Pearson Edexcel

Mark Scheme (Results)

June 2019

Pearson Edexcel International Advanced Level
In Physics (WPH05)
Paper 01 Physics from Creation to Collapse

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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.

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.

Question Number	Answer	Amplification	Mark
1	**A**	The only correct answer is **A** B is not correct because very high pressures are not required C is not correct because hydrogen is readily available on Earth D is not correct because strong magnetic fields can be provided	**1**
2	**D**	The only correct answer is **D** A is not correct because count rate and count have different dimensions B is not correct because this will not give the corrected count rate C is not correct because count rate and count have different dimensions	**1**
3	**C**	The only correct answer is **C** A is not correct because absolute zero is a theoretical temperature B is not correct because hydrogen liquefies at a higher temperature D is not correct because deep space is at a temperature above absolute zero	**1**
4	**C**	The only correct answer is **C** A is not correct because the card and aluminium will block uniformly across the top and bottom third B is not correct because the card and aluminium will block uniformly across the top and bottom third D is not correct because the card will not reduce beta radiation in top third	**1**
5	**C**	The only correct answer is **C** A is not correct because $a = \omega^2 r$ has been used incorrectly B is not correct because $a = \omega^2 r$ has been used incorrectly D is not correct because $a = \omega^2 r$ has been used incorrectly	**1**
6	**C**	The only correct answer is **C** A is not correct because the magnitude of amplitude at 50 Hz is not the greatest B is not correct because the magnitude of amplitude at 50 Hz is not the greatest D is not correct because the magnitude of amplitude at 50 Hz is not the greatest	**1**
7	**C**	The only correct answer is **C** A is not correct because it will deform very little B is not correct because the deformation will not be permanent D is not correct because it will deform very little	**1**
8	**B**	The only correct answer is **B** A is not correct because not all standard candles are variable stars C is not correct because the radiation flux can be measured for other stars D is not correct because the radius of standard candles is not known	**1**
9	**A**	The only correct answer is **A** $F \propto \frac{L}{d^2}$ and $d \propto \frac{1}{\theta}$ combine to give $L \propto \frac{F}{\theta^2}$ B is not correct because this relationship has not been used C is not correct because this relationship has not been used D is not correct because this relationship has not been used	**1**
10	**B**	The only correct answer is **B** A is not correct because the temperature is too high C is not correct because the temperature and luminosity are too low D is not correct because the temperature is too low	**1**

Question Number	Answer	Mark
11(a)	Use of $\Delta E = mc\Delta\theta$ **(1)** Use of $P = \frac{\Delta W}{\Delta t}$ **(1)** t = 250 s **(1)** <u>Example of calculation:</u> $44 \times 85 \text{ W} = 110 \text{ kg} \times 720 \text{ J kg}^{-1}\text{K}^{-1} \times \frac{(28\text{-}16)\text{ K}}{\Delta t}$ $\Delta t = \frac{110 \text{ kg} \times 720 \text{ J kg}^{-1}\text{ K}^{-1} \times 12 \text{ K}}{44 \times 85 \text{ W}} = 254 \text{ s}$	**3**
11(b)	Conduction through the walls and windows of the carriage **Or** Heating the materials of the carriage. **Or** Warm air escaping from the carriage (and replaced by cooler air) **Or** Not all the energy from the people is used to raise the temperature of the air **(1)**	**1**
		4

Question Number	Answer	Mark
12	Dark matter adds mass to the universe (and hence increases the average density of the universe). **(1)** The absence of dark matter (in parts of the universe) would reduce the density of the universe **Or** the absence of dark matter (in parts of the universe) would reduce the gravitational forces (between galaxies in these regions) **(1)** The ultimate fate of the universe is dependent upon the (average) density (of the universe) **Or** The rate of expansion of the universe is dependent upon the size of the gravitational forces **(1)** If the (average) density of the universe is less than a critical value, then the universe may continue to expand forever **(1)**	**4**
		4

