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Mark Scheme (Results)

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Pearson Edexcel International Advanced Level in Physics (WPH04) Paper 01

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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.

For example:

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] [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.]	✓	**1**

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:

'Show that' calculation of weight

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] [Bald answer scores 0, reverse calculation 2/3]	✓	**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.

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

Question Number	Answer		Mark
11(a)	(+2/3) + (−1/3) + (−1/3) = 0 **Or** (+)2/3 −1/3 −1/3 = 0 **Or** (+)2/3e −1/3e −1/3e = 0 [summation to 0 must be shown]	**(1)**	**1**
11(b)	Δ^-/baryon has 3 quarks π^-/meson has a quark antiquark (Accept 2quarks, one quark and one antiquark)	**(1)** **(1)**	**2**
11(c)	$\Delta^{++} \rightarrow$uuu π charge$\rightarrow$ +1 **Or** +e **Or +** 1.6×10^{-19} C	**(1)** **(1)**	**2**
	Total for Question 11		**5**

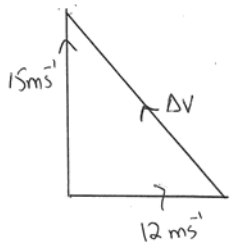
Question Number	Answer		Mark
12	Use of $W = QV$ Use of $E_k = p^2/2m$ **Or** use of $E_k = \frac{1}{2}mv^2$ Use of $\lambda = h/p$ **Or** use of $\lambda = h/mv$ using calculated p or v $\lambda = (2.1-2.3) \times 10^{-11}$ m (if $E_k = mv^2/2$ used $v = 3.25 \times 10^7$ m s^{-1}) <u>Example of calculation</u> $p^2 = 2meV$ $\lambda = h/\sqrt{(2meV)}$ $\lambda = 6.63 \times 10^{-34}$ J /$\sqrt{(2 \times 9.11 \times 10^{-31}}$ kg $\times 1.6 \times 10^{-19}$ C $\times$ 3000 V) $\lambda = 2.2 \times 10^{-11}$ m	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for Question 12		**4**

Question Number	Answer	Mark
13(a)	Use of $f = 1/T$ with 10 or 10×10^{-3} on the denominator **(1)** $f = 100$ Hz **(1)** Example of calculation $f = 1/T = 1/(10 \times 10^{-3}\ \text{s}) = 100$ Hz	**2**
13(b)	See or use $(N)\Phi = NBA$ **(1)** $B = 0.016$ T **(1)** Example of calculation $N\Phi = NBA$ $B = N\Phi/NA = 2 \times 10^{-2}$ Wb / ($500 \times 2.5 \times 10^{-3}$ m^2) $B = 0.016$ T	**2**
13(c)	tangent drawn at 2.5, 7.5 or 12.5 ms **Or** linear section of graph used ±0.5 vertical scale **(1)** Value(s) substituted into $\varepsilon = \Delta(N\Phi)/\Delta t$ **(1)** $\varepsilon = (\pm)12.5\ \text{V} - 14.0\ \text{V}$ **(1)** [common error is to find average value over half a cycle →8 V scores MP2 only] **Or** Use of $\varepsilon = BNA\omega$ (ecf B from(b) and f from (a)) **(1)** Use of $\omega = 2\pi f$ **(1)** $\varepsilon = 12.6$ V **(1)**	**3**
	Total for Question 13	**7**

Question Number	Answer		Mark
14(a)	Velocity/direction changing **Or** (object is) accelerating Force towards centre (of circle)	**(1)** **(1)**	**2**
***14(b)(i)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Identifies a horizontal component of lift **Or** refers to $L \sin \theta$ Which acts as a centripetal force **Or** which provides a centripetal acceleration **Or** force perpendicular to velocity of plane so acts to centre (of circle) (MP2 **dependent mark** and only awarded for reference to a horizontal force)	**(1)** **(1)**	**2**
14(b)(ii)	Resolve vertically $L\cos\theta = mg$ Resolve horizontally $L\sin\theta = mv^2/r$ Use their value of L in their horizontal equation **Or** uses $\tan\theta = v^2/rg$ r = 1.6 km <u>Example of calculation</u> $L\cos\theta = mg$ $L = 2.4 \times 10^6\,\text{kg} \times 9.81\,\text{kg N}^{-1} / \cos 25^\circ = 2.6 \times 10^7\,\text{N}$ horizontally $L\sin\theta = mv^2/r$ $r = mv^2 / L\sin\theta = 2.4 \times 10^6\,\text{kg} \times 85^2\,\text{m}^2\,\text{s}^{-2} / 2.6 \times 10^7\,\text{N} \times \sin 25^\circ$ r = 1578 m	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for Question 14		**8**

