Physics

Higher level

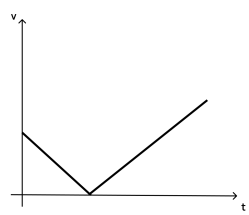
Paper 2

Markscheme

Question	Answer	Note	Marks
1 (a)	$mgh = \frac{1}{2}mv^2$ $(2.0\ \mathrm{kg})\left(9.81\ \mathrm{m\ s^{-2}}\right)(3.0\ \mathrm{m}) = \frac{1}{2}(2.0\ \mathrm{kg})v^2$ 58.86 $v^2 = 58.86$ $v = 7.67$	✔ Correct application of conservation of mechanical energy ✔ Substitution of correct values ✔ Final correct answer with unit	3
1 (b)	$\text{Kinetic Energy} = \frac{1}{2}mv^2$ $\frac{1}{2}(2.0\ \mathrm{kg})\left(7.67\ \mathrm{m\ s^{-1}}\right)^2 = 58.86\ \mathrm{J}$	✔ Correct substitution into kinetic energy formula ✔ Correct final answer (Accept 58.9 J)	2

1 (c)	$W = Fd$ $Fd = 58.86\ \text{J}$ $(4.0\ \text{N})d = 58.86\ \text{J}$ $d = \dfrac{58.86}{4.0} = 14.72\ \text{m}$	✔ Recognition that work done = kinetic energy ✔ Correct substitution of values ✔ Correct final answer with unit (Accept 14.7 m)	3
1 (d)	The total energy of an isolated system remains constant; energy cannot be created or destroyed but can be transformed from one form to another. ✔ The block's gravitational potential energy is converted into kinetic energy as it slides down the ramp. On the rough surface, the kinetic energy is then converted into thermal energy due to work done by friction. ✔		2

Question	Answer	Note	Marks
2 (a)	$mg = \rho V g$ ✔ $V = \frac{m}{\rho}$ $V = \frac{240}{1000}$ $V = 0.24\ \mathrm{m}^3$ ✔		2
2 (b)	$s = ut + \frac{1}{2}at^2$ $a = \frac{2s}{t^2}$ ✔ $a = \frac{2(8)}{8^2}$ $a = 0.25\ m\ s^{-2}$ $F_{net} = ma$ ✔ $F_{net} = (240)(0.25)$ $F_{net} = 60\ N$ Force from fan: $F_{fan} = \frac{\Delta p}{\Delta t}$ $F_{fan} = \frac{\Delta m}{\Delta t}v$ ✔ $F_{fan} = (16)(5.0)$ $F_{fan} = 80\ N$ Resistive force: $F_{net} = F_{fan} - F_r$		4

	$F_r = 80 - 60$ $F_r = 20\ N$ ✔		
2 (c)	$s = \frac{1}{2}(u+v)t$ $v = \frac{2s}{t}$ $v = \frac{2(8)}{8}$ $v = 2\ m\ s^{-1}$ ✔ $u' = u - v$ $u' = 5 - 2$ $u' = 3\ m\ s^{-1}$ ✔✔	Accept -3 m s^{-1}	3
2 (d)		✔ for properly labeled axes ✔ for straight line(s) ✔ for **sharp** turning point at x-axis Only penalize 1 point for line going below x-axis	3

Question	Answer	Note	Marks
3 (a)	$mg\Delta h = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$ ✔ $\Delta h = (R+r) - (R+r)\cos\theta$ $\Delta h = (R+r)(1-\cos\theta)$ ✔ $\frac{1}{2}I\omega^2 = \frac{1}{2}(\frac{2}{5}mr^2)(\frac{v^2}{r^2})$ $\frac{1}{2}I\omega^2 = \frac{1}{5}mv^2$ ✔ $mg(R+r)(1-\cos\theta) = \frac{1}{5}mv^2 + \frac{1}{2}mv^2$ $mg(R+r)(1-\cos\theta) = \frac{7}{10}mv^2$ $\therefore v = \sqrt{\frac{10}{7}g(R+r)(1-\cos\theta)}$ ✔		4
3 (b)	$\frac{mv^2}{R+r} = mg\cos\theta - N$ ✔ When the ball loses contact, *N = 0* ✔ $\frac{mv^2}{R+r} = mg\cos\theta$ $\frac{m\sqrt{\frac{10}{7}g(R+r)(1-\cos\theta)}^2}{R+r} = mg\cos\theta$ $\frac{10}{7}mg(1-\cos\theta) = mg\cos\theta$ $\frac{10}{7}(1-\cos\theta) = \cos\theta$ ✔ $\frac{17}{7}\cos\theta = \frac{10}{7}$ $\cos\theta = \frac{10}{17}$ $\theta \approx 54°$ ✔		4

