EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examination 2025
9749 PHYSICS
MARK SCHEME

Paper 1 – Multiple Choice Questions

1	**Answer: C**
	The average value is 47.78 mm which is not close to the true value so not accurate. There is a variation in measurements. So it is not precise.

2	**Answer: D**
	time taken to travel first 90 km = $\frac{\text{distance}}{\text{<speed>}} = \frac{90}{80} = 1.125$ hour time taken for remaining 110 km = 0.875 hour $< speed > = \frac{\text{total distance}}{\text{total time}} = \frac{110\text{ km}}{0.875\text{ hour}} = 126\text{ km h}^{-1}$

3	**Answer: A**
	$3kx = mg\ ---(1)$ $2kx' = mg\ ---(2)$ $\frac{(2)}{(1)}: \frac{2x'}{3x} = 1$ $x' = \frac{3}{2}x$ $x' - x = \frac{3}{2}x - x = 0.5x = 0.5(0.40) = 0.20\text{ cm}$

4	**Answer: A**
	$mg - T = ma$ $(0.50)(9.81) - T = (0.50)a\ ---(1)$ $T - friction = m'a$ $T - 3.5 = (0.20)a\ ---(2)$ Solving (1) and (2): $a = 2.0\text{ m s}^{-2}$

5	**Answer: B**
	Change in velocity = final velocity – initial velocity $= \sqrt{0.40^2 + 0.30^2} = 0.50\text{ m s}^{-1}$ Change in momentum = $m\,\Delta v$ = (0.20)(0.50) = 0.10 kg m s^{-1}

6	**Answer: C**
	$Thrust = weight$ $4\frac{m}{t}\Delta v = mg$ $4\left(\frac{0.400}{1.00}\right)(v - 0) = 1.20(9.81)$ $v = 7.36\text{ m s}^{-1}$

7	**Answer: B**
	$(3m)(4) = mv\sin\theta$ $(2m)(6) = mv\cos\theta$ $\tan\theta = 1$ $\theta = 45°$

8	Answer: B
	Constant speed, so no change in E_k. $E_p = mgh$ $\frac{dE_p}{dt} = mg\frac{h}{t} = mgv$ hence constant gradient

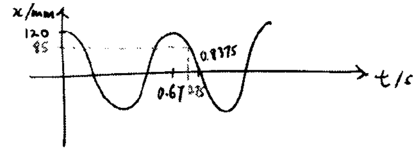
9	Answer: A
	$F_{drive} = F_{resistive} + W\sin\theta$ $\frac{60}{100}\frac{P}{v} = F_{resistive} + mg\sin\theta$ $\frac{60}{100}\times\frac{80000}{6.5} = F_{resistive} + (1000)(9.81)(\sin 45°)$ $F_{resistive} = 450$ N

10	Answer: A
	Vertical equilibrium: $kx\cos\theta = mg$ --- (1) Vertical component of tension = weight Horizontal component of tension provides centripetal force $kx\sin\theta = mr\left(\frac{2\pi}{T}\right)^2$ --- (2) $\frac{(2)}{(1)}: \tan 27° = \frac{4\pi^2(0.108\sin 27°)}{T^2(9.81)}$ $T = 0.62$ s

11	Answer: A
	For satellite in orbit, $TE = -KE$, so option A is correct. Since $KE = \frac{GMm}{2r}$, larger m with same KE requires larger r, so option B is incorrect. Since $T^2 = \frac{4\pi^2}{GM}r^3$, larger r will result in larger T, so option C is incorrect. Since $\omega = \frac{2\pi}{T}$, larger T means smaller ω, so option D is incorrect.

12	Answer: C
	"It has a property that varies linearly with temperature" is **not strictly essential** but rather an **assumption** used in constructing **empirical centigrade scales.**

13	Answer: D
	$T = \frac{1}{f} = \frac{1}{1.5} = 0.67$ s $x = x_0\cos\omega t$ $x = 0.12\cos[(2\pi)(1.5)(0.75)]$ $x = 0.0848$ m $= 85$ mm



Distance = 120 × 4 + (120 – 85) = 515 mm

14	Answer: C
	Particles are displaced away from the equilibrium positions towards the centre of the compression. Right is taken to be positive (distance from P) Particles displaced rightwards have positive displacements and leftwards have negative displacements.

