Pearson Edexcel

Mark Scheme (Results)

January 2020

Pearson Edexcel International Advanced Subsidiary Level In Physics (WPH12) Paper 01 Waves and Electricity

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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. '<u>resonance</u>'

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]
[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 is the correct answer** (A path difference of λ would cause constructive interference A is not the correct answer as this path difference would cause destructive interference C is not the correct answer as this phase difference would cause neither constructive nor destructive interference D is not the correct answer as this phase difference would cause destructive interference	**(1)**
2	**D is the correct answer** (Polarised waves have oscillations in one direction and perpendicular to the direction of wave travel) A is not the correct answer as the single plane of polarisation includes the direction of wave travel and is not perpendicular to it B is not the correct answer as polarised waves do not contain many plames C is not the correct answer as polarised waves do not contain many directions	**(1)**
3	**D is the correct answer** (Total resistance in series is 10Ω and 2.5Ω in parallel) A is not the correct answer as the two resistances are the wrong way around B is not the correct answer as this assumes the formulae for series and parallel resistors are the same C is not the correct answer as this assumes the formulae for series and parallel resistors are the same	**(1)**
4	**A is the correct answer** (Both points X and Y represent positions on the graph where there is infinite resistance as the current is zero) B is not the correct answer as there is a non-infinite resistance at Z C is not the correct answer as there is also infinite resistance at Y D is not the correct answer as there is a non-infinite resistance at Z	**(1)**
5	**D is the correct answer** (Drift velocity is I/nqA) A is not the correct answer as drift velocity is not I/nA B is not the correct answer as drift velocity is not nqA/I C is not the correct answer as drift velocity is not nA/I	**(1)**
6	**B is the correct answer** ($hf = \Phi + KE_{max}$ so increasing f increases KE_{max}) A is not the correct answer as electrons are released instantaneously C is not the correct answer as increasing intensity only increases the number of electrons released and each electron still has the same kinetic energy D is not the correct answer as it is higher frequency, not wavelength, that eventually passes a threshold value to release electrons	**(1)**
7	**A is the correct answer** (Reading on V_1 decreases, readings on V_2 and A increase) B is not the correct answer as the decreased resistance of the thermistor will lead to a greater share of the p.d. across the fixed resistor C is not the correct answer as the meter readings show what would happen if the temperature decreased D is not the correct answer as none of the three meter readings would change in the ways stated	**(1)**

8	**C is the correct answer** (Both transverse and longitudinal waves can be refracted) A is not the correct answer as it is only electromagnetic waves that travel at the same speed in a vacuum – there are other transverse waves which travel at different speeds B is not the correct answer as transverse waves have vibrations that are perpendicular to the direction of wave travel D is not the correct answer as light is a transverse wave that can travel through liquids	**(1)**
9	**C is the correct answer** (The diffraction grating is set up so that it is parallel to the screen) A is not the correct answer as θ is calculated by taking measurements of diffraction grating to screen distance and the distance between bright dots then using trigonometry B is not the correct answer as the diffraction grating should be perpendicular to the laser light beam D is not the correct answer as the distance between the bright dots is best measured using a metre rule	**(1)**
10	**A is the correct answer** (Evidence for the wave nature of electrons came from experiments involving diffraction) B is not the correct answer C is not the correct answer D is not the correct answer	**(1)**

Question Number	Answer	Mark
11a	Recognises that node to node distance = $\lambda/2$ **Or** $\lambda = L/2$ stated (1) Wavelength = 0.85m (1) <u>Example of calculation</u> Node to node distance = $\lambda/2$. String has 4 loops so total length of string is 2λ λ = 1.70 m / 2 = 0.85 m.	**(2)**
11b	Use of $v = \sqrt{(T/\mu)}$ (1) Use of $T = mg$ (1) $v = 21\ \text{m s}^{-1}$ (1) <u>Example of calculation</u> $T = mg = 0.20\ \text{kg} \times 9.81\ \text{N kg}^{-1} = 1.96\ \text{N}$ $v = \sqrt{(T/\mu)} = \sqrt{(1.96\ \text{N} / 4.5 \times 10^{-3}\ \text{kg m}^{-1})} = 20.9\ \text{m s}^{-1}$	**(3)**
11c	T and μ are the same **Or** (As f decreases,) λ *in*creases (1) Speed would be the same **Or** There is no effect (on the speed) (1)	**(2)**
	Total for question 11	**7**

