H2 PHYSICS

9646

SUGGESTED MARK SCHEME

October/November 2016

Paper 1
Multiple Choice

Qns	*Key*	*Qns*	*Key*	*Qns*	*Key*	*Qns*	*Key*
1	**B**	11	**A**	21	**C**	31	**A**
2	**C**	12	**D**	22	**D**	32	**C**
3	**B**	13	**D**	23	**D**	33	**D**
4	**D**	14	**C**	24	**C**	34	**B**
5	**D**	15	**C**	25	**C**	35	**B**
6	**C**	16	**A**	26	**B**	36	**B**
7	**D**	17	**D**	27	**C**	37	**D**
8	**D**	18	**A**	28	**A**	38	**C**
9	**B**	19	**B**	29	**B**	39	**C**
10	**C**	20	**D**	30	**B**	40	**C**

Notes:

Q5: Ball must fall again to reach ground after rising, so need a multiplier of 2.

Paper 2
Structured Questions

Note: Need to read questions, diagrams and graphs carefully. Definitions need to be precise.

Qns		Marks
1(a)	SI unit for electrical resistance	
	is when a potential difference of one volt per ampere of current flows through a conductor	B1
	Note: do not make mistake of defining *resistance* or mixing up units/quantities.	
1(b)(i)	$V = IR$	
	$R = \frac{V}{I} = \frac{1.50}{0.32}$ $(= 4.6875\ \Omega)$	C1
	$R = \frac{\rho L}{A}$	
	$\rho = \frac{RA}{L} = \frac{R\left[\pi\left(\frac{d}{2}\right)^2\right]}{L} = \frac{R\pi d^2}{4L}$	C1
	$= \frac{R\pi\left(0.23 \times 10^{-3}\right)^2}{4\left(40 \times 10^{-2}\right)}$	M1
	$= 4.87 \times 10^{-7}\ \Omega$	A1
	Note: be careful of the powers of ten for mm and cm	

Qns		Marks

1(b)(ii)

$$\rho = \frac{R\pi d^2}{4L} = \frac{\pi}{4}\left(\frac{V}{I}\right)\left(\frac{d^2}{L}\right)$$

$$\frac{\Delta\rho}{\rho} = \frac{\Delta V}{V} + 2\frac{\Delta d}{d} + \frac{\Delta I}{I} + \frac{\Delta L}{L}$$

$$\Delta\rho = \rho\left(\frac{\Delta V}{V} + 2\frac{\Delta d}{d} + \frac{\Delta I}{I} + \frac{\Delta L}{L}\right)$$

$$= \left(4.87\times10^{-7}\right)\left(\frac{0.01}{1.50} + 2\frac{0.01}{0.23} + \frac{0.01}{0.32} + \frac{0.1}{40.0}\right)$$ M1

$$= 6.2\times10^{-8}\ \Omega\text{m}$$ A1

Note: since *d* is squared, there needs to be a multiplier of 2 to its associated fractional uncertainty.

OR

$$\rho = \frac{R\pi d^2}{4L} = \frac{\pi}{4}\left(\frac{V}{I}\right)\left(\frac{d^2}{L}\right)$$

$$\Delta\rho = \frac{1}{2}\left(\rho_{max} - \rho_{min}\right)$$

$$= \frac{\pi}{2(4)}\left[\left(\frac{V_{max}}{I_{min}}\right)\left(\frac{d^2_{max}}{L_{min}}\right) - \left(\frac{V_{min}}{I_{max}}\right)\left(\frac{d^2_{min}}{L_{max}}\right)\right]$$

$$= \frac{\pi}{8}\left[\left(\frac{1.51}{0.31}\right)\left(\frac{\left(0.24\times10^{-3}\right)^2}{39.9\times10^{-2}}\right) - \left(\frac{1.49}{0.33}\right)\left(\frac{\left(0.22\times10^{-3}\right)^2}{40.1\times10^{-2}}\right)\right]$$ M1

$$= 6.2\times10^{-8}\ \Omega\text{m}$$ A1

Note: *actual* uncertainty should be quoted to 2 s.f. It is only 1 s.f. when paired with the actual quantity, as per the next part.

1(b)(iii)

$$\rho = \left(4.9 \pm 0.6\right)\times10^{-7}\ \Omega\text{m}$$ A1

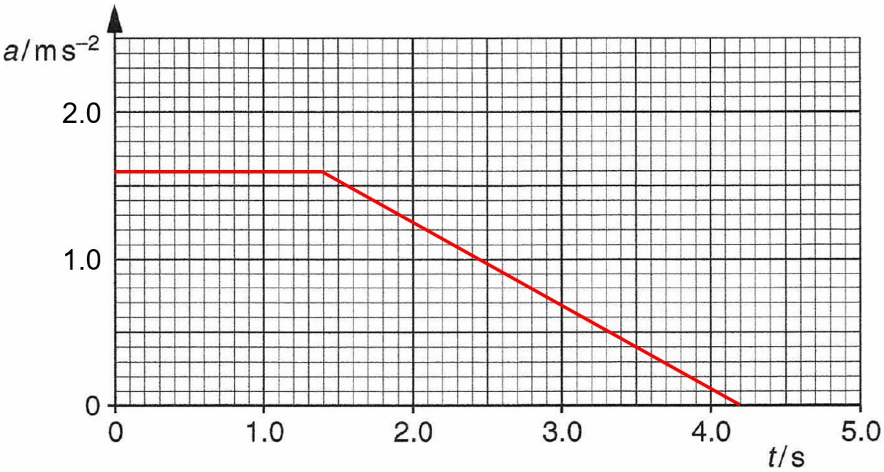
Note: need to check that the power of tens are the same before quoting the quantity to the 1 s.f. version of the actual uncertainty.

