Mark Scheme (Results)

June 2017

Pearson Edexcel
Advanced Level in Physics (9PH0/02)
Paper 2 Advanced Physics II

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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.
- All eaminers 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.

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 e.g. '**and'** when two pieces of information are needed for 1 mark.

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 This does not apply in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.3 The mark will not be awarded for the same missing or incorrect unit only once within one clip in epen.

2.4 Occasionally, it may be decided not to insist on a 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.

2.5 The mark scheme will indicate if no unit error is to be applied by means of [no ue].

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not be prevent a mark being awarded if the answer given rounds to the answer in the MS.

3.2 Too few significant figures will mean that the final mark cannot be awarded in 'show that' questions where one more significant figure than the value in the question is needed for the candidate to demonstrate the validity of the given answer.

3.3 The use of one significant figure might be inappropriate in the context of the question e.g. reading a value off a graph. If this is the case, there will be a clear indication in the MS.

3.4 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 mean that one mark will not be awarded. (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

3.5 In questions assessing practical skills, a specific number of significant figures will be required e.g. determining a constant from the gradient of a graph or in uncertainty calculations. The MS will clearly identify the number of significant figures required.

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.

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Question Number	Answer	Mark
1	**C - polarisation**	**1**
	Incorrect Answers: A – diffraction is exhibited by sound waves B – interference is exhibited by sound waves D – refraction is exhibited by sound waves	
2	**B – 4 cm**	**1**
	Incorrect Answers: Correct method: 1. force on one spring is 20 N ÷ 2 = 10 N, 2. spring constant k = 10 N ÷ 8 cm = 1.25 N cm^{-1}, 3. extension = 5 N ÷ 1.25 N cm^{-1} = 4 cm A – 2 cm, omits step 1 C – 8 cm, applies 10 N in step 3 D – 16 cm, applies 20 N in step 3	
3	**B – 0.40 Hz**	**1**
	Incorrect Answers: Correct method: f = 24 ÷ 60 s = 0.40 Hz A – uses 1 minute ÷ 24 C – uses 60 s ÷ 24 D – uses 24 ÷ 1 minute	
4	**D Both fields act on all particles.**	**1**
	Incorrect Answers: A – this is a similarity B – this is a similarity C – this is a similarity	

5	**B – 545 ÷ 838 000**	**1**
	Incorrect Answers: Correct method: mass = energy transfer ÷ latent heat of vaporisation A – uses energy transfer ÷ latent heat of fusion C – uses latent heat of fusion ÷ energy transfer D – uses latent heat of vaporisation ÷ energy transfer	
6	**B – (point on graph with luminosity ≠ $L_\odot$)**	**1**
	Incorrect Answers: A – luminosity ≠ $L_\odot$ C – luminosity ≠ $L_\odot$ D – luminosity ≠ $L_\odot$	
7	D - 8L	**1**
	Incorrect Answers: Correct method: ÷ 2 for area change and × 24 for temperature change A – only applies ÷ 2 for area change B – applies ÷ 2 for area change and × 2 for temperature change C – applies ÷ 1/2 for area change and × 2 for temperature change Or applies ÷ 2 for area change and × (2 × 4) for temperature change	

8	**D –** $\frac{(656.3 - 654.9)}{654.9} \times 3 \times 10^8 \text{ m s}^{-1}$	**1**
	Incorrect Answers: correct method: $\frac{change\ in\ wavelength}{wavelength\ in\ laboratory} \times speed\ of\ light$ A – uses $\frac{wavelength\ from\ star}{wavelength\ in\ laboratory} \times speed\ of\ light$ B – uses $\frac{wavelength\ in\ laboratory}{change\ in\ wavelength} \times speed\ of\ light$ C – uses $\frac{wavelength\ in\ laboratory}{wavelength\ from\ star} \times speed\ of\ light$	
9	**C - 1.5**	**1**
	Incorrect Answers: all select incorrect data from question Correct method: image distance ÷ object distance A – uses focal length ÷ object distance B – uses object distance ÷ image distance D − uses object distance ÷ focal length	
10	**D – using laser light with a higher frequency**	**1**
	Incorrect Answers: A – this would have no effect B – this would make the maxima further from the central maximum C − this would make the maxima further from the central maximum	

(Total for Multiple Choice Questions = 10 marks)

