Mark Scheme Results

October 2020

Pearson Edexcel GCE
In Physic (9PH0)
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.
- 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.

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 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.

1. Quality of Written Communication

1.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

1.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

2. Graphs

2.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

2.2 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.

2.3 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.

2.4 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	Acceptable answer	Additional guidance	Mark
1	B	The only correct answer is **B** because m is the SI unit for length. A is not correct because C is not a base unit C is not correct because g is not a base unit D is not correct because °C is not a base unit	**1**
2	C	The only correct answer is **C** because X is a smaller nucleus for which the binding energy per nucleon could increase through a process of fusion and Y is a larger nucleus for which the binding energy per nucleon could increase through a process of fission A I not correct because it states fission for both X and Y B is not correct because the processes are reversed D is not correct because it states fusion for both X and Y	**1**
3	C	The only correct answer is **C** because for the original spring $F = kx$ so $x = F/k$, so $E = ½\ Fx = ½\ F^2/\mathrm{k}$. For $2F$ and $2k$ the epe is $E \times 2^2 / 2 = 2E$ A is not correct because it is $E/2$ B is not correct because it is E A is not correct because it is $8E$	**1**
4	C	The only correct answer is **C** because the correct method for a nearby star is parallax, for a nearby galaxy is standard candle and for a very distant galaxy is red shift A is not correct because only the nearby star method is correct B is not correct because only the nearby galaxy method is correct D is not correct because none of the methods are correct	**1**
5	D	The only correct answer is **D** because when damping is decreased maximum amplitude increases and the frequency at which it occurs increases A is not correct because it states that they both decrease B is not correct because it states that the maximum amplitude decreases C is not correct because it states that the frequency decreases	**1**
6	B	The only correct answer is **B** because the electric field is always positive except at infinity, when it is zero A is not the correct choice because the statement is correct C is not the correct choice because the statement is correct D is not the correct choice because the statement is correct	**1**

7	D	The only correct answer is **D** because the frequency is inversely proportional to the square root of length and independent of the mass, so if length is quadrupled, frequency is halved to $f/2$ A is not the correct answer because it is $4f$ B is not the correct answer because it is $2f$ C is not the correct answer because it is f	**1**
8	A	The only correct answer is **A** because a real image is produced at a distance of 30 cm from the lens B is not the correct answer because the object distance is less than the focal length so the image is virtual C is not the correct answer because diverging lenses produce virtual images with real objects D is not the correct answer because diverging lenses produce virtual images with real objects	**1**
9	B	The only correct answer is **B** because the y axis is luminosity and the x axis shows temperature decreasing A is not the correct answer because the y axis is luminosity but the x axis shows temperature increasing C is not the correct answer because the x axis is luminosity and the y axis is luminosity D is not the correct answer because the x axis is luminosity and the y axis is luminosity	**1**
10	C	The only correct answer is **C** because the corrected count rate at 30 cm is 40 counts per minute, the corrected rate at twice the distance is a quarter of this value, which is 10 counts per minute, and adding the background gives the value of 34 A is not the correct answer because it is 16 C is not the correct answer because it is 32 D is not the correct answer because it is 44	**1**

(Total for Multiple Choice Questions = 10 marks)

Question Number	Acceptable answers		Additional guidance	Mark
11 a	• Use of $\Delta Q = mc\Delta\theta$ • … for correct temperature differences • Final temperature is 61.4 °C which is above range	**(1)** **(1)** **(1)**	Example of calculation $0.180\ \text{kg} \times 4200\ \text{J kg}^{-1}\ \text{K}^{-1} \times (82\ °\text{C} - \theta_f)$ $= 0.068\ \text{kg} \times 3900\ \text{J kg}^{-1}\ \text{K}^{-1} \times (\theta_f - 2.7\ °\text{C})$ $\theta_f = 61.4\ °\text{C}$ Answers making comparisons based on equivalent Physics may be awarded MP3 e.g. 16 600 J must be transferred from coffee to reach 60°C but required energy transfer to milk is only 15 200 J	**3**

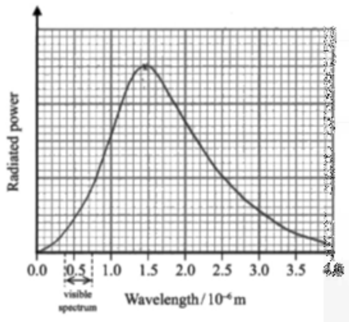
(Total for Question 11 = 3 marks)

