Mark Scheme (Results)

October 2020

Pearson Edexcel International Advanced Level
In Physics (WPH15) Paper 01
Thermodynamics, Radiation, Oscillations
and Cosmology

Question Number	Answer	Mark
1	**D is the correct answer** A is not the correct answer as paper did not absorb radiation B is not the correct answer as both aluminium and lead absorb radiation C is not the correct answer as paper did not absorb radiation	**(1)**
2	**C is the correct answer** A is not the correct answer as graph shows that low mass nuclei fusing gives less energy than when fission of massive nucleus occurs B is not the correct answer as graph shows that energy is released not absorbed D is not the correct answer as graph shows that energy is released not absorbed	**(1)**
3	**B is the correct answer** A is not the correct answer as this is the ratio of the mean squared velocities C is not the correct answer as this is the inverse of the correct answer D is not the correct answer as this is the inverse of the ratio of the mean squared velocities	**(1)**
4	**A is the correct answer** B is not the correct answer as there is a larger proportion of the total pd across the LDR C is not the correct answer as current in the circuit decreases D is not the correct answer as current in the circuit decreases and there is a larger proportion of the total pd across the LDR	**(1)**
5	**B is the correct answer** A is not the correct answer as T for the pendulum is 2.00 s not 1.00 s C is not the correct answer as incorrect value of T used and equation has not been correctly rearranged D is not the correct answer as equation has not been correctly rearranged	**(1)**
6	**D is the correct answer** A is not the correct answer as the background readings must be subtracted B is not the correct answer as the background readings must be subtracted C is not the correct answer as it is necessary to use the same time in each case	**(1)**
7	**C is the correct answer** A is not the correct answer as the relationship is not linear B is not the correct answer as a smaller thickness must cause a reduction less than 50% D is not the correct answer as the relationship is exponential	**(1)**
8	**C is the correct answer** A is not the correct answer as the mean molecular kinetic energy is unchanged B is not the correct answer as the mean molecular kinetic energy is unchanged D is not the correct answer as the mean molecular potential energy increases	**(1)**

Question Number	Answer	Mark
9	**B is the correct answer** A is not the correct answer as T is inversely proportional to the square root of k C is not the correct answer as T is inversely proportional to the square root of k D is not the correct answer as T is inversely proportional to the square root of k	**(1)**
10	**A is the correct answer** B is not the correct answer as 'normal' is not the correct description C is not the correct answer as 'optimum' is not the correct description D is not the correct answer as 'damping' is not the correct description	**(1)**

Question Number	Answer	Mark
11	Similarity: Both fields obey an inverse square law (for point masses/charges) **Or** both fields have an infinite range (1) Difference: Electric fields can be attractive or repulsive, whereas gravitational fields can only be attractive **Or** electric fields exert forces on charges whereas gravitational fields exert forces on masses (1)	2
	Total for question 11	**2**

Question Number	Answer	Mark
12(a)	The (massive) planet exerts a (large) gravitational force on the star. (1) The velocity of the star relative to the Earth changes. (1) (which causes a varying) Doppler shift (1)	**3**
12(b)	Use of $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ (1) v = 220 m s^{-1} (1) <u>Example of calculation</u> $v = \dfrac{3.19 \times 10^{-13}\ \text{m}}{4.35 \times 10^{-7}\ \text{m}} \times 3.0\times10^{8}\ \text{m s}^{-1} = 220\ \text{m s}^{-1}$	**2**
	Total for question 12	**5**

Question Number	Answer		Mark
13	(Very) high temperatures are needed to give hydrogen/nuclei/protons enough kinetic energy to overcome the repulsive force (between charges).	(1)	
	High densities are needed to enable a high enough collision rate (of nuclei to sustain the fusion reactions) **Or** High densities are needed to enable a high collision rate (of nuclei) in order to sustain the fusion reactions	(1)	
	If the material/plasma undergoing fusion (on Earth) were to touch the container the temperature would decrease and fusion would stop **Or** If the material/plasma undergoing fusion (on Earth) were to touch the container then the container would melt (and containment cease)	(1)	
	(On Earth) strong magnetic fields are required because there are containment problems for a material undergoing fusion.	(1)	**4**
	Total for question 13		**4**