Question	Answer	Note	Marks
4 (a)	$F = PA$ $F = P(2\pi r^2 + 2\pi rl)$ ✔ $F = 170000(2\pi(0.025)^2 + 2\pi(0.025)(0.15))$ $F \approx 4700\ N$ ✔		2
4 (b)	$n = \frac{m}{M_r}$ $n = \frac{0.35 + 0.21}{29}$ $n \approx 0.0193\ mol$ ✔ $PV = nRT$ $T = \frac{PV}{nR}$ ✔ $T = \frac{(170000)(\pi(0.025)^2(0.15)}{(0.0193)(8.31)}$ $T \approx 312\ K \approx 39°C$ ✔	Do not award final answer mark if given in K only	3

Question	Answer	Note	Marks
5 (a)	Positive ✔		1
5 (b)	$PV = \text{constant}$ $(12.0 \times 10^5)(4.0 \times 10^{-3}) = (6.0 \times 10^5)x$ ✔ $x = 8.0 \times 10^{-3}\ m^3$ ✔		2

5 (c)	$PV = nRT$ $T = \dfrac{PV}{nR}$ $T = \dfrac{(12 \times 10^5)(8 \times 10^{-3})}{2(8.31)}$ $T \approx 578\ K$ ✔		1
5 (d)	Method 1: $W = (12.0 \times 10^5)(8.0 \times 10^{-3} - 4.0 \times 10^{-3}) - (6.0 \times 10^5)(8.0 \times 10^{-3} - 4.0 \times 10^{-3})$ ✔ $W = 2400\ J$ ✔ Method 2: Area enclosed by graph $W = (6.0 \times 10^5)(4.0 \times 10^{-3})$ ✔ $W = 2400\ J$ ✔		2

Question	Answer	Note	Marks
6 (a)	$L = \dfrac{5\lambda}{2}$ $L = \dfrac{(5)(12)}{2}$ $L = 30\ cm$ ✔		1
6 (b)	$f = \dfrac{c}{\lambda}$ $f = \dfrac{3 \times 10^8}{0.12}$ $f \approx 2.5 \times 10^9\ Hz$ ✔		1

6 (c)	Cube A will not be heated up ✔ as it is at the position of a node ✔		2
6 (d) (i)	$Q = mc\Delta T$ $Q = (0.005)(3350)(30)$ $Q \approx 500\ J$ ✔		1
6 (d) (ii)	$E = \frac{1}{2}m\omega^2 x_0^2$ $m_w c\Delta T = \frac{1}{2}m_w \omega^2 x_0^2$ ✔ $c\Delta T = \frac{1}{2}\omega^2 x_0^2$ $\omega = 2\pi f \rightarrow c\Delta T = 2\pi^2 f^2 x_0^2$ ✔ $x_0 = \sqrt{\frac{c\Delta T}{2\pi^2 f^2}}$ $x_0 \approx 3.2\times 10^{-8}\ m$ ✔		3
6 (e)	Microwaves reflect off metal [walls of microwave] ✔ Inserting metal into the microwave oven [create unintended surfaces for microwaves to reflect off of and] disrupt the standing wave ✔		2

Question	Answer	Note	Marks
7 (a)	$f_0=\frac{c}{\lambda}$ $f_0=\frac{3\times10^8}{680\times10^{-9}}$ $f_0\approx4.4\times10^{14}\ Hz$ ✔		1
7 (b)	$\frac{\Delta\lambda}{\lambda}=\frac{v}{c}$ $\lambda'=\lambda-\lambda\frac{v}{c}$ ✔ $\lambda'=680-680(\frac{900\times10^3}{3\times10^8})$ $\lambda'\approx678\ nm$ ✔		2
7 (c)	Blueshifted ✔		1
7 (d)	Moving source: $f'=f_0\frac{c}{c-v}$ ✔		1
7 (e) (i)	Without time dilation: $f'=f_0\frac{c}{c-v}$ $t'=t_0\frac{c-v}{c}$ With time dilation: $t'=\gamma t_0\frac{c-v}{c}$ ✔ $t'=t_0\frac{c-v}{c\sqrt{1-\frac{v^2}{c^2}}}$ $t'=t_0\frac{c-v}{\sqrt{c^2-v^2}}$ $t'=t_0\frac{c-v}{\sqrt{(c-v)(c+v)}}$ ✔		3

