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Mark Scheme (Results)

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in Physics (WPH02)
Paper 01 Physics at Work

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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] [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] 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.

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	**The only correct answer is B** ***A*** *is not correct as it is an incorrect unit for current.* ***C*** *is not correct as these are not base units and is an incorrect unit for current.* ***D*** *is not correct as these are not base units and is an incorrect unit for current.*	**(1)**
2	**The only correct answer is B** ***A*** *is not correct as it has an incorrect conversion of* mm^2 *to* m^2 ***C*** *is not correct as it uses an incorrect equation.* ***D*** *is not correct as it uses an incorrect equation and an incorrect conversion of* mm^2 *to* m^2	**(1)**
3	**The only correct answer is C** ***A*** *is not correct as it uses an incorrect expression.* ***B*** *is not correct as it uses an incorrect expression.* ***D*** *is not correct as it uses an incorrect expression.*	**(1)**
4	**The only correct answer is A** ***B*** *is not correct as it uses an incorrect expression.* ***C*** *is not correct as it uses an incorrect expression.* ***D*** *is not correct as it uses an incorrect expression.*	**(1)**
5	**The only correct answer is B** ***A*** *is not correct as it makes incorrect use of the efficiency equation.* ***C*** *is not correct as it combines expressions for power and energy.* ***D*** *is not correct as it combines expressions for power and energy.*	**(1)**
6	**The only correct answer is C** ***A*** *is not correct as the description for wavelength is incorrect.* ***B*** *is not correct as the descriptions for wavelength and frequency are incorrect.* ***D*** *is not correct as the description for frequency is incorrect.*	**(1)**
7	**The only correct answer is C** ***B*** *is not correct as the p.d. across the diode is incorrect.* ***C*** *is not correct as the p.d. across the diode is incorrect.* ***D*** *is not correct as the p.d. across the diode is incorrect.*	**(1)**

8	**The only correct answer is B** ***A*** *is not correct as the use of P and* $\frac{\lambda}{hc}$ *is incorrect.* ***C*** *is not correct as the use of P and* $\frac{\lambda}{hc}$ *is incorrect.* ***D*** *is not correct as the use of P and* $\frac{\lambda}{hc}$ *is incorrect.*	**(1)**
9	**The only correct answer is B** ***A*** *is not correct as this graph shows R decreasing as temperature increases.* ***C*** *is not correct as this graph shows a constant value for R as temperature increases.* ***D*** *is not correct as this graph shows R decreasing as temperature increases.*	**(1)**
10	**The only correct answer is B** ***A*** *is not correct as the description for the drift velocity is incorrect.* ***C*** *is not correct as the descriptions for the current and the drift velocity are incorrect.* ***D*** *is not correct as the descriptions for the current and the drift velocity are incorrect.*	**(1)**
	Total for multiple choice questions	**10**

Question Number	Answer		Mark
11(a)	**Either**	(1)	
	Use of $V=IR$	(1)	
	Use of $P = I^2R$ with I = 0.080A and R = 62 Ω	(1)	
	P = 0.40 W		
	Or		
	Use ratio of resistance to ratio of p.d.s to get V = 4.98V or 5.0V	(1)	
	Use of $P = \frac{V^2}{R}$	(1)	
	P =0.40 W	(1)	**3**
	(accept correct use of V=IR **and** P=VI for MP2)		
	Example of calculation		
	$I = \frac{9\ \text{V}}{112\ \Omega} = 0.080\ \text{(A)}$		
	$P = (0.080\ \text{A})^2 \times 62\ \Omega = 0.40\ \text{W}$		
11(b)	Use of resistors in parallel formula with only 62 Ω **and** 57 Ω	(1)	
	Parallel resistance = 29.7 Ω or 30 Ω	(1)	
	R_{total} = 80 Ω	(1)	**3**
	Example of calculation		
	$\left(\frac{1}{R}\right) = \left(\frac{1}{62\Omega}\right) + \left(\frac{1}{57\Omega}\right)$		
	$R = 29.7\ \Omega$		
	$R_{\text{total}} = 29.7 + 50 = 79.7\ \Omega$		
	Total for question 11		**6**