Question Number	Answer		Mark
13(a)(i)	Use of $pV = NkT$	**(1)**	
	Conversion of temperature to K	**(1)**	
	T = 299 K **Or** θ = 26 °C	**(1)**	**3**
	<u>Example of calculation:</u> $\frac{p}{T}$ =a constant $\frac{5.52 \times 10^5 \text{Pa}}{(273 + 22) \text{ K}} = \frac{5.60 \times 10^5 \text{Pa}}{T}$ T = 299 K θ = 299 – 273 = 26 °C		
13(a)(ii)	N decreases and appropriate reference to $pV = NkT$ [Examples of appropriate references: N decreases, so $\frac{pV}{Nk}$ would increase N decreases, and $T = \frac{pV}{Nk}$ N decreases and $T \propto \frac{1}{N}$]	**(1)**	
	The (calculated) temperature of the air would be higher (Dependent on MP1 being awarded)	**(1)**	**2**
	Max 1 For fewer molecules to exert the same pressure the temperature must increase		

*13(b)	**(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)** As the temperature increases the average/mean kinetic energy of the molecules increases **(1)** Therefore the (average/mean) change in momentum per collision of the molecules increases **(1)** The rate of collision of the molecules with the tyre walls increases **(1)** Hence the rate of change of momentum at the tyre walls increases and so the force increases **(1)**	**4**
		9

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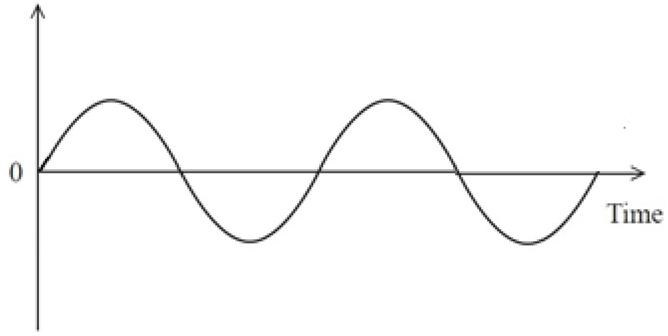
Question Number	Answer		Mark
14(a)	${}^{137}_{55}\text{Cs} \rightarrow {}^{137}_{56}\text{Ba} + {}^{0}_{-1}\beta^{-}$ Top line correct Bottom line correct	 **(1)** **(1)**	**2**
14(b)	Use of $\lambda = \frac{\ln 2}{t_{1/2}}$ Use of $\frac{\Delta N}{\Delta t} = (-)\lambda N$ Use of $N = N_0 e^{-\lambda t}$ $\therefore A = 6.3 \times 10^{14}$ Bq [accept direct use of $A = A_0 e^{-\lambda t}$] <u>Example of calculation:</u> $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{30.2 \times 3.15 \times 10^7 \text{s}} = 7.29 \times 10^{-10}\ \text{s}^{-1}$ $\frac{\Delta N}{\Delta t} = \lambda N = 7.29 \times 10^{-10}\ \text{s}^{-1} \times 1.36 \times 10^{24} = 9.91 \times 10^{14}$ Bq $A = A_0 e^{-\lambda t} = 9.91 \times 10^{14}\ \text{Bq} \times \text{e}^{-7.29\times10^{-10}\text{s}^{-1}\times20\times3.15\times10^7\text{s}}$ $= 6.26 \times 10^{14}$ Bq	**(1)** **(1)** **(1)** **(1)**	**4**
14(c)	Gamma radiation is more penetrating than ß radiation Gamma radiation requires more shielding **Or** A source of gamma radiation must be kept at a greater distance [Accept statement that when gamma radiation interacts with cells in the body it transfers a much larger amount of energy than ß radiation per interaction, for MP1]	**(1)** **(1)**	**2**
			8

