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Mark Scheme (Results)

January 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.

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.

For example:

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] ✓ **1**
[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

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.
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 Incorrect use of case e.g. 'Watt' or 'w' will **not** be penalised.
2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
2.4 The same missing or incorrect unit will not be penalised more than once within one question (one clip in epen).
2.5 Occasionally, it may be decided not to penalise a missing or incorrect 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.
2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. Significant figures

3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.

3.2 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 be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

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.

4.6 Example of mark scheme for a calculation:

<u>'Show that' calculation of weight</u>

Use of L × W × H ✓

Substitution into density equation with a volume and density ✓

Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] ✓
[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark] **3**
[Bald answer scores 0, reverse calculation 2/3]

Example of answer:

80 cm × 50 cm × 1.8 cm = 7200 cm^3

7200 cm^3 × 0.70 g cm^{-3} = 5040 g

5040 × 10^{-3} kg × 9.81 N/kg

= 49.4 N

5. Quality of Written Communication

5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

5.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

6. Graphs

6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

6.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

6.5 For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

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

Question Number	Answer	Mark
11(a)	Most alpha particles passed straight through (the gold foil) **Or** most alpha particles were undeflected (1) Some/few alpha particles were deflected/deviated/scattered (through small angles, indication of <90°) (1) Very few were deflected through an angle greater that 90° **Or** <1% came straight back **Or** 1 in 8000 came straight back (1)	**3**
11(b)	Use of $F = kQ_1Q_2/r^2$ (1) Use of 2 and 79 (1) F = 18 N (1) <u>Example of calculation</u> $F = \frac{8.99\times10^{9}\text{ N m}^2\text{ C}^{-2}\times(2\times1.6\times10^{-19}\text{C})\times(79\times1.6\times10^{-19}\text{C})}{(4.5\times10^{-14}\text{m})^2} = 17.96\text{ N}$	**3**
	Total for question 11	**6**

Question Number	Answer	Mark
12(a)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) There is a changing (magnetic) flux (linkage) **Or** the coil cuts (magnetic) field / flux (lines) (1) Inducing an emf (across the ends of the coil/wire) (1) Generating a current because there is a closed circuit **Or** generating a current because coil is in a circuit (1)	**3**
12(b)	Current produced is a.c. / alternating **Or** the battery needs d.c. (1)	**1**
12(c)	(As rate of rotation of wheels reduces) the rate of change of (magnetic) flux(linkage) reduces **Or** rate of cutting field lines decreases (1) e.m.f. is proportional to the rate of change of flux (linkage) **Or** $\mathcal{E} = \frac{(-)dN\varphi}{dt}$ (1) (induced) e.m.f. decreases (steadily) (1)	**3**
	Total for question 12	**7**

Question Number	Answer		Mark
13(a)(i)	The idea that electrons move from one plate to the other plate through the external circuit When fully charged there is no movement of electrons **Or** As capacitor charges, rate of flow of electrons decreases **Or** (when fully charged) p.d. across the plates/capacitor is equal (and opposite) to the supply p.d. **Or** (when fully charged) equal and opposite charge/electrons on each plate	(1) (1)	**2**
13(a)(ii)	Use of W = ½ CV^2 **Or** use of Q=CV **and** W=½QV W = 0.34 J Example of calculation $W = 0.5 \times 4700 \times 10^{-6}\text{F} \times (12\text{ V})^2 = 0.34\text{ J}$	(1) (1)	**2**
13(b)(i)	Current decreases (over time) Exponentially (a graph of *I/t* with *I* decreasing can score MP1. Must be indicated as exponential for MP2)	(1) (1)	**2**
13(b)(ii)	Use of $V = V_0 e^{-t/RC}$ **Or** see $\ln(V/V_0) = -t/RC$ Use V = 1.2 (V) **and** V_0 = 12(V) **Or** use $\frac{V}{V_0}$ =0.1 R = 2300 Ω Example of calculation $V = V_0 e^{-t/RC}$ $ln\left(\frac{V}{V_0}\right) = \frac{-t}{RC}$ $ln(0.1) = \frac{-25\text{ s}}{R \times 4700 \times 10^{-6}\text{ F}}$ $R = \frac{-25\text{ s}}{ln0.1 \times 4700 \times 10^{-6}\text{ F}}$ R = 2300 Ω	(1) (1) (1)	**3**
	Total for question 13		**9**

