Mark Scheme (Results)

June 2010

GCE

GCE Physics (6PH05)

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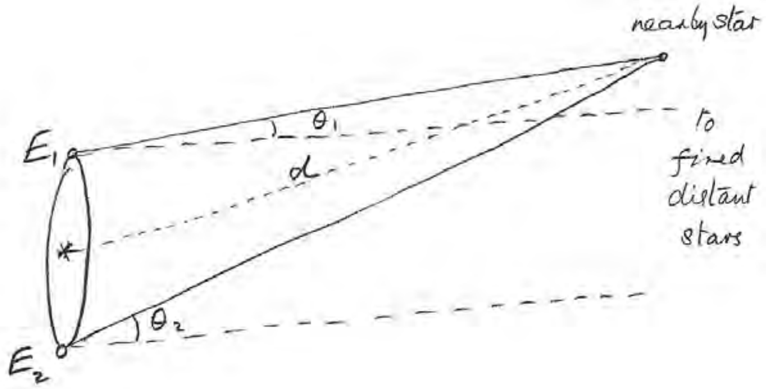
Question Number	Answer	Mark
1	B	**(1)**
2	D	**(1)**
3	A	**(1)**
4	B	**(1)**
5	C	**(1)**
6	D	**(1)**
7	C	**(1)**
8	C	**(1)**
9	C	**(1)**
10	B	**(1)**

Question Number	Answer	Mark
11(a)	(Net force) $(\Delta)F=-k(\Delta)x$ (1) Used with $F=ma$ (1)	**(2)**
11(b)	Use of $F=(-)kx$ (1) Correct answer for k OR substitution of expression for k into formula below (1) Use of $\omega^2=k/m$ OR $T=2\pi\sqrt{\frac{m}{k}}$ OR $a_{max}=-\omega^2 A$, with a_{max}=9.81 Nkg^{-1} (1) Use of $\omega=2\pi f$ OR $f=1/T$ (1) Correct answer for f (1) Example of calculation: $k=\frac{0.15\,\text{kg}\times 9.81\,\text{N kg}^{-1}}{0.2\,\text{m}}=7.4\,\text{Nm}^{-1}$ $\omega=\sqrt{\frac{7.4\,\text{N m}^{-1}}{0.15\,\text{kg}}}=7.0\left(\text{rad s}^{-1}\right)$ $f=\frac{\omega}{2\pi}=\frac{7\,\text{s}^{-1}}{2\pi}=1.1\,\text{Hz}$	**(5)**
	Total for question 11	**(7)**

Question Number	Answer	Mark
12(a)	β-particles can (easily) penetrate the body/skin (1) Since they are not very ionising OR reference to what will stop them (1)	**(2)**
12(b)(i)	Use idea that number of unstable atoms halves every 8 days OR that 24 days represents 3 half-lives (1) Correct answer (1) Example calculation: $N_0 \rightarrow \frac{N_0}{2} \rightarrow \frac{N_0}{4} \rightarrow \frac{N_0}{8}$ $t = 0 \quad t = t_{1/2} \quad t = 2t_{1/2} \quad t = 3t_{1/2}$ Fraction decayed = 100% - 12.5% = 87.5%	**(2)**
12(b)(ii)	Use of $\lambda T_{1/2} = \ln 2$ (1) Use of an appropriate decay equation (1) Correct answer (1) Example of calculation: $\lambda = \frac{\ln 2}{T_{1/2}} = \frac{0.693}{8\,\text{day}} = 0.0866\,\text{day}^{-1}$ $1.50\,\text{MBq} = A_0\,e^{-0.0866\,\text{day}^{-1} \times 1\,\text{day}}$ $A_0 = 1.50\,\text{MBq}\,e^{0.0866} = 1.64\,\text{MBq}$	**(3)**
	Total for question 12	**(7)**

Question Number	Answer	Mark
13(a)	Idea that the Earth is orbiting the Sun (1) Reference to (trigonometric) parallax (1) Idea that more distant stars have "fixed" positions (1)	**(3)**
13(b)	Diagram to show how to measure angular displacement of star over a 6 month period e.g.  (1) [Diagram should indicate the Earth in two positions at opposite ends of a diameter, with lines drawn heading towards a point with a relevant angle marked; accept the symmetrical diagram seen in many textbooks.] Use trigonometry to calculate the distance to the star (1) [May be indicated by an appropriate trigonometric formula. Do not accept use of Pythagoras] Need to know the diameter/radius of the Earth's orbit about the Sun (1) [This may be marked on the diagram or seen in a trigonometric formula]	**(3)**
13(c)	Standard candle/Cepheid variable/supernovae (1)	**(1)**
	Total for question 13	**(7)**

Question Number	Answer	Mark
14(a)	Alpha-radiation only has a range of a few cm in air / cannot penetrate walls of container / skin (1)	**(1)**
14(b)(i)	Top line: $^{241}Am \; ^{237}Np \; ^{4}\alpha$ (1) Bottom line: $_{95}Am \; _{93}Np \; _{2}\alpha$ (1)	**(2)**
14(b)(ii)	Attempt at calculation of mass defect (1) Use of $(\Delta)E=c^2(\Delta)m$ OR use of 1 u = 931.5 MeV (1) Correct answer [5.65 MeV; accept 5.6 – 5.7 MeV] (1) Example of calculation: $\Delta m = 241.056822\,u - 237.048166\,u - 4.002603\,u = 0.006053\,u$ $\Delta m = 0.006053\,u \times 1.66 \times 10^{-27}\ kg\,u^{-1} = 1.005 \times 10^{-29}\ kg$ $E = 1.005 \times 10^{-29}\ kg \times \left(3 \times 10^{8}\ ms^{-1}\right)^2 = 9.04 \times 10^{-13}\ J$ $E = \dfrac{9.04 \times 10^{-13}\ J}{1.6 \times 10^{-13}\ MeV\,J^{-1}} = 5.65\,MeV$	**(3)**
14(c)	Reference to half-life and typical lifespan (1)	**(1)**
	Total for question 14	**(7)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>15(a)(i)</td><td>Use of $\lambda_{max}T = 2.898 \times 10^{-3}$ (1)

Correct answer (1)

Example of calculation:
$$T = \frac{2.898 \times 10^{-3}\ \text{mK}}{5.2 \times 10^{-7}\ \text{m}} = 5570\ \text{K}$$</td><td>(2)</td></tr>
<tr><td>15(a)(ii)</td><td>Use of $F = L/4\pi d^2$ (1)

Correct answer (1)

Example of calculation:
$$L = 1370\ \text{Wm}^{=2} \times 4\pi \times \left(1.49 \times 10^{11}\ \text{m}\right)^2 = 3.8 \times 10^{26}\ \text{W}$$</td><td>(2)</td></tr>
<tr><td>15(a)(iii)</td><td>Use of $L = 4\pi r^2 \sigma T^4$ (1)

Correct answer (7.46×10^8 m) (1)

Example of calculation:
$$r^2 = \frac{3.82 \times 10^{26}\ \text{W}}{4\pi \times 5.67 \times 10^{-8}\ \text{Wm}^{-2}\text{K}^{-4} \times \left(5570\ \text{K}\right)^4} = 5.57 \times 10^{17}\ \text{m}^2$$
$$r = \sqrt{5.57 \times 10^{17}\ \text{m}^2} = 7.46 \times 10^8\ \text{m}$$
<table><tr><th></th><th>3.8×10^{-26} W</th><th>4×10^{26} W</th></tr><tr><td>5570 K</td><td>7.46</td><td>7.6</td></tr><tr><td>6000 K</td><td>6.4</td><td>6.6</td></tr></table></td><td>(2)</td></tr>
<tr><td>15(b)

QWC</td><td>The answer must be clear, use an appropriate style and be organised in a logical sequence

High temperature AND high density/pressure (1)

Any two reasons from:
Overcome coulomb/electrostatic repulsion (1)
<u>Nuclei</u> come close enough to fuse/for strong (nuclear) force to act (1)
High collision rate/collision rate is sufficient (1)</td><td>(max 3)</td></tr>
<tr><td></td><td>Total for question 15</td><td>(9)</td></tr>
</table>

Question Number	Answer		Mark
16(a)	Any two from: Air behaves as an ideal gas Temperature (in the lungs) stays constant Implication of no change in mass of gas	 (1) (1) (1)	**(max 2)**
16(b)(i)	Use of $\rho = m/V$ Correct answer (1.3×10^{-4} kg s^{-1}) Example of calculation: $m = V.\rho = 2.5 \times 10^{-4}\ m^3 \times 1.2\ kg\,m^{-3} = 3 \times 10^{-4}\ kg$ $\frac{\Delta m}{\Delta t} = 3 \times 10^{-4}\ kg \times \frac{25}{60\,s} = 1.25 \times 10^{-4}\ kg\,s^{-1}$	(1) (1)	**(2)**
16(b)(ii)	Use of $\Delta E = mc\Delta\theta$ Correct answer (2.2 W) ecf Example of calculation: $P = 1.25 \times 10^{-4}\ kg\,s^{-1} \times 1000\ J\,kg^{-1}\,K^{-1} \times (37.6 - 20.0)K = 2.2\ W$	(1) (1)	**(2)**
	Total for question 16		**(6)**

Question Number	Answer	Mark
17(a)(i)	Calculation of time period (1) Use of $v = \frac{\Delta s}{\Delta t}$ *or* $\omega = \frac{2\pi}{T}$ (1) Use of $a = \frac{v^2}{r}$ *or* $a = r\omega^2$ (1) Correct answer (1) Example of calculation: $T = \frac{24 \times 60 \times 60\, s}{15} = 5760\, s$ $v = \frac{2\pi r}{T} = \frac{2\pi \times 6.94 \times 10^6\, m}{5760\, s} = 7.57 \times 10^3\, ms^{-1}$ $a = \frac{v^2}{r} = \frac{(7.6 \times 10^3\, ms^{-1})^2}{6.94 \times 10^6\, m} = 8.26\, ms^{-2}$ OR $\omega = \frac{2\pi}{T} = \frac{2\pi}{5760\, s} = 1.09 \times 10^{-3}\, ms^{-1}$ $a = r\omega^2 = 6.94 \times 10^6 \times (1.09 \times 10^{-3})^2 = 8.26\, ms^{-2}$	**(4)**
17(a)(ii)	mg equated to gravitational force expression (1) g (= a) = 8.3 ms^{-2} substituted (1) Correct answer (1) Example of calculation: $mg = \frac{GMm}{r^2}$ $\therefore 8.3\, ms^{-2} = \frac{6.67 \times 10^{-11}\, N\, m^2\, kg^{-2} M}{(6.94 \times 10^6\, m)^2}$ $\therefore M = \frac{8.3\, ms^{-1} \times (6.94 \times 10^6\, m)^2}{6.67 \times 10^{-11}\, Nm^2 kg^{-2}} = 6.0 \times 10^{24}\, kg$	**(3)**
17(b)	The observed wavelength is longer than the actual wavelength / the wavelength is stretched out (1) One from: The universe is expanding (1) (All distant) <u>galaxies</u> are moving apart (1) The (recessional) velocity of <u>galaxies</u> is proportional to distance (1) The furthest out <u>galaxies</u> move fastest (1)	**(max 2)**

17(c)(i)	A light year is the distance travelled (in a vacuum) in 1 year by light / em-radiation (1) The idea that light has only been able to travel to us for a time equal to the age of the universe. (1)	**(2)**
17(c)(ii)	(Use of v = H_o d to show) $H_o = \frac{1}{t}$ (1) Correct answer (1) Example of calculation: $H_o = \frac{1}{t} = \frac{1}{12 \times 3.15 \times 10^{16}\ s} = 2.65 \times 10^{-18}\ s^{-1}$	**(2)**
17(c)(iii) **QWC**	The answer must be clear and be organised in a logical sequence There is considerable uncertainty in the value of the Hubble constant (1) Any sensible reason for uncertainty (1) Idea that a guess implies a value obtained with little supporting evidence OR the errors are so large that our value is little better than a guess (1)	**(3)**
	Total for question 17	**(16)**

Question Number	Answer		Mark
18(a)	Resonance System driven at / near its natural frequency	(1) (1)	**(2)**
18(b)(i)	Any zero velocity point	(1)	**(1)**
18(b)(ii)	Any maximum/minimum velocity point	(1)	**(1)**
18(c)	Select 70 mm distance from passage/see 35 mm Use of $a = -\omega^2 x$ Use of $v = \omega A$ Correct answer Example of calculation: $\omega = \sqrt{\frac{0.89\,\mathrm{m s^{-1}}}{3.5\times10^{-2}\,\mathrm{m}}} = 5.04\,\mathrm{rad\,s^{-1}}$ $v = \omega A = 5.04\,\mathrm{s^{-1}} \times 3.5\times10^{-2}\,\mathrm{m} = 0.18\,\mathrm{m\,s^{-1}}$	(1) (1) (1) (1)	**(4)**
18(d) **QWC**	The answer must be clear and be organised in a logical sequence The springs/dampers absorb energy (from the bridge) (Because) the springs deform/oscillate with natural frequency of the bridge Hence there is an efficient/maximum transfer of energy Springs/dampers must not return energy to bridge / must dissipate the energy	 (1) (1) (1) (1)	**(max 3)**
	Total for question 18		**(11)**

Mark Scheme (Results)

January 2011

GCE

GCE Physics (6PH05) Paper 01

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Section A

Question Number	Answer	Mark
1	D	**1**
2	C	**1**
3	D	**1**
4	C	**1**
5	B	**1**
6	B	**1**
7	B	**1**
8	B	**1**
9	A	**1**
10	D	**1**