Question Number	Answer	Mark
12ai	Use of $I = P/A$ (1) Maximum energy received in one hour = 3.6×10^{19} J (1) <u>Example of calculation</u> $P = I \times A = (1100 \text{ Wm}^{-2}) \times (9.2 \times 10^{12} \text{ m}^2) = 1.0 \times 10^{16}$ W $E = P \times t = (1.0 \times 10^{16} \text{ W}) \times (60 \times 60) = 3.6 \times 10^{19}$ J	**(2)**
12aii	Calculates total energy usage in 2014 **Or** Calculates total energy received by solar panels in 1 year (1) Comparison of energies (hours with hours or years with years) to come to a correct conclusion. (1) Allow e.c.f. from values in (a)(i) Possible comparisons: (see table below) <u>Example of calculation</u> Total E worldwide in 1 year = 23,800 × (3.6×10^{15} J) = 8.6×10^{19} J 8.6×10^{19} J / 3.6×10^{19} J = 2.4 (hours), so worldwide electrical energy consumption for 2014 would be produced in less than 3 hours	**(2)**
12b	**MAX 2** from: Sand(storms) reduce amount/intensity/energy/power of light (1) Fewer electrons released in the (solar) panel (1) Sand(storms) absorbs/blocks/reflects some light (1) Sand(storms) reduces area of panel/desert (1)	**(2)**
	Total for question 12	**6**

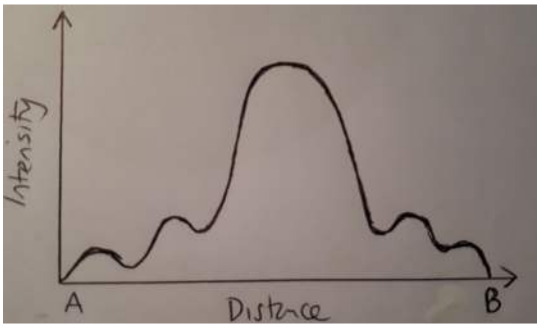
Possible comparisons (12aii):

Total energy worldwide in 2014	**Total energy received by solar panels**
23800 TWh (in a year)	87,600,000 TWh (if using 24 hours)
23800 TWh (in a year)	43,800,000 TWh (if using 12 hours)
8.6×10^{19} J (in a year)	3.2×10^{23} J (if using 24 hrs)
8.6×10^{19} J (in a year)	1.6×10^{23} J (if using 12 hrs)
9.8×10^{15} J (in an hour)	3.6×10^{19} J (in an hour)

Question Number	Answer	Mark
*13	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. Number of indicative marking points seen in answer → Number of marks awarded for indicative marking points: 6 → 4 5–4 → 3 3–2 → 2 1 → 1 0 → 0 The following table shows how the marks should be awarded for structure and lines of reasoning. Number of marks awarded for structure of answer and sustained line of reasoning: Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout → 2 Answer is partially structured with some linkages and lines of reasoning → 1 Answer has no linkages between points and is unstructured → 0 **Indicative content** • Ultrasound is reflected from boundaries/baby • (This reflection is caused by) change in density • Time taken between pulse being sent and received measured • Speed of ultrasound is known • Speed = distance/time can be used (to calculate the distance to boundary) • Clear indication that this calculation includes ½ time or ½ distance (Candidates can potentially achieve 1 linkage mark if they have scored both IC1 and IC2. They can potentially achieve 1 linkage mark if they have scored 3 of IC3-6)	**(6)**
	Total for question 13	**6**

