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: $k_{max}=\frac{3\left(3.3\times10^2\times1.08\right)^2\left(1.29+0.09\right)}{9.9\times10^4\times0.93}=5.712$ $k_{max}=\frac{3\left(3.3\times10^2\times0.92\right)^2\left(1.29-0.09\right)}{9.9\times10^4\times1.07}=3.132$ $\Delta k=\frac{1}{2}\left(5.712-3.132\right)=1.29=1$ $k=4\pm1$	**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) $-7.8 = \left(5.9\sin 60^o\right)t + \frac{1}{2}\left(-9.81\right)t^2$ $t = 1.9$ 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) $\tan\theta = \frac{13.4}{2.95}$ $\theta = 78^o$	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

<table>
<tr><th>Qns</th><th>Answer</th><th>Marks</th></tr>
<tr><td>3(a)</td><td>For a system in equilibrium,

sum of clockwise moments about a (or any) point equals sum of anticlockwise moments about the same point</td><td>B1

B1</td></tr>
<tr><td>3(b)</td><td>Let the length of the rod be L.

Take moment about the point of contact between the rod and the ground.

<table>
<tr><th>sum of clockwise moments</th></tr>
<tr><td>$1000\left(\frac{L}{2}\cos 30^o\right)$
OR
$1000\left(\frac{L}{2}\sin 60^o\right)$</td></tr>
<tr><th>sum of anticlockwise moments</th></tr>
<tr><td>$T\sin 17^o\left(L\right)$
OR
$T\cos 73^o\left(L\right)$</td></tr>
</table>

OR
<table>
<tr><th>sum of clockwise moments</th></tr>
<tr><td>$1000\left(\frac{L}{2}\cos 30^o\right)+T\cos 47^o\left(L\sin 30^o\right)$
OR
$1000\left(\frac{L}{2}\sin 60^o\right)+T\sin 43^o\left(L\cos 60^o\right)$</td></tr>
<tr><th>sum of anticlockwise moments</th></tr>
<tr><td>$T\sin 47^o\left(L\cos 30^o\right)$
OR
$T\cos 43^o\left(L\sin 60^o\right)$</td></tr>
</table>

T = 1500 N (or 1480 N)</td><td>C1

C1

(C1)

(C1)

A1</td></tr>
</table>

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] 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] Solve equations [1] and [2], $v_2 = 2.857 = 2.9$ m s^{-1}	C1 C1 A1
4(b)	By Principle of Conservation of Energy, Loss in kinetic energy = Gain in Gravitational Potential Energy $\frac{1}{2}mv^2 - 0 = mgh$ $\frac{1}{2}\left(2.857^2\right) = 9.81h$ $h = 0.416$ m Consider maximum angle $h = L - L\cos\theta = L\left(1-\cos\theta\right)$ $0.416 = 1.5\left(1-\cos\theta\right)$ $\theta = 43.7°$	C1 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 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
	$k = 17.6 = 18$ 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)
	$k = 17.4 = 17$ N m^{-1}	(A1)
5(c)	Loss in KE = Work done against resistive force	B1
	0.23 = (average resistive force)$\left(0.30 + 0.25 + 2\pi(0.12)\right)$	
	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
	$E = (1.6 \times 10^{-10} \times 9.81) / (0.27 \times 10^{-9})$	
	$= 5.8$ N C^{-1}	A1
6(c)	Magnetic force provides centripetal force	B1
	$Bqv = mv^2 / r$	C1
	$B = (1.6 \times 10^{-10} \times 0.78) / (0.27 \times 10^{-9} \times 3.4) = 0.14$ 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 $=0.28$ AU $\times(1.5\times10^{11})=4.2\times10^{10}$ m	B1
	$I=\dfrac{P}{4\pi r^2}=\dfrac{3.8\times10^{26}}{4\pi\left(4.2\times10^{10}\right)^2}$	B1
	$I=1.714\times10^4 \;=1.7\times10^4$ W m^{-2}	
9(a)(ii)	$P_{received}=IA(efficiency)$	
	$P_{received}=(1.7\times10^4)(6.5)(0.28)$	C1
	$P_{received}=3.1\times10^4$ W	A1
9(b)(i)	$P_r=\left(\dfrac{I}{c}+R\right)=\left(\dfrac{1.7\times10^4}{3.00\times10^8}\right)\times\dfrac{100}{99.8}\times\dfrac{0.15}{100}$	M1
	$=8.5\times10^{-8}$ Pa	
9(b)(ii)	$E_k=\dfrac{1}{2}mv^2$	M1
	$p=mv$	
	Showing BOTH the above to be awarded 1 mark	
	$E_k=\dfrac{1}{2}m\left(\dfrac{p}{m}\right)^2$	M1
	Therefore $E_k=\dfrac{p^2}{2m}$	
9(b)(iii)	$F=PA=(8.5\times10^{-8})(6.5)=5.5\times10^{-7}$ N	C1
	Using $E=\dfrac{p^2}{2m}$, $F=\left(\dfrac{N}{t}\right)\Delta p=\left(\dfrac{N}{t}\right)\sqrt{2mE}$	C1
	$5.5\times10^{-7}\;=\left(\dfrac{N}{t}\right)\sqrt{2(4\times1.66\times10^{-27})(5.0\times10^6\times1.6\times10^{-19})}$	
	$\dfrac{N}{t}=5.4\times10^{12}$ s^{-1}	A1
9(c)	activity = $\dfrac{\text{count rate}}{\text{sensitivity}}=\dfrac{3.6\times10^5}{1.2\times10^4}$	C1
	$=30$ GBq	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)	$N_o = \frac{2.2 \times 10^{-11}}{13\left(1.66 \times 10^{-27}\right)} = 1.0 \times 10^{15}$ $N = N_o e^{-\lambda t}$ $= \left(1.0 \times 10^{15}\right) e^{-(6.9 \times 10^{-2})(15)}$ $= 3.6 \times 10^{14}$	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