1(c)

Accuracy is how close a measurement is to the true value.
Accepted value lies within the range in the answer to (b)(iii) of $\rho = \left(4.9 \pm 0.6\right)\times10^{-7}\ \Omega\text{m}$ and so is accurate. B1

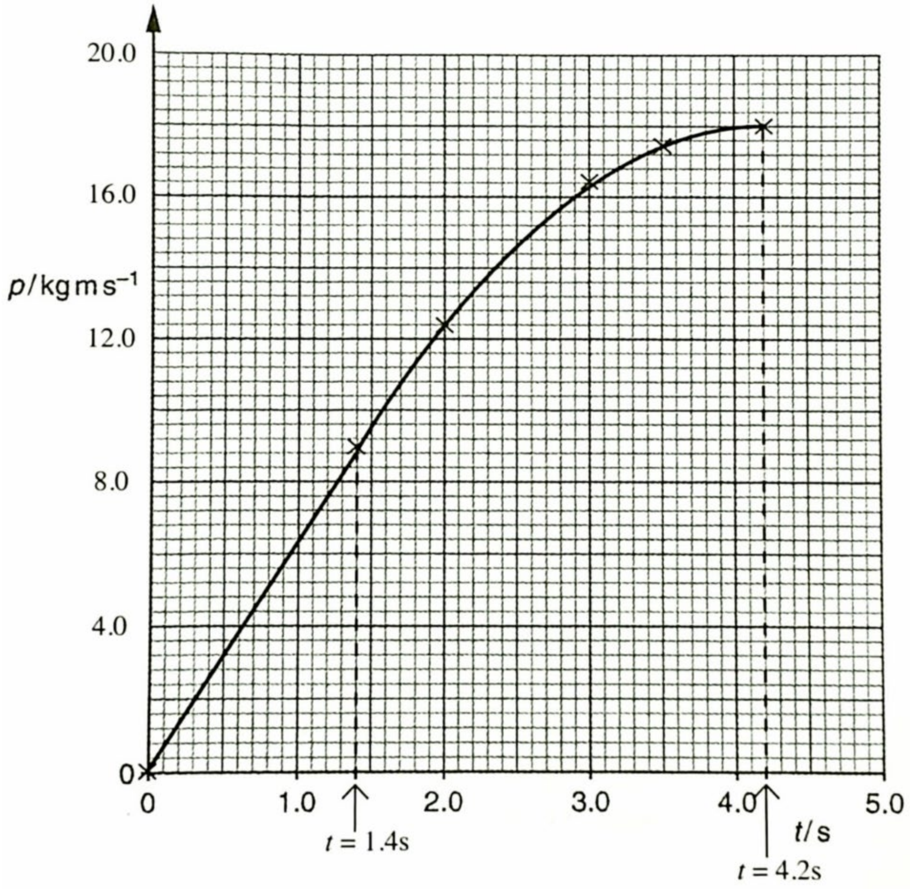
Precision is the degree to which repeated measurements agree with each other. The range of values result in a percentage uncertainty $\frac{\Delta\rho}{\rho}\times100\% = \frac{0.6}{4.9}\times100\% = 12\%$ and so precision is poor. B1

Note: answer needs to make reference to the value in part (b)(iii).

Qns		Marks
2(a)	When t = 0.70 s, F = 6.4 N	M1 (read graph)
	$F = ma$ $a = \frac{F}{m} = \frac{6.4}{4.0}$ $= 1.6 \text{ ms}^{-2}$	A1
2(b)	 B1: $a = 1.6 \text{ ms}^{-2}$ until t = 1.4 s, B1: straight line until (4.2, 0)	
2(c)	Area under $F - t$ graph is impulse (change in momentum)	M1
	area from t = 0 to t = 1.4s: 6.4 × 1.4 = 8.96 N s	A1
	Note: the area required is the initial rectangle only and not of the triangle later, past t = 1.4 s.	

Qns	Marks

2(d)



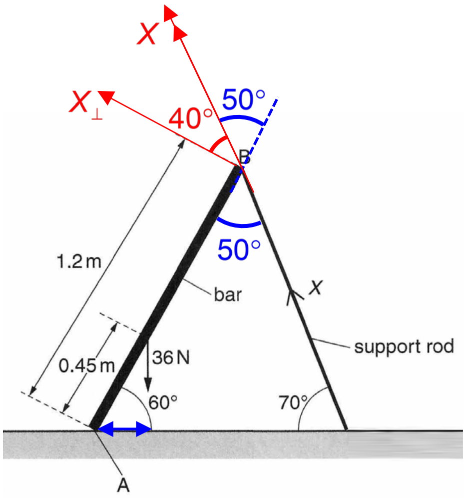
B1: object starts from rest so zero momentum at t = 0 s
use answer to part (c) to plot (1.4, 8.96) connected to origin via straight line