Question Number	Answer	Mark
14a	Minimum energy required to release/emit a (photo)electron (from the surface of the metal) (1)	**(1)**
14b	Ultraviolet has a higher (photon) energy (than visible light) (1) Ultraviolet (photons) have an energy greater than the work function **Or** Visible light (photons) have an energy less than the work function (1) **OR** Ultraviolet has a higher frequency (than visible light) (1) Ultraviolet has a frequency greater than the threshold frequency **Or** Visible light has a frequency less than the threshold frequency (1) (Allow converse statements for MP1)	**(2)**
14ci	(Increased intensity means) more <u>photons</u> per second (1) (More photons leads to) more electrons emitted (per second) (1) Reading on ammeter is increased **Or** Current is increased (1) (For MP1 there needs to be an indication of rate e.g. "per unit time")	**(3)**
14cii	Use of $E = hf$ (1) Use of $V = W/Q$ (1) Use of $hf = \Phi + ½ mv^2_{max}$ (1) Work function = 7.6×10^{-19} (J) (1) **<u>Example of Calculation</u>** $hf = \Phi + ½ mv^2_{max} = hf = \Phi + QV$ $hf = (6.63 \times 10^{-34}\text{ Js})(2.00 \times 10^{15}\text{ Hz}) = 1.33 \times 10^{-18}\text{ J}$ $QV/eV = (1.60 \times 10^{-19}\text{ C})(3.59\text{ V}) = 5.74 \times 10^{-19}\text{ J}$ hf – eV = 7.56×10^{-19} J	**(4)**
	Total for question 14	**10**

Question Number	Answer	Mark
15a	There is a decrease in speed/velocity (1) Part of the wavefront meets the boundary before the rest (1) (Ignore references to density and refractive index) (Allow MP2 for correct addition to the diagram by eye for wavefronts both before and after the boundary)	**(2)**
15bi	Use of $v = \sqrt{\frac{g\lambda}{2\pi}}$ to find speed in deep water (1) Use of $v = \sqrt{(gd)}$ to find speed in shallow water (1) Calculates ratio of speeds (1) Correctly equates ratio of speeds to ratio of sine of each angle (1) $r = 17°$ (1) <u>Example of calculation</u> $v = \sqrt{\frac{g\lambda}{2\pi}} = \sqrt{\frac{(9.81\text{ms}^{-2} \times 15\text{ m})}{2\pi}} = 4.8\text{ ms}^{-1}$ (deep water) $v = \sqrt{(gd)} = \sqrt{(9.81\text{ ms}^{-2} \times 0.50\text{ m})} = 2.2\text{ ms}^{-1}$ (shallow water) ratio of speeds = $(4.8\text{ ms}^{-1}) / (2.2\text{ ms}^{-1}) = 2.2$ $\sin r = \sin(40) / 2.2 = 0.29$ $r = 17°$	**(5)**
15bii	Use of $f = 1/T$ and $v = f\lambda$ to find speed of wave (1) Use of $v = \sqrt{\frac{g\lambda}{2\pi}}$ to find same speed in deep water, confirming that deep water equation is the correct equation for this wave (1) Deep water equation only works if $d > 342 / 2$ so d must be > 171m (1) <u>Example of calculation</u> $f = 1 / 14.8\text{ s} = 0.0676\text{ Hz}$ $v = 0.0676\text{ Hz} \times 342\text{ m} = 23.1\text{ ms}^{-1}$ $v = \sqrt{\frac{g\lambda}{2\pi}} = \sqrt{\frac{(9.81\text{ms}^{-2} \times 342\text{ m})}{2\pi}} = 23.1\text{ ms}^{-1}$ (deep water)	**(3)**
	Total for question 15	**10**

Question Number	Answer		Mark
16a	Waves spread out (as they pass through the gap) Each point on the wave(front) acts as a source of new/secondary wave(let)s	(1) (1)	**(2)**
16b	Maximum intensity halfway between A and B (by eye) Central maximum broader than other maxima (by eye) Central maximum greater than twice the height from zero intensity (by eye) of other maxima 	(1) (1) (1)	**(3)**
	Total for question 16		**5**

Question Number	Answer		Mark
17a	Energy (supplied) to/per unit charge **Or** Work done (supplied) to/per unit charge **Or** The work done moving unit charge around the whole circuit	(1)	**(1)**
17bi	Use of sum of e.m.f. = sum of p.d. **Or** see $\mathcal{E} = V + Ir$ with correct substitutions $r = 1.9 \times 10^{-2}\ \Omega$ <u>Example of calculation</u> $\mathcal{E} = V + Ir$, 12.0 V = 11.81 V + (9.83 A) r. so $r = 0.0193\ \Omega$	(1) (1)	**(2)**
17bii	Plot V against I Determine the gradient Gradient is $-r$ **OR** Plot I against V Determine the gradient Gradient is – $(1/r)$ **OR** Plot $(\mathcal{E} - V)$ against I Determine the gradient Gradient is r	(1) (1) (1) (1) (1) (1) (1) (1) (1)	**(3)**