Question Number	Answer		Mark
15(a)(i)	Use of $F = \frac{GMm}{r^2}$ and $F = m\omega^2 r$ Use of $\omega = \frac{2\pi}{T}$ Algebra to show $T^2 = \frac{4\pi^2 r^3}{GM}$ **Or** Use of $F = \frac{GMm}{r^2}$ and $F = \frac{mv^2}{r}$ Use of $v = \frac{2\pi r}{T}$ Algebra to show $T^2 = \frac{4\pi^2 r^3}{GM}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
15(a)(ii)	Use of $T^2 = \frac{4\pi^2}{GM}.r^3$ Uses $N = \frac{24\times3600}{T}$ to calculate number of orbits $N = 2$, hence 4 crossings per day <u>Example of calculation:</u> $T^2 = \frac{4\pi^2}{GM}.r^3$ $= \frac{4\pi^2}{6.67 \times 10^{-11}\text{N m}^2\text{kg}^{-2} \times 6.0 \times 10^{24}\text{kg}} \times (2.66 \times 10^7 \text{ m})^3$ $T = \sqrt{1.857 \times 10^9 s^2} = 4.31\times10^4\text{s}$ $N = \frac{24 \times 3600 \text{ s}}{4.31\times10^4\text{s}} = 2$ So 4 crossings per day	**(1)** **(1)** **(1)**	**3**
15(b)	$g = \frac{GM}{r^2}$ **Or** $g \propto \frac{1}{r^2}$ g decreases as Δh increases, so the actual value of ΔE_{grav} would be less than the calculated value	**(1)** **(1)**	**2**
			8

Question Number	Answer		Mark
16(a)(i)	^{56}Fe has the largest binding energy <u>per nucleon</u> (of all isotopes) Hence it is the most stable (nucleus) **Or** hence it requires the greatest energy to break up the nucleus **Or** hence it releases the greatest energy when the nucleus is formed **Or** hence fusion of nuclei less massive than ^{56}Fe releases energy **and** fission of nuclei more massive than ^{56}Fe releases energy	**(1)** **(1)**	**2**
16(a)(ii)	Calculation of mass defect Use of $\Delta E = c^2 \Delta m$ Conversion of energy to eV B.E./nucleon = 8.8 (MeV) <u>Example of calculation:</u> Mass defect = 26 × 1.673 × 10^{-27} kg + (56 – 26) ×1.675 × 10^{-27} kg − 9.287 × 10^{-26} kg = 8.78 × 10^{-28} kg $\Delta E = c^2 \Delta m$ = (3.00 × 10^8 m s^{-1})^2 ×8.780 × 10^{-28} kg = 7.902 × 10^{-11} J $\Delta E = \frac{7.902 \times 10^{-11}\text{ J}}{1.60 \times 10^{-19}\text{ J eV}^{-1}} = 4.94 \times 10^8$ eV $\therefore$B.E./nucleon= $\frac{494.0\text{ MeV}}{56} = 8.82$ MeV	**(1)** **(1)** **(1)** **(1)**	**4**
16(a)(iii)	Use of binding energy/nucleon to scale the energy axis Binding energy /nucleon of ^{2}H = 0.98 MeV (ecf from (a)(ii)) <u>Example of calculation:</u> Binding energy /nucleon of ^{2}H = $\frac{1}{9}$ ×8.8 MeV = 0.98 MeV	**(1)** **(1)**	**2**
16(b)	(In the fission process) total mass decreases Mass-energy is conserved, so energy is released **Or** (In the fission process) binding energy (per nucleon) increases Energy is conserved, so energy is released	**(1)** **(1)** **(1)** **(1)**	**2**
			10

Question Number	Answer		Mark
17(a)	The acceleration of an object is proportional to the displacement from the equilibrium position and (always) directed towards the equilibrium position **Or (**always) in the opposite direction to displacement [Accept answers given in terms of force] [Answers using defined equations acceptable (as long as symbols are identified).] [Accept equilibrium point, centre point, undisplaced position instead of equilibrium position; do not accept mean position]	**(1)** **(1)**	**2**
17(b)(i)	Time multiple (complete) oscillations [Accept measure nT, accept a number ≥ 3] Repeat timing and calculate a mean time period Use a (fiducial) marker to indicate the centre/timing position **Or** Time the oscillations from centre (position) [Accept equilibrium or undisplaced instead of centre]	**(1)** **(1)** **(1)**	**3**
17(b)(ii)	Use of $\omega = \frac{2\pi}{T}$ Use of $v_{\text{max}} = \omega A$ $v_{\text{max}} = 0.22 \text{ m s}^{-1}$ <u>Example of calculation:</u> $\omega = \frac{2\pi}{T} = \frac{2\pi}{0.57 \text{ s}} = 11.0 \text{ rad s}^{-1}$ $v_{\text{max}} = \omega A = 11.0 \text{ s}^{-1} \times 2.0 \times 10^{-2} \text{ m} = 0.22 \text{ m s}^{-1}$	**(1)** **(1)** **(1)**	**3**