Question Number	Answer		Mark
14(a)	See energy = QV **Or** W=QV **Or** E=QV **Or** F=EQ **and** E=V/d Equate QV and $\frac{1}{2}mv^2$ **Or** equate QV and $\frac{p^2}{2m}$	(1) (1)	**2**
***14(b)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) the (magnetic) field acts at a right angle to the direction of motion **Or** the velocity of the ion is perpendicular to the (magnetic) field the force is perpendicular to the direction of motion. the force acts as a centripetal force **Or** this is the condition for circular motion	 (1) (1) (1)	**3**
14(c)	See mass of ion = $80 \times 1.66 \times 10^{-27}$ (kg) in velocity/p calculation **Or** 1.328×10^{-25} (kg) in velocity/p calculation Use of $m/Q = 2V/v^2$ with $Q = (-)\ 1.6\text{x}10^{-19}$ (C) Use of $BQv = \frac{mv^2}{r}$ **Or** use of $r = \frac{p}{BQ}$ **and** $p = mv$ (do not award this mark if speed of light is used) $r = 0.47$ m <u>Example of calculation</u> $m/Q = 2V/v^2 \quad v = \sqrt{(2VQ/m)}$ $v = \sqrt{\frac{2 \times 3000\text{ V} \times 1.6 \times 10^{-19}\text{ C}}{80 \times 1.66 \times 10^{-27}\text{kg}}}$ $v = 8.5 \times 10^4$ (ms^{-1}) $r = mv/BQ$ $r = \frac{80 \times 1.66 \times 10^{-27}\text{kg} \times 8.5 \times 10^4\text{m s}^{-1}}{0.15\text{ T} \times 1.6 \times 10^{-19}\text{C}}$ $r = 4.7 \times 10^{-1}$ m	 (1) (1) (1) (1)	**4**
	Total for question 14		**9**

Question Number	Answer	Mark
15(a)(i)	At B the ball is accelerating **Or** at B the ball is increasing in speed (1) At C ball has zero acceleration (in the absence of friction) **Or** at C the ball has a constant speed (in the absence of friction) **Or** at C the ball is decelerating (due to friction) **Or** at C the speed of the ball decreases (due to friction) (1)	**2**
15(a)(ii)	Use of $F = \Delta p/\Delta t$ (1) $F = 23$ N (1) <u>Example of calculation</u> $F = \dfrac{(1.5\text{ kg} \times 3.0\text{ m s}^{-1})}{0.2\text{ s}} = 22.5\text{ N}$	**2**
15(b)(i)	Use of $p=mv$ (1) Resolve horizontal components of momentum / velocity (1) Velocity = 1.8 (m s^{-1}) (1) <u>Example of calculation</u> $1.5\text{ kg} \times v = (1.2\text{ kg} \times 1.8\text{ m s}^{-1}) \cos 20$ $+ (1.5\text{ kg} \times 0.7\text{m s}^{-1}) \cos 45$ v=1.8 (m s^{-1})	**3**
15(b)(ii)	Correct calculation of E_k before collision 2.4 - 2.6 (J) (show that value for v gives 3.0 (J)) (ecf value for v from (b)(i)) (1) Correct calculation of E_k after collision 2.3 (J) with comparison (1) <u>Example of calculation</u> E_k (before) = $0.5 \times 1.5\text{ kg} \times (1.8\text{ m s}^{-1})^2 = 2.4$ (J) E_k (after) = $(0.5 \times 1.5 \times 0.7^2) + (0.5 \times 1.2 \times 1.8^2) = 2.3$ (J) E_k (before) > E_k (after)	**2**
	Total for question 15	**9**

Question Number	Answer	Mark
16(a)	Use of $\omega = \frac{2\pi}{T}$ **Or** Use of $\omega = \theta/t$ (1) $\omega = 1.13\times10^{-3}$ (rad s^{-1}) (1) <u>Example of calculation</u> $\omega = \frac{2\pi\times15.5}{(24\times60\times60\text{ s})} = 1.13\times10^{-3}$ (rad s^{-1})	**2**
16(b)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) (although speed is constant) velocity is changing since direction is changing (1) Therefore ISS is accelerating (1) So (by N1/2) there must be a resultant / centripetal force (1)	**3**
16(c)	Use of $F = mr\omega^2$ **Or** $F = \frac{mv^2}{r}$ and $v = r\omega$ **Or** use $F \propto \frac{1}{r^2}$ (1) $F = 3.6 \times 10^6$ N ecf value of *w* from (a) (1) <u>Example of calculation</u> $F = 4.19 \times 10^5\text{ kg} \times (6.4 \times 10^6\text{m} + 4 \times 10^5\text{m}) \times (1.13 \times 10^{-3}\text{ rad s}^{-1})^2$ $= 3.6 \times 10^6$ N	**2**
	Total for question 16	**7**