17c	Calculates circuit current using $I = \varepsilon$ / Total R **Or** Calculates p.d. across fixed resistor using potential divider equation (1) Use of a power equation (to calculate Power dissipated in fixed resistor) (1) Divides final power by initial power **Or** Divides difference in power by initial power **Or** Calculates 70% of initial power (1) Calculated value for final power/initial power is greater than 70% of initial power so student incorrect **Or** Calculated value for difference between initial and final power is less than 30% so student incorrect **Or** Calculated value for 70% of initial power is less than the final power so student incorrect (1) (Candidates who use incorrect values of I, V or R in either power calculation for MP2 cannot be awarded MP3 or MP4) <u>Example of calculation</u> Initially $I = \varepsilon$ / Total R = 9.0 V / (5.0 + 0.10 Ω) = 1.76 A Power of external resistor = $I^2 R$ = $(1.76\text{ A})^2$ (5.0 Ω) = 15.5 W When r = 0.50 Ω, $I = \varepsilon$ / Total R = 9.0 V / (5.0 + 0.50 Ω) = 1.64 A Power of external resistor = $I^2 R$ = $(1.64\text{ A})^2$ (5.0 Ω) = 13.4 W Percentage of original value = (13.4 W) / (15.5 W) = 0.86 (or 86%)	**(4)**
	Total for question 17	**10**

Question Number	Answer	Mark
18a	Use of speed = distance / time (1) Calculates distance travelled by sound in 3s = 1020 (m) **Or** calculates time taken for sound to travel 1 km = 2.94 (s) **Or** calculates speed to travel 1000m in 3 seconds = 333 (ms^{-1}) (1) Time taken by light to reach 1 km is almost instantaneous / 3.3×10^{-6} s so teacher is (approximately) correct. (1) Example of calculation For light, $t = d/v$ = 1000 m / 3.00×10^8 ms^{-1} = 3.33×10^{-6} s For sound, $t = d/v$ = 1000 m / 340 ms^{-1} = 2.94 s Difference in arrival time = 2.94 s ≈ 3 s	**(3)**
18bi	Use of $Q = It$ (1) Q = 0.75 C (1) Example of calculation $Q = It$ = 25,000 A × (30 × 10^{-6} s) = 0.75C	**(2)**
18bii	Use of $P = VI$ (1) $P = 3.0 \times 10^{13}$ W (1) Example of calculation $P = VI$ = (1.2 × 10^9 V) × 25,000 A = 3.0×10^{13} W	**(2)**
18biii	Use of $A = \pi r^2$ (1) Use of $R = \rho l/A$ (1) ρ = 0.24 (Ω m) (1) Example of calculation Cross sectional area of wire = $\pi r^2 = \pi (2.5 \times 10^{-2})^2 = 1.96 \times 10^{-3}$ m^2 $R = V/I$ = (1.2 × 10^9 V) / 25,000 A = 48,000 Ω ρ = RA/l = (48,000 Ω) (1.96 × 10^{-3} m^2) / 400 m = 0.235 Ωm	**(3)**
18biv	Air in the lightning channel has been ionised **Or** Lightning channel unlikely to have a uniform diameter / CSA (1)	**(1)**

18ci	Energy levels (in atoms) are discrete/specific (1) (Energy makes) electrons move up energy levels **Or** Electrons are excited (1) (Electrons) move back down energy levels, releasing photons **Or** (Electrons) are de-excited, releasing photons (1) Energy difference (between levels) is proportional to frequency of photon (resulting in line spectrum being produced) **Or** Photon energy is proportional to frequency (resulting in line spectrum being produced) (1)	**(4)**
18cii	Different atoms/elements have different (differences in) energy levels (1)	**(1)**
	Total for question 18	**16**

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