B1: calculate impulse from t = 1.4 s to t = 4.2 s via area of triangle in Fig 2.1

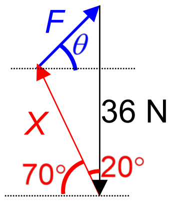
$$\Delta p = \frac{1}{2}(4.2 - 1.4)(6.4)$$
$$= 8.96 \text{ Ns}$$
$$p_{t=4.2\text{ s}} = p_{t=1.4\text{ s}} + \Delta p$$
$$= 8.96 + 8.96$$
$$= 17.92 \text{ Ns}$$

B1: smoothly curving line from (1.4, 8.96) to (4.2, 17.92)

Note: the momentum is still generally increasing as the force applied remains positive in direction. mark out the points accurate to half a small square

Qns		Marks
3(a)		
	take pivot at A, by Principle of Moments, sum of clockwise moments = sum of anticlockwise moments	M1
	$(36)\left[0.45\cos(60°)\right] = \left[X\cos(40°)\right](1.2)$	M1
	$X = 8.8$ N	A0
3(b)(i)	vector sum of forces is zero along all directions;	
	horizontally, weight of bar has no rightward component of force to cancel leftward component of X	B1
	no resultant moment about any point;	B1
	the 3 lines of action of (i) force at A, (ii) weight of bar and (iii) *X* must meet at a common point the perpendicular distance of all 3 forces from the common point, and therefore the sum of moments at this common point, is zero	
	Note: the explanation has to relate how the specific situation satisfies the two conditions for equilibrium	

Qns		Marks
3(b)(ii)	Let F be at an angle of θ anticlockwise to the horizontal axis.	



By cosine rule,

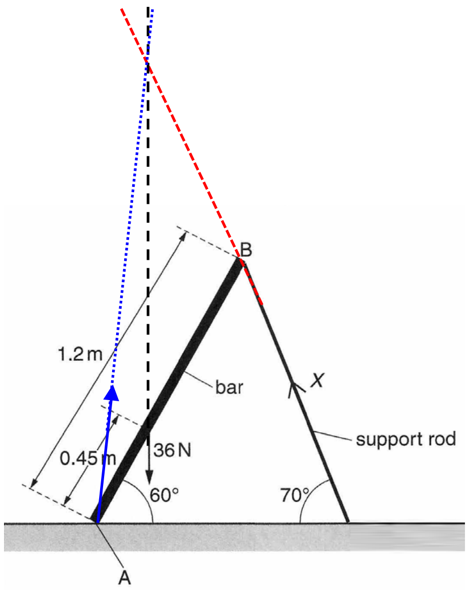
$$F^2 = X^2 + 36^2 - 2(36)(X)\cos 20°$$

$$F = \sqrt{8.8^2 + 36^2 - 2(36)(8.8)\cos 20°}$$

$$= 27.9 \text{ N}$$

Note: since part (a) is a "Show …", it is safe to quote X as the printed value of 8.8 N. Note that F has both vertical and horizontal components. Be careful of the angles used; it is easy to mix up when applying cosine rule.

3(b)(iii)



4(a)1. vast majority of alpha particles pass straight through thing metal foil or are deviated by small angles

most of the target atom is empty space and the volume of the nucleus is very small compared to the atom — B1

4(a)2. a very small minority of about 1 in 8000 alpha particles are scattered through angles greater than 90°

the mass of the positively charged nucleus makes up the majority of the mass of the atom, and is concentrated in a very small nucleus region. — B1

Qns		Marks
4(b)(i)	$E_K = \frac{1}{2}m_\alpha v_\alpha^2$	M1
	$v_\alpha = \sqrt{\frac{2E_K}{m_\alpha}} = \sqrt{\frac{2E_K}{4u}}$	
	$= \sqrt{\frac{2\left(4.8\times10^6\right)\left(1.6\times10^{-19}\right)}{4\left(1.66\times10^{-27}\right)}}$	M1
	$= 1.52\times10^7\ \text{ms}^{-1}$	A0
4(b)(ii)	<u>work done per unit positive charge</u> <u>in moving a small test charge</u> <u>from infinity to that point</u>	
4(b)(iii)	By Principle of Conservation of Energy,	
	loss in E_K = gain in E_P	M1
	$E_K = \frac{1}{4\pi\varepsilon_0}\frac{Q_{Au}Q_\alpha}{d}$	
	$d = \frac{1}{4\pi\varepsilon_0}\frac{Q_{Au}Q_\alpha}{E_K} = \frac{1}{4\pi\varepsilon_0}\frac{(79e)(2e)}{E_K}$	
	$= \frac{1}{4\pi\left(8.85\times10^{-12}\right)}\frac{\left(79\left(1.6\times10^{-19}\right)\right)\left(2\cancel{e}\right)}{\left(4.8\times10^6\right)\left(\cancel{e}\right)}$	M1
	$= 4.74\times10^{-14}\ \text{m}$	A1
	Note: common mistakes include • using the field strength equation, ending up with $\frac{1}{d^2}$ • omitting electronic charge for the gold nucleus/alpha • using 4*e* instead of 2*e* for the alpha charge • using mass numbers instead of proton numbers for charge.	
5(a)	For sinusoidal alternating voltage, $V_{r.m.s.} = \frac{V_0}{\sqrt{2}}$	
	mean power $\langle P\rangle = \frac{V_{r.m.s.}^2}{R}$	M1
	$= \frac{1}{2}\frac{V_0^2}{R}$	
	$= \frac{1}{2}P_{max}$	
5(b)(i)	$\omega = \frac{2\pi}{T}$	
	$= \frac{2\pi}{18\times10^{-3}}$	
	$= 349\ \text{rad s}^{-1}$	A1

