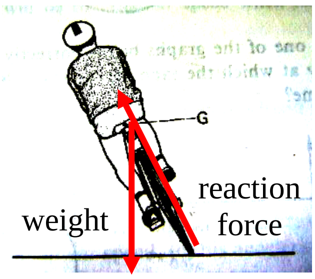
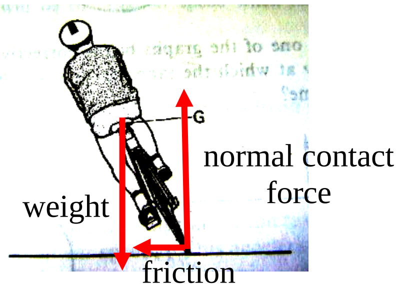
Qn		Answers	Marks
1	**a**	units of $v^2 = (\text{m s}^{-1})^2 = \text{m s}^{-2}$ units of $u^2 = (\text{m s}^{-1})^2 = \text{m s}^{-2}$ units of $2as = \text{m s}^{-2} \times \text{m} = \text{m s}^{-2}$ Since the units of all the terms are the same, the equation is homogenous. units of v^2, u^2, and $2as$ presentation and conclusion	B1 B1
	b	$mass = (length \times width \times height) \times density$ $= (1.99 \times 1.95 \times 2.02) \times 1.24 = 9.7199 = 9.71\ g$ $By\ calculating\ percentage\ /\ fractional\ uncertainty: \frac{\Delta m}{m}$ $= \frac{\Delta l}{l} + \frac{\Delta w}{w} + \frac{\Delta h}{h} + \frac{\Delta \rho}{\rho} = 0.01 + 0.01 + 0.01 + \frac{0.05}{1.24}$ $= 0.070323 \Delta m = 0.070323 \times 9.7199 [* M1] = 0.68353$ $= 0.7\ g$ $mass = (9.7 \pm 0.7)\ g$ Alternatively, max-mean method: m_{max} = (1.99 x 1.01)(1.95 x 1.01)(2.02x1.01)(1.29) = 10.418 g $\Delta m = m_{max} - m_{mean} = 10.418 - 9.7199 = 0.7\ g$	C1 C1 C1 A1 (C1) (C1)

2	**a**	Use of *mgh = ½ m v²* ***and*** *makes h subject* h = 14.7 or 15 m	 A1
	bi	Calculate the final vertical velocity at C (using v = 0 + at=9.81x1.6) v = 15.7 or 16 m s^{-1}	C1 A1
	bii	Straight line of positive gradient) Starting at 0 ms^{-1} and ends at 16 ms^{-1} at 1.6 s.	 A1
	biii	Use of pythagoras' theorem: resultant $v^2 = 15.7^2 + 17^2$ v = 23 or 23.1 m s^{-1}	M1
	c	slope: smaller change in vertical component of velocity/ smaller change in vertical component of momentum by Newton's second law, the force experienced = rate of change of momentum is less, so less risk of injury	M1 A1
3	**ai**	Archimedes' Principle states that the <u>upthrust</u> on a body completely or partially submerged in a fluid is <u>equal</u> in magnitude and opposite in direction <u>to the weight of the fluid</u> the body <u>displaces</u>.	B1
	aii	Pressure increases with depth in a fluid. When an object is submerged in a fluid, bottom is at a greater depth than at the top, hence, the <u>pressure is greater at the bottom than at the top of the object</u>. The difference in pressure <u>results in a net upward force</u> acting on the object, which is upthrust.	B1 B1
	b	$F_{net} = 0$ $m_{total}g = U + F_{resistive}$ $m_{submarine}g + m_{seawater}g = \rho g V_{submarine} + F_{resistive}$ $4800(9.81) + m_{seawater}(9.81) = (1030 \times 9.81 \times 5) + 1100$ $m_{seawater} = 462$ kg	 C1 C1 A1
	c	$P = P_o + \rho g h$ $= 1.01 \times 10^5 + (1030 \times 9.81 \times 200)$ $= 2.12 \times 10^6$ Pa	 A1