Question Number	Answer	Mark
11(a)	Use of $pV=NkT$ (1) $T =$ 870 (K) OR p = 12.4 (atmospheres) (1) If final pressure is given as 1.24 × 10^6 Pa, then just "use of" mark <u>Example of calculation</u>: $T = \frac{pV}{Nk} = \frac{12 \times 1.0 \times 10^5 \text{ Nm}^{-2} \times 3.00 \times 10^{-4} \text{ m}^3}{3 \times 10^{22} \times 1.38 \times 10^{-23} \text{ JK}^{-1}} = 869.6 \text{ K}$ OR $p = \frac{NkT}{V} = \frac{3 \times 10^{22} \times 1.38 \times 10^{-23} \text{ JK}^{-1} \times 900 \text{ K}}{3 \times 10^{-4} \text{ m}^3}$ $\therefore p = 1.24 \times 10^6 \text{ Pa} = \frac{1.24 \times 10^6 \text{ Pa}}{3 \times 10^{-4} \text{ Pa}} = 12.4$	**2**
11(b)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) <u>Atoms/molecules</u> would gain energy (1) <u>Atoms/molecules</u> would escape from the liquid OR liquid propellant would vaporise / turn into gas OR the amount of gas in can would increase (1) Pressure would increase due to **both** temperature/energy increase **and** increase in amount of gas OR pressure would increase more for the same temperature increase OR pressure would be greater than 12 atmospheres before 900 K (1) Can would explode before 900 K reached (1)	**Max 3**
	Total for question 11	**5**

Question Number	Answer	Mark
12(a)	Use of $L/4\pi d^2$ **or** $F \propto 1/d^2$ (1) $F_{mars} / F_{earth} = 0.43$ (1) Accept 1 : 2.35 or other ratio simplifying to 0.43 <u>Example of calculation</u> $F = \frac{L}{4\pi\pi^2}$ $\frac{F_{mars}}{F_{earth}} = \frac{d^2_{earth}}{d^2_{mars}} = \left(\frac{1.5 \times 10^{11}\,m}{2.3 \times 10^{11}\,m}\right)^2 = 0.43$	**2**
12(b)	Observation that (radiation) flux is about half that on the Earth OR Earth has about double the (radiation) flux of Mars (ecf answer to (a)) (1) Sensible comment that makes reference to energy/intensity/number of photons OR sensible comparison with polar or deep sea regions on the Earth OR reference to a thinner atmosphere (allowing a greater fraction of photons get through to surface) (1)	**2**
	Total for question 12	**4**

Question Number	Answer	Mark
13(a)	Object must have a standard/known luminosity OR luminous properties independent of its position (1) It can be used to calculate distances (1) Reference to any **two** of the following: ♦ Radiation/energy flux <u>measured</u> (1) ♦ Observed brightness compared with luminosity (1) ♦ Use of inverse square law [accept if equation quoted] (1) ♦ Object must be commonly found in the universe (1)	**Max 4**
13(b)	When star contracts (front of) star is moving away from observer OR explanation in terms of a rotating/binary star (1) Movement away from observer results in a decrease in the frequency of the radiation/red shift (1) Accept converse argument for an expanding star	**2**
	Total for question 13	**6**

Question Number	Answer	Mark
14(a)(i)	Use of πr^2 or $\pi d^2/4$ (1) Use of $\rho = m/V$ (1) m = 1960 (kg) (1) Reverse argument leading to ρ = 9130 (kg m^{-3}) scores max 2 <u>Example of calculation</u> $V = \pi r^2 \ell = \pi \times (0.815 \times 10^{-3}\,m)^2 \times 105 \times 10^3\,m = 0.219\,m^3$ $m = \rho V = 8960\,kgm^{-3} \times 0.219m^3 = 1962\,kg$	**3**
14(a)(ii)	Use of $\Delta E = mc\Delta T$ (1) $\Delta E = 8.0 \times 10^8$ J (1) $\Delta E = 8.2 \times 10^8$ J if show that value used <u>Example of calculation</u> $\Delta E = m c \Delta\theta = 1962\,kg \times 385\,JK^{-1}kg^{-1} \times (1085 - 25)K = 8.0 \times 10^8\,J$	**2**
14(b)	Idea that whilst copper is being heated to melting point, energy supplied is (mainly) transformed into K.E. of atoms/molecules (1) At melting point: no change in K.E. of atoms/molecules OR energy supplied is transformed into P.E. of atoms/molecules (1)	**2**
	Total for question 14	**7**

Question Number	Answer	Mark
15(a)(i)	Use of $\omega=2\pi/T$ (1) ω = 2.66 × 10^{-6} (rad s^{-1}) (1) <u>Example of calculation</u> $\omega = \frac{2\pi}{T} = \frac{2\pi}{27.3 \times 24 \times 3600\text{s}} = 2.66 \times 10^{-6}\,(\text{rad})\text{s}^{-1}$	**2**
15(a)(ii)	See $(F =)\frac{Gm_1m_2}{r^2}$ (1) Evidence that gravitational force equated to centripetal force (1) Correct substitution [e.c.f.] (1) r = 3.92 × 10^8 m (1) If show that value is used, r = 3.62 × 10^8 m <u>Example of calculation</u> $\frac{GMm}{r^2} = m\omega^2 r$ $r^3 = \frac{GM}{\omega^2}$ $\therefore \text{r} = \sqrt[3]{\frac{6.67\times10^{-11}\,\text{Nm}^2\text{kg}^{-2}\times6.4\times10^{24}\,\text{kg}}{(2.66\times10^{-6}\,\text{s}^{-1})^2}} = 3.92\times10^8\ \text{m}$	**4**
15(b)(i)	Max **two** from: ♦ Gravitational force on moon is reduced (1) ♦ (Therefore) ω or v is decreased (1) ♦ (Hence) the orbital time increases (1) ♦ Valid reference to Kepler's law: $T^2 \alpha\ r^3$ (1)	**Max 2**
15(b)(ii)	Rate of increase = 4 (cm per year) (1) <u>Example of calculation</u> Rate of increase = 800 cm / 200 yr = 4 cm yr^{-1}	**1**
15(b)(iii)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Answers based on expanding universe/galaxies/stars do not gain credit Idea that in the past the moon was closer OR the gravitational pull would have been larger (1) In the past the tidal effects would have been greater/stronger (1) The rate of change of orbital radius would have been greater (1)	**3**
	Total for question 15	**12**

Question Number	Answer	Mark
16(a)(i)	Use of $f=1/T$ (1) f = 8 Hz (1) <u>Example of calculation</u> $f = \frac{1}{T} = \frac{1}{2 \times 0.0625\,\text{s}} = 8\text{ Hz}$	**2**
16(a)(ii)	At the equilibrium (position) / centre of the oscillation / mid-point (1)	**1**
16(a)(iii)	Use of $v_{max}=2\pi fA$ OR $v_{max}=\omega A$ (1) v_{max} = 2.5 ms^{-1} [ecf for (a)(i), see table below] (1) <u>Example of calculation</u> $v = 2\pi f A = 2\pi \times 8\,\text{s}^{-1} \times 5 \times 10^{-2}\text{ m} = 2.5\text{ m s}^{-1}$	**2**
16(b)(i)	Idea that the system is forced / driven into oscillation at / near its <u>natural</u> frequency OR driver / forcing frequency is equal / near to <u>natural</u> frequency (1) Leads to large/max energy transfer OR large/max/increasing amplitude (1)	**2**
16(b)(ii)	**Max 2** ♦ Rubber feet (deform and) absorb (vibration) energy (1) ♦ Reference to damping (1) ♦ Idea that energy is removed from system (1) ♦ **Hence** amplitude does not build up (1)	**max 2**
	Total for question 16	**9**

When marking 16(a)(iii) the table below may be helpful:

f/Hz	A/cm	v/ms^{-1}	Marks
8	5	2.5	2
16	5	5	2
8	10	5	1
16	10	10	1

Question Number	Answer	Mark
17(a)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Appropriate reference to the following: ▪ The penetrating power of beta radiation ▪ The ionising effects of the beta radiation ▪ The shielding effect that the cylinder might have had ▪ The constant activity over the 5 day period Examples of responses: Beta radiation is (moderately) ionising Beta radiation is able to penetrate the body Once inside the body beta radiation may damage / kill / mutate / alter DNA of cells Beta radiation is absorbed by a few mm of aluminium Cylinder may have reduced the radiation to safe levels / absorbed the beta radiation Greater risk of exposure if cylinder damaged or cracked Long half life means that: source stays active for a long time/activity unlikely to lower over 5 days	**max 3**
17(b)	Top line: $^{137}\mathrm{Ba}$ $^{0}\beta^{-}$ (1) Bottom line: $_{56}\mathrm{Ba}$ $_{-1}\beta^{-}$ (1)	**2**
17(c)(i)	Cannot identify which atom/nucleus/particle will be the next to decay OR cannot say when a given atom/nucleus/particle will decay OR cannot state exactly how many atoms/nuclei/particles will decay in a set time OR can only estimate the fraction of the total number that will decay in the next time interval (1)	**1**

17(c)(ii)	Use of $\lambda T_{1/2} = \ln 2$ (1) Decay constant, $\lambda = 7.3 \times 10^{-10}$ (s^{-1}) (1) <u>Example of calculation</u> $\lambda = \frac{\log_e 2}{T_{½}} = \frac{0.693}{30 \times 365 \times 24 \times 3600\,s} = 7.32 \times 10^{-10}\ s^{-1}$	**2**
17(d)	Use of $\frac{dN}{dt} = \left(\frac{dN}{dt}\right)_0 e^{-\lambda t}$ (1) activity = 3.3×10^{13} Bq [3.3×10^{13} Bq if show that value used] (1) Use of $dN/dt = \lambda N$ (1) $N = 4.5 \times 10^{22}$ [4.8×10^{22} if show that value used] (1) OR Use of $dN/dt = \lambda N_o$ (1) $N_o = 7.1 \times 10^{22}$ [$N_o = 7.4 \times 10^{22}$ if show that value used] (1) Use of $N = N_0 e^{-\lambda t}$ (1) $N = 4.5 \times 10^{22}$ [4.8×10^{22} if show that value used] (1) <u>Example of calculation</u> $\frac{dN}{dt} = \left(\frac{dN}{dt}\right)_0 e^{-\lambda t} = 5.2 \times 10^{13}\ Bq \times e^{-7.32 \times 10^{-10}\ s^{-1} \times 20 \times 365 \times 24 \times 3600\,s}$ $= 3.28 \times 10^{13}\ Bq$ $N = \frac{dN/dt}{\lambda} = \frac{3.28 \times 10^{13}\ s^{-1}}{7.32 \times 10^{-10}\ s^{-1}} = 4.48 \times 10^{22}$	**4**
17(e)(i)	${}^{95}_{37}Rb \quad + \quad 4 \times {}^{1}_{0}n$ (1)	**1**
17(e)(ii)	Idea that at least one neutron needs to be available to be absorbed for a chain reaction to be sustained (1) Appreciation of the need to control/limit/restrict the number of neutrons (which can go on to produce another fission) (1)	**2**
	Total for question 17	**12**

Question Number	Answer	Mark
18(a)	**Max 4** Assumption: that no energy is transferred to the surroundings OR all energy transferred from washers to water OR energy required to raise temperature of container is negligible OR no water evaporates (1) Measure the mass of the washers and water (using a balance) (1) (Use a thermometer to) measure the temperature of the water before and after the washers are plunged into the water (1) Equate thermal energy lost by steel to the energy gained by water (1) Use a (standard) value for the specific heat capacity of the water OR specific heat capacity of water is known (1)	**Max 4**
18(b)(i)	Infra-red (1)	**1**
18(b)(ii)	Use of $\lambda_{max}T = 2.898 \times 10^{-3}$ (1) T = 1450 (K) OR $\lambda_{max} = 1.93 \times 10^{-6}$ (m) (1) <u>Example of calculation</u> $T = \frac{2.898 \times 10^{-3}\ \text{mK}}{2 \times 10^{-6}\ \text{m}} = 1450\ \text{K}$	**2**
18(b)(iii)	Use of $L = 4\pi r^2 \sigma T^4$ (1) Correct substitution of radius (1) L = 1970 W [2250W if show that value used] (1) <u>Example of calculation</u> $L = 4\pi \times (2.5 \times 10^{-2}\ \text{m})^2 \times 5.67 \times 10^{-8}\ \text{Wm}^{-2}\text{K}^{-4} (1450\text{K})^4 = 1970\ \text{W}$	**3**
18(b)(iv)	Curve with higher peak (1) Shifted over to left (1)	**2**
	Total for question 18	**12**

Mark Scheme (Results)

June 2011

GCE Physics (6PH05) Paper 01
Physics from Creation to Collapse

Question Number	Answer	Mark
1	A	**1**
2	D	**1**
3	A	**1**
4	D	**1**
5	C	**1**
6	D	**1**
7	C	**1**
8	B	**1**
9	D	**1**
10	A	**1**

Question Number	Answer		Mark
11(a)	(A star/astronomical) object of known luminosity (due to some characteristic property of the star/object)	**(1)**	**1**
11(b)	Use of $F = L/4\pi d^2$ $F = 1.09 \times 10^{-7}$ W m^{-2} <u>Example of calculation</u> $F = \frac{L}{4\pi d^2} = \frac{8.94 \times 10^{27}\text{ W}}{4\pi(8.08 \times 10^{16}\text{ m})^2} = 1.0896 \times 10^{-7}\text{ W m}^{-2}$	**(1)** **(1)**	**2**
	Total for question 11		**3**

Question Number	Answer		Mark
12(a)	See $F = mg$ and $F = (-)GmM/r^2$ Equate and cancel m on either side	**(1)** **(1)**	**2**
12(b)	Substitute into $g = GM/r^2$ to obtain $g = 9.78$ N kg^{-1} [condone m s^{-2}] <u>Example of calculation</u> $g = \frac{GM}{r^2} = \frac{6.67 \times 10^{-11}\text{ N m}^2\text{ kg}^{-2} \times 5.97 \times 10^{24}\text{ kg}}{(6.38 \times 10^6\text{ m})^2} = 9.783\text{ N kg}^{-1}$	**(1)**	**1**
	Total for question 12		**3**