Question Number	Answer	Mark
17(a)	Upward arrow added to diagram (1) **Justification** (From results) there is force downwards / into paper (1) This is the force on the magnet and by N3 the force on the rod is in the opposite direction (1) Reference to LH rule (leads to direction of magnetic field) (1)	**4**
17(b)	Refers to $F = BIl$ (1) Calculate weights **Or** uses F = mg (1) Measure (perpendicular) length of rod within the magnetic field (1) Identifies a suitable graph (see below) (1) Determines gradient of graph (1) Correct calculation of *B* consistent with their graph (see below) (1)	**6**
	Total for question 17	**10**

y axis	**x axis**	**B =**
F	*I*	gradient/l
I	*F*	1/(gradient x l)
F	*Il*	gradient
Il	*F*	1/gradient
m	*I*	(gradient x g) / l
I	*m*	g / (gradient x l)
m	*Il*	gradient x g
Il	*m*	g / gradient
m	*Il/g*	gradient
Il/g	*m*	1/gradient

Question Number	Answer	Mark
18(a)	p is uud (1) n is udd (1) (If candidates have p and n correct but think neutrino or beta plus (e^+) are composed of quarks, score 1 mark only)	**2**
18(b)	Identifies the charge of all four particles **Or** see $+1 \rightarrow 0 + (+1) + 0$ (assume charge written in same order as symbols in equation unless otherwise stated) (1) Charge is conserved (1) (Only award MP2 if an attempt at MP1 has been made, e.g. candidate only identifies positive particles) (Accept methods that use charge conservation of individual quarks of the proton and neutron. However, those who think the neutrino or beta plus (e^+) are composed of quarks can only score a max of 1 mark)	**2**
18(c)	See 1.58 + 0.511 + 0.511 **Or** 2.602 (MeV) (1) Conversion of eV to J (multiply by 1.6×10^{-19}) (1) (Ignore any use of c^2 for this mark) Use of E = hf **and** use of λ = c/f **Or** use of $E = \frac{hc}{\lambda}$ (1) $\lambda = 9.6 \times 10^{-13}$ m (1) (Use of $\frac{1}{2}mv^2$ to find *v* to use de Broglie equation scores 0/4) <u>Example of calculation</u> total energy= $(1.022 + 1.58\text{ J}) \times 1.6 \times 10^{-19}\text{ C} \times 1 \times 10^6$ $= 4.16 \times 10^{-13}$ J $\lambda = \frac{(6.63\times10^{-34}\text{ J s} \times 3\times10^8\text{ m s}^{-1})}{(0.5 \times 4.16\times10^{-13}\text{J})} = 9.56 \times 10^{-13}$ m	**4**
18(d)(i)	Use of *p* =*E/c* with value of c = $3.0 \times 10^8\text{ m s}^{-1}$ (p=1.067×10^{-17} kg m s^{-1}) (do not penalise use of eV for *E*) (1) Use of *λ* =*h/p* with their value for p (1) λ=6.2×10^{-17} m (1) (Candidates who substitute into p=mv to find v (> c) can score a maximum of 1 mark only) <u>Example of calculation</u> $\lambda = \frac{hc}{E} = \frac{6.63\times10^{-34}\text{ J s} \times 3\times10^8\text{ m s}^{-1}}{20\times10^9\text{ J C}^{-1} \times 1.6\times10^{-19}\text{ C}} = 6.2 \times 10^{-17}$ m	**3**

18(d)(ii)	**Either** Idea that path of electrons may be deflected (1) Due to the (electrostatic) force between electrons and protons / quarks (1) **Or** Diffraction (1) wavelength of electron is similar to diameter/gap for proton/quark (1)	**2**
	Total for question 18	**13**

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