4 **(a)**





1 mark for correct direction of arrows B1
1 mark for similar length of arrows in vertical direction B1

(b) Since frictional force provides for the centripetal force,

$$f = \frac{mv^2}{R}$$

$$70 = \frac{(80)v^2}{55}$$

$$v = 6.9 \text{ m s}^{-1}$$ A1

(c) **(i)** For a surface which is banked, the horizontal component of the normal reaction is an <u>additional source of the centripetal force</u>. B1

Since <u>Centripetal Force = $\frac{mv^2}{r}$</u>, an increase in the centripetal force would allow the rider to turn the corner at a higher speed without slipping, provide the <u>mass of cyclist and bicycle and radius of turn remain constant.</u> B1

(ii) Considering forces acting on the rider/bicycle in the horizontal direction:

$$N \sin 20° + f \cos 20° = \frac{mv^2}{r} \quad \text{---------------------- (1)}$$ C1 C1

For the equilibrium in the vertical direction:

$$N\cos 20° = mg + f\sin 20° \quad \text{--------------------(2)}$$

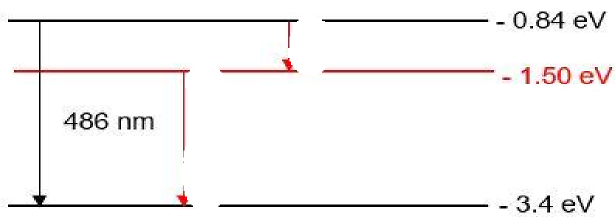
Solving (1) & (2),

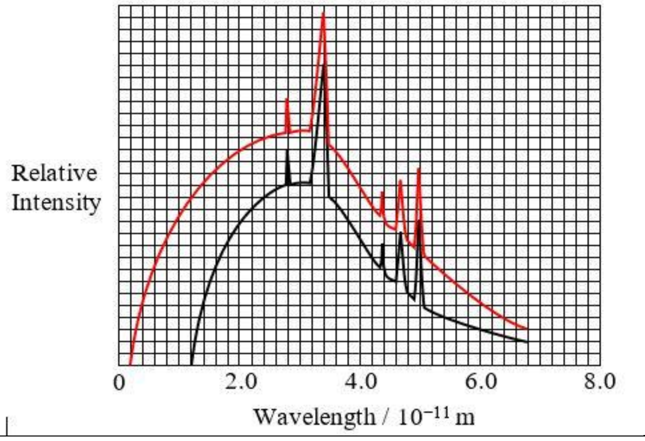
$$\tan 20° \left(mg + f \sin 20°\right) = \frac{mv^2}{r} - f \cos 20°$$ A1

∴max velocity during turning v = 15.7 m s^{-1}

5	**a**	The rocket experiences equal and opposite gravitational forces exerted by Earth and Moon. Hence there is zero net force as the forces cancel out.	B1
	b	1. Moon does not have an atmosphere hence there is no need to supply energy to do work against air resistance. 2. The gain in gravitational potential energy from Moon to P is much lower than that from Earth to P hence less kinetic energy is required for the rocket to move from Moon to P.	B1 B1
	c	At P, $F_E = F_M$ $\frac{GM_E m}{d_E^{\,2}} = \frac{GM_M m}{d_M^{\,2}}$ $M_M = \frac{(5.97 \times 10^{24})(3.80 \times 10^7)^2}{(3.46 \times 10^8)^2}$ $= 7.20 \times 10^{22}$ kg	 C1 A1
	di	The gravitational potential at a point is the work done per unit mass in bringing a point mass from infinity to that point.	B1
	dii	$\phi_P = -\frac{GM_E}{d_E} - \frac{GM_M}{d_M}$ $= -(6.67 \times 10^{-11})\left(\frac{5.97 \times 10^{24}}{3.46 \times 10^8} + \frac{7.20 \times 10^{22}}{3.80 \times 10^7}\right)$ $= -1.277 \times 10^6$ J kg^{-1} KE = Loss in GPE $= (7.5)\left[0 - (-1.277 \times 10^{16})\right]$ $= 9.58 \times 10^6$ J	 C1 C1 A1