15	Answer: C
	$I = (I_0\cos^2(30°))(\cos^2(60°))$ $I = 0.19I_0$

16 **Answer: C**

$A_{net} = A_P + A_Q = A + A = 2A$

$I = kx_0^2 \rightarrow I = k(2A)^2 ---(1)$

$A_{net} = A_P + A_Q = 2A + A = 3A$

$I = kx_0^2 \rightarrow I' = k(3A)^2 ---(2)$

$\frac{(2)}{(1)}: \frac{I'}{I} = \frac{k(3A)^2}{k(2A)^2} \rightarrow I' = 2.3I$

17 **Answer: C**

$x = \frac{\lambda D}{a} = \left(\frac{3.00\times10^8}{1.5\times10^{12}}\right)\left(\frac{4.0}{80\times10^{-3}}\right) = 10 \text{ mm}$

$2.5x = 25$ mm

18 **Answer: A**

$d\sin\theta = n\lambda$

4 orders are observed and for max angle of 90°,

$d\sin90° = (4)(5.50\times10^{-7})$

$d = 2.20\times10^{-6}$ m

If 5 orders were to be observed,

$d\sin90° = (5)(5.50\times10^{-7})$

$d = 2.75\times10^{-6}$ m

Larger the value of d results in more orders observed.

OR

$4 \le \left[\frac{d\sin90°}{\lambda} = n\right] < 5$

$4\lambda \le d < 5\lambda$

$2.20\times10^{-6} \le d < 2.75\times10^{-6}$

19 **Answer: C**

$\frac{s}{r} = \frac{\lambda}{b}$

$\frac{s}{20\times3.00\times10^8\times365\times24\times60\times60} = \frac{550\times10^{-9}}{3.0}$

$s = 3.47\times10^{10}$ m

20 **Answer: A**

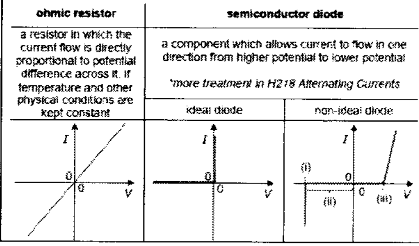
$I = nAve$, where n is electron density

$I = \frac{N}{AL}Ave$, where N is the number of electrons

$v = \frac{IL}{Ne} = \frac{5\times2}{1.5\times10^{24}\times1.6\times10^{-19}} = 4.17\times10^{-5}\ ms^{-1}$

21 **Answer: D**

After overcoming the threshold voltage, the diode's resistance become negligible. The resistance of the fixed resistor is shown by having a constant V to I ratio, i.e. a straight line graph that cuts through the origin.



22 **Answer: C**

$R = \frac{\rho l}{A} = \frac{\rho V^{\frac{1}{3}}}{V^{\frac{2}{3}}} = \frac{\rho}{V^{\frac{1}{3}}}$

23	**Answer: A**
	Since both branches have the same ratio vertically downwards, there is no current flowing through the middle horizontal wire. $\frac{1}{R_{eff}} = \frac{1}{10k + 30k} + \frac{1}{6.0k + 18k}$ $R_{eff} = 15\ k\Omega$ **OR** Since p.d. across the 10 kΩ and 6 kΩ resistors are the same, they can be treated as being a parallel connection. Similarly the 30 kΩ and 18 kΩ resistors can be viewed as a parallel connection also. $R_{eff} = \left(\frac{1}{10} + \frac{1}{6.0}\right)^{-1} + \left(\frac{1}{30} + \frac{1}{18}\right)^{-1}$ $= 15\ k\Omega$ The 1st method only works if resistors in both branches have the same ratio. The 2nd method always works.

24	**Answer: A**
	$V_{15\Omega} = V_R + V_{2.0\Omega}$ and using $V = IR$ $(0.48)(15) = (0.45)R + (0.45)(2.0)$ $R = 14\ \Omega$ $V_{15\Omega} = E - V_r$ $(0.48)(15) = 10 - (0.45 + 0.48)r$ $r = 3.0\ \Omega$

25	**Answer: B**
	For particle *Y* to be undeflected, electric force and magnetic force acting on *Y* must be in opposite direction. E field direction must be upwards for the electric force acting on particle *Y* to be in the opposite direction as the magnetic force (applying Fleming's Left Hand Rule) regardless of the polarity of particle *Y*.

26	**Answer: C**
	Increasing current I_S increases the magnetic force on *XY*. This increases the moment from the magnetic force pushing *XY* into the paper. Sliding the weight towards *WZ* increases the the perpedicular distance between the weight and pivot *KL*. This helps to counter-balance the increased moment from the magnetic force.