Qns		Marks
5(b)(ii)	$V_{\text{r.m.s.}} = \dfrac{V_0}{\sqrt{2}} = \dfrac{170}{\sqrt{2}} = 120\ \text{V}$	A1
5(c)	$V^2 = 170^2$ $V_{\text{m.s.}} = \dfrac{170^2(9)}{18} = \dfrac{170^2}{2}$ $V_{\text{r.m.s.}} = \sqrt{\dfrac{170^2}{2}} = \dfrac{170}{\sqrt{2}} = 120\ \text{V}$	
5(d)(i)1.	alternating p.d. in the primary coil results in alternating current in the primary coil sets up a changing magnetic flux	B1
	there is rate of change of magnetic flux linkage with secondary coil	B1
	Note: need to specific actual location of "source" of changing magnetic flux and location of "receiver" of changing magnetic flux linkage. Answers should not omit terms such as "flux linkage" and "rate of change" of flux linkage.	
5(d)(i)2.	ideal transformer so same magnetic flux at both secondary and primary coil less coils at secondary coil so proportionally less magnetic flux linkage	B1
	induced e.m.f. is directly proportional to the rate of magnetic flux linkage, so the e.m.f. induced across secondary coil is proportionally lower	B1
	Note: "use Faraday's law … to explain" is required so cannot quote $\dfrac{N_s}{N_p} = \dfrac{V_s}{V_p}$. The transformer is described as *ideal* and the secondary circuit is an open circuit so cannot attribute the lower p.d. to eddy current losses or heat losses.	

Qns		Marks

5(d)(ii) consider r.m.s. p.d.'s:

$$\frac{V_{sec}}{V_{pri}} = \frac{N_{sec}}{N_{pri}}$$

$$V_{sec} = \frac{N_{sec}}{N_{pri}} V_{pri}$$

$$= \frac{20}{500} 120$$

$$= 4.8 \text{ V}$$ C1

ideal transformer so:

$$\langle P_{pri} \rangle = \langle P_{sec} \rangle$$

$$V_{pri} I_{pri} = \frac{V_{sec}^2}{R}$$

$$I_{pri} = \frac{V_{sec}^2}{V_{pri} R}$$

$$= \frac{4.8^2}{120(15)}$$

$$= 0.0128 \text{ A}$$ A1

Note: do not mix up the values of current and p.d.'s between the primary, secondary, peak and r.m.s. values of the 2 circuits

6(a)(i) period T generally increases with increasing mass M

the rate of increase in T with respect to the variation of mass M $\left(\frac{dT}{dM}\right)$ increases with as the length of wire l increases. B1

6(a)(ii) To show $T = k\sqrt{M}$, need to keep length l constant.

Taking l = 1.00 m,

T/s	M / kg	$k = \frac{T}{\sqrt{M}}$ / s kg$^{-0.5}$	$\left\lvert\frac{k - \langle k \rangle}{\langle k \rangle}\right\rvert \times 100\%$
1.56	0.20	3.49	0.15
2.06	0.35	3.48	0.03
2.46	0.50	3.48	0.12

M1

Since constant of proportionality k is constant of 3.5 s kg$^{-0.5}$ to 2 s.f. and the percentage difference of each k value is less than 1% from the average A1

Likely that T is proportional to $\sqrt{M}$

Qns		Marks
6(a)(iii)	To show $T = c\sqrt{l}$, need to keep mass *M* constant.	

Taking *M* = 0.50 kg,

T/s	l / m	$c = \frac{T}{\sqrt{l}}$ / s m$^{-0.5}$	$\left\lvert\frac{c - \langle c\rangle}{\langle c\rangle}\right\rvert \times 100\%$
1.23	0.25	2.46	0.002
1.74	0.50	2.46	0.027
2.13	0.75	2.46	0.022
2.46	1.00	2.46	0.002