Question Number	Acceptable answers	Additional guidance	Mark
11	• use of $\Delta E = mc\Delta\theta$ **(1)** • use of $P = E/t$ **(1)** • Correct calculation of an appropriate quantity **and** comment consistent with their value. **(1)**	**MP2** Candidates need to calculate either a time, a final temperature, an energy or a power Examples: Yes, because t = 30 s, which is less than one minute **Or** Yes, because it could reach temperature of 408 °C in one minute **Or** Yes, because it would transfer 156 000 J in one minute **Or** Yes, because the power required is 1.3 kW <u>Example of calculation</u> ΔE = 0.89 kg × 450 J kg^{-1} K^{-1} × (215 °C - 18 °C) = 78 900 J t = 78 900 J ÷ 2600 W = 30 s	**3**

(Total for Question 11 = 3 marks)

Question Number	Acceptable answers		Additional guidance	Mark
12(a)	• use of $F = Gm_1m_2/r^2$ • force = 6.5×10^{31} N	**(1)** **(1)**	Example of calculation $F = 6.67 \times 10^{-11}$ N m^2 kg^{-2} $\times$ 29 $\times$ 1.99×10^{30} kg $\times$ 36 $\times$ 1.99×10^{30} kg / $(6.5 \times 10^{10}$ m$)^2$ force = 6.5×10^{31} N	**2**
12(b)	**Either** • use of $F = mv^2/r$ ecf from (a) • use of $v = 2\pi r/T$ • $T = 1.1 \times 10^6$ s **Or** • use of $F = m\omega^2 r$ ecf from (a) • use of $\omega = 2\pi/T$ • $T = 1.1 \times 10^6$ s	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	Example of calculation $F = mv^2/r = m(2\pi r/T)^2/r$ $T^2 = 4\pi^2 mr/F$ $= 4\pi^2 \times 29 \times 1.99 \times 10^{30}$ kg $\times$ 3.6×10^{10} m / 6.5×10^{31} N $= 1.21 \times 10^{12}$ s^2 $T = 1.12 \times 10^6$ s = 18700 min = 312 hours = 13 days	**3**

(Total for Question 12 = 5 marks)

Question Number	Acceptable answers	Additional guidance	
13(a)	• Object of known luminosity **(1)**		**1**
13(b)	• The (parallax) angle becomes very small **Or** the diameter of the Earth's orbit is very small **(1)** • Giving a (very) large percentage uncertainty **(1)**		**2**
13(c)	• Measure change in wavelength / frequency **(1)** • Determine relative velocity using redshift formula **(1)** • Then apply $v = H_0 d$ **(1)**		**3**

(Total for Question 13 = 6 marks)

Question Number	Acceptable answers	Additional guidance	Mark
14(a)	• Fusion involves an increase in binding energy (per nucleon) as the number of nucleons increases **(1)** • Fission involves an increase in binding energy (per nucleon) as the number of nucleons decreases **(1)** • If binding energy per nucleon increases energy is released in the process **(1)**	Accept reference to larger/smaller nuclei for number of nucleons increases/decreases	**3**
14(b)	An explanation that makes reference to: • Identifies (very) high temperature **and** (very) high density **(1)** • (Very) high temperature to provide enough energy to overcome the (electrostatic) repulsive force between nuclei **(1)** • (Very) high density to give big enough collision rate to maintain reaction **(1)**	Accept pressure for density in MP1 Accept correct reference to strong force	**3**

(Total for Question 14 = 6 marks)

15

This question assesses a student's ability to show a coherent and logical structured answer with linkage 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 points seen in answer	Number of marks awarded for indicative points
6	4
5-4	3
3-2	2
1	1
0	0

Indicative content

- Light from the source is unpolarised
  Or light from source has oscillations in all planes.
- Intensity is reduced to ½ by filter 1
- By absorbing the perpendicular components
  Or by transmitting the parallel components.
- At 0° / 180° filter 2 aligned with filter 1 so all light through filter 1 passes through filter 2
- As filter 2 is rotated only the component of the light from filter 1 in the plane of filter 2 is allowed through, so the intensity reduces.
- At 90°, all light is absorbed because their planes (of polarisation) are at right angles.

The following table shows how the marks should be awarded for structure and lines of reasoning

	Number of marks awarded for structure and lines of reasoning
Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkage between points and is unstructured	0

Number of IC points awarded	**Possible linkage marks**
0,1	0
2, 3	1
4, 5, 6	2

IC3,6 allow, no light passes through, blocked by, stopped by

6

(Total for question 15 = 6 marks)