27	**Answer: A**
	By Faraday's Law, $\lvert E \rvert = \frac{N\Delta BA}{\Delta t}$ $= \frac{50(0.40)(0.08 \times 0.05)}{0.20}$ $= 0.40\ V$ By Lenz's Law, current flows in a direction to oppose the decrease in magnetic flux density (into page). This means that it should flow to produce more magnetic flux into page. By right hand grip rule, the induced current flows clockwise.

28	**Answer: C**
	For sine wave, $V_{rms\_1} = \sqrt{\dfrac{\dfrac{V_o^2}{2} \times T}{T}} = \dfrac{V_o}{\sqrt{2}}$ For half-wave square wave, $V_{rms\_2} = \sqrt{\dfrac{V_o^2 \times \dfrac{T}{2}}{T}} = \dfrac{V_o}{\sqrt{2}}$ Ratio required = $\dfrac{\dfrac{V_o}{\sqrt{2}}}{\dfrac{V_o}{\sqrt{2}}} = 1$

29	**Answer: D**
	The is not enough energy between the highest and lowest energy levels of a Hydrogen atom to emit X-rays.

30	**Answer: C**
	This is because most of the alpha particles go through the empty space undeflected. Most of the atom's mass must be concentrated.

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Paper 2 – Structured

Qns	Answer	Marks
1(a)	k = [(3)(1.29) (3.3 × 10^2)^2] / (9.9 × 10^4) = 4.3	 A1
1(b)	Method 1: fractional uncertainty = $2\times\frac{8}{100}+0.07+\frac{0.09}{1.29}=0.30$ $\Delta k=0.3\times4.2=1.3=1$ (allow 1 s.f.) Method 1: $k_{max}=\frac{3(3.3\times10^2\times1.08)^2(1.29+0.09)}{9.9\times10^4\times0.93}=5.712$ $k_{max}=\frac{3(3.3\times10^2\times0.92)^2(1.29-0.09)}{9.9\times10^4\times1.07}=3.132$ $\Delta k=\frac{1}{2}(5.712-3.132)=1.29=1$ $k=4\pm1$	C1 C1 C1 (calc of both kmax and kmin) C1 A1
1(c)	unit of fA = unit of speed unit of A = unit of (speed/f) unit of A = $\frac{\text{m s}^{-1}}{\text{s}^{-1}}$ = m	 M1 A1

Qns	Answer	Marks
2(a)(i)	$s=ut+\frac{1}{2}at^2$ (Taking upwards as positive) $-7.8=(5.9\sin60°)t+\frac{1}{2}(-9.81)t^2$ $t=1.9$ s (or 1.89 s)	 C1 A1
2(a)(ii)	Vertically: (Taking upwards as positive) $v^2=u^2+2as$ $v_v^2=(5.9\sin60)^2+2(-9.81)(1.2-9.0)$ v_v = -13.4 m s^{-1} or $v=u+at$ = -5.9 sin60 + 9.81 (1.885) = -13.4 m s^{-1} (Correct substitution and answer) horizontally: v_h = 5.9cos60 v_h = 2.95 (Correct substitution and answer) $\tan\theta=\frac{13.4}{2.95}$ $\theta=78°$	 C1 C1 A1
2(b)(i)	speed **decrease**, (So) viscous force / drag (force) **decrease** (resultant force decreases as) upthrust and weight remain the same	B1 B1
2(b)(ii)	$U=\rho Vg$ $U=(1000)(9.81)(7.5\times10^{-2})$ = 736 N = 740 N	M1
2(b)(iii)	resultant force = **740** + 950 – (78)(9.81) = 925 acceleration = F / m = 925 / 78 = 12 m s^{-2} (vertically) upwards	 C1 A1 A1

Qns	Answer	Marks
3(a)	For a system in equilibrium, sum of clockwise moments about a (or any) point equals sum of anticlockwise moments about the same point	B1 B1
3(b)	Let the length of the rod be *L*. Take moment about the point of contact between the rod and the ground. **sum of clockwise moments** $1000\left(\frac{L}{2}\cos 30^\circ\right)$ OR $1000\left(\frac{L}{2}\sin 60^\circ\right)$	C1
	sum of anticlockwise moments $T\sin 17^\circ(L)$ OR $T\cos 73^\circ(L)$	C1
	OR	
	sum of clockwise moments $1000\left(\frac{L}{2}\cos 30^\circ\right)+T\cos 47^\circ(L\sin 30^\circ)$ OR $1000\left(\frac{L}{2}\sin 60^\circ\right)+T\sin 43^\circ(L\cos 60^\circ)$	(C1)
	sum of anticlockwise moments $T\sin 47^\circ(L\cos 30^\circ)$ OR $T\cos 43^\circ(L\sin 60^\circ)$	(C1)
	T = 1500 N (or 1480 N)	A1