	$t'=t_0\frac{\sqrt{c-v}}{\sqrt{c+v}}$ $\therefore f'=f_0\sqrt{\frac{c+v}{c-v}}$ ✔		
7 (e) (ii)	$f'=f_0\sqrt{\frac{c+v}{c-v}}$ $f'=4.4\times10^{14}\sqrt{\frac{1+0.95}{1-0.95}}$ $f'\approx2.8\times10^{15}\ Hz$ ✔ $\lambda=\frac{c}{f'}=\frac{3\times10^8}{2.8\times10^{15}}$ $\lambda\approx1.1\times10^{-7}\ m$ Laser beam is ultraviolet (using data booklet) ✔		2

Question	Answer	Note	Marks
8 (a)	Anticlockwise ✔		1
8 (b)	$\frac{mv^2}{r}=qvB$ ✔ $r=\frac{mv^2}{qvB}$ $r=\frac{mv}{qB}$ $r=\frac{p}{qB}$ ✔		2
8 (c)	$T=\frac{2\pi r}{v}$ $T=\frac{2\pi mv}{qvB}$		2

	$T = \frac{2\pi m}{qB}$ ✔ Not dependent on the particle's velocity as no *v* term/all variables are independent of *v* ✔		
8 (d)	$r = \frac{\gamma m v}{qB}$ ✔		1
8 (e)	$T = \frac{2\pi r}{v}$ $T = \frac{2\pi \gamma m}{qB}$ ✔ Dependent on particle's velocity as γ is dependent on v ✔		2
8 (f) (i)	$T = \frac{2\pi m}{qB}$ $T = \frac{2\pi(1.673\times10^{-27})}{(1.6\times10^{-19})(50\times10^{-3})}$ $T \approx 1.3\times10^{-6}\ s$ ✔		1
8 (f) (ii)	$T = \frac{2\pi \gamma m}{qB}$ $T = \frac{2\pi(1.673\times10^{-27})}{(1.6\times10^{-19})(50\times10^{-3})}\left(\frac{1}{\sqrt{1-0.99^2}}\right)$ $T \approx 9.3\times10^{-6}\ s$ ✔		1

Question	Answer	Note	Marks
9 (a)	Red supergiant undergoes supernova and collapses into a neutron star ✔		1
9 (b)	$v_{orb}=\sqrt{\frac{GM}{R}}$ $R=\frac{GM}{v_{orb}^2}$ ✔ $R=\frac{(6.67\times10^{-11})(3.0\times10^{30})}{(4.04\times10^6)^2}$ $R\approx1.23\times10^7\ m$ ✔		2
9 (c)	Orbital radius of probe A will decrease and orbital radius of probe B will increase ✔ Magnetic force on probe A is inwards and magnetic force on probe B is outwards radially [from Fleming's left-hand rule] ✔✔		3
9 (d) (i)	$G\frac{Mm}{r^2}+qvB=\frac{mv^2}{r}$ ✔ $qvBr^2-mv^2r+GMm=0$ ✔ $(10)(4.04\times10^6)(1.0)r^2-(400)(4.04\times10^6)^2r+(6.67\times10^{-11})(3.00\times10^{30})(400)=0$ $r\approx1.33\times10^7\ m$ (using GDC) ✔		3

9 (d) (ii)	$G\frac{Mm}{r^2}-qvB=\frac{mv^2}{r}$ ✔ $-qvBr^2-mv^2r+GMm=0$ $-(10)(4.04\times10^6)(1.0)r^2-(400)(4.04\times10^6)^2r+(6.67\times10^{-11})(3.00\times10^{30})(400)=0$ $r\approx1.14\times10^7\ m$ (using GDC) ✔		2

Question	Answer	Note	Marks
10 (a)	3 ✔		1
10 (b)	Slow down neutrons ✔ to increase collisions between neutrons and nuclei ✔		2
10 (c)	$\Delta m = 235.043923 - 136.907084 - 95.934284$ $\Delta m = 2.202555\ u$ ✔ $P = \frac{2.202555}{235.043923}(7.0\times10^{-7})(3.0\times10^8)^2$ ✔ $P \approx 5.90\times10^8\ W \approx 590\ MW$ ✔		3
10 (d)	$Q = mL$ $\frac{\Delta m}{\Delta t} = \frac{P}{L}$ $\frac{\Delta m}{\Delta t} = \frac{5.9\times10^8}{2268}$ $\frac{\Delta m}{\Delta t} \approx 2.6\times10^5\ g\ s^{-1}$ [$\approx 2600\ kg\ s^{-1}$] ✔		1

10 (e)	Spins a coil of wire in a magnetic field ✔ Magnetic flux in the coil changes with rotation ✔ Induces an electric current ✔		3