Question Number	Answer	Mark
14(a)	Use of $I = \frac{L}{4\pi d^2}$ (1) L_{Sun} = 3.9 × 10^{26} (W) (1) <u>Example of calculation</u> $L_{\text{Sun}} = 4\pi \times (1.50 \times 10^{11}\ \text{m})^2 \times 1.37 \times 10^3\ \text{W} = 3.87 \times 10^{26}\ \text{W}$	**2**
14(b)	Use of $\Delta E = c^2 \Delta m$ **and** use of $P = \frac{\Delta W}{\Delta t}$ (1) Δm = 1.4 × 10^{17} kg ecf from (a) (1) <u>Example of calculation</u> $\Delta m = \frac{3.87 \times 10^{26}\ \text{J}\ s^{-1} \times 3.15 \times 10^7\ \text{s}}{(3.0 \times 10^8\ \text{m s}^{-1})^2} = 1.35 \times 10^{17}\ \text{kg}$	**2**
	Total for question 14	**4**

Question Number	Answer		Mark
15(a)	One pair of readings taken from graph 2 pairs of readings taken from graph Attempt to show that gr^2 is constant **OR** Use of $F = \frac{GMm}{r^2}$ with $F = mg$ Algebra to show that $g = \frac{GM}{r^2}$ Statement that GM is constant <u>Example of calculation</u>	(1) (1) (1) (1) (1) (1)	3

g / N kg^{-1}	r / R_E	$g r^2$ / N kg^{-1} R_E^2
8.0	1.1	9.7
5.0	1.4	9.8
2.0	2.2	9.7
9.8	1.0	9.8
2.4	2.0	9.6
0.6	4.0	9.6

Question Number	Answer		Mark
15(b)(i)	(The graph shows) g is not constant (from the surface of the Earth to height of $5R_E$) **Or** the gravitational field is not uniform over this distance	(1)	1
15(b)(ii)	Use of $V_{grav} = -\frac{GM}{r}$ Use of $\Delta E_{grav} = m \, \Delta V_{grav}$ $\therefore \Delta E_{grav} = 1.8 \times 10^{11}$ J <u>Example of calculation</u> $\Delta V_{grav} = \frac{GM}{R_E} - \frac{GM}{6R_E}$ $\therefore \Delta V_{grav} = \frac{6.67 \times 10^{-11} \text{N m}^2 \text{kg}^{-2} \times 6.0 \times 10^{24} \text{kg}}{6.4 \times 10^6 \text{m}} \left(1 - \frac{1}{6}\right) = 5.2 \times 10^7 \text{ J kg}^{-1}$ $\therefore \Delta E_{grav} = 3.5 \times 10^3 \text{kg} \times 5.2 \times 10^7 \text{ J kg}^{-1} = 1.82 \times 10^{11}$ J	(1) (1) (1)	3
	Total for question 15		**7**

Question Number	Answer		Mark
16(a)	At the top of the main sequence Accept a sketch of H-R diagram with the stars correctly marked on the main sequence	(1)	**1**
16(b)	Use of $\lambda_{\text{max}}T = 2.898 \times 10^{-3}$ m K $\lambda_{max} = 9.7 \times 10^{-8}$ m <u>Example of calculation</u> $\lambda_{\text{max}}=\dfrac{2.898\times10^{-3}\text{m K}}{3.00\times10^{4}\text{K}}=9.66\times10^{-8}$ m	(1) (1)	**2**
16(c)	Use of $L = \sigma T^4 A$ $r = 2.3 \times 10^{10}$ m <u>Example of calculation</u> $5.37 \times 10^5 \times 3.85 \times 10^{26}\text{W} = 5.67\times10^{-8}\text{ W m}^{-2}\text{ K}^{-1}\times4\pi\times r^2\times(2.75\times10^4\text{ K})^4$ $\therefore r = \sqrt{\dfrac{2.07 \times 10^{32}\text{W}}{5.67\times10^{-8}\text{ W m}^{-2}\text{ K}^{-1}\times4\pi\times\left(2.75\times10^{4}\text{K}\right)^{4}}}=2.25\times10^{10}$ m	(1) (1)	**2**