Qns	Answer	Marks
4(a)	By Principle of Conservation of Linear Momentum $(0.50)(2.0) + (0.20)(0) = (0.50)(v_1) + (0.20)(v_2)$ [1]	C1
	By Relative speed of approach = relative speed of separation $u_1 - u_2 = v_2 - v_1$ $2.0 - 0 = v_2 - v_1$ [2]	C1
	Solve equations [1] and [2], $v_2 = 2.857 = 2.9$ m s^{-1}	A1
4(b)	By Principle of Conservation of Energy, Loss in kinetic energy = Gain in Gravitational Potential Energy $\frac{1}{2}mv^2 - 0 = mgh$ $\frac{1}{2}(2.857^2) = 9.81h$ $h = 0.416$ m	C1
	Consider maximum angle $h = L - L\cos\theta = L(1-\cos\theta)$ $0.416 = 1.5(1-\cos\theta)$ $\theta = 43.7^\circ$	C1 A1
4(c)	There is an **external resultant force** acting on the bob provided by the **tension in the string** and **weight**.	B1

Qns	Answer	Marks
5(a)	Rate of change of angular displacement	B1
5(b)(i)	At minimum speed, normal contact force = 0 AND Weight provides centripetal force	B1
	$mg = \frac{mv^2}{r}$ $9.81 = \frac{v^2}{0.12}$	C1
	$v = 1.08$ or $1.1\ \text{m s}^{-1}$	A1
5(b)(ii)	Loss in EPE = Gain in GPE + Gain in KE $\frac{1}{2}kx^2 = mgh + \frac{1}{2}mv^2$	B1
	$\frac{1}{2}k(0.16)^2 = (0.076)(9.81)(0.24) + \frac{1}{2}(0.076)(1.1)^2$	C1
	$k = 17.6 = 18\ \text{N m}^{-1}$	A1
	OR	
	$\frac{1}{2}k(0.16)^2 = (0.076)(9.81)(0.24) + \frac{1}{2}(0.076)(1.08)^2$	(C1)
	$k = 17.4 = 17\ \text{N m}^{-1}$	(A1)
5(c)	Loss in KE = Work done against resistive force 0.23 = (average resistive force)$(0.30 + 0.25 + 2\pi(0.12))$	B1
	average resistive force = 0.18 N	A1

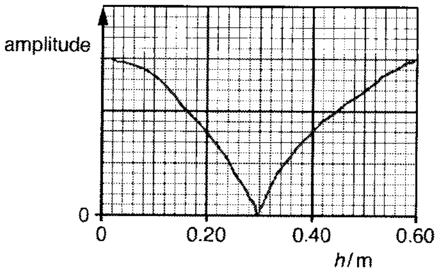
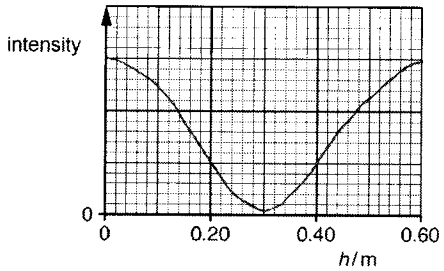
Qns	Answer	Marks
6(a)(i)	(vertically) downwards	B1
6(a)(ii)	magnetic force (on sphere) is always perpendicular to its velocity	M1
	no work done by force, hence no change in kinetic energy and speed.	A1
6(b)	$mg = Eq$	C1
	$E = (1.6 \times 10^{-10} \times 9.81) / (0.27 \times 10^{-9})$ $= 5.8\ \text{N C}^{-1}$	A1
6(c)	Magnetic force provides centripetal force	B1
	$Bqv = mv^2 / r$	C1
	$B = (1.6 \times 10^{-10} \times 0.78) / (0.27 \times 10^{-9} \times 3.4) = 0.14\ \text{T}$	A1

Qns	Answer	Marks
7(a)	Transition emits (one) photon with energy equal to the difference in energy between the two levels	B1
	photon energy = h x (frequency of radiation)	B1
	Thus, single frequency of radiation for each transition	
7(b)(i)	line to the left of the pair in Fig. 8.2, labelled A AND larger gap between line A and the nearest of the pair in Fig. 7.2, than between the lines in the pair	B1
7(b)(ii)	line to the left of both the pair in Fig. 7.2 and line A, labelled B AND larger gap between line B and line A, than between line A and the nearest one of the pair in Fig. 7.2	B1
7(c)	$\Delta E = E_{photon} = hf$ $(E_3 - E_1) = (E_2 - E_1) + (E_3 - E_2) = hf_A + hf_B$	C1
	$E_3 = E_1 + h(f_A + f_B)$	A1