17(b)(iii)	 Sinusoidal graph with a = 0 at t = 0 of any constant amplitude **(1)** Acceleration graph leading velocity graph by one quarter of a cycle [π/2 rad] and with same period as velocity graph **(1)**	**2**
17(b)(iv)	The oscillation is damped **(1)** Viscous/resistive/frictional forces dissipate energy **Or** Viscous/resistive/frictional forces cause energy to be transferred to the water **(1)**	**2**
		12

Question Number	Answer		Mark
18(a)(i)	Use of $\lambda_{max}T$=2.898 × 10^{-3} m K	**(1)**	
	λ_{max} = 9.2 × 10^{-7} m	**(1)**	**2**
	<u>Example of calculation:</u> $\lambda_{max} = \frac{2.898 \times 10^{-3}\text{ m K}}{3150\text{ K}} = 9.20 \times 10^{-7}\text{ m}$		
18(a)(ii)	Use of $L = 4\pi r^2 \sigma T^4$	**(1)**	
	$\frac{L_L}{L_S}$=0.011	**(1)**	**2**
	<u>Example of calculation:</u> $\frac{L_L}{L_S} = \frac{r_L^2}{r_S^2} \times \frac{T_L^4}{T_S^4} = (0.35)^2 \times \left(\frac{3150\text{ K}}{5800\text{ K}}\right)^4 = 0.0107$		
18(a)(iii)	Use of $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$	**(1)**	
	$\frac{1}{2}m\langle c^2\rangle = 6.5 \times 10^{-20}$ J	**(1)**	**2**
	<u>Example of calculation:</u> $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2} \times 1.38 \times 10^{-23}\text{ J K}^{-1} \times 3150\text{ K} = 6.52 \times 10^{-20}$ J		
***18(b)(i)**	**(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)**		
	There is a Doppler shift (of the emitted radiation)	**(1)**	
	Motion (of atoms) towards the observer decreases the wavelength detected **Or** motion (of atoms) away from the observer increases the wavelength detected	**(1)**	
	The hydrogen atoms have a range of (components of) velocities hence there is a range of wavelengths detected	**(1)**	**3**

18(b)(ii)	Use of $\frac{\Delta\lambda}{\lambda} = \sqrt{\frac{kT}{mc^2}}$ **(1)** Use of $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ **(1)** $v =$ 5100 m s^{-1} **(1)** <u>Example of calculation:</u> $\frac{\Delta\lambda}{\lambda} = \sqrt{\frac{1.38 \times 10^{-23} \text{J K}^{-1} \times 3150 \text{ K}}{1.67 \times 10^{-27} \text{kg} \times (3 \times 10^{8} \text{ m s}^{-1})^2}} = 1.70 \times 10^{-5}$ $\therefore v = 3 \times 10^{8} \text{ m s}^{-1} \times 1.70 \times 10^{-5} = 5100 \text{ m s}^{-1}$		3
*18(c)	**(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)** Luyten's star has smaller gravitational forces acting (than the Sun) **(1)** Hence the temperature in the <u>core</u> of Luyten's star would be less **Or** the density/pressure in the <u>core</u> of Luyten's star would be less **(1)** Luyten's star would have a lower rate of fusion, hence would exhaust its hydrogen (in the core) more slowly **Or** Hydrogen fusion in Luyten's star would cease in a longer time **(1)** **OR** The Sun has larger gravitational forces acting than Luyten's star **(1)** Hence the temperature in the <u>core</u> of the Sun would be greater **Or** the density/pressure in the <u>core</u> of the Sun would be greater **(1)** The Sun would have a higher rate of fusion, hence would exhaust the hydrogen (in its core) more quickly **Or** Hydrogen fusion in the Sun would cease in a shorter time **(1)**		3
			15