Question Number	Answer	Mark
16(d)	Use of $I = \frac{L}{4\pi d^2}$ (1) $I_A = 4.6 \times 10^{-8}$ Wm^{-2} and $I_M = 3.6 \times 10^{-8}$ Wm^{-2} **Or** $\frac{I_A}{I_M} = 1.25$ (1) Comparison of the intensities of the two stars and appropriate deduction. Dependent on MP1 (1) **OR** Alnilam is about 6 times as luminous as Mintaka, but Alnilam is twice as far away And the intensity of a star is given by $I = \frac{L}{4\pi d^2}$ **Or** The intensity of a star is proportional to luminosity and inversely proportional to the distance squared Dependent on MP1 (1) Hence the intensity of Alnilam is greater than that from Mintaka and so Mintaka has the lower intensity. Dependent on MP1 and MP2. (1) <u>Example of calculation</u> $\frac{I_A}{I_M} = \frac{L_A}{L_M} \times \left(\frac{d_M}{d_A}\right)^2$ (1) $\therefore \frac{I_A}{I_M} = \frac{5.37 \times 10^5}{9.0 \times 10^4} \times \left(\frac{8.7 \times 10^{18}\text{ m}}{1.9 \times 10^{19}\text{ m}}\right)^2 = 1.25$	3
	Total for question 16	**8**

Question Number	Answer		Mark
17(a)	Use of circumference = $2\pi r$	**(1)**	
	Use of $V = \frac{4\pi r^3}{3}$	**(1)**	
	Conversion of temperature to kelvin	**(1)**	
	Use of $pV = NkT$	**(1)**	
	Excess pressure calculated	**(1)**	
	Excess pressure is 79 kPa, so ball meets FA rules	**(1)**	**6**
	<u>Example of calculation</u> $r = \frac{0.685\text{ m}}{2\pi} = 0.109\text{ m}$ $V = \frac{4\pi}{3} \times (0.109\text{ m})^3 = 5.42 \times 10^{-3}\text{ m}^3$ $p = \frac{NkT}{V} = \frac{2.5 \times 10^{23} \times 1.38 \times 10^{-23}\text{ J K}^{-1} \times (16+273)}{5.42 \times 10^{-3}\text{ m}^3} = 1.84 \times 10^5\text{ Pa}$ Excess pressure = 1.84×10^5 Pa – 1.05×10^5 Pa = 7.9×10^4 Pa (79 kPa)		

Question Number	Answer	Mark
***17(b)**	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 structure and lines of reasoning.	

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

Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning

IC points	IC mark	Max linkage mark	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

Indicative content

- As the temperature of the air decreases the average/mean kinetic energy of the molecules decreases
- So the (root mean square) velocity/speed of the molecules decreases
  Or (Since $E_k = \frac{p^2}{2m}$) the (average) momentum of the molecules decreases
- The change of momentum of a molecule during a collision with the container walls decreases
- The rate of collision of molecules with the walls of the container decreases
- So the rate of change of momentum decreases and so the force on the container walls decrease s
- Hence the pressure exerted by the gas decreases, since $p = F/A$ **6**

