Mark Scheme (Results)

January 2015

Pearson Edexcel International Advanced Subsidiary Level in Physics (WPH02) Paper 01

Edexcel and BTEC Qualifications

January 2015
Publications Code IA040643

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

Question Number	Answer	Mark
11	Current zero for negative V **(1)** **Or** current zero when reverse bias (accept current doesn't flow **or** no current) **Max 2 for additional points from** Current only in one direction because resistance infinite in other direction (accept very high resistance) **(1)** small (positive) p.d. before there is a current (accept reference to threshold voltage, 0.6 V or 0.7 V) **(1)** as V increases, resistance of diode decreases **(1)** **Or** as I increases, resistance of diode decreases	**3**
	Total for Question 11	**3**

Question Number	Answer	Mark
12(a)	(Motion of person causes) a change in frequency/wavelength **(1)** Compared to the signal from X directly **(1)** Correctly states change in frequency/wavelength for motion described **(1)**	**3**
12(b)	Pulse-echo gives the distance of an object **Or** Pulse-echo gives the position of an object **Or** Pulse-echo can detect a person who is not moving **Or** Pulse-echo can detect inanimate objects **Or** Doppler only works with moving objects Accept any sensible physics based suggestion that doesn't also apply to the Doppler system **(1)**	**1**
	Total for Question 12	**4**

Question Number	Answer		Mark
13(a)(i)	angle of incidence (for light travelling from denser medium) which has angle of refraction of 90˚ (may refer to leaving along surface/boundary) (accept answers based on maximum angle of incidence (1) For light to enter second medium (1))	**(1)** **(1)**	**2**
13(a)(ii)	use of speed of light in vacuum / speed of light in medium = refractive index μ = 1.52 to at least 3 sf <u>Example of calculation</u> $\mu = 3.00 \times 10^8$ m s^{-1} ÷ 1.97×10^8 m s^{-1} = 1.52	**(1)** **(1)**	**2**
13(a)(iii)	Use of μ = sin *i* / sin *r* (accept stating sin *c* = 1 / μ) *c* = 41˚ (n.b. ue applies) Allow ecf from (ii) <u>Example of calculation</u> sin *c* = 1 / μ = 1 / 1.52 *c* = 41˚	**(1)** **(1)**	**2**
13(b)	Light strikes side at greater than critical angle <u>Total internal reflection</u> repeats along the fibre	**(1)** **(1)**	**2**
	Total for Question 13		**8**

Question Number	Answer		Mark
14(a)(i)	*x*: position **Or** distance (accept undisturbed position) **Or** displacement *y*: amplitude **Or** <u>maximum</u> displacement Labels may be added to graph or written on answer lines, but if in both places, the answer line version is marked	**(1)** **(1)**	**2**
14(a)(ii)	Waves now in antiphase **Or** waves π out of phase **Or** waves 180° out of phase Idea of superposition / interference Producing zero amplitude (accept displacement always zero)	**(1)** **(1)** **(1)**	**3**
14(b)(i)	70 cm **Or** 0.7 m	**(1)**	**1**
14(b)(ii)	Use of $v = f\lambda$ Wave speed = 137 m s^{-1} [allow ecf] <u>Example of calculation</u> v = 196 Hz × 0.7 m = 137 m s^{-1}	**(1)** **(1)**	**2**
	Total for Question 14		**8**

Question Number	Answer	Mark
15(a)	Lowest energy state of atom **Or** electron in lowest energy level **(1)**	**1**
***15(b)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Electrons/atoms move to higher energy levels **Or** Electrons/atoms are excited **(1)** They then move to lower energy levels (accept ground state) **(1)** The energy (from the change) is given out in the form of a photon **(1)** The energy levels are discrete **Or** only certain energy levels are possible **(1)** The energy of the photon must be equal to the difference in energy levels **Or** $hf = E_2 - E_1$ **Or** $hc/\lambda = E_2 - E_1$ **(1)** There are only a limited number of energy differences and only a corresponding set of frequencies/wavelengths (looking for energy differences /changes **not** energy levels) **(1)** [MP1,2 reference must be to atoms or electrons] [MP5 must be equals, not depends on etc] (Answers with no reference to wavelength are awarded a maximum of 5 marks) (Some marks above may be obtained from a suitably labelled diagram – but the order of excitation and de-excitation cannot be assumed just from the presence of both)	**6**
	Total for Question 15	**7**

Question Number	Answer	Mark
16*(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) With waves energy could build up **(1)** Any ke could be possible **Or** ke would not be limited **(1)** One photon to one electron **(1)** $E = hf$, so energy transfer limited **Or** $\frac{1}{2} mv^2 = hf - \varphi$ so there is a maximum ke **(1)**	**4**
16(b)	Use of $E = hf$ **(1)** Correct use of 1.6×10^{-19} C **(1)** Use max ke = $hf - \varphi$ **(1)** $\frac{1}{2} mv^2 = 1.3 \times 10^{-18}$ J **(1)** <u>Example of calculation</u> $E = 6.63 \times 10^{-34}$ J s $\times 2.5 \times 10^{15}$ Hz $= 1.7 \times 10^{-18}$ J $\varphi = (2.3$ eV $\times 1.6 \times 10^{-19}$ C) J $= 3.7 \times 10^{-19}$ J $\frac{1}{2} mv^2 = 1.7 \times 10^{-18}$ J $- 3.7 \times 10^{-19}$ J $= 1.3 \times 10^{-18}$ J	**4**
	Total for Question 16	**8**