Question Number	Answer		Mark
15(a)	Use of $T = RC$ $T = 0.3$ s Example of calculation $T = RC = 1500\ \Omega \times 200 \times 10^{-6}$ F $T = 0.3$ s	**(1)** **(1)**	**2**
15(b)	B5 = (6V - E4)/1.5 (k Ω) **Or** I = (E−V)/R **Or** I = (6.0 – 3.33)/1.5 Correct units or comment about mA and kΩ (allow 1 mark for B5 =C5/(A5-A4) and 1 mark for use of exponential equation)	 **(1)** **(1)**	**2**
15(c)(i)	3 points plotted accurately ± ½ small square Line of best fit drawn (smooth by eye)	**(1)** **(1)**	**2**
15(c)(ii)	Initial tangent drawn $t = 0.19$ s −0.26 s **Or** 37% of initial current found $t = 0.24$ s −0.26 s **Or** half life determined and use of half life = 0.693RC $t = 0.23$ s −0.26 s **Or** uses a pair of points off the graph in exponential equation $t = 0.24$ s −0.26 s	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**2**
15(c)(iii)	Reduce the time interval	**(1)**	**1**
***15(d)**	Reference to $I = I_0 e^{-t/RC}$ **Or** $\ln I = \ln I_0 - t/RC$ **Or** states that there is exponential relationship between I and t Plot $\ln I$ against t **Or** $\ln (I/I_0)$ against t The time constant = –1/gradient	 **(1)** **(1)** **(1)**	**3**
	Total for Question 15		**12**

Question Number	Answer		Mark
***16(a)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Magnetic field/force is perpendicular to path/velocity /motion(of charged particles). (Magnetic) force / acceleration to centre (of circle) **Or** (magnetic) force acts as centripetal force See a relevant equation: $F = Bqv$ **Or** $Bqv = mv^2/r$ **Or** $r = p/BQ$ Sensible comment on variables based on r being constant	**(1)** **(1)** **(1)** **(1)**	**4**
16(b)	Reference to $r = p/BQ$ Leading to a statement that indicates that the (strength of the) magnetic field needs to increase (**dependent mark**)	**(1)** **(1)**	**2**
16(c)(i)	Use of $E = mc^2$ $E = 1.64 \times 10^{-13}$ (J) (candidates who do not multiply by 2 can score MP1) <u>Example of calculation</u> $E = mc^2$ $E = 2 \times 9.1 \times 10^{-31}\,\text{kg} \times (3 \times 10^8\,\text{m s}^{-1})^2$ $E = 1.64 \times 10^{-13}\,\text{J}$	**(1)** **(1)**	**2**
16(c)(ii)	Divide by 1.6×10^{-13} to convert J to MeV Divide by 2 Rest mass = 5.1×10^{-1} (MeV/c^2) ecf E from (i) (for MP1&2 ignore any additional use of c^2) If candidates omit the factor 2 in (i) and the factor 2 in (ii) they can score 2 marks for (ii) If candidates do a new calculation for a single electron, they score max 2 as they have not used their minimum energy from (i) <u>Example of calculation</u> $E = (1.64 \times 10^{-13}\,\text{J})/(1.6 \times 10^{-13}\,\text{C}) = 1.02$ MeV Divide by 2 to find energy for one particle $\rightarrow 5.1 \times 10^{-1}$ MeV Rest mass = 5.1×10^{-1} MeV/c^2	**(1)** **(1)** **(1)**	**3**
	Total for Question 16		**11**

