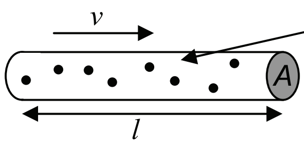
PH1

<table>
<tr><th colspan="3">Question</th><th>Marking details</th><th>Marks Available</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>Rate of change [accept: increase] of velocity [not speed].
accept: $\frac{v-u}{t}$ or $\frac{\Delta v}{t}$ or $\frac{\Delta v}{\Delta t}$ (not $\frac{v}{t}$)</td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>Both ΣF calculated correctly (20 N and 4 N) (1)
Use of $a = \frac{\Sigma F}{m}$ (1)
Accelerations = 10 m s^{-2} and 2 m s^{-2} (e.c.f.) (1)
[Accept answers based upon calculating resultant acceleration]</td><td>3</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Diagram with forces shown in opposition (1) and horizontal (1)
[B.o.d. on plan-view forces unless clearly incorrect]</td><td>2</td></tr>
<tr><td></td><td>(c)</td><td></td><td><table>
<tr><th>Statement</th><th>Must be true</th><th>Could be true</th><th>Cannot be true</th></tr>
<tr><td>xxxxxxxxxxx</td><td></td><td></td><td>✓</td></tr>
<tr><td>xxxxxxxxxx</td><td></td><td>✓</td><td></td></tr>
<tr><td>xxxxxxxxx</td><td></td><td>✓</td><td></td></tr>
<tr><td>xxxxxxxxxx</td><td></td><td></td><td>✓</td></tr>
</table></td><td>4

[10]</td></tr>
<tr><td>2.</td><td>(a)</td><td></td><td>Same p.d. in both branches (1)
2 × resistance in upper branch (or converse) (1) } Correct qualitative
½ current in upper branch (or converse) (1) } answer → 1 mark
Currents add up to 0.12 A (1)</td><td>4</td></tr>
<tr><td></td><td>(b)</td><td>(i)
(ii)</td><td>4.8 V
9.6 V</td><td>1
1</td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>Correct use of $R = \frac{V}{I}$ (1) [or by implication] = 120 Ω (1)
[e.g. $\frac{4.8}{0.04}$ ✓, $\frac{9.6}{0.08}$ (✓ b.o.d.) or $\frac{9.6}{0.4}$ ✓ not $\frac{9.6}{1.2}$ ×]</td><td>2</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>$\frac{1}{R} = \frac{1}{R_A} + \frac{1}{R_B}$ [or equiv.] and use of correct values of R_A and R_B. [or by impl.](1)
R = 80 Ω (1)
or $R = \frac{9.6}{0.12}$ (1) =80 Ω (1)</td><td>2

[10]</td></tr>
</table>

Question			Marking details	Marks Available
3	*(a)*	(i)	2.4 V	1
		(ii)	$\frac{V}{V_{\text{TOTAL}}} = \frac{R}{R_{\text{TOTAL}}}$ or $V_{\text{OUT}} = \frac{R_1}{R_1 + R_2} V_{\text{IN}}$, selected [or by impl.] Substitution, e.g. $3.6 = \frac{225}{225 + R_2} 6.0$ (1) [or by impl.] Manipulation (1); $R_2 = 150\ \Omega$ (1) **Or** – from 1st principles: $\frac{3.6}{225}(1) = 0.016\text{ A}\ (1)$; $\frac{2.4}{0.016}(1) = 150\,\Omega\,(1)$ [or $\frac{6.0}{0.016} = 375\,\Omega$ then 375 – 225 = 150 Ω]	4
	(b)	(i)	R_2 changed to 1500 Ω	1
		(ii)	Initial current = $\frac{6.0}{375\text{e.c.f.}}$ (1) = 0.016 A (1) Final current = 0.0016 A (1) [**or** accept answer based upon a good qualitative argument] N.B. Calculation of final current → only 2 unless current previously calculated]	3
				[9]
4.	*(a)*		Collisions between electrons and lattice [or atoms of the conductor or [metal] ions] (1) Kinetic energy of electrons transferred to lattice (1) <u>No collisions</u> (and ∴ no energy transfer) in superconductors) (1) [accept: interactions instead of collisions]	3
	(b)	(i)	–190°C	1
		(ii)	A→B [accept –250 - –190, or "temperatures below –190] [full region required]	1
	(c)		liquid nitrogen [accept: liquid helium]	1
				[6]