Question Number	Answer	Mark
17(a)	(Plane) waves before a gap or edge **and** curved waves spread out after gap or barrier **(1)** Direction indicated and wavelength constant throughout **(1)**	**2**
17(b)(i)	Wavelength approx. 4 cm (Accept specific value from 3.5 cm to 4 cm or a range) **(1)** **Max 3 from** No detector output when no gap because microwaves reflected by metal **(1)** Little/no detector output when gap very small because there is a large angle of diffraction but most of the wave (energy) is reflected (allow there is little diffraction) **(1)** Max output when gap approx. equal to wavelength because there is maximum diffraction **(1)** Output less/decreases for larger gaps because less/little diffraction when gap (much) larger than wavelength **(1)**	**4**
17(b)(ii)	Most rapid change in shape between 3 and 5 cm **Or** the peak value is about 4 cm **(1)** Sensible further comment, e.g. But most frequent readings for smaller gap sizes (while the change is steady) **(1)** **Or** the readings are not taken at regular intervals **Or** the student hasn't taken sufficient readings to tell where the peak is	**2**
	Total for Question 17	**8**

Question Number	Answer	Mark
18(a)(i)	Use of power = flux × area **(1)** Power = 0.31 (W) [no ue] **(1)** <u>Example of calculation</u> Power = 49 W m^{-2} × 6.4 × 10^{-3} m^2 *P* = 0.314 W	**2**
18(a)(ii)	Use of *P* = *IV* **(1)** Use of efficiency = (output power/input power) × 100% **(1)** Efficiency = 12 % **or** 0.12 Allow ecf from (i) **(1)** <u>Example of calculation</u> *P* = 0.0068 *A* × 5.6 V = 0.038 W efficiency = (0.038 W /0.31 W) × 100% = 12 % (OR 0.12)	**3**
18(b)	Use of *Q* = *It* **(1)** Use of *W* = *QV* **(1)** Maximum energy = 19 000 J **(1)** **Or** Use of *P* = *IV* **(1)** Use of *W* = *Pt* **(1)** Maximum energy = 19 000 J **(1)** (**Or** Use of *W* = *VIt* scores 2 Maximum energy = 19 000 J) <u>Example of calculation</u> *Q* = 1.5 A × (60 × 60) s = 5400 C *W* = 5400 C × 1.2 V × 3 = 19 400 J	**3**
18(c)	*W* = *IVt*, and *W* is the same for each (rechargeable) cell (and *V* varies in the same way) **(1)** Because the (6.8 mA) current undivided for cells in series, the current is greater so the time is shorter (accept charges more quickly) **Or** reverse argument for parallel **(1)**	**2**
	Total for Question 18	**10**

Question Number	Answer	Mark
19(a)(i)	cross-sectional area = 9.2×10^{-7} m^2 **(1)** <u>Example of calculation</u> $A = \pi \times (0.00108 \text{ m} \div 2)^2$ $= 9.2 \times 10^{-7}$ m^2	**1**
19(a)(ii)	Use of $\rho l/A = R$ **(1)** Length = 16.4 m **(1)** <u>Example of calculation</u> $l = RA/\rho$ $= 0.3\ \Omega \times 9.2 \times 10^{-7}$ m$^2 \div 1.68 \times 10^{-8}\ \Omega$ m = 16.4 m	**2**
19(a)(iii)	Comparison based on answer to (a) (ii), e.g. 2 m / 13% out so not very good **(1)**	**1**
19(a)(iv)	Resistance only to nearest 0.1 Ω (accept 1 sig fig) **Or** diameter to nearest 0.01mm (accept 3 sig fig) **(1)** For resistance that is plus or minus 17% (accept 33%) **Or** for diameter that is plus or minus 0.5 % (accept 1%) **(1)** Comparison of the percentage uncertainty of the diameter with percentage uncertainty of the resistance **(1)**	**3**
19(a)(v)	(Apply pd and) measure pd and current with voltmeter and ammeter (accept circuit diagram if power supply shown and meters correctly placed) **(1)** Calculate resistance using $V = IR$ **Or** Plot V against I and use gradient (of the straight line) for R **(1)** The meters will give more sig figs (than the ohmmeter reading) **Or** there can be a lower percentage uncertainty with the meters **Or** you can select a pd and current much larger than the uncertainty generated by the limit of precision (accept graph would reduce the effect of random errors) **(1)**	**3**
19(b)(i)	Use of $P = IV$ **(1)** I = 5.2 A **(1)** <u>Example of calculation</u> 1200 W = I × 230 V I = 5.22 A	**2**
19(b)(ii)	Use of $P = I^2R$ **(1)** P = 8.1 W Allow ecf from (b)(i) **(1)** <u>Example of calculation</u> $P = (5.2 \text{ A})^2 \times 0.3\ \Omega$ P = 8.1 W	**2**
	Total for Question 19	**14**

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