Qns	Answer	Marks
8(a)	$hc / \lambda = \Phi + E_{MAX}$ AND hc = gradient	C1
	gradient = e.g. $[(0.40 - 0.20) \times 1.60 \times 10^{-19}] / [(2.25 - 2.09) \times 10^{6}]$ (*working needed*) ($= 2.0 \times 10^{-25}$)	M1
	$h = (2.0 \times 10^{-25}) / (3.00 \times 10^{8}) = 6.7 \times 10^{-34}$ J s (*both working and answer needed*)	A1
8(b)	straight line with same gradient as the original AND straight line with *x*-axis intercept greater than 1.93×10^{6} m^{-1}	B1
8(c)	(for $E_{MAX} = 0$,) $1 / \lambda_0 = 1.93 \times 10^{6}$ (m^{-1}) $f_0 = (3.00 \times 10^{8})(1.93 \times 10^{6})$ $= 5.8 \times 10^{14}$ Hz	C1
	$\Phi = hf_0 = (6.63 \times 10^{-34})(5.8 \times 10^{14})$ $= 3.9 \times 10^{-19}$ J $= 2.4$ eV	M1
	so potassium	A1
8(d)	more photons (per unit time) so (rate of emission) increases	A1

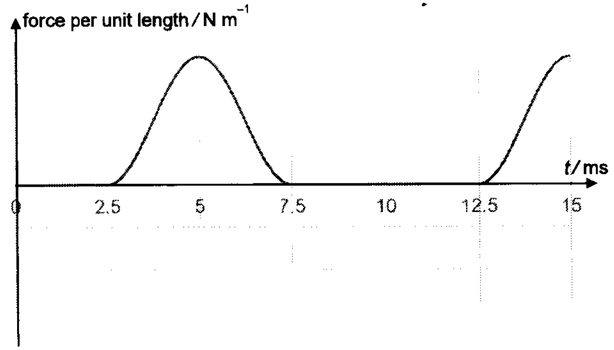
Qns	Answer	Marks
9(a)(i)	distance $= 0.28 \text{ AU} \times (1.5\times10^{11}) = 4.2\times10^{10}$ m $I = \dfrac{P}{4\pi r^2} = \dfrac{3.8\times10^{26}}{4\pi(4.2\times10^{10})^2}$ $I = 1.714\times10^{4} = 1.7\times10^{4}$ W m^{-2}	B1 B1
9(a)(ii)	$P_{received} = IA(efficiency)$ $P_{received} = (1.7\times10^{4})(6.5)(0.28)$ $P_{received} = 3.1\times10^{4}$ W	C1 A1
9(b)(i)	$P_r = \left(\dfrac{I}{c} + R\right) = \left(\dfrac{1.7\times10^{4}}{3.00\times10^{8}}\right)\times\dfrac{100}{99.8}\times\dfrac{0.15}{100}$ $= 8.5\times10^{-8}$ Pa	M1
9(b)(ii)	$E_k = \dfrac{1}{2}mv^2$ $p = mv$ Showing BOTH the above to be awarded 1 mark	M1
	$E_k = \dfrac{1}{2}m\left(\dfrac{p}{m}\right)^2$ Therefore $E_k = \dfrac{p^2}{2m}$	M1
9(b)(iii)	$F = PA = (8.5\times10^{-8})(6.5) = 5.5\times10^{-7}$ N	C1
	Using $E = \dfrac{p^2}{2m}$, $F = \left(\dfrac{N}{t}\right)\Delta p = \left(\dfrac{N}{t}\right)\sqrt{2mE}$ $5.5\times10^{-7} = \left(\dfrac{N}{t}\right)\sqrt{2(4\times1.66\times10^{-27})(5.0\times10^{6}\times1.6\times10^{-19})}$	C1
	$\dfrac{N}{t} = 5.4\times10^{12}$ s^{-1}	A1
9(c)	activity $= \dfrac{\text{count rate}}{\text{sensitivity}} = \dfrac{3.6\times10^{5}}{1.2\times10^{4}}$ $= 30$ GBq	C1 A1