Question Number	Acceptable answers	Additional guidance	Mark
16(a)	• use of $\rho = m/V$ **and** $W = mg$ to calculate upthrust **(1)** • use of downward force of lid = upthrust – weight of diver **(1)** • downward force of lid = 0.021 (N) **(1)**	Example of calculation $m_{displaced} = 1.0 \times 10^3$ kg m^{-3} × 8.0×10^{-6} m^{-3} $= 8.0 \times 10^{-3}$ kg $U = 8.0 \times 10^{-3}$ kg × 9.81 N kg^{-1} = 0.0785 N W = 0.0059 kg × 9.81 N kg^{-1} = 0.0579 N Lid force = 0.0785 N - 0.0579 N = 0.0206 N	**3**
16(b)	**Either** • use of force of lid = $V\rho g$ **(1)** • volume of air = 8.0×10^{-6} m^{-3} - their value **(1)** • volume of air = 5.9×10^{-6} (m^3) **(1)** **Or** • use of upthrust on diver = weight of diver **(1)** • use of upthrust = $V\rho g$ **(1)** • volume of air = 5.9×10^{-6} (m^3) **(1)**	Example of calculation volume = 0.0206 N ÷ 9.81 N kg^{-1} ÷ 1.0×10^3 kg m^{-3} $= 2.1 \times 10^{-6}$ m^{-3} new volume of air = 8.0×10^{-6} m^{-3} - 2.1×10^{-6} m^{-3} $= 5.9 \times 10^{-6}$ m^3	**3**
16(c)	• use of pV = constant **(1)** • $p = 1.4 \times 10^5$ Pa **(1)**	Example of calculation $p_1 \times V_1 = p_2 \times V_2$ $p_2 = 1.01 \times 10^5$ N m^{-2} × 8.0×10^{-6} m^{-3} / 5.9×10^{-6} m^3 $p = 1.37 \times 10^5$ Pa	**2**

(Total for Question 16 = 8 marks)

17(a)

This question assesses a student's ability to show a coherent and logical structured answer with linkage 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 points seen in answer	Number of marks awarded for indicative points
6	4
5-4	3
3-2	2
1	1
0	0

Indicative content

- photon energy $E = hf$
- photon energy must be greater than work function (of metal) for photon to provide enough energy for photoemission
- UV photons have sufficient energy for photoemission but lab light photons do not
- one photon interacts with one electron
- with larger area more photons are absorbed/incident in a given time
- more electrons are emitted in a given time (so the charge is lost more quickly)

The following table shows how the marks should be awarded for structure and lines of reasoning

	Number of marks awarded for structure and lines of reasoning
Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkage between points and is unstructured	0

IC2 accept answers in terms of threshold frequency
IC5 & 6 there must be the idea of 'rate' once

Number of IC points awarded	**Possible linkage marks**
0,1	0
2, 3	1
4, 5, 6	2

6

17(b)	• would be of form $Q = Q_0 e^{-kt}$ **(1)** • plot ln charge against time **(1)** • if straight line with negative gradient it's exponential **(1)** **Or** • would be of form $Q = Q_0 e^{-kt}$ **(1)** • Calculate Q/Q_0 for pairs of values with same time interval t **Or** calculates $t_{1/2}$ at least twice **(1)** • If equal, then it's exponential **(1)**	MP3 accept some indication that gradient is negative For both MS options MP3 is dependent on MP2	**3**

(Total for Question 17= 9 marks)

Question Number	Acceptable answers	Additional guidance	Mark
18(a)	• use of $P = 1/f$ **(1)** • use of $P = P_1 + P_2$ etc **(1)** • total power = 63.8 (D) **(1)** • Comparative statement consistent with their values **(1)**	**MP4** An attempt at a % must be made and a clear comparison with the 80% must be made e.g % for cornea from 44.8 / 63.8 is 71% which is not 80% so no Example of calculation P_{cornea} = 1/ 0.0223 m = 44.84 D P_{lens} = 1/ 0.0527 m = 18.98 D Total power = 63.82 D	**4**
18(b) (i)	• use of $1/f = 1/u + 1/v$ **(1)** • u = 4.8 cm **(1)**	Example of calculation 1/1.6 cm = 1/u + 1/ 2.4 cm u = 4.8 cm	**2**
18(b)(ii)	• use of $n = c / v$ **(1)** • use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ **Or** n = sin i / sin r with correct angles **(1)** • $\theta = 11°$ **(1)**	Accept use of $v_2 \sin\theta_1 = v_1 \sin\theta_2$ for MP1 and MP2 but $v_1 \sin\theta_1 = v_2 \sin\theta_2$ scores neither Example of calculation $n = 3 \times 10^8$ m s^{-1} / 2.18×10^8 m s^{-1} = 1.376 $1 \times \sin 15° = 1.376 \times \sin\theta$ $\theta = 10.8°$	**3**
18(c)	• difference in speed for air to cornea much greater than difference in speed from water to cornea **Or** lower refractive index for water to cornea (= 1.03) **(1)** • so less refraction **Or** so power of eye/cornea reduced **Or** so focal length of eye/cornea increased **(1)** • if goggles worn the interface is with air and refraction is as normal **Or** if goggles worn the interface is with air and image focused on retina **(1)**	MP1: Seeing values of refractive index as 1.03 and 1.38 is not enough, a comparison is required.	**3**