6	**ai**	Total resistance of the 4 parallel resistors = $(1/2R + 1/2R)^{-1} = R$. $I = E/(R + r)$.	B1 A1
	aii	Power in the 4 parallel resistors = $I^2 R$, where $I = E/(R+r)$ Power in the battery = IE $\frac{power\ in\ external\ resistors}{power\ by\ batter} = \frac{I^2 R}{IE}$ or $\frac{I^2 R}{I^2(R+r)}$ $= \frac{I\ R}{E}$ $= \frac{E\ R}{R+r}\frac{1}{E}$ $= \frac{R}{R+r}$	M1 A0
	aiii	Having 4 resistors in a network shown in Fig. 6.1, each resistor only dissipates ¼ of the power compared to a single resistor. Hence one of the resistors in Fig. 6.1 is less likely to exceed the power rating.	B1
	bi	There will be no deflection in the galvanometer when the p.d across JY = 1.5 V. Let the balance length (between J and Y) be L. Then $V_{JY} = \frac{L \times 1.50}{(1.50+0.50)} \times 4.0 = 1.5$ L = 0.500 m.	C1 A1
	bii	When 4.7 ∧ connected with the 1.5 V cell, the terminal p.d across the 4.7 ∧ is $V = \frac{4.7}{4.7+0.50} \times 1.5 = 1.356\,V$ There will null deflection when V_{JY} = 1.356 V. Then $V_{JY} = \frac{L' \times 1.50}{(1.50+0.50)} \times 4.0 = 1.356$ L' = 0.452 m. Alternative working: $L' = \frac{1.356}{3} \times 1.0 = 0.452\ m$	C1 C1 A1

7	a	{Similarity} The discrete lines of both absorption and emission spectrum occur at <u>same frequencies</u>, {Difference} the absorption has <u>dark lines</u> against a continuous spectrum whereas the emission spectrum has <u>coloured lines</u> against a black background.	B1 B1
	bi	E = hf = $\frac{hc}{\lambda}$ = $\frac{(6.63\times10^{-34})\times(3.0\times10^{8})}{656\times10^{-9}\times(1.6\times10^{-19})}$ = 1.90 eV	M1 A1
	bii	 Energy level labelled -1.50 eV and nearer to -0.84 eV	A1
	c	0.92 eV Nothing happens to the lithium atom (ie. it stays in the -5.02 eV level) 0.92 – (5.02 – 4.53) = 0.43 eV Atom will be excited to the -4.53 eV level	A1 B1 A1 B1
	di	When the <u>highly energetic electrons</u> <u>knock out the electrons</u> in the <u>inner shell of the atoms</u>, leaving a vacancy. Electrons in the next higher energy levels <u>transit down</u> to the vacancy and <u>X-ray photons are produced</u> with energy equal to the energy difference between the 2 energy levels.	B1 B1
	dii	$eV = \frac{hc}{\lambda_o}$ $V = \frac{hc}{e\lambda_o} = \frac{(6.63\ x\ 10^{-34})(3.0\ x\ 10^{8})}{(1.6\ x\ 10^{-19})(1.2\times10^{-11})}$ $= 1.04\times10^{5}\ V$ = 104 kV	C1 A1
	diii	Same characteristic wavelengths, lower threshold wavelength, higher intensity	A1

<table>
<tr><td></td><td></td><td>
</td><td></td></tr>
<tr><td>8</td><td>(a)</td><td>There are <u>3 positively charged particles</u>
<u>Applying Fleming's Left Hand Rule</u>, there are 3 lines curving to the left.</td><td>A1
M1</td></tr>
<tr><td></td><td>(b)(i)</td><td>$r \alpha \frac{p}{q}$
Compared to other tracks, the <u>radius of the track in Fig. 8.3 is the smallest</u>.
The <u>mass of electron is small</u>. Its momentum and the radius will be small.