Question Number	Acceptable answers		Additional guidance	Mark
12(a)	• Use of trigonometry to determine angle of ray to normal in liquid • Use of n sin θ = constant • $n = 1.42$	**(1)** **(1)** **(1)**	Example of calculation $(10.2 - 4.0) \div 2 = 3.1$ cm $\tan\theta = 3.1\ \text{cm} / 35\ \text{cm}$ $\theta = 5.06°$ $n = \sin 7.2° / \sin 5.06°$ $n = 1.42$	**3**
12 (b)	• Use of $n = c / v$ • $v = 2.1 \times 10^8\ \text{m s}^{-1}$ (allow ecf from (a))	**(1)** **(1)**	Example of calculation $v = c/n$ $= 3.00 \times 10^8\ \text{m s}^{-1} / 1.42$ $= 2.11 \times 10^8\ \text{m s}^{-1}$	**2**

(Total for Question 12 = 5 marks)

Question Number	Acceptable answers	Additional guidance	Mark
13 (a)	- because the (resultant) force is (directly) proportional to displacement from equilibrium position **(1)** - force is in the opposite direction to displacement **or** force is (always) acting towards the equilibrium position **(1)**		2
13 (b)	- use of graph to find gradient = k (= F/x) **(1)** - use of $T = 1/f$ **(1)** - use of $T = 2\pi\sqrt{\frac{m}{k}}$ **(1)** - m = 0.05 (kg) **or** k using 50 g and 2 Hz = 7.9 (N m^{-1}) **or** f using 50 g and k from graph = 2.0 (Hz) **or** T using 50 g and k from graph = 0.50 (s) **(1)** - Comparison and correct conclusion (dependent on MP4) **(1)**	<u>Example of calculation</u> k = 0.55 N / 0.07 m = 7.86 N m^{-1} T = ½ = 0.5 s $0.5\text{ s} = 2\pi\sqrt{\frac{m}{7.86\text{ N m}^{-1}}}$ m = 0.050 kg (0.0498 kg) A smaller mass means a shorter period, so smaller than 0.05 kg would be a higher frequency than 2 Hz, so 50 g is smallest mass.	5

(Total for Question 13 = 7 marks)

Question Number	Acceptable answers		Additional guidance	Mark
14 (a)	• Use of $P = IV$ • Use of $L = A\sigma T^4$ • $T = 1800$ K	**(1)** **(1)** **(1)**	<u>Example of calculation</u> $P = 2.0\text{ V} \times 0.37\text{ A} = 0.74\text{ W}$ $0.74\text{ W} = 0.35 \times 3.9 \times 10^{-6}\text{ m}^2 \times 5.67 \times 10^{-8}\text{ Wm}^{-2}\text{K}^{-4}\text{ W} \times T^4$ $T^4 = 9.56 \times 10^{12}\text{ K}^4$ $T = 1758$ K	**3**
14 (b)(i)	• Use of $\lambda_{max} T = 2.898 \times 10^{-3}$ m K • $\lambda_{max} = 1.4 \times 10^{-6}$ (m) • correct black body radiation shape • peak at correct wavelength • line not zero at long wavelength **and** not positive at 0.0 on wavelength axis	**(1)** **(1)** **(1)** **(1)** **(1)**	<u>Example of calculation and graph</u> $\lambda_{max} \times 2026\text{ K} = 2.898 \times 10^{-3}$ m K $\lambda_{max} = 1.43 \times 10^{-6}$ m 	**5**
14 (b) (ii)	• Most radiation at infrared **or** λ_{max} isn't in the visible spectrum **or** only a small proportion of radiation/power in visible spectrum • Ratio of useful output/input is therefore very small **Or** so proportion of energy transfer that is useful is small	**(1)** **(1)**		**2**
			(Total for Question 14 = 10 marks)	

Question Number	Acceptable answers		Additional guidance	Mark
15(a)	• Waves are reflected at ends of strings • The reflected waves meet and superpose/interfere • Where they meet in phase constructive interference takes place producing points of maximum amplitude **Or** Where they meet in phase constructive interference takes place producing antinodes **Or** Where they meet in antiphase destructive interference takes place producing points of zero/minimum amplitude **Or** Where they meet in antiphase destructive interference takes place producing nodes	**(1)** **(1)** **(1)**		**3**
15 (b)(i)	• Wavelength = 44 cm	**(1)**		**1**
15(b) (ii)	• Use of $v = \sqrt{\frac{T}{\mu}}$ • Use of $v = f\lambda$ (ecf from (i)) • f = 320 Hz	**(1)** **(1)** **(1)**	<u>Example of calculation</u> $v = \sqrt{\frac{88.6\ \text{N}}{4.47 \times 10{-}3\ \text{kg m}{-}1}}$ = 141 m s^{-1} f = 141 m s^{-1} / 0.44 m = 320 Hz	**3**