Question Number	Answer		Mark
13(a)	Use of $P=IV$ I = 9.1 A <u>Example of calculation</u> $I=\frac{P}{V}=\frac{2100\ \text{W}}{230\ \text{V}}=9.13\ \text{A}$	**(1)** **(1)**	 **2**
13(b)(i)	Use of $\Delta E = mc\Delta\theta$ (for t =1s) $\theta = 51^{o}$C or 324 K <u>Example of calculation</u> $\Delta\theta=\frac{\Delta E}{mc}=\frac{2100\ \text{J}}{0.068\ \text{kg}\times 1010\ \text{J kg}^{-1}\ {}^{o}\text{C}^{-1}}=30.6\ {}^{o}\text{C}$ $\theta = 30.6 + 20 = 50.6\ {}^{o}$C	**(1)** **(1)**	 **2**
13(b)(ii)	Thermal energy (is transferred) to <u>air</u> (molecules) Kinetic energy [E_k] of (air) molecules is increased	**(1)** **(1)**	 **2**
	Total for question 13		**6**

Question Number	Answer		Mark
14(a)(i)	Use of p/T= a constant $p = 1.8 \times 10^5$ (Pa) (no ue) <u>Example of calculation</u> $\frac{p_2}{T_2} = \frac{p_1}{T_1}$ $\therefore p_2 = \frac{(273+40)\ \text{K} \times 1.65 \times 10^5\ \text{Pa}}{(273+20)\ \text{K}} = 1.76 \times 10^5\ \text{Pa}$	**(1)** **(1)**	**2**
14(a)(ii)	Air behaves as an ideal gas / mass of air remains constant / number of molecules remains constant/same amount of air/number of moles remains constant/no air escapes	**(1)**	**1**
14(b)	Use of $V=4\pi r^3/3$ Use of $pV = NkT$ $N = 1.5 \times 10^{22}$ <u>Example of calculation</u> $V = \frac{4\pi r^3}{3} = \frac{4\pi(\frac{0.225\ \text{m}}{2})^3}{3} = 5.96 \times 10^{-3}\ \text{m}^3$ $N = \frac{pV}{kT} \therefore \Delta N = \frac{V(p_2 - p_1)}{kT}$ $\Delta N = \frac{5.96 \times 10^{-3}\ \text{m}^3 (1.76 \times 10^5 - 1.65 \times 10^5)\ \text{Pa}}{1.38 \times 10^{-23}\ \text{J K}^{-1} \times 313\ \text{K}}$ $\Delta N = 1.52 \times 10^{22}$	**(1)** **(1)** **(1)**	**3**
	Total for question 14		**6**

Question Number	Answer		Mark
15(a)	Force (or acceleration): • (directly) proportional to displacement • always acting towards the equilibrium position	**(1)** **(1)**	**2**
15(b)	Use of $\omega = 2\pi f$ OR $\omega = 2\pi/T$ Use of $v = A\omega \sin\omega t$ OR $v = A\omega$ $v = 0.35 \text{ m s}^{-1}$ [If 5 cm or 10 cm is substituted instead of 2.5 cm then still award second mark] <u>Example of calculation</u> $\omega = 2\pi \text{ rad} \times \left(\frac{10}{4.5 \text{ s}}\right) = 14.0 \text{ rad s}^{-1}$ $v = 2.5 \times 10^{-2} \text{ m} \times 14.0 \text{ s}^{-1} = 0.35 \text{ m s}^{-1}$	**(1)** **(1)** **(1)**	**3**
15(c)	Any **THREE** from • Node at fixed end or antinode at free end • Distance from node to antinode = $\lambda/4$ • As (vibrating) length increases, wavelength increases • Reference to $v = f\lambda$ • The shorter the ruler the higher the frequency	**(1)** **(1)** **(1)** **(1)** **(1)**	**Max 3**
	Total for question 15		**8**

Question Number	Answer		Mark
16(a)(i)	Use of $\lambda = \ln 2 / t_{½}$ Use of $dN/dt = -\lambda N$ $dN/dt = 7.6 \times 10^{13}$ (Bq) (no ue) <u>Example of calculation</u> $\lambda = \frac{\ln 2}{138 \times 24 \times 60 \times 60 \text{ s}} = 5.81 \times 10^{-8} \text{ s}^{-1}$ $\frac{dN}{dt} = -\lambda N = -5.81 \times 10^{-8} \text{ s}^{-1} \times 1.3 \times 10^{21} = 7.55 \times 10^{13} \text{ s}^{-1}$	**(1)** **(1)** **(1)**	**3**
16(a)(ii)	Conversion from MeV to J Use of $P = \Delta W / \Delta t$ $P = 64$ (W) (no ue) <u>Example of calculation</u> $P = 7.55 \times 10^{13} \text{ s}^{-1} \times 5.3 \times 1.6 \times 10^{-13} = 64 \text{ W}$	**(1)** **(1)** **(1)**	**3**
16(b)(i)	5% factor seen Use of $P = 4\pi r^2 \sigma T^4$ $T = 970$ K <u>Example of calculation</u> $T = \sqrt[4]{\frac{3.2 \text{ W}}{4\pi(2.25 \times 10^{-3} \text{ m})^2 \times 5.67 \times 10^{-8} \text{ W m}^{-2}\text{K}^{-4}}}$ $T = 971$ K	**(1)** **(1)** **(1)**	**3**
16(b)(ii)	Use of $\lambda_{max} T = 2.898 \times 10^{-3}$ $\lambda_{max} = 3.0 \times 10^{-6}$ m <u>Example of calculation</u> $\lambda_{max} = \frac{2.898 \times 10^{-3} \text{ m K}}{971 \text{ K}} = 3.0 \times 10^{-6} \text{ m}$	**(1)** **(1)**	**2**
16(b)(iii)	Infrared	**(1)**	**1**
16(c)	Alphas are highly ionising (therefore) will not penetrate the skin (and enter the body)	**(1)** **(1)**	**2**
	Total for question 16		**14**

Question Number	Answer		Mark
17(a)(i)	Use of m =1.67 x 10^{-27} kg Use of ½ $m<c^2>$ = 3/2 kT c_{rms} = 2,800(m s^{-1}) (no ue) <u>Example of calculation</u> $<c^2> = \frac{3kT}{m} = \frac{3 \times 1.38 \times 10^{-23}\ J\ K^{-1} \times 310\ K}{1.0087 \times 1.66 \times 10^{-27}\ kg} = 7.66 \times 10^6\ m^2\ s^{-2}$ $<c^2> = 7.66 \times 10^6\ m^2\ s^{-2}$ $c_{rms} = \sqrt{7.66 \times 10^6 m^2 s^{-2}} = 2.77 \times 10^3\ m\ s^{-1}$	(1) (1) (1)	3
17(a)(ii)	$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{236}_{92}U \rightarrow ^{138}_{55}Cs + ^{96}_{37}Rb + 2 \times ^{1}_{0}n$ Nucleon, proton numbers correct [236, 55] Number of neutrons correct [2]	 (1) (1)	2
17(a)(iii)	Attempt at calculation of mass defect Use of $\Delta E = c^2 \Delta m$ OR use of 1 u = 931.5 MeV Use of $fission\ rate = \frac{power\ output}{energy\ per\ fission}$ Fission rate = 8.8 × 10^{19} s^{-1} <u>Example of calculation</u> $\Delta m = (235.0439\text{-}137.9110 - 95.9343\text{-}1.0087)\ u$ $\Delta m = 0.1899 \times 1.66 \times 10^{-27}\ kg = 3.15 \times 10^{-28}\ kg$ $\Delta E = (3 \times 10^8\ m\ s^{-1})^2 \times 3.15 \times 10^{-28}\ kg = 2.84 \times 10^{-11}\ J$ $\text{Fission rate} = \frac{2.5 \times 10^9\ W}{2.84 \times 10^{-11}\ J} = 8.8 \times 10^{19}\ s^{-1}$	(1) (1) (1) (1)	4

***17(b)(i)**	(QWC- Work must be clear and organised in a logical manner using technical wording where appropriate.) Max THREE from first 5 marking points • Very high temperatures (>10^7 K)needed **(1)** • To overcome electrostatic repulsion / forces **(1)** • Nuclei come close enough to fuse / for strong (nuclear) force to act **(1)** • Very high densities needed **(1)** • (Together with high nuclei speeds) this gives a sufficient collision rate **(1)** • (Very high) temperatures lead to confinement problems **(1)** • Contact with container causes temperature to fall (and fusion to cease) **(1)**	**Max 4**
17(b)(ii)	$${}^{2}_{1}D + {}^{2}_{1}D \rightarrow {}^{3}_{1}H + {}^{1}_{1}X$$ **(1)** X is a proton [accept hydrogen nucleus]	**1**
17(b)(iii)	Any **TWO** from • (Hydrogen) fuel for fusion is (virtually) unlimited whereas fission relies upon (uranium) a relatively limited resource **(1)** • Fusion results in few radioactive products, but radioactive products produced in fission present significant disposal problems **(1)** • For a given mass of fuel, the energy released by fusion is greater than the energy released by fission **(1)**	**Max 2**
	Total for question 17	**15**

Question Number	Answer		Mark
18(a)(i)	Gravitation OR gravity OR gravitational attraction / pull / force	**(1)**	**1**
18(a)(ii)	Use of $F = Gm_1m_2/r^2$ $F = 4.2 \times 10^{35}$ (N) (no u.e.) <u>Example of calculation</u> $F = \frac{Gm_1m_2}{r^2}$ $F = \frac{6.67\times10^{-11}\ \text{N m}^2\text{kg}^{-2}\ (1.6\times10^{39}\text{kg})(4.0\times10^{37}\text{kg})}{(3.2\times10^{15}\ \text{m})^2}$ $F = 4.17\times10^{35}$ N	**(1)** **(1)**	**2**
18(a)(iii)	Use of $F = m\omega^2 r$ or $F = mv^2/r$ Use of $T = 2\pi/\omega$ or $T = 2\pi r/v$ T = 108 (years) [accept 107 – 111 years] (no ue) [If r^3 appears in solution, max 1 mark out of 3. If $\omega = \sqrt{\frac{G(M+m)}{(R+r)^3}}$ used, then full credit may be given. This method leads to T = 109 years] <u>Example of calculation</u> $\omega = \sqrt{\frac{4.2\times10^{35}\ \text{N}}{(1.6\times10^{39}\ \text{kg})\times7.7\times10^{13}\ \text{m}}}$ $\omega = 1.85\times10^{-9}\ \text{rad s}^{-1}$ $T = \frac{2\pi\ \text{rad}}{1.85\times10^{-9}\ \text{rad s}^{-1}} = 3.40\times10^{9}\ \text{s}$ $T = \frac{3.40\times10^{9}\ \text{s}}{365\times24\times60\times60\ \text{s year}^{-1}} = 108\ \text{years}$	**(1)** **(1)** **(1)**	**3**

***18(b)(i)**	(QWC- Work must be clear and organised in a logical manner using technical wording where appropriate.) Radiation (is received) with a longer/stretched wavelength (compared to that emitted) OR lower/smaller frequency **(1)** This indicates that distant galaxies are receding / distance between galaxies is increasing/galaxies are moving apart **(1)** (Hence) the universe is expanding / provides evidence for Big Bang **(1)**	**3**
18(b)(ii)	The rotational motion (of the black holes) is small compared with that due to the overall recession **(1)** (So) both black holes are still moving away OR (hence) the overall effect when the black hole is approaching is to cause a small reduction in the observed red (rather than a blue) shift **(1)** ALTERNATIVE APPROACH: Reference to plane of orbit being perpendicular to line of sight from the Earth **(1)** Therefore there is no change in wavelength due to rotation of black holes **(1)**	**2**
18(b)(iii)	Use of $z = v/c$ **(1)** Use of $v = H_0 d$ **(1)** $d = 7.1 \times 10^{25}$ m **(1)** Example of calculation $v = Zc = 0.38 \times 3 \times 10^8 \text{ m s}^{-1} = 1.14 \times 10^8 \text{ m s}^{-1}$ $d = \frac{1.14 \times 10^8 \text{ m s}^{-1}}{1.6 \times 10^{-18} \text{ s}^{-1}} = 7.13 \times 10^{25}$ m	**3**
	Total for question 18	**14**

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Mark Scheme (Results)
January 2012

GCE Physics (6PH05) Paper 01
Physics from Creation to Collapse

Question Number	Answer	Mark
1	C	**1**
2	C	**1**
3	A	**1**
4	B	**1**
5	C	**1**
6	B	**1**
7	B	**1**
8	B	**1**
9	A	**1**
10	A	**1**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>11</td><td>See $g = \frac{GM}{r^2}$ (1)
Correct substitution into $g = \frac{GM}{r^2}$ (1)
$r_E/r_m = 3.7$ (1)

(Correct inverse ratio i.e. $r_m/r_E = 0.27$, scores full marks)

<u>Example of calculation</u>
$g_E = \frac{GM_E}{r_E^2} \qquad g_m = \frac{GM_m}{r_m^2}$
$\therefore \frac{g_E}{g_m} = \frac{GM_E/r_E^2}{GM_m/r_m^2} = \frac{M_E}{M_m} \times \frac{r_m^2}{r_E^2}$
$\therefore 6 = 81 \times \frac{r_m^2}{r_E^2}$
$\therefore \frac{r_E}{r_m} = \sqrt{\frac{81}{6}} = 3.67 \approx 3.7$</td><td>3</td></tr>
<tr><td></td><td>Total for question 11</td><td>3</td></tr>
</table>

Question Number	Answer		Mark
12(a)	Use of $P = 4\pi r^2 \sigma T^4$ Power = 2.3×10^{17} W [Temperature in °C or incorrect conversion to Kelvin can score 1st mark] Example of calculation $P = 4\pi(6.4\times10^{6}\text{ m})^2 \times 5.67\times10^{-8}\text{ W m}^{-2}\text{ K}^{-4} \times (298\text{ K})^4$ $\therefore P = 2.3\times10^{17}\text{ W}$	**(1)** **(1)**	**2**
12 (b)	Use of $\lambda_{max}T = 2.898\times10^{-3}$ λ_{max} = 9.7×10^{-6} m [Temperature in °C or incorrect conversion to Kelvin can score 1st mark] Example of calculation $\lambda_{max} = \dfrac{2.898\times10^{-3}\text{ m K}}{298\text{ K}} = 9.7\times10^{-6}\text{ m}$	**(1)** **(1)**	**2**
12 (c)	Infra-red (radiation/light/wave) [accept Infrared/IR]		**1**
	Total for question 12		**5**