Question			Marking details	Marks Available
5.	*(a)*		Flow of charge	1
	(b)	(i)	 n [free] electrons per unit volume [or electron density] [or in written answer] Diagram (1) Volume of conductor = Al Number of free electrons = nAl Total charge flowing within $l = nAle$ } (1) [Accept without [ ] **if** diagram is clear] $I = \frac{nAle}{t}$ (1) and $v = \frac{l}{t}$ (1)	4
		(ii)	$v = \frac{I}{nAe}$ $= \frac{3.0}{5.0 \times 10^{28} \times 2 \times 10^{-6} (1) \times 1.6 \times 10^{-19}} = 1.9 \times 10^{-4}$ m s^{-1} ((**unit**))(1)	2
		(iii)	I. ……the same as II. …….half…..	1 1 **[9]**
6	*(a)*		Units of LHS = N = kg m s^{-2} Units of RHS = (kg m^{-3} . m^2) (+ manip.)(1) × (m^2 s^{-2}) (1) $v^2 = \frac{2.8 \times 10^4}{1.2 \times 15 \times 4.2}$ (1) [or by impl.] v = 19.2 m s^{-1} (1)	3 2
	(b)	(i)	Centre of gravity	1
		(ii)	Bottom of near-side wheel labelled as 'pivot' $F_{wind} \times 2.1$ (1) = $1.0 \times 10^5 \times 1.4$ (1) [or by impl.] $\therefore F_{wind}$ = 67 kN (1) [accept 66 kN ✓b.o.d.]	1 3 **[10]**

Question			Marking details	Marks Available
7.	*(a)*	(i)	Ball is seen to stay directly in front of the passenger [**or** clearly implied by 2nd statement]. (1) No [horizontal] forces on ball [so horizontal speed is constant, with the same value as the train] (1)	2
		(ii)	Observer sees the ball moving in the same direction as the train [with the same speed]. [Accept: "moving with the train."]	1
	(b)		Passenger sees the ball accelerating [or moving] 'backwards' [or towards the rear of the train]. Observer sees the ball moving in the same direction as the train with decreasing speed. (1) Net [horizontal] force on ball [due to air resistance] towards the back of the train. (1)	3
		(i)	The graph is symmetrical / up time = down time.	1
		(ii)	$x = 11$ m ; $t = 1.5$ s (1) $x = \frac{u+v}{2}t$, **or** $11 = \frac{u}{2} \times 1.5$ (1) **or** $v^2 = u^2 + 2ax$ **or** $0 = u^2 + 2 \times 9.81 \times 11$ (1) **or** $x = ut + ½ at^2$, **or** $11 = 1.5u + ½\, 9.81 \times 1.5^2$ (1) $\therefore u = 14.7$ m s^{-1} (1) [accept $v = u + at$ with $v = 0$ and $t = 1.5$ s]	3
		(iii)	**Graph**: v axis – 20 to + 20 e.c.f. (1) Intercept on v axis 14.7 m s^{-1} e.c.f. (1) Straight line graph (1) to intercept time axis of 1.5 s (1) Graph continued straight beyond 1.5 s to negative values of v (1)	5 **[15]**

Question			Marking details	Marks Available
8	*(a)*		Energy cannot be created or destroyed (1) …[only] changed from one form into another (1) [Accept: total energy [in the Universe] is constant for 1st mark]	2
	(b)	(i)	Area under graph = energy stored (1) [or by impl.] x = 70 m chosen (1) [or by impl.] Elastic potential energy [= ½ ×1600 × 70] = 56 kJ (1) **Alternative:** calculation of k [22.9 N m^{-1}] or left as, e.g. $\frac{1600}{70}$ ✓ Use of x = 70 m to calculate energy ✓; Energy stored = 56 kJ ✓	3
		(ii)	70 kJ – 56 kJ (e.c.f.) (1) = mgh (1) [**Or** E_p(grav) lost = 60×9.81×96 (1) [= 56 kJ]. ∴ 14 kJ = mgh (1)] ∴ h = 23.8 m (1) **Alternative:** 7.0 × 10^4 J = mgh ✓→ h = 118.92 m ✓ Then subtract 96 m → 22.92 m ✓	3
		(iii)	Tension in 'bungee' = weight of Jumper = 60 × 9.81 [= 589 N] (1) From graph x = 26 [± 1] m (1) [or from k → 25.8 m] ∴ d = 52 m. (1)	3 **[11]**