	Total for question 17	**12**

Question Number	Answer	Mark
18(a)	$^{48}_{20}\mathrm{Ca} + {}^{249}_{98}\mathrm{Cf} \rightarrow {}^{294}_{118}\mathrm{Og} + \mathbf{3} \times {}^{1}_{0}\mathrm{n}$ (1)	**1**
18(b)(i)	Cyclotron **Or** Linac **Or** Particle accelerator (1)	**1**
18(b)(ii)	Conversion of energy to J (1) Conversion of mass to kg (1) Use of $E_k = \frac{1}{2}mv^2$ (1) $v = 3.1 \times 10^7$ m s^{-1} (1) Comparison of calculated value of v and c and valid conclusion (1) <u>Example of calculation</u> $E_k = 245 \times 10^6$ eV $\times 1.6 \times 10^{-19}$ J eV^{-1} = 3.92×10^{-11} J m = 47.95×1.66 x 10^{-27} kg = 7.96×10^{-27} kg $v = \sqrt{\frac{2 \times 3.92 \times 10^{-11}\,\mathrm{J}}{7.96 \times 10^{-26}\,\mathrm{kg}}} = 3.14 \times 10^7$ m s^{-1}	**5**
18(c)	Use of $\lambda = \frac{\ln 2}{t_{1/2}}$ (1) Use of $N = N_0 e^{-\lambda t}$ (1) $N_0 = 3.5 \times 10^3$ (1) <u>Example of calculation</u> $\lambda = \frac{0.693}{0.89 \times 10^{-3}\,\mathrm{s}} = 779$ s^{-1} $500 = N_0 \mathrm{e}^{-780\,\mathrm{s}^{-1} \times 2.5 \times 10^{-3}\,\mathrm{s}}$ $N_0 = \frac{500}{0.142} = 3.50 \times 10^3$	**3**

Question Number	Answer		Mark
18(d)	Handle the source with tongs	(1)	
	As alpha particles can only travel a few cm in air [Accept alpha particles have a very short range] **Or** The greater the distance, the lower the intensity of radiation received	(1)	
	OR		
	Handle the source for as short a time a possible	(1)	
	As the ionising effect is cumulative	(1)	**2**
	Total for question 18		**12**

Question Number	Answer		Mark
19(a)	The natural frequency of the water molecule is about 10 GHz	(1)	
	The microwave radiation frequency (2.45 GHz) is not at/about the natural frequency of the water molecule and so this is not resonance **Or** The driving frequency is not is not at/about the natural frequency of the water molecule and so this is not resonance	(1)	**2**
19(b)(i)	The (rotating) water molecules collide with other molecules (in the food)	(1)	
	There is a transfer of kinetic energy to (adjacent) molecules (in the food)	(1)	
	This increases the internal energy and hence the temperature of the food **Or** this increases the (average) kinetic energy (of the molecules) and hence the temperature of the food	(1)	**3**
19(b)(ii)	Ice is a solid and so the molecules have fixed positions	(1)	
	This prevents the molecules in the solid ice from rotating **Or** only molecules in liquid water around the ice can rotate	(1)	**2**

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>19(c)(i)</td><td>Use of $\Delta E = mc\Delta\theta$ and use of $P = \frac{\Delta W}{\Delta t}$

Use of efficiency = $\frac{\text{useful power output}}{\text{power input}}$
Or
Use of efficiency = $\frac{\text{useful energy output}}{\text{energy input}}$

Efficiency = 56 %, so the manufacturer's claim is invalid

<u>Example of calculation</u>
$P = \frac{0.325\text{ kg}\times 4190\text{ J kg}^{-1}\text{ K}^{-1}\times(85.0 - 25.0)\ ^\circ\text{C}}{225\text{ s}} = 363\text{ W}$
efficiency= $\frac{363\text{ W}}{650\text{ W}} \times 100\ \% = 55.8\ \%$</td><td>(1)

(1)

(1)</td><td>3</td></tr>
<tr><td>19(c)(ii)</td><td>Energy transfer from water cooling =
energy transfer to melt ice + energy transfer to heat ice

