edexcel

Mark Scheme (Results)

Summer 2016

Pearson Edexcel
International Advanced Level
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.

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

Example of answer:

$80 \text{ cm} \times 50 \text{ cm} \times 1.8 \text{ cm} = 7200 \text{ cm}^3$

$7200 \text{ cm}^3 \times 0.70 \text{ g cm}^{-3} = 5040 \text{ g}$

$5040 \times 10^{-3} \text{ kg} \times 9.81 \text{ N/kg}$

$= 49.4 \text{ N}$

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

Question Number	Answer		Mark
11 (a)	Use of $v = f\lambda$ λ = 0.012 (m) or 1.2 (cm) Example of calculation $\lambda = 0.24 \text{ m s}^{-1} / 20 \text{ Hz} = 0.012 \text{ m}$	**(1)** **(1)**	**2**
11 (b)	Diffraction occurs At 7cm, the gap > wavelength and the wave passes through with little diffraction/spreading As the gap narrows diffraction becomes more significant **Or** diffraction maximum/180° when gap = λ When wavelength greater than gap size diffraction occurs but at a lower intensity **Or** When wavelength greater than gap size (diffraction occurs but) most of the energy/wave is reflected back (Do not accept no diffraction)	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 11		**6**

Question Number	Answer		Mark
*12	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 4 for photon description** The idea that an electron is excited to higher energy level then falls back down so light is emitted Violet has (the lowest wavelength and therefore) the highest frequency Violet light photons have the highest energy ($E = hf$) (Quoting $E = hc/\lambda$ to justify violet having the highest energy gains MP2 as well) (This could be explained by assuming that) absorption can only be a single photon for a single electron And that there is a minimum/certain amount of energy that must be absorbed for the effect **Or** only violet light photons have sufficient/correct energy for the effect **Max 2 marks for wave description** With waves energy would build up over time So it should work with any frequency/wavelength/colour	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question 12		**5**

Question Number	Answer		Mark
***13**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Doppler effect causes a change in frequency/wavelength **Or** Motion of the source causes a change in frequency/wavelength	**(1)**	
	(Before X) the car is moving towards the observer so the frequency is increased and (after X) the car is moving away from the observer so the frequency is decreased	**(1)**	
	Maximum 2 from Comment explaining decrease/increase in wavelength, e.g. the wavefronts get closer/further respectively **Or** Comment explaining increase/decrease in frequency, e.g. the waves arrive at shorter/longer intervals respectively	**(1)**	
	since $v = f\lambda$, a decrease in wavelength causes an increase in frequency (when moving towards) **Or** since wavelength is inversely proportional to frequency, an increase in wavelength causes a decrease in frequency (when moving away)	**(1)**	
	At X the frequency observed is the frequency of the sound emitted	**(1)**	**4**
	Total for question 13		**4**

Question Number	Answer	Mark
14 (a)	Determines time period = 25 (μs) **(1)** Frequency = 40 000 Hz **(1)**	**2**
14 (b)	The signals from the emitters are in phase **Or** the emitters are coherent sources **(1)** Idea of a path/phase difference between the waves arriving from each source **(1)** Superposition / interference takes place **(1)** If the path difference is nλ, they are in phase **Or** If the path difference is (n + ½) λ, they are in antiphase **(1)** For path difference is nλ constructive interference occurs **Or** When in phase constructive interference occurs **Or** For path difference is (n + ½) λ destructive interference occurs **Or** When in antiphase destructive interference occurs **(1)** Constructive interference creates maximum amplitude **Or** Destructive interference creates minimum amplitude (Accept almost zero amplitude for minimum amplitude) **(1)** (For path difference version of MP4 and 5 accept specific values of n)	**6**
	Total for question 14	**8**

Question Number	Answer		Mark
15 (a)	Use of $R = V/I$ with $V = 3.5$ V $R = 5.6\ \Omega$ to $6.0\ \Omega$ (Do not accept use of the gradient for either mark) <u>Example of calculation</u> $R = 3.5$ V / 610 mA = 5.7 Ω	**(1)** **(1)**	**2**
15 (b)	Initially (there is zero current, so) the resistance is infinite / very high Once current flows the resistance decreases (rapidly) **Or** when a threshold p.d. is reached the resistance decreases (rapidly) **Or** when 2.25 V is reached the resistance decreases (rapidly) (If neither MP1 or MP2 awarded, accept 'as p.d. increases resistance decreases' for 1 mark)	**(1)** **(1)**	**2**
15 (c)	Use of $W = QV$ Use of $E = hf$ $h = 6.3 \times 10^{-34}$ (J s) to 6.6×10^{-34} (J s) **Or** $V = 2.26$ (V) Comparison of candidate's value to value of *h* from data list **Or** Comparison of candidate's value of threshold p.d. with graph (Comparison must be consistent with their value. Also accept % difference calculations) <u>Example of calculation</u> $W = 1.6 \times 10^{-19}$ C × 2.3 V = 3.68×10^{-19} J $h = 3.68 \times 10^{-19}$ J / 5.7×10^{14} Hz = 6.46×10^{-34} J s	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 15		**8**