Question Number	Answer		Mark
13(a)	Acceleration is: • (directly) proportional to displacement from equilibrium position • (always) acting towards the equilibrium position **Or** idea that acceleration is in the opposite direction to displacement [accept undisplaced point/fixed point/central point for equilibrium position] **Or** Force is: • (directly) proportional to displacement from equilibrium position • (always) acting towards the equilibrium position **Or** idea that force is a restoring force e.g. "in the opposite direction" [accept towards undisplaced point/fixed point/central point for equilibrium position] [An equation with symbols defined correctly is a valid response for both marks. e.g $a \propto -x$ or $F \propto -x$]	**(1)** **(1)** **(1)** **(1)**	**2**
13(b)(i)	Amplitude = 2.3 m [allow ±0.1 m] Time period = 24 hours [allow ±0.5 hour] [24 hours = 86 400 s] <u>Example of calculation</u> Amplitude = (6.1 m – 1.5 m)/2 = 2.3 m Period = (48 hr – 0 hr)/2 = 24 hr	**(1)** **(1)**	**2**
13(b)(ii)	Use of $\omega = \frac{2\pi}{T}$ Use of $v = (-)A\omega \sin \omega t$ [$v_{max} = \omega A$] v_{max} = 0.60 m hr^{-1} <u>Example of calculation:</u> $\omega = \frac{2\pi}{T} = \frac{2\pi \text{ rad}}{24 \text{ hr}} = 0.262 \text{ rad hr}^{-1}$ $v_{max} = 0.262 \text{ rad hr}^{-1} \times 2.3 \text{ m} = 0.602 \text{ m hr}^{-1}$ **Or** Attempt to calculate gradient with a max Δt = 12 hours, and max Δx = 6 m Rate of change of depth in range (0.54 – 0.66) m hr^{-1} Rate of change of depth in range (0.57 – 0.63) m hr^{-1} <u>Example of calculation</u> Rate of change of depth = $\frac{(6.5-1.0)}{(11.0-1.5)} = 0.57$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
13(b)(iii)	Graph with correct shape [minus sine curve, at least 30 hours] Same time period as graph given, constant amplitude	**(1)** **(1)**	**2**
	Total for question 13		**9**

Question Number	Answer	Mark
*14	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate **Max 5** • Reference to resonance **(1)** • The sounding box is forced to vibrate (at the frequency of the tuning fork) **(1)** • Tuning fork and sounding box have similar natural frequencies **(1)** • Energy transferred from the tuning fork to the box **(1)** • The sounding box sets a large amount/mass/volume of air into vibration **(1)** • (Hence) the sound (wave) produced (in the air) has a larger amplitude **(1)** • Sounding box dampens the vibration (of the tuning fork) **(1)** • Larger rate of transfer of energy (to the air) means that the vibration persists for a shorter time **(1)**	**5**
	Total for question 14	**5**

Question Number	Answer		Mark
15(a)	Use of $\Delta E = mc\Delta\theta$ Energy transferred = 2.8 × 10^6 J Example of calculation $\Delta\theta$ = (60 – 15) = 45 °C $E = mc\Delta\theta = 15\,\text{kg} \times 4200\,\text{J kg}^{-1}\,\text{K}^{-1} \times 45\,\text{K} = 2.84 \times 10^6\ \text{J}$	**(1)** **(1)**	**2**
15 (b)(i)	Use of $P = \frac{\Delta W}{\Delta t}$ Time = 1100 s (Allow answers that use ΔW in range 2.5 MJ → 3.4 MJ. t = 1200s if 3MJ used and 1000s to 1360 s for allowed range,) Example of calculation $\Delta t = \frac{\Delta W}{P} = \frac{2.84 \times 10^6\ \text{J}}{2500\,\text{W}} = 1136\,s \approx 1100\,s$	**(1)** **(1)**	**2**
15 (b)(ii)	Idea that all energy supplied results in a rise in temperature [e.g. only water heated up **Or** no energy transferred to surroundings etc]	**(1)**	**1**
15(c)	Use of $P = IV$ Current = 11A Example of calculation $I = \frac{P}{V} = \frac{2500\,\text{W}}{230\,\text{V}} = 10.9\,\text{A}$	**(1)** **(1)**	**2**
	Total for question 15		**7**

Question Number	Answer	Mark
16(a)	The weight of the moon **Or** the gravitational force of the Earth (on the moon) **(1)** The (mass of the Earth and) speed/velocity of the moon **(1)**	**2**
16(b)	A centripetal / unbalanced force is needed (because the water is moving in a circular path) **(1)** **Max 2** At the highest point the (unbalanced) force is weight of water plus reaction from bucket **(1)** Idea that the minimum force needed (towards the centre of the circle) is the weight of the water **(1)** Minimum velocity where $\frac{mv_{\text{min}}^2}{r} = mg$ **Or** $v_{\text{min}}^2 = rg$ **(1)** [Credit may be given for a diagram with appropriate annotations]	**Max 3**
	Total for question 16	**5**

Question Number	Answer	Mark
17(a)	Use of $\omega = \sqrt{\frac{k}{m}}$ and $T = \frac{2\pi}{\omega}$ OR use of $T = 2\pi\sqrt{\frac{m}{k}}$ **(1)** Time period = 0.43 s [allow any value that rounds to 0.4 s] **(1)** Example of calculation $\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{120\,\text{N m}^{-1}}{0.55\,\text{kg}}} = 14.8\,\text{rad s}^{-1}$ $T = \frac{2\pi\,\text{rad}}{14.8\,\text{rad s}^{-1}} = 0.425\,\text{s}$	**2**
17(b) (i)	Energy of the system is dissipated or energy is removed from the system (by frictional forces) **(1)** (Hence) the amplitude reduces **(1)**	**2**
17(b) (ii)	Sinusoidal graph with at least 2 cycles **(1)** Decreasing amplitude **(1)** Approximately constant time period **(1)**	**3**
	Total for question 17	**7**

Question Number	Answer	Mark
18 (a)	A radioactive isotope has an unstable nucleus **(1)** (Which decays and) emits radiation **Or** α/β/γ (radiation) specified **(1)**	**2**
18 (b)	**Max 2** We can't know when an individual nucleus will decay **(1)** We can't know which nucleus will decay next **(1)** (In a given time interval) each nucleus has a fixed probability of decay **Or** (In a given time interval) a fixed fraction of nuclei undergo decay **(1)** [accept atom for nucleus, but there is a one mark penalty for using particle, molecule or isotope]	**2**
18 (c)	Identify half life = 5730 years **(1)** Use of $\lambda = \frac{\ln 2}{t_{1/2}}$ **(1)** Decay constant = 1.21×10^{-4} (yr^{-1}) [3.84×10^{-12} (s^{-1})] **(1)** $N/N_0 = 0.60$ **(1)** Use of $N = N_0 e^{-\lambda t}$ **(1)** Age = 4220 yr [1.34×10^{11} s] **(1)** Example of calculation $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{5730} = 1.21 \times 10^{-4}\ \text{yr}^{-1}$ $\frac{N}{N_0} = 0.6 = e^{-1.21 \times 10^{-4} t}$ $\therefore \ln(0.6) = -1.21 \times 10^{-4} t$ $\therefore t = \frac{\ln(0.6)}{-1.21 \times 10^{-4}} = 4220\ \text{yr}$	**6**
18(d)	Ratio of C-14 to C-12 (in living material) was greater in the past **(1)** Appreciation that we are not comparing 'like with like' e.g. ratio used is from current matter **(1)** (Hence) the age of Stonehenge has been underestimated **(1)**	**3**
	Total for question 18	**13**

Question Number	Answer		Mark
***19 (a)**	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate **Process of fusion: Max 2** In nuclear fusion small nuclei fuse / join together to produce a larger nucleus Mass of the fused nucleus < total mass of initial nuclei (Energy is released as) $\Delta E = c^2 \Delta m$ **Or** B.E./nucleon increases (so energy is released) **Conditions: Max 3** A very high temperature To overcome the (electrostatic) repulsion between nuclei A (very) high pressure/density To maintain a high/sufficient collision rate **Difficult to replicate: Max 2** (Very high) temperatures lead to confinement problems Contact with container causes temperature to fall (and fusion to cease) Very strong magnetic fields are required	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**Max 6**
19 (b)	Idea that ^{56}Fe is the peak of the graph If nuclei were to be formed with A > 56, the B.E./nucleon would decrease This would require a net input of energy (and so does not occur)	**(1)** **(1)** **(1)**	**3**
19 (c)(i)	(A star/astronomical) object of known luminosity (due to some characteristic property of the star/object)	**(1)**	**1**
19(c)(ii)	Use of $F = \dfrac{L}{4\pi d^2}$ Distance = 9.3×10^{24} m Example of calculation $d = \sqrt{\dfrac{2.0 \times 10^{36}\ \text{W}}{4\pi \times 10^{-15}\ \text{W m}^{-2}}} = 9.30 \times 10^{24}\ \text{m}$	**(1)** **(1)**	**2**
19(c)(iii)	The galaxy is receding / moving away from the Earth	**(1)**	**1**
19(c)(iv)	Use of $Z = v/c$ Use of $v = \text{H}d$ Hubble constant = $2.1 \times 10^{-18}\ \text{s}^{-1}$ Example of calculation $v = Zc = 0.064 \times 3 \times 10^8\ \text{m s}^{-1} = 1.92 \times 10^7\ \text{m s}^{-1}$ $H = \dfrac{v}{d} = \dfrac{1.92 \times 10^7\ \text{m s}^{-1}}{9.30 \times 10^{24}\ \text{m}} = 2.06 \times 10^{-18}\ \text{s}^{-1}$	**(1)** **(1)** **(1)**	**3**
	Total for question 19		**16**

Mark Scheme (Results)

Summer 2012

GCE Physics (6PH05) Paper 01
Physics from Creation to Collapse

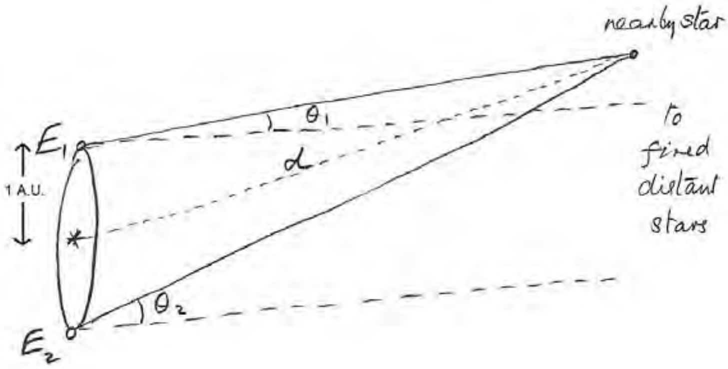
Question Number	Answer	Mark
1	D	**1**
2	B	**1**
3	D	**1**
4	B	**1**
5	C	**1**
6	A	**1**
7	D	**1**
8	D	**1**
9	B	**1**
10	B	**1**

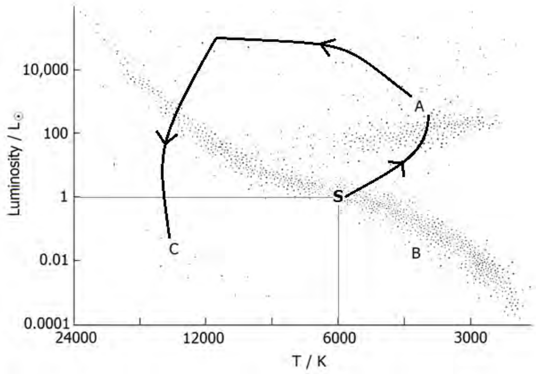
Question Number	Answer		Mark
11	**MAX 3** The existence of the microwave background:		
	• Originates from the Big Bang	**(1)**	
	• Microwave radiation comes from the universe itself **Or** it is <u>cosmic background</u> radiation [accept CMB]	**(1)**	
	• Microwave wavelength linked to temperature of universe [e.g. indicates a temperature of space of about 3 K]	**(1)**	
	• Originally the universe was a hotter place than it is now **O**r temperature decreases as the universe expands	**(1)**	
	• Wavelength has been increased Or frequency decreased. (Do not credit changes due to movement of galaxies)	**(1)**	**3**
	Total for question 11		**3**

Question Number	Answer		Mark
12(a)	Use of $\Delta E = mc\Delta\theta$ Energy = 780 J	**(1)** **(1)**	**2**
	<u>Example of calculation</u> $\Delta E = 34 \times 10^{-3}\,\text{kg} \times 490\,\text{J kg}^{-1}\text{K}^{-1} \times (100 - 53)\text{K} = 783\,\text{J}$		
12(b)	Heat / thermal energy is transferred from the sphere to the wax	**(1)**	
	Idea that the lead sphere has insufficient energy for melting the wax (e.g. The lead sphere transfers less heat / thermal energy (than the steel sphere). Credit a supporting calculation)	**(1)**	**2**
	Total for question 12		**4**