M1

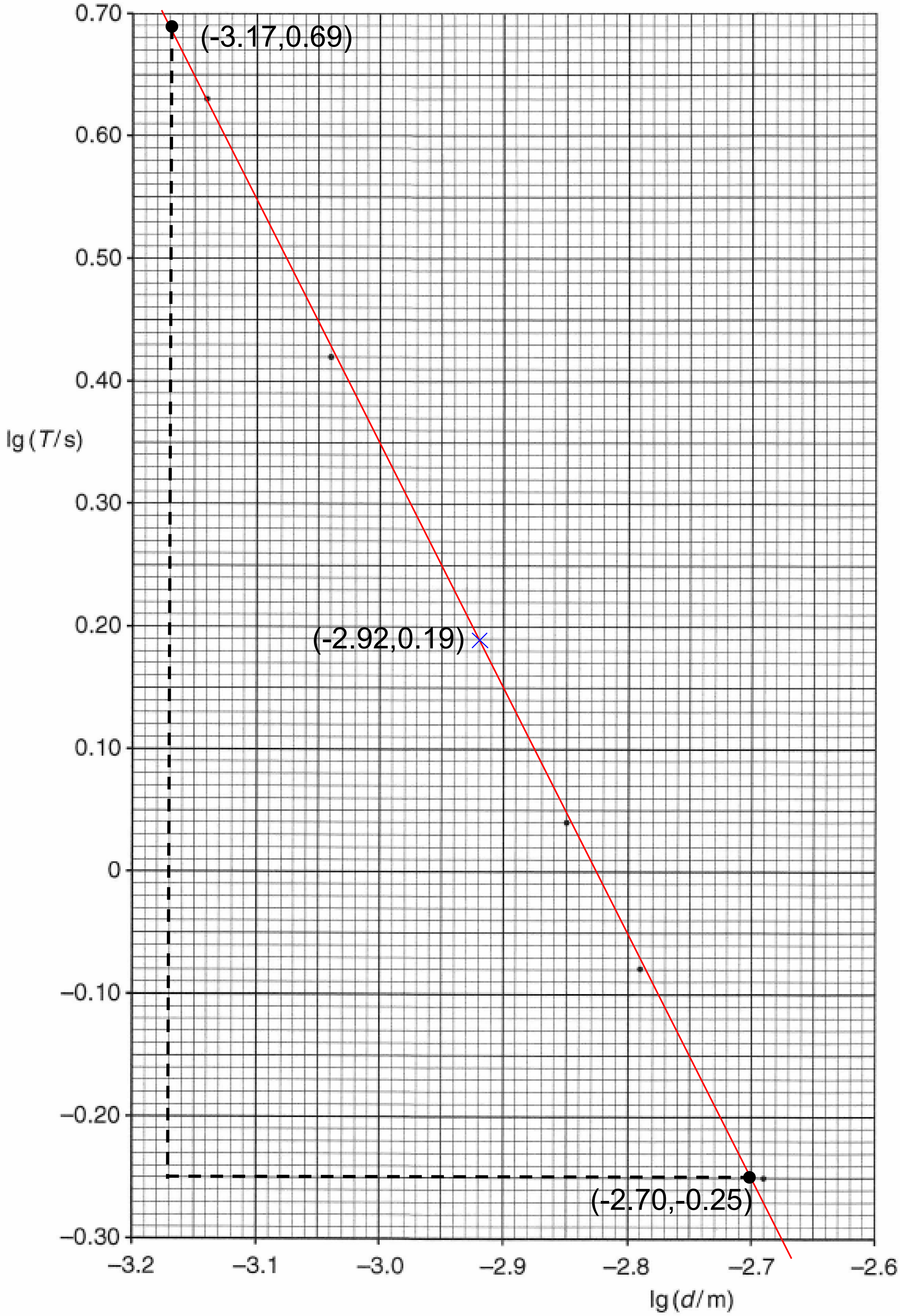
Since constant of proportionality *c* is constant of 2.46 s m$^{-0.5}$ s kg$^{-0.5}$ to 3 s.f. and the percentage difference of each *c* value is less than 1% from the average — A1

Likely that *T* is proportional to $\sqrt{l}$

Note: minimally 3 sets of data to establish relationship. Proportionality constants given to 2 or 3 s.f. and not left as fractions. Need to state the proportionality equation.

6(b)(i)

T/s = 1.56
lg (*T*/s) = 0.19
lg (*d*/m) = - 2.92 — A1

Qns		Marks
6(b)(ii)1 6(b)(ii)2		

Qns		Marks
6(b)(iii)	gradient $=\dfrac{\Delta y}{\Delta x}=\dfrac{-0.25-0.69}{-2.7-(-3.17)}=-2.00$	M1 A1
	Note: avoid careless mistakes when subtracting negative numbers or performing $\dfrac{\Delta x}{\Delta y}$ instead	
6(c)(i)	$T=Kd^{n}\sqrt{Ml}$ $\lg T=n\lg d+\lg\left(K\sqrt{Ml}\right)$ Plot of lg *T* against lg *d* should give a straight line graph of gradient *n* and y-intercept $\lg\left(K\sqrt{Ml}\right)$	 A1
6(c)(ii)	*n* = gradient = -2.00	A1
6(d)	Using *M* = 0.40 kg , *l* = 0.50 m , *n* = -2.00 and (-3.0,0.35) $\lg T=n\lg d+\lg\left(K\sqrt{Ml}\right)$ $=n\lg d+\lg K+\frac{1}{2}\lg(Ml)$ $\lg K=\lg T-n\lg d-\lg\left(\sqrt{Ml}\right)$ $K=10^{0.35-(-2)(-3.0)-\lg\sqrt{(0.4)(0.5)}}$ $=5.01\times10^{-6}$	 C1 A1
6(e)(i)	Displacement from equilibrium position, *x* maximum displacement (amplitude), x_0 Time corresponding to displacement, *t* Period, *T*.	 B1
6(e)(ii)	the displacement from equilibrium position, *x*, can be described by the sinusoidal function $x=x_0\sin\left(\frac{2\pi}{T}t\right)$ which is a solution to the simple harmonic equation $a=-\omega^{2}x$	 B1

