. across resistor is equal to e.m.f. of cell (producing maximum current) As charge builds up on the capacitor the p.d. across resistor decreases (reducing the current) **Or** As charge builds up on the capacitor, this opposes the flow of electrons/charge (reducing the current). When capacitor is fully charged the p.d. across resistor is 0V (so current is zero) **Or** Eventually, the p.d. across C = e.m.f. of cell (so current is zero)	(1) (1) (1)	**3**
17(b)(i)	Attempt to determine area by using rectangle and triangle Use of $C = \frac{Q}{V}$ **Or** $C = \frac{It}{V}$ C = 4.2 × 10^{-2} F <u>Example of calculation</u> $C = \frac{(100 \times 2.4 \times 10^{-3}\text{ C}) + (0.5 \times 10 \times 2.4 \times 10^{-3}\text{C})}{6\,V} = 4.2 \times 10^{-2}\text{ F}$	(1) (1) (1)	**3**
17(b)(ii)	Use of $E = \frac{1}{2}CV^2$ **Or** $E = \frac{1}{2}QV$ **Or** $E = \frac{1}{2}\frac{Q^2}{C}$ E=0.76 J (e.c.f. from (i)) <u>Example of calculation</u> $E = 0.5 \times 0.042\text{ F} \times (6\text{ V})^2 = 0.76\text{ J}$	(1) (1)	**2**
17(c)(i)	See $lnI = lnI_0 - \frac{t}{RC}$ Determines gradient $C = \frac{-1}{R\times gradient}$ **Or** gradient $= \frac{-1}{R\times C}$	(1) (1) (1)	**3**
17(c)(ii)	Use of $t = RC$ t = 0.86 s Statement recognising that the capacitor would discharge in a very short time **Or** $t_{½}$ = 0.69RC $t_{½}$ = 0.59s Statement recognising that the capacitor would discharge in a very short time **Or** time to fully discharge = 5RC time to fully discharge = 4.29s Statement recognising that the capacitor would discharge in a very short time <u>Example of calculation</u> $t = 390\Omega \times 2200 \times 10^{-6}\text{F} = 0.86\text{ s}$	(1) (1) (1) (1) (1) (1) (1) (1) (1)	**3**
	Total for question 17		**14**

Question Number	Answer		Mark
18(a)	Most of atom is empty space	(1)	**1**
18(b)	equally spaced radial lines (minimum of 4) pointing outwards 	(1) (1)	**2**
18(c)(i)	Use of $F = \frac{kQ_1Q_2}{r^2}$ F= 25 N <u>Example of calculation</u> $F = \frac{8.99 \times 10^9 \text{N m}^2\text{C}^{-2} \times (79 \times 1.6 \times 10^{-19}\text{ C}) \times (2 \times 1.6 \times 10^{-19}\text{ C})}{(3.8 \times 10^{-14}\text{ m})^2}$ $F = 25.2$ N	(1) (1)	**2**
18(c) (ii)	Converts MeV to J Use of $E = p^2/2m$ with $m = 4 \times (1.67 \times 10^{-27})$ **Or** Use of $E = \frac{1}{2}mv^2$ **and** $p = mv$ with $m = 4 \times (1.67 \times 10^{-27})$ $\Delta p = 1.1 \times 10^{-19}$ (N s) <u>Example of calculation</u> $E = 6.0 \times 10^6 \times (1.6 \times 10^{-19}) = 9.6 \times 10^{-13}\text{J}$ $p = \sqrt{2 \times 9.6 \times 10^{-13}\text{J} \times 4 \times 1.67 \times 10^{-27}\text{kg}} = 1.13 \times 10^{-19}$ N s	(1) (1) (1)	**3**
	Total for question 18		**8**

Question Number	Answer	Mark
19(a)	**<u>Similarities</u>** An electric <u>field</u> accelerates the particles **(1)** the time spent in each dee and each tube is constant **Or** Particles increase in speed **only** in the gaps between dees and tubes **Or** Particles travel at constant speed in dees and tubes **(1)** **<u>Differences</u>** Cyclotron uses magnetic <u>field</u> (for circular path) but the linac doesn't **(1)** Idea that they manage the increasing speed of the particles in different ways, in the linac the drift tubes get longer and in the cyclotron the radius of the path increases **(1)**	**4**
19(b)(i)	Use of $\lambda = \frac{h}{mv}$ using electron mass **(1)** $\lambda = 8.9 \times 10^{-11}$ (m) **(1)** <u>Example of calculation</u> $\lambda = \frac{6.63\times10^{-34}\text{ J s}}{9.11\times10^{-31}\text{kg}\times8.2\times10^{6}\text{m s}^{-1}} = 8.9 \times 10^{-11}$ m	**2**
19(b)(ii)	Wavelength (much) larger than the diameter of the proton, (so no diffraction) **(1)**	**1**
19(c)(i)	(speed of light)^2 / c^2 **(1)** speed of electrons (tends towards but) cannot be greater than c **Or** Particles cannot travel at the speed of light **(1)**	**2**
19(c)(ii)	v^2 is not proportional to E_k **(1)** Not a straight line (for high(er) values of E_k) **Or** graph doesn't show a linear relationship **Or** the gradient decreases (with increasing E_k) **(1)**	**2**
	Total for question 19	**11**

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