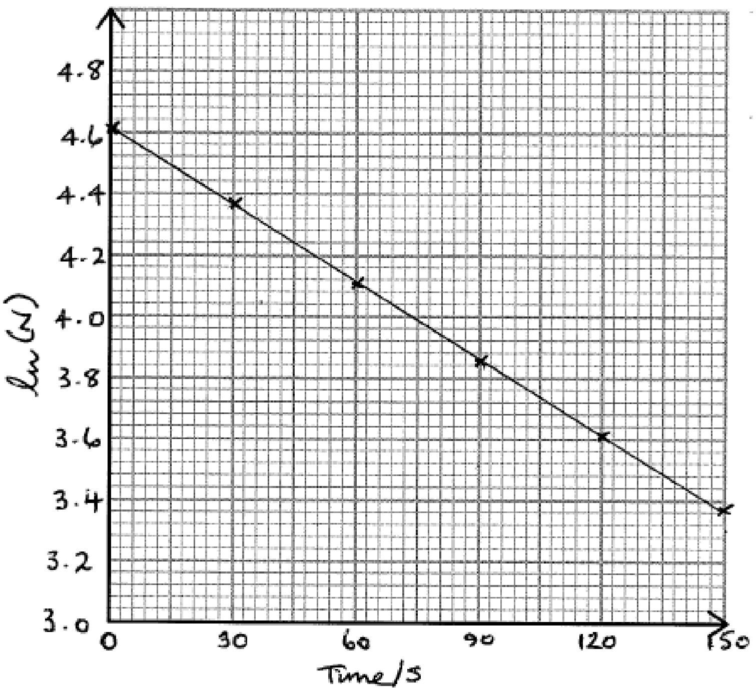
Question Number	Answer		Mark
13(a)(i)	16 µm [accept ±1µm]	**(1)**	**1**
13(a)(ii)	Use of $\lambda_{max}T = 2.898\times10^{-3}$ Temperature = 180 K (ecf from (a)(i)) [161 K for 18 µm, 170 K for 17 µm, 193 K for 15 µm, 207 K for 14 µm] <u>Example of calculation</u> $T = \dfrac{2.898\times10^{-3}\text{ mK}}{16\times10^{-6}\text{ m}} = 181\text{K}$	**(1)** **(1)**	**2**
13(b)	Mass of the Sun G **Or** gravitational constant **Or** 6.67×10^{-11} (N m^2 kg^{-2}) [can be next to either answer prompt]	**(1)** **(1)**	**2**
13(c)	Use of $g = \dfrac{GM}{r^2}$ Field strength = 5.6×10^{-6} N kg^{-1} [accept m s^{-2}] <u>Example of calculation</u> $g = \dfrac{6.67\times10^{-11}\text{ N m}^2\text{ kg}^{-2}\times1.9\times10^{27}\text{ kg}}{(1.5\times10^{11}\text{ m})^2} = 5.63\times10^{-6}\text{ N kg}^{-1}$	**(1)** **(1)**	**2**
	Total for question 13		**7**

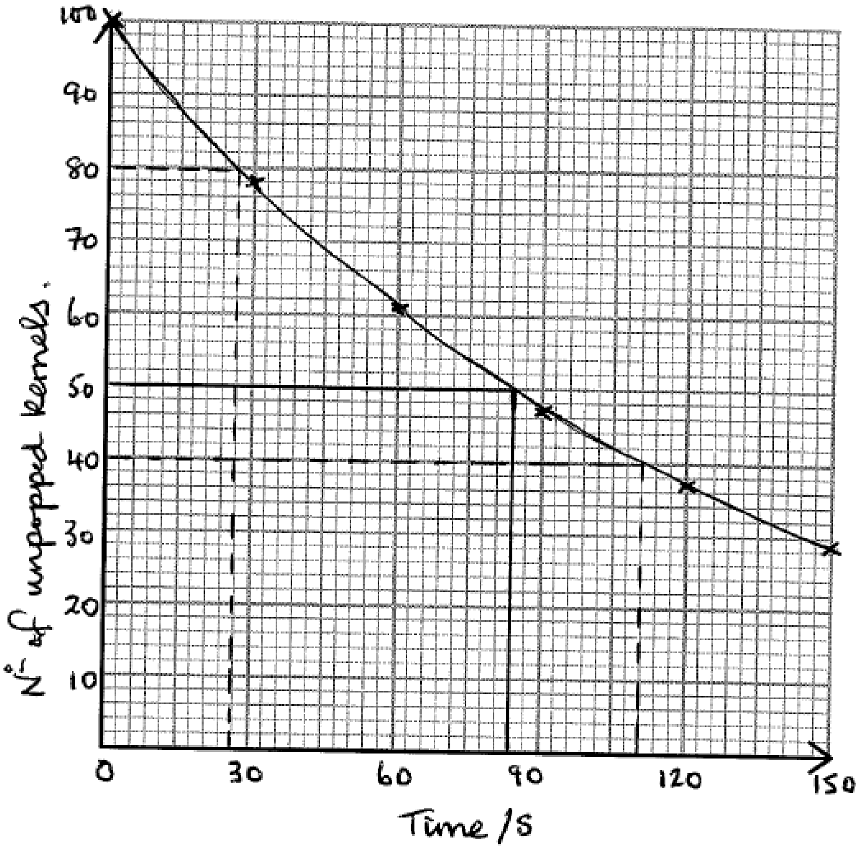
Question Number	Answer		Mark
14(a)	Use of $pV = NkT$	**(1)**	
	Number of molecules = 2.2×10^{23} (Use of the number of molecules to get a pressure of 0.99×10^5 Pa can score both marks. Allow use of pV = nRT leading to correct answer for 2 marks, but no credit for a substitution of incorrect values into this equation) <u>Example of calculation</u> $N = \dfrac{1.1 \times 10^5 \text{ Pa} \times 8.2 \times 10^{-3} \text{ m}^3}{1.38 \times 10^{-23} \text{ J K}^{-1} \times 295 \text{ K}} = 2.2 \times 10^{23}$	**(1)**	**2**
14(b)	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate **(For this question accept answers in terms of atoms, molecules or particles)**		
	• Internal energy is (sum of) molecular kinetic and potential energies	**(1)**	
	• In (an ideal) gas the molecules have only kinetic energy **Or** the molecules do not have potential energy.	**(1)**	
	• $E_k = 3kT/2$ **Or** $E_k \propto T$ **Or** (above 0 K) the air molecules are in (continual) random motion	**(1)**	
	• If the gas reached absolute zero, then the K.E. of the molecules would be zero and so the statement is correct **Or** If air is identified as not being ideal, then allow idea that molecules would still have potential energy at 0 K, and so statement is incorrect	**(1)**	**4**
	Total for question 14		**6**

Question Number	Answer	Mark
15(a)	**Max 2** • Angles are measured using the fixed background of more distant stars **(1)** • Find angular displacement of the star (as Earth moves around the Sun) over a 6 month period / over a diameter of the Earth's orbit **(1)** • Diameter of the Earth's orbit about the Sun must be measured/known **(1)** [Full marks can be obtained from an annotated diagram] 	**2**
15(b)	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate Idea that red shift is the (fractional) increase in wavelength of light received **(1)** (due to) recession of the source from the Earth/observer **(1)** Doppler/red shift is used to find v (allow reference to use of red shift equation e.g. $v = zc$) **(1)** Appropriate reference to Hubble's Law **Or** $v = H_O d$ **(1)** [for 1st marking point allow "decrease in frequency" for "increase in wavelength"]	**4**
	Total for question 15	**6**

Question Number	Answer		Mark
16(a)(i)	A = Red Giants **Or** Giants B = Main Sequence C = White Dwarfs **Or** Dwarfs	**(1)** **(1)** **(1)**	**3**
16(a)(ii)	 S → A correctly marked (straight line or curve starting at S going near A) A → C correctly marked (some upward curving from near A, near to C but can go beyond C)	**(1)** **(1)**	**2**
16(b)	We determine the star's • temperature T (from Wien's law) • luminosity L (from the H-R diagram) • (Then) r is calculated using (Stefan's Law) $L=4\pi r^2\sigma T^4$ **Or** $L=A\sigma T^4$ [accept a re-arranged equation for A **Or** r]	**(1)** **(1)** **(1)**	**3**
	Total for question 16		**8**

Question Number	Answer	Mark
17(a)(i)	Resonance **(1)**	**1**
17(a)(ii)	The vibrations from the engine/road surface/wheels must drive/force the tiger's head (to vibrate) **(1)** at a frequency equal/close to its natural frequency **(1)** **Or** Driver/forcing frequency **(1)** Matches natural frequency **(1)**	**2**
17(b)(i)	Use of $\omega = \frac{2\pi}{T}$ **(1)** Use of $a_{max} = \omega^2 A$ **(1)** Amplitude = 2×10^{-2} m **(1)** <u>Example of calculation</u> $\omega = \frac{2\pi}{0.8\ s} = 7.85\ (rad)s^{-1}$ $A = \frac{1.2\ ms^{-2}}{(7.85\ s^{-1})^2} = 1.95 \times 10^{-2}\ m$	**3**
17(b)(ii)	Correct shape and phase (in antiphase with acceleration) for graph **(1)** Amplitude (ecf from (b)(i)) **and** a time marked on axes **(1)**	**2**
	Total for question 17	**8**

Question Number	Answer		Mark
18(a)	**Max 4 with at least ONE similarity and ONE difference** **Similarities**: • Radioactive decay and corn popping are both random events **Or** the time at which any given nucleus will decay **and** any kernel will pop cannot be predicted **Or** can't tell which nucleus will decay **nor** which kernel will pop next	**(1)**	
	• (With a large number) the rate of decay / popping for both depends upon the number of unchanged nuclei / kernels	**(1)**	
	• Both have a decreasing rate of decay	**(1)**	
	• The rate of decay / popping depends upon the type of nucleus (isotope) / size of kernel	**(1)**	
	• Radioactive decay is an irreversible change, as is corn popping	**(1)**	
	Differences: • Not all the kernels are identical, whereas (for a given isotope) all the nuclei are identical	**(1)**	
	• Popping of corn depends on external factors and radioactive decay does not. (examples such as heating acceptable)	**(1)**	
	• The kernels do not emit standard fragments when they decay whereas radioactive nuclei emit radiation.	**(1)**	**4**
18(b)(i)	Log graph drawn	**(1)**	
	Suitable scales [not starting from 0 on y-axis]	**(1)**	
	Correct plotting of 6 points	**(1)**	
	Valid attempt at gradient calculation	**(1)**	
	Use of $t_{1/2}$ = ln 2/gradient	**(1)**	
	$t_{1/2}$ = 82 ± 3 s	**(1)**	**6**
	<u>Example of Calculation</u> 		

	$gradient = \frac{(4.4-3.4)}{(26-145)\,s} = 8.4\times10^{-3}s^{-1}$ $t_{1/2} = \frac{0.693}{8.4\times10^{-3}s^{-1}} = 82\,s$ **Or [Max 4]** Suitable scales Correct plotting $t_{1/2}$ = 82 ± 3 s accurate from their graph Half life found from curve for at least two initial values of N <u>Example of calculation</u>  $t_{½}$ = (84 – 0) s = 84 s $t_{½}$ = (111 – 27) s = 84 s	 (1) (1) (1) (1)	
18(b)(ii)	(Identify that ¼ of kernels **or** 25 kernels are left, so 2 half lives have elapsed) 2 × answer in (i) **Or** read from graph **Or** 160 s <u>Example of calculation</u> $N = 100 - 75 = 25 \therefore \frac{N}{N_0} = \frac{25}{100} = \frac{1}{4}$ t = 2 × 82 s = 164 s	(1)	
	Total for question 18		**11**

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>19(a)</td><td>Similarity: Same number of protons Or same magnitude of charge Or both have 1 proton

Difference: Different number of neutrons / nucleons Or different mass Or D has 1 neutrons and T has 2 neutrons</td><td>(1)

(1)</td><td>2</td></tr>
<tr><td>19(b)</td><td>Use of $P = \frac{\Delta E}{\Delta t}$ (do not penalise a power of ten error)
Energy = 7.5×10^6 (J)

<u>Example of calculation</u>
$E = 500 \times 10^{12}\ \text{W} \times 15 \times 10^{-9}\ \text{s} = 7.5 \times 10^6\ \text{J}$</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>19(c)(i)</td><td>$^{2}_{1}\text{D} + ^{3}_{1}\text{T} \rightarrow ^{4}_{2}\text{He} + ^{1}_{0}\text{n}$

<table><tr><td>Top line</td><td>2</td><td>3</td><td>4</td><td>1</td></tr><tr><td>Bottom line</td><td>1</td><td>1</td><td>2</td><td>0</td></tr></table></td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>19(c)(ii)</td><td>Attempt at calculation of mass difference
Energy released = 17.5 (MeV) [17.5 must be clearly identified as an energy]

<u>Example of calculation</u>
Δm= (1875.6 + 2808.9 – 3727.4 – 939.6) MeV/c^2 = 17.5 MeV/c^2
ΔE = 17.5 MeV</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>19(c)(iii)</td><td>Conversion of energy to consistent units
Number of nuclei = 3×10^{18}

<u>Example of calculation</u>
In each fusion $\Delta E = 17.5 \times 10^6\ \text{eV} \times 1.6 \times 10^{-19}\ \text{J eV}^{-1} = 2.8 \times 10^{-12}\ \text{J}$
$\therefore N = \frac{7.5 \times 10^6\ \text{J}}{2.8 \times 10^{-12}\ \text{J}} = 2.68 \times 10^{18}$
<table><tr><th>Energy MJ (b)</th><th>Energy MeV (c)(ii)</th><th>N × 10^{18}</th></tr><tr><td>7.5</td><td>17.5</td><td>2.7</td></tr><tr><td>7.5</td><td>20</td><td>2.3</td></tr><tr><td>8</td><td>17.5</td><td>2.9</td></tr><tr><td>8</td><td>20</td><td>2.5</td></tr></table></td><td>(1)
(1)</td><td>2</td></tr>
</table>

19(c)(iv)	Application of momentum conservation Deduction that $V_N = 4\ V_\alpha$ [$v_N = 3.967\ v_\alpha$] Use of $E_K = \frac{1}{2}mv^2$ (ratio as shown **or** sum = 17.5 MeV) Energy = 14 MeV (ecf (c)(ii), 14.1 MeV, if $v_N = 3.967\ v_\alpha$ 16 MeV if 20 MeV used) **Or** Application of momentum conservation Use of $E_k = p^2/2m$ Deduction that $E_N = 4\ E_\alpha$ Energy = 14 MeV Example of calculation (1st method) $m_N V_N = m_\alpha V_\alpha$ $V_N = \frac{m_\alpha}{m_N} \times V_\alpha = 4V_\alpha$ $\frac{E_N}{E_\alpha} = \frac{\frac{1}{2}m_N V_N^2}{\frac{1}{2}m_\alpha V_\alpha^2} = \frac{1}{4} \times \left(\frac{4}{1}\right)^2 = 4$ $\therefore E_N = \frac{4}{5} \times 17.5\ \text{MeV} = 14\ \text{MeV}$ Example of calculation (2nd method) $p_\alpha = p_N$ $p_\alpha^2 = p_N^2$ $E_\alpha \times 2m_\alpha = E_N \times 2m_N$ $\therefore E_\alpha = E_N \times \frac{m_N}{m_\alpha} = \frac{E_N}{4}$ Also, $E_\alpha + E_N = 17.5\ \text{MeV}$ $\therefore \frac{E_N}{4} + E_N = 17.5\ \text{MeV}$ $\therefore E_N = \frac{4}{5} \times 17.5\ \text{MeV} = 14\ \text{MeV}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	4
19(d)	**Max 3** A heavy **nucleus** absorbs a neutron. [accepts "collides with" / "fired into" for "absorbs"] The **nucleus** becomes unstable **and** splits into two (roughly equal sized) fragments [accept "decays" / "breaks up" for "splits"] Idea that a few neutrons are also emitted in the fission process These neutrons cause further fissions **Or** these neutrons cause a chain reaction (if atom is used instead of nucleus **only penalise once**)	**(1)** **(1)** **(1)** **(1)**	3
	Total for question 19		**17**