15 (c)(i)	• Use of stress = F/A • Use of Young modulus = stress / strain • Use of strain = $\Delta x/x$ • Extension = 0.053 m	**(1)** **(1)** **(1)** **(1)**	<u>Example of calculation</u> stress = 93.4 N / 6.6 ×10^{-7} m^2 = 1.42 ×10^8 N m^{-2} strain = 1.42 ×10^8 N m^{-2} / 1.8 ×10^9 N m^{-2} = 0.0786 extension = 0.0786 × 0.68 m = 0.053 m	**4**
15 (c)(ii)	• Increase tension so increase wavespeed since $v = \sqrt{\frac{T}{\mu}}$ **Or** decrease μ so increase wavespeed since $v = \sqrt{\frac{T}{\mu}}$ • Since $v = f\lambda$ and wavelength unchanged, this increases frequency	**(1)** **(1)**		**2**
(Total for Question 15 = 13 marks)				

Question Number	Acceptable answers		Additional guidance	Mark
16 (a) (i)	• 8 alpha • 6 beta	**(1)** **(1)**	<u>Example of calculation</u> 238−206 = 32 32 ÷ 4 = 8 alpha 92−82 = 10, 8 × 2 = 16 16 – 10 = 6 beta	**2**
16 (a)(ii)	• Use of $\ln 2 = t_{½} \times \lambda$ • Use of $N = N_0\, e^{-\lambda t}$ • $t = 4.3 \times 10^9$ (year)	**(1)** **(1)** **(1)**	<u>Example of calculation</u> $\ln 2 = 4.47 \times 10^9$ year × λ $\lambda = 1.55 \times 10^{-10}$ year^{-1} $53 = 103\, e^{-1.55 \times 10^{-10}\ \text{year}^{-1} \times t}$ $\ln 53 = \ln 103 - 1.55 \times 10^{-10}$ year$^{-1} \times t$ $t = 4.3 \times 10^9$ year	**3**
16 (b)	• Use of $V_{grav} = -GM/R$ • Calculate $\Delta V_{grav} = V_{grav\ Moon} - V_{grav\ Earth}$ • Use of $m\, \Delta V_{grav} = E_{k} = ½\, mv^2$ • v = 11 000 m s^{-1}	**(1)** **(1)** **(1)** **(1)**	<u>Example of calculation</u> $V_{grav} = -6.67 \times 10^{-11}$ N m^2 kg^{-1} × 5.97 × 10^{24} kg / 6 370 000 m = −62.5 MJ kg^{-1} ΔV_{grav} = −62.5 MJ kg^{-1} − −1.28 MJ kg^{-1} = −61.2 MJ kg^{-1} $½\, v^2$ = 61.2 MJ kg^{-1} v = 11 100 m s^{-1}	**4**
16(c)	• Use of $F = Gm_1m_2/r^2$ **and** $F = mv^2/r$ • Use of $v = 2\pi r/T$ • T = 488 000 s = 5.7 days **OR** • Use of $F = Gm_1m_2/r^2$ **and** $F = m\omega^2 r$ • Use of $\omega = 2\pi/T$ • T = 488 000 s = 5.7 days	**(1)** **(1)** **(1)**	‘Use of’ can be with any mass m for the orbiting body, or by algebraic combination with no m <u>Example of calculation</u> $F = GMm/r^2 = mv^2/r$ $GM/r^2 = v^2/r$ $v = 2\pi r/T$ $T^2 = 4\pi^2 r^3 / GM$ $= 4\pi^2 (1.34 \times 10^8\ \text{m})^3 / 6.67 \times 10^{-11}$ N m^2 kg^{-1} × 5.97 × 10^{24} kg = 2.39 × 10^{11} s^2 T = 488 000 s = 5.7 days	**3**

(Total for Question 16 = 12 marks)

Question Number	Acceptable answers	Additional guidance	Mark
*17(a)	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.	The following table shows how the marks should be awarded for structure and lines of reasoning	

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	Max linkage mark available	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

	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

Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

	Indicative content Observations • Photoelectrons emitted instantaneously when radiation incident on surface • There is no photoemission below the threshold frequency • The maximum ke of the photoelectrons is independent of the intensity of the incident radiation • The rate of photoemission is proportional to the intensity of the incident radiation Models • One photon is absorbed by one electron **Or** all of the energy of one photon is transferred to one electron • With waves, energy can be supplied to the electron continuously **Or** with waves, energy can 'build up'	There are 4 observations and 2 models. Linkage is demonstrated by linking observations and models. Two linkage marks can only be awarded if reference is made to both models and more than one observation	**6**