Qns	Answer	Marks
9(d)(i)	$\lambda_\alpha = \frac{\ln 2}{t_{\frac{1}{2}}} = \frac{\ln 2}{20} = 0.035 \text{ min}^{-1}$ $\lambda_\beta = \frac{\ln 2}{t_{\frac{1}{2}}} = \frac{\ln 2}{10} = 0.069 \text{ min}^{-1}$	A1 A1
9(d)(ii)	$\lambda_{eff} = 0.01\lambda_\alpha + 0.99\lambda_\alpha$ $= 0.01(0.035) + 0.99(0.069)$ $= 6.87 \times 10^{-2} \text{ min}^{-1}$	M1
9(d)(iii)	$N_o = \frac{2.2 \times 10^{-11}}{13\left(1.66 \times 10^{-27}\right)} = 1.0 \times 10^{15}$ $N = N_o e^{-\lambda t}$ $= \left(1.0 \times 10^{15}\right) e^{-(6.9\times10^{-2})(15)}$ $= 3.6 \times 10^{14}$	C1 C1 A1
9(d)(iv)	${}^{13}_{7}N \rightarrow {}^{13}_{6}C + {}^{0}_{1}e + neutrino$ (accept anti-neutrino and symbols $\nu, \bar{\nu}$)	A1
9(e)	Any of the following: relate distance from the Sun to intensity via the inverse-square law solar activity (e.g., solar flares) panel orientation, dust accumulation temperature effects on solar cell efficiency	B1

Qns	Answer	Marks
1(a)	(incident) wave reflects at end/top of tube	B1
	(incident) wave and reflected wave superpose	B1
	waves have same frequency, wavelength and speed	B1
1(b)(i)	line has maximum value of amplitude at h = 0 and h = 0.60 m only AND line has minimum/zero value of amplitude at h = 0.30 m only	M1
	modulus cosine graph (Sharp at h = 0.30 m)  	A1
1(b)(ii)	line has maximum value of amplitude at h = 0 and h = 0.60 m only AND line has minimum/zero value of amplitude at h = 0.30 m only AND modulus cosine-squared graph  	B1
1(c)(i)	vertical/along length of tube/along axis of tube	B1
1(c)(ii)	phase difference = 0	A1
1(c)(iii)	phase difference = 180°	A1
1(d)	$v = f\lambda$	C1
	$f = 340 / (2 \times 0.60)$	

Qns	Answer	Marks
	= 280 Hz	A1
1(e)(i)	f = 340 / 0.60	
	= 570 Hz (or 2 x 280 = 560 Hz)	A1
1(e)(ii)	0.60 / 4 = 0.15 m	A1

Qns	Answer	Marks
2(a)(i)	$R=\frac{\rho L}{A}=\frac{\rho L}{\pi r^2}$ $=\frac{(1.1\times10^{-6})(120\times10^{-2})}{\pi(\frac{1.1}{2}\times10^{-3})^2}$ $=1.38898...=1.4\ \Omega$ (2 s.f.)	M1
2(a)(ii)	Let potential at Y be 5.0 V $R_{PQ}//1.8\ \Omega=\frac{1.4\times1.8}{1.4+1.8}=0.7875\ \Omega$ PD across $R_{PQ}=\frac{0.7875}{0.7875+2.5}\times5.0=1.198$ V	C1
	PD across XY $=5.0-\frac{1.198}{2}$ $=4.4$ V	C1 A1
2(b)(i)	**Current in wire A is in magnetic field produced by current in wire B.** Wire A experiences a magnetic force towards wire B according to **Fleming's Left Hand Rule**.	B1
	From **Newton's third law**, an equal and opposite force acts on wire B. (or apply FLH rule again on wire B)	B1
2(b)(ii)1.	$I_A=-3.0\cos(200\pi t)=-3.0\cos(200\pi(6.5\times10^{-3}))$ $=1.76$ A From graph, $I_B=1.2$ A	C1 For both I_A and I_B
	$B_B=\frac{\mu_0 I}{2\pi d}$ $=\frac{(4\pi\times10^{-7})(1.2)}{2\pi(0.05)}=4.8\times10^{-6}$ F per unit length on wire A $=B_BI_AL/L=B_BI_A$ $=(4.8\times10^{-6})(1.76)$	C1
	$=8.4\times10^{-6}$ N m^{-1}	A1

Qns	Answer	Marks
2(b)(ii)2.		
	• positions and shape of graph during intervals of non-zero force • positions of intervals of zero force	B1 B1
2(b)(ii)3.	$\langle P\rangle=I_{rms}^2R=\left(\frac{3.0}{2}\right)^2(15)$ $=34$ W	A1