(Total for Question 18= 12 marks)

Question Number	Acceptable answers	Additional guidance	Mark
19(a)	• top: 40, 0 **(1)** • bottom: 20, -1 **(1)**		**2**
19(b)(i)	• Use of ratio of atoms and atoms per g **(1)** • Number of nuclei = 2.9×10^{17} **(1)**	$N = 0.3\ g \times 8.1 \times 10^{21}\ g^{-1} \times 0.012/100$ $= 2.9 \times 10^{17}$	**2**
19(b)(ii)	• use of ln 2 = $\lambda t_{1/2}$ **(1)** • use of activity = λN (ecf from (b)(i)) **(1)** • activity = 5.1 (Bq) (use of show that value gives 5.3 Bq) **(1)**	ln 2 = $\lambda \times 1.25 \times 10^9$ years = $\lambda \times (1.25 \times 10^9 \times 365 \times 24 \times 60 \times 60)$ s $\lambda = 1.76 \times 10^{-17}\ s^{-1}$ $A = 1.76 \times 10^{-17}\ s^{-1} \times 2.9 \times 10^{17}$ = 5.1 Bq	**3**
19(b)(iii)	• use of count rate = (counts – background counts) / time **(1)** • calculates percentage of activity from (b)(ii) **Or** applies 7.5% to activity from (b)(ii) **(1)** • Comparative statement consistent with their values **(1)**	**MP3** can only be awarded if Activity from (ii) is used. A clear comparison with the corresponding value must be made e.g. percentage = 0.8 % which is < 7.5 % so not efficient **Or** detects 176 but should detect 379 counts in 10 min, so not efficient **Or** should detect a rate of at least 0.63 Bq, so not efficient <u>Example of calculation</u> Recorded count rate = (176 - 150) ÷ 600 s = 0.04 Bq 0.04 Bq × 100 ÷ 5.1 Bq = 0.78 % (ecf from (b)(ii) for MP3)	**3**

19(b)(iv)	**Max two from** • emissions are in all directions **(1)** • some emitted particles may be absorbed by the material in the sample **(1)** • some emitted particles may be absorbed by the window **(1)** • some emitted particles pass (right) through detector **(1)**		**2**
19(c)	• so the proportion of unstable nuclei does not change significantly over time **Or** activity does not change significantly over time **(1)**		**1**

(Total for Question 19 = 13 marks)

Question Number	Acceptable answers		Additional guidance	Mark
20(a)	• use of $f = 1/T$ • use of $v = f\lambda$ • wavelength = 7.5×10^{6} m	**(1)** **(1)** **(1)**	MP3: accept variations e.g. 1.75 waves or two wavelengths averaged with correct calculation Example of calculation 2 waves $2T = 0.05$ s $T = 0.025$ s $f = 1/0.025$ s $= 40$ Hz $\lambda = 3.00 \times 10^{8}$ m s^{-1} ÷ 40 Hz $= 7.5 \times 10^{6}$ m	**3**
20(b)(i)	• use of strain = extension / length • change in length = 4.8×10^{-18} (m) **Or** max strain for 0.001× proton size = 2.2×10^{-22} • comparison of their change in length to 8.8×10^{-19}(m) **Or** comparison of their max strain to 1.2×10^{-21}	**(1)** **(1)** **(1)**	Example of calculation Change in length = $1.2 \times 10^{-21} \times 4000$ m = 4.8×10^{-18} m Fraction of proton diameter = 4.8×10^{-18} m ÷ 8.8×10^{-16} m = 0.0055	**3**
20(b)(ii)	• half wavelength path difference means waves in antiphase • so destructive interference takes place • this results in zero amplitude, (so no signal detected) • a change in length will result in a change in path difference, so signal detected **Or** a change in length will result in a change in phase difference, so signal detected	**(1)** **(1)** **(1)** **(1)**	Do not accept 'out of phase' for MP1 Accept reference to being 'not out of phase' for MP4	**4**
20(b)(iii)	• if initially the path difference is zero there will be a maximum signal • a change from max amplitude would represent a much smaller percentage (therefore less sensitive)	**(1)** **(1)**	MP2 alternative**:** a change from minimum amplitude would represent a much larger percentage (therefore more sensitive) MP2 Accept 'it is easier to detect the change from no light to light' MP2 Accept suitable reference to uncertainty	**2**

(Total for Question 20 = 12 marks)

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