Qns		Marks
7 Measure variables	Run #1: keep using same sphere to keep *d* constant vary *h* by supporting wooden plank at two corners using a pair of retort stands, bosses and clamps, and then changing height of the elevated edge of the plank measure *h* using half metre rule from benchtop	1
	Run #2: keep *h* constant vary *d* by using spheres of different diameters measure *d* using Vernier caliper	1
	Both Runs: [can be from diagram] pair of light gates mounted on a wooden plank such that distance between light gates is kept constant. measure distance between light gates using metre rule, "*s*" average speed is *s* divide by time interval as sphere passes both gates	1 1
	linearization $\ln(v) = \ln(C) + x\ \ln(d) + y\ \ln(h)$	1
Analysis	keep *d* constant, plot $\ln(v)$ against $\ln(h)$ straight line with gradient *y*, y-intercept $[\ln(C) + x\ \ln(d)]$	1
	keep *h* constant, plot $\ln(v)$ against $\ln(d)$ straight line with gradient *x*, y-intercept $[\ln(C) + y\ \ln(h)]$	1
	Having found *y* and *x*, using available values, calculate average C using $C = \frac{v}{d^x\ h^y}$	1
Safety	safety precaution use of a net at bench edge / tray of sand on floor to catch rolling sphere	1
Extras	Any good/further detail. Examples of creditworthy points might be: • Method to keep path of sphere straight e.g. carve shallow straight track or U-channel in wooden plank perpendicular to light gates to guide rolling sphere • use same material (and therefore density) for different spheres of varying diameters OR keep same mass of different spheres by using material of different densities for different diameters • measure *d* across different diameters to obtain average diameter • check elevated edge of wooden plank is horizontal using spirit level release sphere at the same position on the wooden plank for all runs	3

Note: Draw line for benchtop such that apparatus doesn't seem to be floating. Clamps and support, when used , should be drawn and labelled. Do not write "control variables"; instead describe how these quantities are kept constant. The distance travelled and the time taken for the spherical objects to roll down needs to be consistent.

In analysis, both the straight line gradient and y-intercept need to be stated.

Paper 3
Longer Structured Questions

Note: Answer questions directly; do not waste time repeating sections of the questions.

Qns		Marks
1(a)	Gain in KE = Loss in Electric PE	
	$\frac{1}{2}mv^2 = qV$	
	$v = \sqrt{\frac{2qV}{m}}$	
	$= \sqrt{\frac{2(1.6\times10^{-19})(850)}{9.11\times10^{-31}}}$	M1
	$= 1.7\times10^{7}\ \text{m s}^{-1}$	A0
1(b)	In horizontal direction,	
	$a_x = 0$	
	$s_x = u_x t$	
	$t = \frac{s_x}{u_x}$	
	$= \frac{5.1\times10^{-2}}{1.7\times10^{7}}$	M1
	$= 3.0\times10^{-9}\ \text{s}$	
	In vertical direction,	
	$a_y = \frac{F_y}{m}$	
	$= \frac{4.0\times10^{-15}}{9.11\times10^{-31}}$	M1
	$= 4.39\times10^{15}\ \text{m s}^{-1}$	
	$v_y = u_y + a_y t$	
	$= 0 + (4.39\times10^{15})(3.0\times10^{-9})$	
	$= 1.32\times10^{7}\ \text{m s}^{-1}$	A1
	Note: A common mistake was to assume that the acceleration continued for 5.1 cm.	
1(c)	$v = \sqrt{v_x{}^2 + v_y{}^2}$	
	$= \sqrt{(1.7\times10^{7})^2 + (1.32\times10^{7})^2}$	M1
	$= 2.2\times10^{7}\ \text{m s}^{-1}$	A1

Qns		Marks
2(a)	Any one: evaporation occurs at <u>any</u> temperature while boiling occurs at a <u>fixed</u> temperature evaporation occurs at the <u>surface</u> of the liquid while boiling occurs <u>throughout</u> the liquid	B1
2(b)	Work done against atmosphere $= p\Delta V$ $= (1.05\times10^5)(1.69)$ $= 1.77\times10^5$ J	 M1 A1
2(c)	Heat supplied to boil 1 kg of water, $Q = ml_v = (1.00)(2.30\times10^6)$ J Work done on gas, $W = -1.77\times10^5$ J (-ve as gas is expanding) Applying first law of thermodynamics, $\Delta U = Q + W$ $= (2.30\times10^6) + (-1.77\times10^5)$ $= 2.12\times10^6$ J Number of molecules in 1.00 kg of water, $N = \frac{1.00}{\text{molar mass}} \times N_A$ $= \frac{1.00}{0.018} \times (6.02\times10^{23})$ $= 3.34\times10^{25}$ Average increase in internal energy of a water molecule $= \frac{\Delta U}{N}$ $= \frac{2.12\times10^6}{3.34\times10^{25}}$ $= 6.35\times10^{-20}$ J **Note:** be careful to distinguish that the question asked for increase per molecule and not per mole.	 M1 M1 A1