Use of $\Delta E = mc\Delta\theta$

Use of $\Delta E = mL$

$\theta = 59\ ^\circ\text{C}$

<u>Example of calculation</u>
Energy transfer from water cooling = energy transfer to melt ice + energy transfer to heat ice
$m_{\text{water}}\, c\, \Delta\theta_{\text{water}} = m_{\text{ice}}\, L + m_{\text{ice}}\, c\, \Delta\theta_{\text{ice}}$
$0.325\text{ kg} \times 4190\text{ J kg}^{-1}\text{K}^{-1}\ (85.0 - \theta)$
$= 0.0625\text{ kg} \times 3.33 \times 10^{5}\text{ J K}^{-1} + 0.0625\text{ kg} \times 4190\text{ J kg}^{-1}\text{ K}^{-1}(\theta - 0.0)$
$1362\,\theta + 262\,\theta = +1.16 \times 10^{5}\text{ J} - 2.08 \times 10^{4}\text{ J}$
$\therefore \theta = \frac{9.52 \times 10^{4}}{1620} = 58.8\ ^\circ\text{C}$</td><td>(1)

(1)

(1)

(1)</td><td>4</td></tr>
<tr><td></td><td>Total for question 19</td><td></td><td>14</td></tr>
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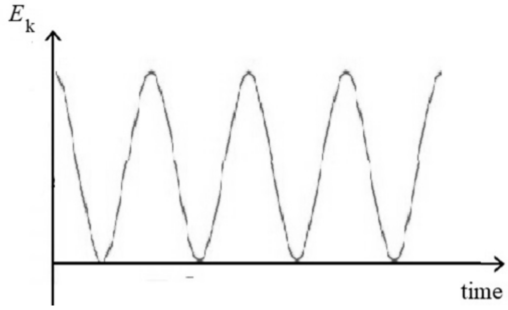
Question Number	Answer	Mark
20(a)	(For simple harmonic motion the) acceleration is: • (directly) proportional to <u>displacement</u> from equilibrium position (1) • acceleration is in the opposite direction to displacement **Or** (always) acting towards the equilibrium position (1) **OR** (For simple harmonic motion the resultant) force is: • (directly) proportional to <u>displacement</u> from equilibrium position (1) • force is in the opposite direction to displacement **Or** (always) acting towards the equilibrium position (1) (An equation with symbols defined correctly is a valid response for both marks For equilibrium position accept: undisplaced point/position **or** fixed point/position **or** central point/position)	**2**
20(b)	Use of $F = k\Delta x$ (1) Use of $T = 2\pi\sqrt{\frac{m}{k}}$ (1) Use of $v_{max} = \omega A$ with $\omega = \frac{2\pi}{T}$ (1) Use of $E_k = \frac{1}{2}mv^2$ (1) $E_k = 9.1 \times 10^{-3}$ J (1) **OR** Use of $F = k\Delta x$ (1) Statement that E_k max = ΔE_{el} (1) Because energy is conserved (1) Use of $\Delta E_{el} = \frac{1}{2}F\Delta x$ with $F = k\Delta x$ (1) $E_k = 9.1 \times 10^{-3}$ J (1) <u>Example of calculation</u> $k = \frac{F}{\Delta x} = \frac{0.25 \text{ kg} \times 9.81 \text{ N kg}^{-1}}{0.165 \text{ m}} = 14.9 \text{ N m}^{-1}$ $T = 2\pi\sqrt{\frac{0.25 \text{ kg}}{14.9 \text{ N m}^{-1}}} = 0.814 \text{ s}$ $E_k = \frac{1}{2} \times 0.25 \text{ kg} \times \left(\frac{2\pi \times 3.5 \times 10^{-2} \text{ m}}{0.814 \text{ s}}\right)^2 = 9.13 \times 10^{-3} \text{J}$	**5**

Question Number	Answer		Mark
20(c)	Sinusoidal curve with twice the frequency of displacement graph Always positive and maximum E_k at t = 0 <u>Example of graph</u> 	(1) (1)	 **2**
20(d)	There would be viscous/drag forces on the mass as it moved through the water This would remove energy (from the oscillation) **Or** this causes damping The amplitude would decrease over time (dependent on MP2)	(1) (1) (1)	 **3**
	Total for question 20		**12**