Question Number	Answer		Mark
12(a)	Diffraction (after passing through the gap) **Or** Microwaves spread out (after passing through the gap)	(1)	
	Because wavelength (of microwaves is approximately) the same as the size of the gap	(1)	**2**
12(b)	The idea of <u>two</u> (diffracted) waves **Or** the idea that there are waves from both gaps	(1)	
	that interfere/superpose	(1)	
	Constructive (interference) if in phase **Or** Constructive (interference) if path difference = $n\lambda$	(1)	
	Destructive (interference) if in antiphase **Or** destructive (interference) if path difference = $(n + ½)\lambda$	(1)	
	maximum <u>amplitude</u> for constructive (interference) **And** minimum/zero <u>amplitude</u> for destructive (interference)	(1)	**5**
	Total for question 12		**7**

Question Number	Answer		Mark
13(a)(i)	Minimum/lowest frequency (of radiation/light) at which electrons are emitted/released (from the surface of the zinc plate)	(1)	**1**
***13(a)(ii)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) (In the particle theory) one <u>photon</u> interacts with one electron	(1)	
	<u>Photon</u> energy increase as frequency increases (so there is a minimum frequency required)	(1)	
	If the <u>photon</u> energy is less than the work function (for the metal) no electrons are released (accept converse)	(1)	
	In wave theory sufficient energy would eventually be transferred (so the electrons would be released) at any frequency	(1)	**4**
13(b)	**Either** Uses graph to determine E_{max} at 2.4×10^{15} Hz (5.2 to 5.6 eV)	(1)	
	Conversion of eV to J	(1)	
	Use of $E_k = \frac{1}{2}mv^2$ using $m = 9.11 \times 10^{-31}$kg	(1)	
	$v = 1.4 \times 10^6$ m s^{-1}	(1)	
	Or Use graph to determine f_0	(1)	
	Use of $E = hf$ for either 2.4×10^{15} Hz or 1.0×10^{15} Hz	(1)	
	Use of $E_k = \frac{1}{2}mv^2$ using $m = 9.11 \times 10^{-31}$kg	(1)	
	$v = 1.4 \times 10^6$ m s^{-1}	(1)	**4**
	<u>Example of Calculation</u> $E_k = 5.5 \text{ eV} \times 1.6 \times 10^{-19} \text{ C} = 8.8 \times 10^{-19}$ J $v = \sqrt{\frac{2 \times 8.8 \times 10^{-19} \text{ J}}{9.11 \times 10^{-31} \text{ kg}}} = 1.4 \times 10^6$ m s^{-1}		
	Total for question 13		**9**

Question Number	Answer	Mark
14(a)	Waves are reflected back **Or** waves are (travelling) in opposite directions (1) They superpose / interfere (1) Producing nodes and antinodes (1)	**3**
14(b)	Determine time period from graph (1) Use of $f = \frac{1}{T}$ (1) Use of $v = f\lambda$ (1) Use $\lambda = 2l$ (1) $l = 0.76$ m (1) (accept use of $\lambda = vt$ or $\lambda = vT$ for MP2 and MP3 combined) <u>Example of calculation</u> $T = 0.004$ s $f = \frac{1}{0.004} = 250$ Hz $l = \frac{380 \text{ m s}^{-1}}{2 \times 250 \text{ Hz}} = 0.76$ m	**5**
	Total for question 14	**8**

Question Number	Answer		Mark
15(a)	Use of $s = vt$ with $v = 3.00 \times 10^8$ m s^{-1} Calculates difference in distances or differences in times Correct use of factor of 2 v = 23 m s^{-1} Example of calculation $\Delta d = \frac{3.00 \times 10^8 \text{ m s}^{-1} \times 571 \times 10^{-9} \text{ s}}{2} - \frac{3.00 \times 10^8 \text{ m s}^{-1} \times 533 \times 10^{-9} \text{ s}}{2}$ $\Delta d = 5.7$ m $v = \frac{5.7 \text{ m}}{0.25 \text{ s}} = 22.8$ m s^{-1}	(1) (1) (1) (1)	**4**
15(b)	Reflection (of pulse) is not detected (Pulse) diverges/spreads/diffracts **Or** Energy/intensity (of pulse) decreases over a distance **Or** Energy (of pulse) absorbed in atmosphere **Or** Energy loss in reflection (of pulse)	(1) (1)	**2**
	Total for question 15		**6**