17 (b)	• Use of gradient **(1)** • h from graph = 6.74×10^{-34} J s **(1)** • Suitable percentage calculation allowing comparison with 1% and conclusion **(1)**	<u>Example of calculation</u> gradient = 3.00×10^{-19} J ÷ (10.15×10^{14} Hz – 5.70×10^{14} Hz) $h = 6.74 \times 10^{-34}$ J s percentage difference = (6.74×10^{-34} J s – 6.63×10^{-34} J s)/6.63×10^{-34} J s × 100% = 1.66% which is greater than 1% so it is not within 1% **Or** 6.63×10^{-34} J s × 101% = 6.70×10^{-34} J s which is smaller than 6.74×10^{-34} J s so it is not within 1%	**3**
17 (c)	• Use of $E=hf$ **(1)** • Use of $c = f\lambda$ **(1)** • Apply conversion factor of 1.6×10^{-19} for photon energy from J to eV **(1)** • Level = -5.74 (eV) **(1)**	<u>Example of calculation</u> $f = 3.00 \times 10^{8}$ m s^{-1} / 6.1×10^{-7} m = 4.91×10^{14} Hz $E = 6.63 \times 10^{-34}$ J s × 4.91×10^{14} Hz = 3.26×10^{-19} J 3.26×10^{-19} J / 1.6×10^{-19} C = 2.04 eV Level = -3.71 eV - 2.04 eV = -5.75 eV	**4**
17 (d)	• Use of d = 1 / no of slits per metre **(1)** • Use of $n\lambda = d \sin \theta$ **(1)** • $\theta = 21°$ **(1)**	<u>Example of calculation</u> $d = 1 / 600\,000 = 1.67 \times 10^{-6}$ m^{-1} $n = 1$ 6.1×10^{-7} m = 1.67×10^{-6} m^{-1} $\sin \theta$ $\theta = 21.47°$	**3**

(Total for Question 17 = 16 marks)

Question Number	Acceptable answers	Additional guidance	Mark
18(a)	• Calculates change in mass **(1)** • Converts from u to kg **(1)** • Use of $\Delta E = c^2\Delta m$ **(1)** • 2.8×10^{-12} J **(1)**	<u>Example of calculation</u> $\Delta m = ((2.013553 + 3.015501) - (4.001506 + 1.008665))u$ $= 0.01883 \times 1.66 \times 10^{-27}$ kg $= 3.13 \times 10^{-29}$ kg $\Delta E = (3.00 \times 10^8 \text{ m s}^{-1})^2 \times 3.13 \times 10^{-29}$ kg $= 2.8 \times 10^{-12}$ J	**4**
18 (b)	• High temperature so sufficient (kinetic) energy to overcome the repulsion between (positively charged) ions/nuclei **(1)** • High density to ensure ions close enough to each other to maintain collision rate to maintain fusion **(1)**		**2**
18 (c)(i)	• Use total mass / mass of D ion **(1)** • Use of $pV = NkT$ **(1)** • $p = 2.8 \times 10^4$ Pa **(1)**	<u>Example of calculation</u> $N = 5.0 \times 10^{-6}$ kg / 3.3×10^{-27} kg $= 1.5 \times 10^{21}$ $p = 1.5 \times 10^{21} \times 1.38 \times 10^{-23}$ J K^{-1} $\times$ 130 000 000 K / 98 m^3 $= 2.77 \times 10^4$ Pa	**3**
18 (c)(ii)	• Use of $\frac{1}{2} m \langle c^2\rangle = 3/2\ kT$ **Or** $pV = 1/3\ (Nm\langle c^2\rangle)$ (ecf for N and p from (i)) **(1)** • $\sqrt{\langle c^2\rangle} = 1.3 \times 10^6$ m s^{-1} **(1)**	<u>Example of calculation</u> $\frac{1}{2} m \langle c^2\rangle = 3/2\ kT$ $\frac{1}{2} \times (3.3 \times 10^{-27}$ kg$) \times \langle c^2\rangle = 3/2 \times 1.38 \times 10^{-23}$ J K^{-1} $\times$ 130 000 000 K $\langle c^2\rangle = 1.6 \times 10^{12}$ m^2 s^{-2} $\sqrt{\langle c^2\rangle} = 1.28 \times 10^6$ m s^{-1}	**2**
18 (c)(iii)	• Use of $\Delta\lambda / \lambda = v/c$ to determine $\Delta\lambda$ **(1)** • Adds shift to original wavelength **(1)** • 1.075×10^{-6} m **(1)**	<u>Example of calculation</u> $\Delta\lambda / 1.064 \times 10^{-6}$ m $= 15 \times 10^6$ m s^{-1}/3.00×10^8 m s^{-1} $\Delta\lambda = 5.3 \times 10^{-9}$ m $\lambda + 2\Delta\lambda = 1.075 \times 10^{-6}$ m	**3**

(Total for Question 18 = 14 marks)

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