Qns	Answer	Marks
3 (a)(i)	(W =) 2.60 × 10^5 × (3.80 – 2.30) × 10^{-3} = 390 J	A1
3(a)(ii)	no (total) change (in internal energy)	B1
	gas returns to its original temperature/ state/ no change to pressure and volume	B1
3(b)	A to B row all correct (1370, – 390, 980)	B1
	B to C row all correct (0, 550, 550)	B1
	C to A row: ΔU adds to the other two ΔU values to give zero	B1
	C to A row: w = 0 **and** q adds to w to give ΔU value complete correct answer:	B1
3(c)	when vapourising, greater change in separation of atoms or molecules/ bonds are completely broken (compared to partially broken), hence a greater change in potential energy and internal energy	B1
	greater change in volume, hence a greater work done	B1

change	q / J	w / J	ΔU / J
A to B	(+)1370	–390	(+)980
B to C	0	(+)550	(+)550
C to A	–1530	0	–1530

Qns	Answer	Marks
4(a)(i)	product of number of turns of coil, (magnetic) flux density and area	M1
	area perpendicular to the (magnetic) field	A1
	OR	
	Magnetic flux linkage through a loop is product of magnetic flux through the loop and number of turns of wire in the loop.	B1
	Magnetic flux is the product of an area and component of magnetic flux density perpendicular to that area.	B1
4(a)(ii)	flux = $B \times \pi r^2$ = 0.17 × π 0.36^2 = 6.9 × 10^{-2} Wb	C1
	time for one revolution = 1 / 25 s	
	e.m.f. = rate of cutting flux **or** $\frac{\Delta\Phi}{\Delta t}$	C1
	= 0.069 × 25	
	= 1.7 V	A1
4(a)(iii)	current (in disc) is perpendicular to magnetic field causes force to act on disc **OR** current (in disc) is perpendicular to magnetic field **OR** current causes force to act on disc	B1
	force opposes rotation of disc	B1
	Fleming's left-hand rule indicates current is from rim to axle	B1

Qns	Answer	Marks
4(b)(i)	ring cuts (magnetic) flux and causes induced e.m.f. in ring	B1
	(induced) e.m.f. causes (eddy/induced) currents (in ring)	B1
	currents (in ring) cause magnetic field (around ring)	M1
	two fields interact to cause resistive/opposing force	A1
	OR	
	current (in ring) is in a magnetic field	(M1)
	which causes resistive force	(A1)
	OR	
	currents (in ring) dissipate thermal energy	(M1)
	(thermal) energy comes from energy of oscillations	(A1)
4(b)(ii)	current cannot pass all the way around the ring	B1
	(induced) currents smaller (OR no currents)	B1
	smaller resistive force (so more oscillations) (OR no resistive force) **or** smaller rate of dissipation of energy (so more oscillations)	B1

Qns	Answer	Marks
5(a)(i)	energy required to separate the nucleons (in the nucleus)	M1
	to infinity	M1
5(a)(ii)	curve starting close to the origin and forming a single peak peak shown to left of centre, with steep line on LHS of peak and shallow line on RHS of peak	B1

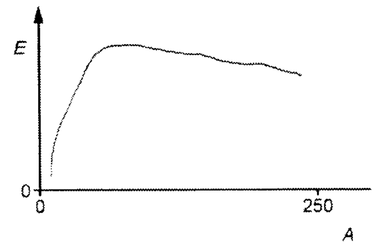


Fig. 5.1

Qns	Answer	Marks
5(b)(i)	Fusion	B1
5(b)(ii)	both particles have low *A* values or both particles are at left-hand end of graph	B1
	He-3 has higher binding energy (per nucleon) than the total binding energy of both H-2	B1
5(c)	Δm = [(2 × 2.014102) – (3.016029 + 1.008665)] u = 0.00351 u (Correct substitution and correct answer)	C1
	$E = \Delta mc^2$	
	= 0.00351 × 1.66 × 10^{-27} × (3.00 × 10^8)^2 = 5.24 × 10^{-13} J (Correct substitution and correct answer)	C1
	1.0 mol of deuterium forms 0.500 mol of helium-3	C1
	total energy = 0.500 × 6.02 × 10^{23} × 5.24 × 10^{-13} (Correct substitution)	C1
	= 1.58 × 10^{11} J	A1