Total marks for this paper = 80

Mark Scheme (Results)

January 2013

GCE Physics (6PH05) Paper 01

Physics From Creation To Collapse

Question Number	Answer	Mark
1	B	1
2	B	1
3	B	1
4	B	1
5	C	1
6	A	1
7	A	1
8	D	1
9	C	1
10	C	1

Question Number	Answer		Mark
11(a)	Pressure (of gas) Amount of gas **Or** mass of gas **Or** number of moles / molecules / atoms	**(1)** **(1)**	**2**
11(b)	Extending/extrapolating the line backwards The volume occupied by a gas will be zero at a particular temperature **Or** The graphs for different gases All cut the x axis at the same temp	**(1)** **(1)** **(1)** **(1)**	**2**
	Total for question 11		**4**

Question Number	Answer		Mark
12(a)	Use of $\lambda = \ln 2/t_{1/2}$ $\lambda = 1.22 \times 10^{-4}$ (yr^{-1}) [$\lambda = 3.86 \times 10^{-12}$ (s^{-1}), $\lambda = 2.31 \times 10^{-10}$ (min^{-1})] Use of $A = A_0 e^{-\lambda t}$ $t = 950$ (yr) [if $\lambda = 1.2 \times 10^{-4}$, then $t = 960$ (yr)] [credit answers that use a constant ratio method to find the number of half lives elapsed] <u>Example of calculation</u> $\lambda = \frac{0.693}{5700\text{ yr}} = 1.22 \times 10^{-4}\text{ yr}^{-1}$ $14.7\text{ s}^{-1} = 16.5\text{ s}^{-1} \times e^{-1.22\times10^{-4}\text{ yr}^{-1}\times t}$ $t = \frac{\ln\left(\frac{14.7\text{ s}^{-1}}{16.5\text{ s}^{-1}}\right)}{-1.22\times10^{-4}\text{ yr}^{-1}} = 947\text{ yr}$	**(1)** **(1)** **(1)** **(1)**	**4**
12 (b)	Initial value of count rate should be bigger than 16.5 min^{-1} **Or** greater count rate from living wood in the past [e.g. A/A_0 smaller] **Or** initial value of count rate underestimated in the calculation **Or** Initial number of undecayed atoms greater [e.g. N/N_0 smaller] Age of sample has been underestimated **Or** ship is older than 950 yr **Or** sample has been decaying for a longer time [If a calculation has been carried out to show that a greater value of initial activity leads to a greater age, then award both marks]	 **(1)** **(1)**	**2**
	Total for question 12		**6**

Question Number	Answer		Mark
13	Use of $\lambda_{max} T = 2.898 \times 10^{-3}$ m K T = 3400 (K) Use of $L = 4\pi r^2 \sigma T^4$ $r_B = 6.8 \times 10^{11}$ (m) [8.82×10^{11} m if T = 3000 K, 6.87×10^{11} m if T = 3400 K] r_B/r_S = 980 [1270 if T = 3000 K, 988 if T = 3400 K] Example of calculation $T = \frac{2.898 \times 10^{-3}\,\text{m K}}{850 \times 10^{-9}\,\text{m}} = 3410\,\text{K}$ $r_B = \sqrt{\frac{4.49 \times 10^{31}\,\text{W}}{4\pi \times 5.67 \times 10^{-8}\,\text{W m}^{-2}\text{K}^{-4} \times (3410\,\text{K})^4}} = 6.83 \times 10^{11}\,\text{m}$ $\frac{r_B}{r_S} = \frac{6.83 \times 10^{11}\,\text{m}}{6.95 \times 10^{8}\,\text{m}} = 983$	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question 13		**5**

Question Number	Answer		**Mark**
14	**QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** Standard candles are (stellar) objects of known luminosity Standard candle's brightness on earth is measured/known/found [accept apparent magnitude or flux in place of brightness] [Do not accept 'used' in place of 'measured'] Use inverse square law [$F=L/4\pi d^2$] **Or** use distance modulus method [M – m = 5log(d/10)] (Hence) distance to standard candle is calculated Dust layer will reduce brightness /magnitude/flux of Cepheid Cepheid will appear to be further away than it is [accept "star" for "standard candle" or for "Cepheid" for MP2 to MP6]	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
	Total for question 14		**6**

Question Number	Answer		Mark
15(a)(i)	Calculation of average time period [accept average time for 10T] Use of $f = \frac{1}{T}$ f = 1.5 Hz Example of calculation $T = \frac{t_1 + t_2 + t_3}{30} = \frac{(6.2 + 6.6 + 6.9)\text{s}}{30} = 0.657\,\text{s}$ $f = \frac{1}{0.657\,\text{s}} = 1.52\,\text{Hz}$	**(1)** **(1)** **(1)**	**3**
15(a)(ii)	Force (or acceleration): proportional to displacement from equilibrium position always acting towards the equilibrium position **Or** always in the opposite direction to the displacement [accept rest/centre point for "equilibrium position"] [both marks can be gained from an equation with terms clearly defined including a correct reference to the negative sign]	**(1)** **(1)**	**2**
15(b)	There is (large) drag force [accept air resistance for drag] Producing a deceleration **Or** the oscillation is (heavily) damped **Or** energy is transferred/removed from the system [e.g. transferred to the surroundings.] [Do not accept "lost" for "transferred"]	**(1)** **(1)**	**2**
15(c)	Resonance Driven at a frequency equal/near the natural frequency of the wings [accept their answer to (a) as a numerical value] [for "driven" accept "forced/made to oscillate"]	**(1)** **(1)**	**2**
	Total for question 15		**9**

Question Number	Answer		Mark
16(a)	Calculate gradient of line Identify gradient with H **Or** use of v = Hd for a point on the line Use of t = 1/H $t = 4.5 \times 10^{17}$ s (accept answers in range 4.2×10^{17} s to 4.8×10^{17} s) **Alternative method:** Pair of d, v values read from the line Values chosen from the upper end of the line Use of t = d/v $t = 4.5 \times 10^{17}$ s [$\pm 0.3 \times 10^{17}$ s] [$t = 1.4 \times 10^{10}$ yr [$\pm 0.1 \times 10^{10}$ yr] <u>Example of calculation</u> $H = \text{gradient} = \frac{(11000-0)\times 10^{3}\,\text{m s}^{-1}}{(50-0)\times 10^{23}\,\text{m}} = 2.2\times 10^{-18}\,\text{s}^{-1}$ $t = \frac{1}{H} = \frac{1}{2.2\times 10^{-18}\,\text{s}^{-1}} = 4.5\times 10^{17}\,\text{s}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
16* (b)	**QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** Measure wavelength of light (from the galaxy) Compare it to the wavelength for a source on the Earth Reference to spectral line **o**r line spectrum Reference to Doppler effect/shift **Or** redshift *v* is found from: fractional change in wavelength equals ratio of speed of source to speed of light **Or** see reference to $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ with terms defined **Or** see reference to $z = \frac{v}{c}$ with terms defined [accept answers in terms of frequency rather than wavelength]	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
16*(c)	**QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** **Max 3** (Due to the) difficulty in making accurate measurements of distances to galaxies Hubble constant has a large uncertainty **Or** age = 1/H may not be valid as gravity is changing the expansion rate Because of the existence of dark matter Values of the (average) density/mass of the universe have a large uncertainty [accept not known] (Hence) measurements of the critical density of the Universe have a large uncertainty Dark energy may mean we don't understand gravity as well as we thought we did (so it's hard to predict how gravity will determine the ultimate fate)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
	Total for question 16		**12**

Question Number	Answer		Mark
17(a)	The gravitational field strength [accept “g”] decreases **Or** the (gravitational) force on the satellite/object/mass decreases It is a centripetal force (and not a centrifugal force) The satellite is accelerating and so is not in balance	**(1)** **(1)** **(1)**	**3**
17(b)(i)	See $\frac{mv^2}{r} = \frac{GmM_E}{r^2}$ **Or** $m\omega^2 r = \frac{GMm}{r^2}$ $\therefore v^2 = \frac{GM_E}{r}$ **Or** $v = \sqrt{\frac{GM_E}{r}}$ GM_E is constant (and so v decreases as r increases) **Or** $v^2 \propto \frac{1}{r}$ **Or** $v \propto \frac{1}{\sqrt{r}}$	**(1)** **(1)** **(1)**	**3**
17(b)(ii)	State $T = \frac{2\pi}{\omega}$ and $\omega = \frac{v}{r}$ **Or** $T = \frac{s}{v}$ and $s = 2\pi r$ Hence $T = \frac{2\pi r}{v}$ (so smaller v leads to a larger value of T) [Accept $T = \frac{2\pi GM_E}{v^3}$ for final mark]	**(1)** **(1)**	**2**
17(c)	Use of $T = \sqrt{\frac{4\pi^2 r^3}{GM}}$ T = 5530 s [92 minutes] <u>Example of calculation</u> $T = \sqrt{\frac{4\pi^2 r^3}{GM}} = \sqrt{\frac{4\pi^2 (6360000\,\text{m} + 400000\,\text{m})^3}{6.67\times10^{-11}\,\text{N m}^2\,\text{kg}^{-2} \times 5.98\times10^{24}\,\text{kg}}} = 5530\,\text{s}$	**(1)** **(1)**	**2**
17(d)	**Max 2** As radius decreases: There is a transfer of gravitational potential energy to kinetic energy [Accept kinetic energy increases and gravitational potential energy decreases] Sum of kinetic and gravitational potential energy decreases **Or** satellite does work against frictional forces **Or** transfer of kinetic energy of satellite to thermal energy **Or** heating occurs	**(1)** **(1)**	**2**
	Total for question 17		**12**

Question Number	Answer		Mark
18 (a)(i)	$$N + \alpha \rightarrow {}^{17}_{8}O + {}_{1}p$$ All values correct	(1)	1
18(a)(ii)	In nuclear fission a chain reaction can be set up **Or** in a chain reaction the (total) energy released can be very large **Or** heavier/larger nuclei release much more energy **Or** a very high reaction rate releases much more energy	(1)	1
18 (b)	Attempt at mass deficit calculation Use of $\Delta E = c^2 \Delta m$ (Allow use of 1 u = 1.66×10^{-27} kg) Use of 1 MeV = 1.6×10^{-13} J (Allow use of 1u = 931.5 MeV/c^2) ΔE = 174 MeV <u>Example of calculation</u> $\Delta m = (390.29989 - 233.99404 - 152.64708 - (2 \times 1.67493)) \times 10^{-27}$ kg $\Delta m = 3.0891 \times 10^{-28}$ kg $\Delta E = (3.00 \times 10^{8}\,\text{m s}^{-1})^2 \times 3.0891 \times 10^{-28}\,\text{kg} = 2.780 \times 10^{-11}$ J $\Delta E = \frac{2.780 \times 10^{-11}\,\text{J}}{1.60 \times 10^{-13}\,\text{J MeV}^{-1}} = 173.8\,\text{MeV}$	(1) (1) (1) (1)	4
18 (c)(i)	Same number of protons [do not accept atomic/proton number], Different numbers of neutrons [do not accept mass/nucleon/neutron number]	(1) (1)	2
18(c)(ii)	Correct calculation for ω [see 6283 or 2000π or $\frac{60\,000 \times 2\pi}{60}$] a = (-) 5.9×10^{6} m s^{-2} <u>Example of calculation</u> $a = -\left(\frac{60000 \times 2\pi}{60\,\text{s}}\right)^2 \times 15 \times 10^{-2}\,\text{m} = 5.92 \times 10^{6}\,\text{m s}^{-2}$	(1) (1)	2
18(c)(iii)	**Max 2** Stiff/stiffness Strong/strength Low density	(1) (1) (1)	2
18(d)	Use of ΔE = mcΔθ Rate at which energy is removed = 3.1×10^{9} (W) Use of the efficiency equation [must have 2.2×10^{9} (W) on top line] Efficiency = 42% [accept 0.42] <u>Example of calculation</u> $\Delta E = 70000\,\text{kg} \times 3990\,\text{J kg}^{-1}\,\text{K}^{-1} \times 11\text{K} = 3.07 \times 10^{9}\,\text{J}$ $\%\,\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100 = \frac{2.2 \times 10^{9}\,\text{W}}{(2.2 + 3.1) \times 10^{9}\,\text{W}} \times 100 = 41.5\%$	(1) (1) (1) (1)	4
	Total for question 18		**16**

Mark Scheme (Results)

Summer 2013

GCE Physics (6PH05)