Qns		Marks
3(a)	$R_{total} = 1.8 + \left(\frac{1}{2.0} + \frac{1}{3.0}\right)^{-1}$	M1
	$= 3.0\ \Omega$	A1
	$I = \frac{E}{R_{total}}$	
	$= \frac{1.5}{3.0}$	M1
	$= 0.50\ \text{A}$	A0
3(b)	Total load resistance $R_{load} = \left(\frac{1}{2.0} + \frac{1}{3.0}\right)^{-1}$	M1
	$= 1.2\ \Omega$	
	current in load I_{load} = current in cell I_{cell}	
	Ratio $= \frac{P_{load}}{P_{total}}$	
	$= \frac{I_{load}{}^2 R_{load}}{I_{cell}{}^2 R_{total}}$	M1
	$= \frac{R_{load}}{R_{total}}$	
	$= \frac{1.2}{3.0}$	
	$= 0.40$	A1
	Note: be careful to find the power dissipated in the external resistors and not the internal resistance.	
3(c)	effective resistance across parallel resistors is larger than before	
	for the same internal resistance, by potential divider ruler, a larger proportion of the cell e.m.f. is applied across the external resistors	M1
	(as $P = \frac{V^2}{R}$), power dissipated across the external resistor takes up a larger proportion of power transfer in cell so ratio increases	A1
	Note: answer needs to deal with (i) increase in effective resistance of the resistors and parallel and (ii) how the change affects the power ratio.	

Qns		Marks
4(a)	magnetic force always normal to velocity/direction of motion	M1
	magnitude of magnetic force constant OR magnitude of velocity is constant/kinetic energy is constant	M1
	so magnetic force provides the centripetal force for particle to move in circular arc	A1
4(b)	electric force is opposite in direction to magnetic force electric force = magnetic force $qE = Bqv$ $E = Bv$ $= (3.2\times10^{-3})(4.7\times10^{5})$	M1
	$= 1.5\times10^{3}\ \text{V m}^{-1}$	A1
4(c)	magnetic force would increase as it is proportional to speed, while electric force would remain the same as it is independent of speed	M1
	particle would deflect upwards in the direction of magnetic force	A1
	Note: when comparing between 2 forces, need to discussion the changes (if any) to both.	
5	(out of syllabus)	
6(a)(i)	unstable product will decay into another product, increasing the existing count rate	B1
6(a)(ii)	background radiation is less than 1 count per second while count rates in this experiment are in the order of 100 counts per second	M1
	hence systematic error from background radiation is negligible	A1
6(b)	best fit curve drawn	M1
	half-life determined by difference in t read off between 2 different R, where one R is half of the other (e.g. difference in t_1 at R_1 = 400 and t_2 at R_2 = 200 is $t_2 - t_1$ = 19.50 – 4.25 = 15.25 days)	M1 A1
	averaging after reading off another value of half-life from the graph (e.g. difference in t_1 at R_1 = 300 and t_2 at R_2 = 150 is $t_2 - t_1$ = 25.00 – 10.00 = 15.00 days average half-life $= \dfrac{15.25 + 15.00}{2} = 15.13$ days)	(M1) (A1)
	Note: when data for multiple half-lifes (and in other scenarios such as periods across multiple oscillations) is available, take across all and average.	
6(c)	β-particles can penetrate skin and cause structural damage to body cells	B1
	cumulative exposure over time could lead to long term medical problems such as cancer	B1

Qns		Marks
7(a)(i) 1	shortest distance <u>moved</u> in a specified direction of the mass from its equilibrium position	B1
7(a)(i) 2	maximum displacement of the mass from its equilibrium position in either direction	B1
7(a)(ii)	A type of motion where the acceleration of an object is always	
	directed towards the equilibrium position, and	B1
	directly proportional to its displacement from that equilibrium position	B1
7(b)	simple pendulum:	
	component of weight	B1
	perpendicular to string / or tangential to circumference of its swing	B1
	floating block:	
	resultant / vector sum of	
	upthrust exerted by the water on the partially submerged block and	B1
	the block's weight	B1
7(c)	lower surface experiences compressive force and is shorter in length	B1
	upper surface experiences tension and is longer in length	B1
	compression at lower surface and tension in upper surface produce an anti-clockwise moment which balances the clockwise moment of the block's weight	B1
7(d)	since C, E, L and M are constant, the expression $a = -\dfrac{CE}{L^3 M}x$ shows that acceleration is directly proportional to displacement	B1
	negative sign in expression shows that acceleration is opposite to displacement/directed towards the equilibrium position	B1
7(e)(i)	from graph, 5 complete oscillations made in 1.05 s	
	$T = \dfrac{1.05}{5} = 0.210$ s	M1
	$\omega = \dfrac{2\pi}{T} = \dfrac{2\pi}{0.210} = 29.9$ rad s^{-1}	A1
7(e)(ii)	$a = -\omega^2 x = -\dfrac{CE}{L^3 M}x$ Hence $\omega^2 = \dfrac{CE}{L^3 M}$	
	value of $C = \dfrac{\omega^2 L^3 M}{E}$	
	$= \dfrac{29.9^2 \times 0.80^3 \times 0.150}{2.0 \times 10^{11}}$	M1
	$= 3.5 \times 10^{-10}$	A1
	Note: be careful of the powers of ten.	