Question Number	Answer		Mark
16(a)	**Either** Increase in the number of collisions (between electrons and ions) (accept frequency of collisions) causing a decrease in (drift) velocity (hence a) decrease in current (for the same p.d., so resistance increases) (MP3 is conditional on either MP2 or MP1 being awarded) **Or** Increase in the number of collisions (between electrons and ions) (accept frequency of collisions) To maintain the same (drift) velocity **Or** conduction electrons do more work **Or** conduction electrons transfer more energy so greater p.d. needed (for the same current, so resistance increases) (MP3 is conditional on either MP2 or MP1 being awarded)	(1) (1) (1) (1) (1) (1)	**3**
16(b)	Use a micrometer (screw gauge) Take measurements in different positions/orientations Calculate the mean/average	(1) (1) (1)	**3**
16(c)	Correct calculation of gradient Use of $R = \frac{\rho l}{A}$ $\rho = 1.2 \times 10^{-6}\ \Omega\ \text{m}$ <u>Example of calculation</u> $\rho = \text{gradient} \times A = 9.0\ \Omega\ \text{m}^{-1} \times 1.3 \times 10^{-7}\text{m}^2 = 1.2 \times 10^{-6}\ \Omega\ \text{m}$	(1) (1) (1)	**3**
16(d)	Due to the resistance of the connecting wires **Or** Due to resistance in the circuit	(1)	**1**
	Total for question 16		**10**

Question Number	Answer		Mark
17(a)(i)	Higher percentage of sugar has a larger refractive index	(1)	
	So greater refraction **or** smaller angle of refraction	(1)	**2**
	(accept converse)		
17(a)(ii)	Use of ${}_1\mu_2 = \frac{\sin i}{\sin r}$ with $i = 40^o$ and $r = 26^o$.	(1)	
	$\mu = 1.47$	(1)	
	reads correct percentage sugar for their value of μ (MP3 is dependent on MP1 being awarded)	(1)	**3**
	Example of Calculation $\mu = \frac{\sin 40}{\sin 26} = 1.47$ From graph percentage sugar = 72 %		
17(b)(i)	(The) single plane containing the oscillations/vibrations (of the polarised wave)	(1)	
	And the direction of the propagation (MP2 is dependent on MP1 being awarded)	(1)	**2**
	(accept energy transfer or wave travel for propagation) (do **not** accept wave motion for propagation)		
17(b)(ii)	(Plane of polarisation of) filter A is perpendicular to (the plane of polarisation) of filter B **Or** the (polarised) light from filter A is perpendicular to (the plane of polarisation) of filter B	(1)	
	(So all) the polarised light (from A) is absorbed by filter B **Or** light transmitted by A is not transmitted by filter B	(1)	**2**
17(b)(iii)	The (plane of polarisation of the) light is rotated by a small angle (do not accept 90º)	(1)	
	only a component of the (polarised) light is transmitted by filter B **Or** a component of the light is not absorbed by filter B	(1)	**2**
17(b)(iv)	(one) filter is rotated	(1)	
	until no light is detected	(1)	
	measure/record the angle through which the filter is rotated **Or** links the angle of rotation of the filter with the angle of the plane of polarisation	(1)	**3**
	Total for question 17		**14**

Question Number	Answer		Mark
***18(a)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Atoms/electrons gain <u>energy</u> (from the charged particles) Electrons move up the energy levels (of the atom) **Or** atom/electron is excited When an electron falls back down it emits a <u>photon</u> **Or** atom/electron is de-excited, emitting a <u>photon</u> The energy of the <u>photon</u> is equal to the difference in the energy levels The frequency of light is proportional to the energy of the <u>photon</u>	(1) (1) (1) (1) (1)	**5**
18(b)	Greater number of collisions so more photons **Or** greater number of excited electrons so more photons Links intensity to the rate of emitted photons	(1) (1)	**2**
18(c)	Each gas has its own unique energy levels (Measuring) the wavelength/frequency/colour of the emitted light indicates the gas present (Measuring) the intensity of light indicates how much of a gas is present	(1) (1) (1)	**3**
	Total for question 18		**10**

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