Question Number	Answer		Mark
16(a)(i)	The graph (only) shows that resistance decreases with increasing temperature A graph of 1/resistance against temperature would be required **Or** A graph of 1/temperature against resistance would be required This would be a straight line through the origin if inverse proportionality (dependent mark) **Or** The graph (only) shows that resistance decreases with increasing temperature Comments on requiring resistance × temperature to be constant Should calculate at least two pairs of products **Or** The graph (only) shows that resistance decreases with increasing temperature Comments on doubling one value causing the other to be halved Should test with at least two pairs of points	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
16(a) (ii)	As temperature increases the atoms/molecules/particles/ions/electrons gain energy **Or** As temperature increases the atoms/molecules/particles/ions vibrate more (So,) as temperature increases, more electrons/charge carriers become free Relevant reference to $I = nAqv$ e.g. Since $I = nAqv$ this allows a smaller v (for the same current), so V is decreased for the same current **Or** Since $I = nAqv$ this allows a greater current (for the same p.d.) Since I increases and $R = V/I$, R decreases **Or** Since V decreases and $R = V/I$, R decreases	**(1)** **(1)** **(1)** **(1)**	**4**

16(b)	Use of ratio of resistors = ratio of p.d.s **Or** Use of $I = V/R$ for fixed resistor and $R = V/I$ for resistance under investigation **(1)** Resistance of thermistor = 2.1 (kΩ) **(1)** Temperature (from graph) = 40 °C to 41 °C **(1)** (temperature consistent with candidate's value of resistance) <u>Example of calculation</u> 5.2 kΩ / total = 8.5 V / 12 V Total resistance = 7.3 kΩ Resistance of thermistor = 7.3 kΩ - 5.2 kΩ = 2.1 kΩ Temperature (from graph) = 41 °C	**3**
16 (c)	The ohmmeter uses a very small current, so it will not have a heating effect **(1)** A larger current's heating effect could mean that the temperature of the thermistor was higher than the recorded temperature of the water **(1)** **Or** With two meters there could be (random/zero/systematic) errors/uncertainties with both meters **(1)** And the (percentage) uncertainty would increase **(1)** **Or** With two meters, both readings need to be taken at the same time **(1)** If they aren't, the values won't match and the value of resistance will be incorrect **(1)** **Or** There may be some current through the voltmeter (if its resistance isn't high enough) **(1)** So the current measured on the ammeter will be too high and the resistance will be too small **(1)**	**2**
	Total for question 16	**12**

Question Number	Answer		Mark
17(a)	With a very high resistance the current is zero/negligible Therefore the lost volts / Ir is very low / zero **and** terminal pd = e.m.f. **Or** $\mathcal{E} = V + Ir$ so $\mathcal{E} = V$ **Or** The resistance of the voltmeter is much greater than the internal resistance of the cell Therefore the lost volts / Ir is very low / zero **and** terminal pd = e.m.f. **Or** $\mathcal{E} = V + Ir$ so $\mathcal{E} = V$	**(1)** **(1)** **(1)** **(1)**	**2**
17 (b) (i)	Use of e.m.f. = sum of p.d.s Use of $V = IR$ (Use of $\mathcal{E} = V + Ir$ gains MP1 and MP2) $r = 35.5\ \Omega$ <u>Example of calculation</u> $2.04\ \text{V} = 1.60\ \text{V} + (12.4 \times 10^{-3}\ \text{A} \times r)$ $r = 35.5\ \Omega$	**(1)** **(1)** **(1)**	**3**
17(b) (ii)	Use of power = intensity × area Use of power = IV (accept other equations if load resistance calculated) Use of efficiency = useful output / input Efficiency = 0.046 **Or** 4.6 % <u>Example of calculation</u> power = intensity × area = $270\ \text{W m}^{-2} \times 1.6 \times 10^{-3}\ \text{m}^2 = 0.432\ \text{W}$ power = IV = $12.4\ \text{mA} \times 1.60\ \text{V} = 1.98 \times 10^{-2}\ \text{W}$ Efficiency = $1.98 \times 10^{-2}\ \text{W} / 0.432\ \text{W}$ Efficiency = 0.046	**(1)** **(1)** **(1)** **(1)**	**4**
17(c)	Use of $Q = It$ Q = 1080 (C) It doesn't store charge – this is the charge that flows **Or** it doesn't store charge, it stores energy **Or** it stores 1080 C × 1.2 V = 1300 J <u>Example of calculation</u> $Q = 0.3\ \text{A} \times (60 \times 60)\ \text{s} = 1080\ \text{C}$	**(1)** **(1)** **(1)**	**3**
	Total for question 17		**12**

Question Number	Answer	Mark
18(a)	polarised light has all oscillations in a single plane and that is the plane of polarisation **(1)** the plane includes the direction of propagation of the light **(1)**	**2**
18(b) (i)	The idea that the analyser is at 90° to the polariser **(1)** So the light is absorbed (accept converse argument about transmission) **(1)**	**2**
18 (b) (ii)	If the (plane of polarisation of the) light is rotated (additionally) by a multiple of 180° (accept any suitable stated angle) the plane of polarisation will be the same again **(1)** So this will also be at 90° so the light will again be absorbed **(1)** States a suitable angle, e.g. 235°, 415° etc **(1)**	**3**
18(b) (iii)	The difference in intensity between nearly maximum intensity and maximum intensity is small **Or** more able to judge when no light seen compared with judging the maximum intensity **(1)** So there will be a greater (percentage) uncertainty when position for maximum intensity is used **(1)**	**2**
18(c)	The electrons are found in discrete/specific energy levels **Or** atoms have discrete/specific energy levels **(1)** Electrons are excited **Or** electrons move to higher levels **(1)** Electrons (rapidly) fall to lower levels **Or** (When) electrons de-excite **(1)** They emit the energy as photons with energy equal to the difference in levels **(1)** Photon energy = hf **Or** Photon energy = hc/λ **(1)** Only specific energy changes/differences are possible, so only specific wavelengths/ frequencies are possible **(1)**	**6**
	Total for question 18	**15**

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