Qns		Marks
7(f)	from $\omega^2 = \frac{CE}{L^3 M}$,	
	$M = \frac{CE}{L^3\omega^2}$	M1
	$= \frac{(3.5\times10^{-10})(7.1\times10^{10})}{0.80^3\times29.9^2}$	M1
	$= 0.053$ kg	A1
	OR	
	from $M = \frac{CE}{L^3\omega^2}$, $M \propto E$	(M1)
	$\frac{M_{Aluminium}}{M_{steel}} = \frac{E_{Aluminium}}{E_{steel}}$	
	$M_{Aluminium} = \left(\frac{E_{Aluminium}}{E_{steel}}\right)M_{steel}$	
	$= \left(\frac{7.1\times10^{10}}{2.0\times10^{11}}\right)0.150$	(M1)
	$= 0.053$ kg	(A1)
8(a)	discrete packet of electromagnetic radiation with	B1
	energy directly proportional to the frequency of the electromagnetic radiation	B1
8(b)(i)	discrete bright lines of different colours	B1
	on a dark background	B1
8(b)(ii)	each coloured/dark line corresponds to one wavelength or frequency which represents photons of a specific energy given by $E = hf$	B1
	that is emitted/absorbed when orbital electrons undergo specific energy changes when de-exciting/promoting between discrete energy levels in the atom	B1
8(c)(i)	$E = \frac{hc}{\lambda}$	
	$= \frac{(6.63\times10^{-34})(3.0\times10^{8})}{400\times10^{-9}}$	M1
	$= 4.97\times10^{-19}$ J	
	$= 3.11$ eV	A1
	violet is at one end of visible spectrum so this is the maximum energy of photon if visible light	B1
	lowest energy transition to -13.6 eV is -3.41 – (–13.6) = 10.19 eV which is of higher energy than that of violet light	B1
	hence all other transitions must also lie outside the visible range	

Qns		Marks
8(c)(ii) 1	3 (-1.51 eV to -3.41 eV, -0.85 eV to -3.41 eV, -0.55 eV to -3.41 eV) **Note:** common wrong responses include 4 and 7	B1
8(c)(ii) 2	shortest wavelength corresponds to maximum energy maximum energy of transition, $E = -0.55 - (-3.41)$ $= 2.86$ eV $= 4.58 \times 10^{-19}$ J $\lambda = \frac{hc}{E}$ $= \frac{(6.63 \times 10^{-34})(3.0 \times 10^{8})}{4.58 \times 10^{-19}}$ $= 4.34 \times 10^{-7}$ m	M1 A1
8(d)(i)	arrow from -3.41 eV to -13.6 eV (longest wavelength means lowest energy transition that has energy higher than work function of 5.6 eV)	B1
8(d)(ii)	transition produces photon of energy *hf* = -3.41 – (-13.6) = 10.19 eV from $hf = \phi + \frac{1}{2}mv_{max}{}^2$ maximum energy $= \frac{1}{2}mv_{max}{}^2$ $= hf - \phi$ $= 10.19 - 5.1$ $= 4.59$ eV	M1 A1
8(e)(i)	$\text{time} = \frac{\text{distance}}{\text{speed}} = \frac{2.6 \times 10^{-10}}{3.0 \times 10^{8}} = 8.7 \times 10^{-19}$ s	B1
8(e)(ii)	8.7×10^{-19} s	B1
8(e)(iii)	out of syllabus	

Qns		Marks
9(a)(i)	$\frac{GM}{x^2}$	B1
9(a)(ii)	$-\frac{GMm}{x}$	B1
9(b)(i)	curve drawn with decreasing trend and correct shape curve passing through 2 or 3 correct points curve passing through all 4 correct points correct points: $x=R,\ g=g_s$ $x=2R,\ g=\frac{g_s}{4}$ $x=3R,\ g=\frac{g_s}{9}$ $x=4R,\ g=\frac{g_s}{16}$	B1 (B1) B2
9(b)(ii)	gravitational field strength *g* is proportional to mass *M* of sphere *M* decreases, hence graph will show lower values of *g* for all values of *x*	B1 B1
9(c)(i)	gravitational force between the two stars provides centripetal force by Newton's third law, gravitational force by A on B is equal in magnitude and opposite in direction to gravitational force by B on A. **Note:** when using N3L, need to be specific with regard to the type of forces	B1 B1
9(c)(ii)	$\omega=\frac{2\pi}{T}$ $=\frac{2\pi}{4.0\times365\times24\times60\times60}$ $=5.0\times10^{-8}$ rad s^{-1}	M1 A1
9(c)(iii)	centripetal force on A = centripetal force on B $M_A r_A \omega_A{}^2 = M_B r_B \omega_B{}^2$ $M_A r_A = M_B r_B$ (since ω is constant) $\frac{M_A}{M_B}=\frac{r_B}{r_A}=3.0$ $\frac{d-r_A}{r_A}=3.0$ (since $r_B=d-r_A$) $\frac{3.0\times10^{11}-r_A}{r_A}=3.0$ $r_A=7.5\times10^{10}$ m	M1 M1 M1 A1

Qns		Marks
9(d)	gravitational force provides centripetal force	
	$$\frac{GM_AM_B}{d^2}=M_Ar_A\omega^2$$	
	$$\frac{GM_B}{d^2}=r_A\omega^2$$	
	$$\frac{(6.67\times10^{-11})M_B}{(3.0\times10^{11})^2}=(7.5\times10^{10})(5.0\times10^{-8})^2$$	M1
	$$M_B=2.5\times10^{29}\text{ kg}$$	A1
	$$M_A=3M_B=7.5\times10^{29}\text{ kg}$$	A1
9(e)	light intensity reaching the Earth will decrease when one star is blocked by another	B1
	time interval during the lowered intensity is half a period	B1