Question Number	Answer	Mark
17(a)	Sum of momenta before (collision) = sum of momenta after (collision) **Or** the total momentum before (a collision) = the total momentum after (a collision) **Or** total momentum remains constant **Or** the momentum of a system remains constant **(1)** Provided no external/unbalanced/resultant force acts **Or** in a closed/isolated system **(1)**	**2**
17(b)	Force equals rate of change of momentum **Or** force is proportional to rate of change of momentum **Or** $F = \Delta(mv)/\Delta t$ with terms defined **Or** $F = \Delta p/\Delta t$ with terms defined **(1)**	**1**
17(c)(i)	Line at right angles to drawn vector, arrow upwards and labelled. **(1)** Resultant vector joined and arrow in correct direction. **(1)** **Correct diagram**  **Wrong direction (**vector addition rather than subtraction: can score 1 mark here but allow full ecf in (c)(ii)  	**2**
17(c)(ii)	Use of Pythagoras **Or** trig. **(1)** Change in velocity = 19 m s^{-1} **(1)** Direction 51° from horizontal. **(1)** (accept $\theta = 51°$ if θ correctly added to diagram) <u>Example of calculation</u> $\Delta v = \sqrt{15^2 + 12^2}$ Δv = 19.2 m s^{-1} Tan θ = 15/12 θ = 51°	**3**
17(c)(iii)	Use of $p=mv$ **and** $F = \Delta p/t$ **(1)** F = 7100 N or 7200 N ecf their value from (c)(ii) **(1)** <u>Example of calculation</u> $F = \Delta p/t$ F = 1500 kg × 19.2 m s^{-1} / 4.0 s 7200 N	**2**
	Total for Question 17	**10**

Question Number	Answer		Mark
18(a)	Thermionic emission	**(1)**	**1**
18(b)	Substitution of 1.6×10^{-19} C and 4800 V in $W = QV$ Use of $E_k = \frac{1}{2}mv^2$ $v = 4.1 \times 10^7$ (m s^{-1}) Example of calculation $v^2 = 2\ E_k/m = 2eV/m$ $v^2 = 2 \times 1.6 \times 10^{-19}$ C $\times$ 4800 V/9.11×10^{-31} kg = 1.69×10^{15} m^2 s^{-2} $v = 4.1 \times 10^7$ m s^{-1}	**(1)** **(1)** **(1)**	**3**
18(c)(i)	Use of $E = V/d$ Use of $E = F/Q$ $F = 2.6 \times 10^{-15}$ N Example of calculation $F = VQ/d$ F = (800 V $\times$ 1.6×10^{-19} C) / 0.05 m $F = 2.6 \times 10^{-15}$ N	**(1)** **(1)** **(1)**	**3**
18(c)(ii)	See a = their $F/9.11 \times 10^{-31}$ kg See t = 0.15 (m) /4.1×10^7 (m s^{-1}) (or show that value or candidate's value) Substitution of calculated values of a and t into formula given $h = 1.9 \times 10^{-2}$ m (ecf from (b) & (c)(i)) (Only award MP3 if methods for MP1 & 2 are correct) Example of calculation $a = 2.6 \times 10^{-15}$ N / 9.11×10^{-31} kg = 2.85×10^{15} m s^{-2} t = 0.15 m / 4.1×10^7 m s^{-1} = 3.66×10^{-9} s $h = at^2/2$ $h = 2.85 \times 10^{15}$ m s^{-2} $\times$ $(3.66 \times 10^{-9}$ s$)^2/2$ $h = 1.88 \times 10^{-2}$ m	**(1)** **(1)** **(1)** **(1)**	**4**
18(d)	(i)Path A: less curved than original (accept labelling (d)(i)) (ii) Path B: more curved than original (accept labelling (d)(ii)) For both lines the curvature must change by the gap between 15 and cm on the label below diagram. Curvature must be consistently less or more whilst between the plates. Minimum of one line to be labelled. If neither line is labelled then 0 marks for both parts.	**(1)** **(1)**	**2**
	Total for Question 18		**13**

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