Hence the proposal is possible.</td><td>M1

A1</td></tr>
<tr><td></td><td>(b)(ii)</td><td>The electron <u>loses energy</u> as it travels through the chamber.
Its <u>momentum and hence its radius decreases</u>, resulting in a spiral.</td><td>B1
B1</td></tr>
<tr><td></td><td>(c)(i)</td><td>Conservation of charge gives
(Charge of K^-) + (proton charge) = Total charge after collision
(-e) + (+e) = (+e) + (–e) + (+e) + q_4
⇒ $q_4 = -e$</td><td>C1
A1</td></tr>
<tr><td></td><td>(c)(ii)</td><td>$r \alpha \frac{p}{q}$
Particle 3 has the lowest momentum because r is smallest.</td><td>A1</td></tr>
<tr><td></td><td>(d)(i)</td><td>It causes little or no ionization in the target atoms, so it leaves no track.</td><td>B1</td></tr>
<tr><td></td><td>(d)(ii)</td><td>They are oppositely charged,

as the paths curve in opposite directions, implying that the magnetic force points in opposite directions,

OR,
because they are formed from a neutral particle.</td><td>B1

B1</td></tr>
<tr><td></td><td>(e)(i) 1.
(e)(i) 2.</td><td><table>
<tr><td>particle</td><td>p_x / 10^{-20} N s</td><td>p_y / 10^{-20} N s</td><td>p_z / 10^{-20} N s</td><td>E / 10^{-12} J</td></tr>
<tr><td>K^-</td><td>438.05</td><td>-13.24</td><td>0.81</td><td>1317.12</td></tr>
<tr><td>p</td><td>0.00</td><td>0.00</td><td>0.00</td><td>150.13</td></tr>
<tr><td>sum</td><td>438.05</td><td>-13.24</td><td>0.81</td><td>1467.25</td></tr>
</table></td><td>A1</td></tr>
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<tr><td></td><td></td><td>
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<tr><th>particle</th><th>p_x / 10^{-20} N s</th><th>p_y / 10^{-20} N s</th><th>p_z / 10^{-20} N s</th><th>E / 10^{-12} J</th></tr>
<tr><td>K^-</td><td>79.03</td><td>1.48</td><td>11.95</td><td>252.50</td></tr>
<tr><td>Ω^-</td><td>7.98</td><td>-0.60</td><td>2.07</td><td>33.38</td></tr>
<tr><td>Ω^+</td><td>2.02</td><td>-6.52</td><td>-1.21</td><td>30.51</td></tr>
<tr><td>P</td><td>80.46</td><td>6.85</td><td>-3.76</td><td>285.22</td></tr>
<tr><td>K^0</td><td>189.10</td><td>-8.69</td><td>-13.07</td><td>574.78</td></tr>
<tr><td>sum</td><td>358.59</td><td>-7.48</td><td>-4.02</td><td>1176.39</td></tr>
</table>
</td><td>A1</td></tr>
<tr><td></td><td>(e)(ii)1</td><td>$p_x = (438.05 - 358.59) \times 10^{-20} = +79.46 \times 10^{-20}$ N s

$p_y = (-13.24 + 7.48) \times 10^{-20} = -5.76 \times 10^{-20}$ N s

$p_z = (0.81 + 4.02) \times 10^{-20} = +4.83 \times 10^{-20}$ N s

$E = (1467.25 - 1176.36) \times 10^{-12} = 290.86 \times 10^{-12}$ J</td><td>A1

A1

A1

A1</td></tr>
<tr><td></td><td>(e)(ii)2</td><td>$m = \sqrt{\frac{E^2 - (p_x{}^2 + p_y{}^2 + p_z{}^2)c^2}{c^4}}$
$= \sqrt{\frac{(290.87 \times 10^{-12})^2 - ((79.46 \times 10^{-20})^2 + (5.77 \times 10^{-20})^2 + (4.83 \times 10^{-20})^2)c^2}{c^4}}$
$= 1.835 \times 10^{-27}$ kg</td><td>C1

A1</td></tr>
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