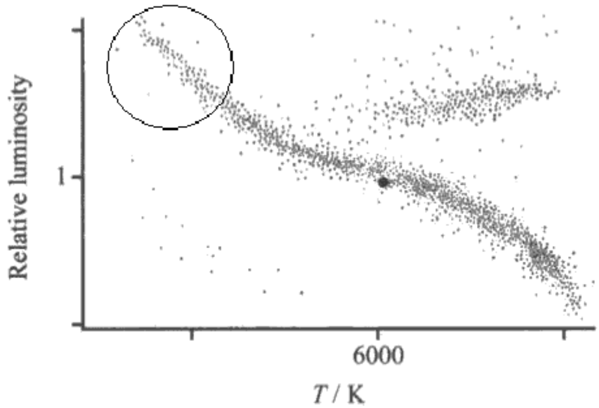
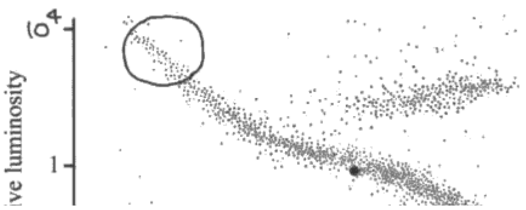
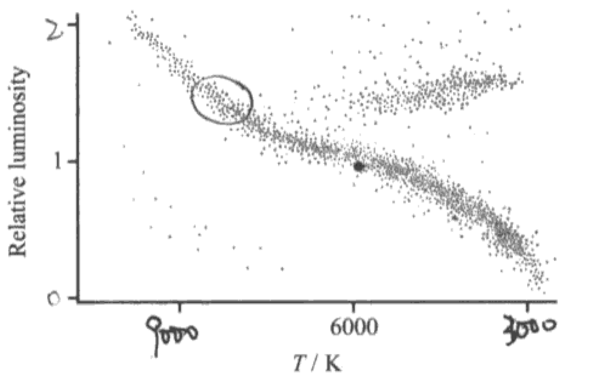
Paper 01: Physics-Creation/Collapse

Question Number	Answer	Mark
1	A	**1**
2	C	**1**
3	C	**1**
4	D	**1**
5	C	**1**
6	C	**1**
7	D	**1**
8	D	**1**
9	B	**1**
10	B	**1**

Question Number	Answer		Mark
11	Galaxies are receding **O**r galaxies are moving away (from us and from each other) **T**he greater the distance the greater the velocity The universe is expanding	**(1)** **(1)** **(1)**	**3**
	Total for question 11		**3**

Question Number	Answer		Mark
12(a)	(B2 =) 2.9×10^{-3}/A2 **Or** (B2 =) $2.9 \times 10^{-3}/\lambda_{max}$ **Or** (B2=) $2.9 \times 10^{-3}/6.85 \times 10^{-7}$ [Ignore incorrect powers of 10]	**(1)**	**1**
12(b)	Use of $L = \sigma T^4 A$ A = 0.21(48) × 10^{19} (m^2) For max 1 Use of $A = 4\pi R^2$ to give A = 2.1(1)× 10^{18} (m^2) <u>Example of calculation:</u> $A = \frac{0.392\times10^{26}\ \text{W m}^{-2}}{5.67\times10^{-8}\ \text{W m}^{-4}\ \text{K}^{-4}\times(4230\ \text{K})^4} = 2.148\times10^{18}\ \text{m}^2$	**(1)** **(1)**	**2**
12(c)	Flux/brightness/intensity measured and distance to star determined (Luminosity calculated using) $L= 4\pi d^2F$ **Alternative mark scheme:** Temperature and type of star identified [e.g. main sequence]	**(1)** **(1)** **(1)**	

	Hertzsprung-Russell diagram used to find luminosity **(1)**	**2**
	Total for question 12	**5**

Question Number	Answer	Mark
13(a)	Luminosity scale: Log scale [$10^3 \rightarrow 10^6$ (top) and $10^{-3} \rightarrow 10^{-6}$ (bottom)] **(1)** Temperature scale: reverse log/power scale [e.g. 12,000 (left) and 3000 (right)] **(1)**	**2**
13(b)(i)	(Fusion of) hydrogen into helium [accept symbols] **(1)**	**1**
13(b)(ii)	Circle around stars top left of main sequence [included in the area indicated below] **(1)**  **Max 2** They have the highest temperatures **Or** they are the most luminous [accept brightest] **(1)** (Because) they fuse H (into He) at the highest/higher rate **(1)** (Because) they have the largest/larger gravitational forces **(1)** [Max 1 mark if no comparative]  Both scale marks and correct area identified  Neither scale mark and area too low	**3**

	Total for question 13	**6**

Question Number	Answer		Mark
14(a)	See (unbalanced force), $F = \frac{Gm_1m_2}{r^2}$	**(1)**	
	Apply N2 with $a = v^2/r$ **Or** Equate F with mv^2/r **Or** Equate F with $m\omega^2 r$	**(1)**	
	Use of $T = 2\pi r/v$ **Or** $T = 2\pi/\omega$ T = 43000 (s)	**(1)** **(1)**	
	Or At height of satellite orbit, use $g = GM/r^2$ Use $g = a = \omega^2 r$ **Or** $g = a = v^2/r$ Use of $T = 2\pi r/v$ **Or** $T = 2\pi/\omega$ T = 43000 (s)	 **(1)** **(1)** **(1)** **(1)**	**4**
	[First 3 marks can be obtained from use of $T = 2\pi\sqrt{\frac{r^3}{GM}}$] [If reverse show that to calculate h = 18 900 km, then max 3 marks] <u>Example of calculation:</u> $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $v = \sqrt{\frac{GM}{r}}$ r = (20200 + 6400) km = 2.66×10^7 m $v = \sqrt{\frac{6.67\times10^{-11}\ \text{N m}^2\ \text{kg}^{-2} \times 6.0\times10^{24}\ \text{kg}}{2.66\times10^7\ \text{m}}} = 3.88\times10^3\ \text{m s}^{-1}$ $T = \frac{2\pi\times2.66\times10^7\ \text{m}}{3.88\times10^3\ \text{m s}^{-1}} = 43100\ \text{s}$		
14(b)	Communications satellites must be in the same position in sky at all times **Or** communications satellites must be in a geostationary orbit	**(1)**	
	(So) communications satellites must rotate at the same rate as the Earth **Or** communications satellites must have same angular velocity as the Earth **Or** communications satellites must have same period as the Earth **Or** communications satellites must be in geosynchronous orbits	**(1)**	**2**
14(c)	The radius of the GPS satellite orbit is smaller	**(1)**	

	The orbit of the communications satellite must be in an equatorial plane **(1)** [Converse accepted for both marks. Do not credit references to velocity or period]		**2**
	Total for question 14		**8**

Question Number	Answer	Mark
15(a)	(When the air is heated) the density (of air in) the balloon decreases **(1)** So the upthrust is greater than the weight of the balloon (plus occupants) **(1)**	**2**
15(b)	Use of $\rho = \frac{m}{V}$ **(1)** Use of $\Delta E = mc\Delta\theta$ [$\Delta\theta$ must be a temperature difference] **(1)** ΔE = 1.3(5) × 10^9 J **(1)** <u>Example of calculation:</u> $m = \rho V = 1.20\,\text{kg m}^{-3} \times 7.4 \times 10^4\ \text{m}^3 = 8.88 \times 10^4\ \text{kg}$ $\Delta E = mc\Delta\theta = 8.88 \times 10^4\ \text{kg} \times 1010\ \text{J kg}^{-1}\ \text{K}^{-1}(35 - 20)\text{K} = 1.345 \times 10^9\ \text{J}$	**3**
15(c)(i)	Use of $pV = NkT$ [temperature in either K or °C] **(1)** p = 9.24 × 10^4 Pa **(1)** <u>Example of calculation:</u> $\frac{p_2}{p_1} = \frac{T_2}{T_1}$ $p_2 = (1.01 \times 10^5)\text{Pa} \times \frac{(273 - 5)\text{K}}{(273 + 20)\text{K}} = 9.238 \times 10^4\ \text{Pa}$	**2**
15(c)(ii)	**Max 2** Hydrogen/gas behaves as an ideal gas **(1)** Mass of hydrogen/gas in balloon stays constant [Accept amount of hydrogen/gas] **(1)** **Or** number of molecules/atoms/particles of hydrogen/gas in balloon stays constant **(1)** Temperature of hydrogen/gas is the same as the temperature of the surroundings	**2**
15(c)(iii)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) The average/mean kinetic energy of the molecules decreases **(1)** Molecules travel slower (on average) **Or** rate of collisions with walls is less **(1)** So rate of change of momentum (during collisions) with walls is less **(1)**	**3**
	Total for question 15	**12**

Question Number	Answer	Mark
16(a)(i)	(A standard candle is) an object of known luminosity **(1)**	**1**
16(a)(ii)	Flux/brightness/intensity of standard candle is measured **(1)** Inverse square law used (to calculate distance to standard candle**)** **(1)** [Reference to measurement of apparent magnitude of star, m, and distance calculated using $m - M = 5\log(d/10\text{ pc})$ can score 2 marks]	**2**
16(b)(i)	An increase in the wavelength (of radiation) received from a receding source **(1)** [accept in terms of a decrease in the frequency]	**1**
16(b)(ii)	Use of $z = v/c$ and $v = H_0 d$ [$z = H_0 d/c$] **(1)** $d = 1.7 \times 10^{25}$ m **(1)** <u>Example of calculation:</u> $v = zc = 0.12 \times 3\times10^{8}$ m s^{-1} = 3.6×10^{7} m s^{-1} $d = v/\text{H} = 3.6 \times10^{7}$ m s^{-1}/2.1×10^{-18} s^{-1} = 1.71×10^{25} m	**2**
***16(c)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 3** Dark matter has mass but does not emit e-m radiation [accept light] **(1)** (Dark matter proposed when) observations of galaxies indicated that they must contain more matter than could be seen. **(1)** The existence of dark matter will increase the (average) density of the universe **(1)** This may make it more likely that the universe is closed [accept will contract **Or** end with a "Big Crunch"] **(1)** **Or** Idea that this may make the ultimate fate of the Universe less certain	**3**
16(d)	**Max 2** The universe started from a small initial point [accept Big Bang] **(1)** Idea that universe has a finite age **(1)** Idea that (observable universe is finite because) we can only see as far as (speed of light) × (age of universe) **Or** light reaching us must have travelled a finite distance since the Big Bang **Or** some parts of the universe are so distant, light has not had time to reach us yet **(1)**	**2**
	Total for question 16	**11**

Question Number	Answer		Mark
17(a)	A radioactive atom has an unstable nucleus which emits α, β, or γ radiation [at least one of α β γ named]	**(1)** **(1)**	**2**
17(b)	$C \rightarrow {}^{11}_{5}B + {}^{0}_{1}e^{+} + \nu_e$ Top line correct Bottom line correct	 **(1)** **(1)**	**2**
17(c)	Attempt at mass diference calculation Attempt at conversion from (M)eV to J $\Delta E = 1.4 \times 10^{-13}$ (J) <u>Example of calculation:</u> ΔE= 10 253.6 – 10252.2-0.5 = 0.889 MeV $\Delta E = 0.889\ \text{MeV} \times 1.6 \times 10^{-13}\ \text{J MeV}^{-1} = 1.42 \times 10^{-13}$ J	**(1)** **(1)** **(1)**	**3**
17(d)	The idea that the sample will not produce radiation for very long (because carbon-11 has a relatively short half-life) β particles are not very ionising **Or** positrons are not very ionising **Or** boron is safe in small amounts	**(1)** **(1)**	**2**
17(e)	Use of $\lambda t_{1/2} = \ln 2$ ($\lambda = 5.68 \times 10^{-4}\ \text{s}^{-1}$) Use of $A = A_0 e^{-\lambda t}$ Use $A = 1.58 \times 10^6$ Bq in $A = A_0 e^{-\lambda t}$ $A_0 = 1.2 \times 10^7$ Bq <u>Example of calculation:</u> $\lambda = \frac{0.693}{1220\ \text{s}} = 5.68 \times 10^{-4}\ \text{s}^{-1}$ $1.58 \times 10^6\ \text{Bq} = A_0 e^{-5.68 \times 10^{-4}\ \text{s}^{-1} \times 60 \times 60\ \text{s}}$ $A_0 = 1.22 \times 10^7$ Bq	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 17		**13**

Question Number	Answer		Mark
18(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) (Hooke's Law:) for a spring, force is proportional to extension **Or** $F = k\,\Delta x$ An extension of the spring causes a force towards the equilibrium position **Or** (resultant force towards the equilibrium position, so) $ma = -k\,\Delta x$ Condition for shm is restoring force [acceleration] is proportional to displacement (from equilibrium position) [QWC question, so max 2 if equations given with no further explanation]	 **(1)** **(1)** **(1)**	 **3**
18(b)	Use of $a = -\omega^2 x$ Use of $T = \frac{2\pi}{\omega}$ T = 1.55 (s) [Credit use of F = k Δx and use of $T = 2\pi\sqrt{\frac{m}{k}}$ for first two marking points] <u>Example of calculation:</u> $\omega = \sqrt{\frac{0.49\,\text{m s}^{-2}}{3.0\times10^{-2}\,\text{m}}} = 4.04\ \text{s}^{-1}$ $T = \frac{2\pi}{4.04\ \text{s}^{-1}} = 1.55\ \text{s}$	**(1)** **(1)** **(1)**	 **3**
18(c)(i)	Damped / damping [Do not accept critical/heavy damping]	**(1)**	**1**
18(c)(ii)	Forced / driven	**(1)**	**1**
18(c)(iii)	Resonance f = 0.65 Hz [accept s^{-1}] [0.625 Hz if show that value is used, 0.64 Hz if unrounded value used] <u>Example of calculation:</u> f = 1/1.55 s = 0.645 Hz [allow 2nd mark if they use either their value from (b) or 1.6 s]	**(1)** **(1)**	 **2**
18(d)	(With a smaller mass baby) the natural frequency of oscillation would increase **Or** The natural frequency of the system would increase		

	Or The periodic time of the system would decrease Smaller mass baby would have to kick at a higher frequency (to force system into resonance) [accept larger mass baby would have to kick at a lower frequency]	**(1)** **(1)**	**2**
	Total for question 18		**12**

Mark Scheme (Results)

Summer 2013

GCE Physics (6PH05)

Paper 01: Physics Creation/Collapse

Question Number	Answer	Mark
1	D	**1**
2	B	**1**
3	C	**1**
4	B	**1**
5	B	**1**
6	D	**1**
7	C	**1**
8	C	**1**
9	B	**1**
10	D	**1**