Qns	Answer	Marks
6(a)	upthrust is greater than weight (resultant force is) upwards	B1 B1
6(b)	At equilibrium, Upthrust = Weight $\rho A hg = Mg$ ---(1) Taking downwards positive, at displacement *x*, Net force = mass x acceleration $Mg - Upthrust = Ma$ $Mg - \rho Vg = Ma$ where *V* is the volume of water displaced $Mg - \rho A(h + x)g = Ma$ $Mg - \rho Ahg - \rho Axg = Ma$ ---(2) Sub (1) into (2): $\rho Ahg - \rho Ahg - \rho Axg = Ma$ $-\rho Axg = Ma$ $a = -\left(\frac{A\rho g}{M}\right)x$ OR Additional upthrust = net force $\rho Axg = Ma$ Since *a* and *x* are opposite in directions, $a = -\frac{A\rho g}{M}x$ Note: For "show that" question, the first method is preferred.	M1 M1 M1 (M1) (M1) M1
6(c)	*A, ρ, g and M are constant, hence* acceleration proportional to displacement negative sign indicates acceleration and displacement in opposite directions	B1 B1
6(d)(i)	$\omega = 2\pi / T$ $\omega = 2\pi / 1.3$ $= 4.8$ rad s^{-1}	C1 A1
6(d)(ii)	$\omega^2 = A\rho g / M$ $4.8^2 = (4.5 \times 10^{-4} \times \rho \times 9.81) / 0.17$ $\rho = 900$ kg m^{-3}	C1 C1 A1

Qns	Answer	Marks
6(d)(iii)1.	Total energy = maximum Kinetic energy Max velocity $v_{max} = \omega x_{max}$ $= \frac{1}{2}mv_{max}^2 = \frac{1}{2}m(\omega x_o)^2 = \frac{1}{2}m\omega^2 x_o^2$ algebra leading to final expression	B1 M1 M1
6(d)(iii)2.	$\frac{1}{2}(0.17)[(4.8)(0.20)]^2$ $= 0.078$ J	 A1
6(d)(iv)	0.92^6 decrease in energy = $0.078 - (0.078 \times 0.92^6)$ = 30.7 mJ	C1 A1
6(d)(v)	wave with same period (or slightly greater) AND peak height decreasing successively	B1 B1

Qns	Answer	Marks
7(a)(i)	work done per unit mass in bringing a small test mass from infinity to that point	B1 B1
7(a)(ii)	potential is zero at infinity Gravitational force is attractive work is done **by** (two) masses in moving them **closer** together work is done **on** (two) masses in moving them **apart** test mass getting closer from infinity loses potential energy	Any 2
7(b)	Loss in kinetic energy = Gain in Gravitational Potential Energy Initial KE – final KE = final GPE – initial GPE $\frac{1}{2}mv^2 - 0 = 0 - m\phi$ $v = \sqrt{-2\phi}$	B1 B1 B1 A0
7(c)	ϕ = –GM / r = – (6.67 × 10^{-11} × 7.3 × 10^{22}) / (1.7 × 10^6) = – 2.9 × 10^6 J kg^{-1}	 C1 A1
7(d)	speed = √(2 × 2.9 × 10^6) = 2400 m s^{-1}	 A1
7(e)	½m<c²> = (3/2)kT ½ 3.34 × 10^{-27} × <c²> = (3/2) (1.38 × 10^{-23})(400) $c_{r.m.s.}$ = 2200 m s^{-1}	C1 C1 A1
7(f)	r.m.s. speed is an average so many molecules have speeds greater than the escape speed **or** there is a distribution of molecular speeds (around the r.m.s. value) so many molecules have speeds greater than the escape speed	B1
7(g)(i)	Loss in GPE = Gain in KE $\left(-\frac{GMm}{r_X}\right)-\left(-\frac{GMm}{r_Y}\right)=\frac{1}{2}mv_Y^2-\frac{1}{2}mv_X^2$ $(6.67\times10^{-11})(1.99\times10^{30})\left[\left(-\frac{1}{8.44\times10^{11}}\right)+\left(\frac{1}{6.38\times10^{10}}\right)\right]=\frac{1}{2}v_Y^2-\frac{1}{2}(34.1\times10^3)^2$ $v_Y = 70.8$ km s^{-1}	B1 C1 C1 A1
7(g)(ii)	both Gravitational Potential Energy and Kinetic Energy equations include *m*, so path is unchanged OR It is independent on *m*, so path is unchanged.	B1 (B1)

Qns	Answer	Marks
7(g)(iii)	Path higher than the original one AND Closest distance of approach is larger And if goes back, the bottom path is lower than the original one.	B1