Question Number	Answer		Mark
11	There is a red shift [accept Doppler shift] The galaxy is receding **O**r the galaxy is moving away from us [Do not accept "the universe is expanding"]	(1) (1)	**2**
	Total for question 11		**2**

Question Number	Answer		Mark
12(a)	Use of electrical power equation e.g. $P = \frac{V^2}{R}$ R = 8.8 Ω [Use of V=IR and P=VI gains mp1] <u>Example of calculation</u> $R = \frac{(230V)^2}{6000W} = 8.82\,\Omega$	(1) (1)	**2**
12(b)	See 30 K [30 °C] **Or** 6000 J s^{-1} Use of ΔE = mcΔθ [Do not penalise wrong temperature conversions, but Δθ must be a temperature difference] $\frac{\Delta m}{\Delta t} = 0.048\,\text{kg}\,\text{s}^{-1}$ [accept 0.048 litre s^{-1} and other volume flow rates with correct units] <u>Example of calculation</u> Δθ = (37.5 – 7.5) °C = 30 °C $\frac{\Delta m}{\Delta t} = \frac{6000\,\text{W}}{4200\,\text{J}\,\text{kg}^{-1}\,\text{K}^{-1} \times 30\,\text{K}} = 0.0476\,\text{kg}\,\text{s}^{-1}$	(1) (1) (1)	**3**
	Total for question 12		**5**

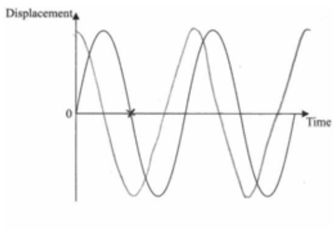
<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>13(a)</td><td>Pendulum C has same/similar length as pendulum X (1)

Therefore C has the same/similar <u>natural</u> frequency as pendulum X
Or idea that C is driven at its <u>natural</u> frequency (1)

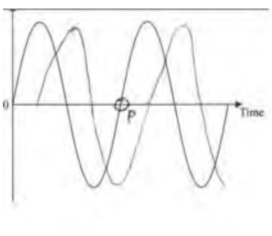
(Hence) the energy transfer from X to C is most efficient
Or
There is a maximum transfer of energy from X to C
Or (1)
A correct reference to resonance</td><td>3</td></tr>
<tr><td>13(b)</td><td>Any zero displacement point marked on original graph [do not insist on “P”] (1)
(Minus) cosine graph drawn with same period as original graph (1)

[Ignore amplitude of graph drawn]

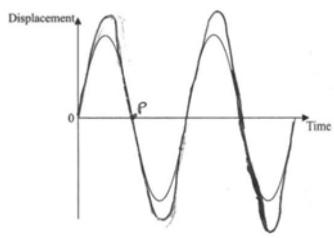
Examples of graphs:



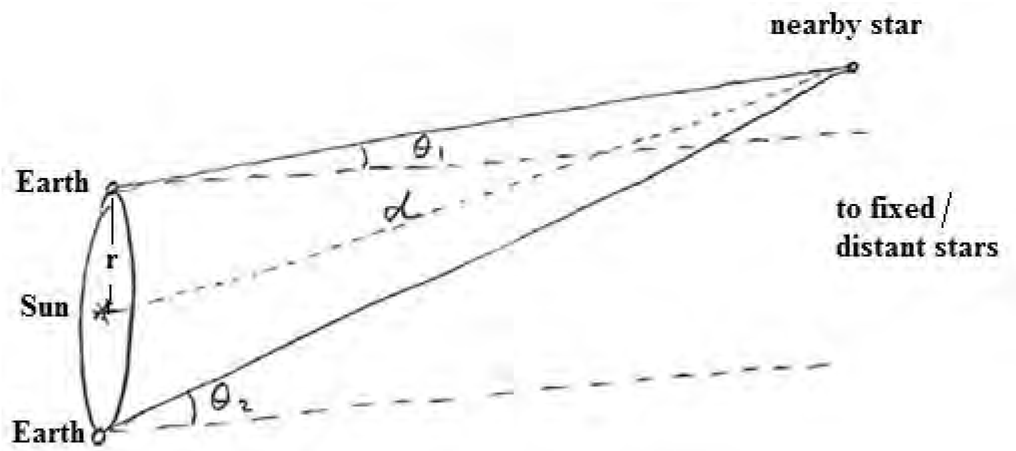
This candidate has identified “P” (although not used “P”) and the cosine graph is well drawn. [2 marks]



This candidate has identified “P” correctly, and has drawn a minus cosine graph. Their graph starts from a time of T/4, which is just about acceptable. [2 marks]



This candidate has identified “P” correctly, but has drawn a sine curve. [1 mark]</td><td>2</td></tr>
<tr><td></td><td>Total for question 13</td><td>5</td></tr>
</table>

Question Number	Answer	Mark
14	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate **Parallax:** The star is viewed from two positions at 6 month intervals **Or** the star is viewed from opposite ends of its orbit diameter about the Sun (1) The (change in) angular position of the star relative to fixed/distant stars is measured (1) The diameter/radius of the Earth's orbit about the Sun must be known and trigonometry is used (to calculate the distance to the star) [Do not accept Pythagoras] (1) [the marks above may be obtained with the aid of a suitably annotated diagram] e.g  [Accept the symmetrical diagram seen in many text books] **Standard candle:** Flux/brightness/intensity of standard candle is measured (1) Luminosity of standard candle is known [accept reference to absolute magnitude **Or** total power output of star] (1) Inverse square law is used (to calculate distance to standard candle) (1)	**6**
	Total for question 14	**6**

Question Number	Answer		Mark
15(a)	Use of $F = \frac{G m_1 m_2}{r^2}$ G = 6.6 × 10^{-11} (N m^2 kg^{-2}) [must see 6.6 × 10^{-11} when rounded to 2 sf] <u>Example of calculation</u> $G = \frac{1.5 \times 10^{-7}\ \text{N} \times (0.23\ \text{m})^2}{160\ \text{kg} \times 0.75\ \text{kg}} = 6.61 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$	(1) (1)	**2**
15(b)(i)	Read (peak) times from graph for at least 3 cycles T = 6.4 min (±0.2 min) [T = (380 ±12) s] [max 1 mark if correct answer shown without working] <u>Example of calculation</u> $T = \frac{(28.0 - 2.5)\text{min}}{4} = 6.38\text{min}$	(1) (1)	**2**
15(b)(ii)	Air resistance acts on the sphere [accept frictional forces **Or** (viscous) drag for air resistance] Energy is removed from the oscillation/system **Or** the oscillation/system is damped [For mp 2 do not credit ‘energy is lost’ but accept ‘energy is dissipated’; answer must indicate idea of transfer of energy]	(1) (1)	**2**
15(b)(iii)	Evidence of values of at least 3 consecutive peaks read from graph [accept values of 3 points separated by equal time intervals] Attempt to obtain amplitudes, by subtracting 0.75 Calculation of two values of A_{n+1}/A_n with corresponding conclusion **Or** Calculation of two values of difference of ln A_{n+1} and ln A_n with corresponding conclusion **Or** Use peaks of graph to sketch curve Use curve to determine “half-life” [accept other ratio] Calculation of two values of “half-life” with corresponding conclusion <u>Example of calculation</u> A_0 = 1.45-0.75 = 0.7, A_1 = 0.75-0.25 = 0.5, A_2 = 1.1-0.75 = 0.35, A_4 = 0.75 – 0.5 = 0.25	(1) (1) (1) (1) (1) (1)	**3**

	$\frac{A_1}{A_0} = \frac{0.50}{0.70} = 0.71$ $\frac{A_2}{A_1} = \frac{0.35}{0.50} = 0.70$ $\frac{A_3}{A_2} = \frac{0.25}{0.35} = 0.71$	
	Total for question 15	**9**

Question Number	Answer		Mark
16(a)	Temperature (of gas) [treat references to oil/room as neutral] Mass of air/gas **Or** number of atoms/molecules/moles of air/gas [accept amount of air/gas, number of particles of air/gas]	(1) (1)	**2**
16(b)	Assumption: idea that volume occupied by trapped air ∝ length of air in tube [e.g. volume = cross-sectional area × length] pL = a constant [accept pV = a constant] **Or** if p doubles, L halves At least 2 pairs of p, L values correctly read from graph Readings show that pL = 4500 (kPa cm) [± 100 kPa cm] **Or** Readings show that p doubles when L is halved [Accept references to V instead of L] <u>Example of calculation</u> p = 400 kPa, L = 11.0 cm pL=400 × 11.0 = 4400 p = 200 kPa, L = 23.0 cm pL=200 × 23.0 = 4600	(1) (1) (1) (1)	**4**
16(c)	Use of $pV=NkT$ [Allow use of pV=nRT **and** $N=n.N_A$] Conversion of temperature to kelvin $N = 8.4 \times 10^{20}$ [Accept answers in range 8.1×10^{20} to 8.4×10^{20}] [Answer in range but with an incorrect temperature conversion score max 2] <u>Example of calculation</u> $N = \frac{450 \times 10^3\,\text{Pa} \times 0.10\,\text{m} \times 7.5 \times 10^{-5}\,\text{m}^2}{1.38 \times 10^{-23}\,\text{JK}^{-1} \times (273 + 20)\text{K}} = 8.35 \times 10^{20}$	(1) (1) (1)	**3**
16(d)(i)	No change	(1)	**1**
16(d)(ii)	Similar curve Shifted higher **Or** shifted to the right [an annotated diagram can score full marks]	(1) (1)	**2**
	Total for question 16		**12**

Question Number	Answer		Mark
17(a)(i)	Reverse direction for temperature [at least 2 values seen] Logarithmic/power temperature variation [at least 3 realistic values seen increasing by the same factor]	(1) (1)	**2**
17(a)(ii)	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate **Area 1: Max 2** The Sun is fusing/burning hydrogen (into helium in its core) When (hydrogen) fusion/burning ceases the core of the Sun cools [accept radiation pressure drops when fusion/burning ceases in the core] The core collapses/contracts (under gravitational forces) **Area 2: Max 2** The Sun expands and becomes a red giant The core becomes hot enough for helium fusion/burning to begin (in the core) Helium begins to run out and the core collapses again (under gravitational forces) **Area 3: Max 2** Idea that outer layers of Sun are ejected into space The temperature doesn't rise enough for further fusion to begin The core/Sun becomes a (white) dwarf star	(1) (1) (1) (1) (1) (1) (1) (1) (1)	**6**
17(b)(i)	Idea of a very high temperature [accept value of about 10^7 K] To overcome repulsive/electrostatic forces between protons/nuclei **Or** so that protons/nuclei get close enough together for the strong (nuclear) force to act **Or** so that protons/nuclei get close enough to fuse Idea of a very high density [accept pressure] to give a sufficient collision rate	(1) (1) (1)	**3**
17(b)(ii)	Attempt at calculation of mass deficit Use of $\Delta E = c^2 \Delta m$ Attempt at conversion from J to (M)eV ΔE = 12.9 (MeV) [If correct mass defect in kg is converted into u and then 1u = 931 Mev used, then full marks may be awarded] <u>Example of calculation</u> $\Delta m = ((5.008238 \times 2) - 6.646483 - (1.673534 \times 2)) \times 10^{-27}$ kg	(1) (1) (1) (1)	**4**

	$\Delta m = 2.2925 \times 10^{-29}$ kg $\Delta E = \left(3.00 \times 10^{8} \text{ms}^{-1}\right)^{2} \times 2.2925 \times 10^{-29} \text{kg} = 2.063 \times 10^{-12} \text{J}$ $\Delta E = \dfrac{2.063 \times 10^{-12} \text{J}}{1.60 \times 10^{-13} \text{J MeV}^{-1}} = 12.9 \text{MeV}$	
	Total for question 17	**15**

Question Number	Answer		Mark
18 (a)(i)	Use of $\lambda t_{1/2} = \ln 2$ $\lambda = 5.8 \times 10^{-8}$ (s^{-1}) Use of $\frac{\Delta N}{\Delta t} = -\lambda N$ $\frac{\Delta N}{\Delta t} = (-)1.5 \times 10^{8}$ Bq [accept s^{-1} **Or** counts s^{-1}] <u>Example of calculation</u> $\lambda = \frac{0.693}{(138 \times 24 \times 3600)s} = 5.81 \times 10^{-8} s^{-1}$ $\frac{\Delta N}{\Delta t} = -5.81 \times 10^{-8} s^{-1} \times 2.54 \times 10^{15} = -1.48 \times 10^{8}$ Bq	(1) (1) (1) (1)	**4**
18(a)(ii)	Use of $N = N_0 e^{-\lambda t}$ Fraction of nuclei remaining = 0.90 10% of nuclei have decayed [accept 0.1 **Or** 1/10] <u>Example of calculation</u> t = 21 × 24 × 3600 s = 1 814 400 s $\frac{N}{N_0} = e^{-5.81 \times 10^{-8} s^{-1} \times 1.81 \times 10^{6} s}$ $\frac{N}{N_0} = e^{-0.105} = 0.900$ Fraction decayed = 1- 0.9 = 0.1	(1) (1) (1)	**3**
18(b)	Idea that α-particles are not able to penetrate the (dead layer of) skin (from outside the body) Damage/danger if energy is transferred to cells/DNA **Or** damage/danger to cells/DNA due to ionisation	(1) (1)	**2**
18 (c)(i)	$^{210}_{84}Po \rightarrow ^{206}_{82}Pb + ^{4}_{2}\alpha$ Top line correct Bottom line correct	(1) (1)	**2**
18 (c)(ii)	So that momentum is conserved	(1)	**1**
18 (d)	Spontaneous means that the decay cannot be influenced by any external factors. Random means that we cannot identify which atom/nucleus will (be the next to) decay **Or** we cannot identify when an individual atom/nucleus will decay **Or** we cannot state exactly how many atoms/nuclei will decay in a set time **Or** we can only estimate the fraction of the total number that will decay in the next time interval	(1) (1)	**2**

18(e)	Idea that traces of the isotope will be excreted from the body (and deposited in the surroundings) (1) Idea that the half life is long enough for the activity to be detectable for a long time (1)	**2**
	Total for question 18	**16**

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