Question	Answer	Marks	AO Element	Notes	Guidance
1	any **two** from: (2) - weight **OR** force of / due to gravity acts down - (force of / due to) air resistance / drag / friction acts up / opposes motion - initially / up to 10 s: resultant force is downward **OR** downward force is greater than upward force - resultant force causes acceleration air resistance increases as speed increases / she accelerates any **two** from: (2) - acceleration (down) initially / for first 10 s - acceleration decreases as air resistance increases / resultant force decreases - zero acceleration / constant speed / terminal velocity reached when upwards force = downwards force **OR** when no / zero resultant **OR** when forces balanced **OR** when downward force = air resistance - terminal velocity / constant speed reached after (about) 10 s **OR** at 60 m / s	**4**			
2(a)	X near (30,60)	**1**			

Question	Answer	Marks	AO Element	Notes	Guidance
2(b)	Y **AND** Z near any horizontal section of graph	**1**			
3(a)	$v = d \div t$ in any form **OR** (t =) $d \div v$ **OR** 3.9 ÷ 0.3 (1) (t =) 13 s (1)	**2**			
3(b)	inward arrow labelled F towards centre of circle	**1**			
4(a)	(a =) $(v - u) \div t$ **OR** (62 – 6.0) ÷ 35 **OR** 56 ÷ 35 (1) 1.6 m / s^2 (1)	**2**			
4(b)	(F =) ma **OR** $\Delta p \div \Delta t$ **OR** $2.5 \times 10^5 \times 1.6$ **OR** $(62 \times 2.5 \times 10^5 - 6.0 \times 2.5 \times 10^5) \div 35$ (1) 4.0×10^5 N (1)	**2**			
4(c)	(p =) mv **OR** $2.5 \times 10^5 \times 6.0$ (1) 1.5×10^6 kg m / s (1)	**2**			

Question	Answer	Marks	AO Element	Notes	Guidance
5	curve of decreasing gradient from (0,0) to a point along dashed line (1) straight line of positive gradient after t = 35 s (1) gradient not zero at t = 35 s **OR** no change of gradient (at t = 35 s) (1)	**3**			
6	rate of change of velocity **OR** change in speed per unit time / s	**1**			
7	gradient (1) (gradient =) change of speed ÷ time (1)	**2**			
8(a)	$a = \Delta v / \Delta t$ **OR** $a = (v - u) / t$ in any form words, symbols or numbers **OR** (a =) $\Delta v / \Delta t$ **OR** (a =) $(v - u) / t$ **OR** 15 (– 0) / 5.0 **OR** (a =) gradient (1) 3.0 m / s^2 (1)	**2**			

Question	Answer	Marks	AO Element	Notes	Guidance
8(b)	(*F* =) *ma* in any form words, symbols or numbers **OR** (*F* =) *ma* **OR** 2300 × 3.0 (1) 6900 N (1)	**2**			
9	line starts at origin **AND** is asymptotic to *x*-axis (1) increasing gradient initially **AND** no decrease (1) constant **AND** clearly positive gradient finally (1)	**3**			
10(a)	*v* = *d*/*t* **OR** *v* = 2*d*/*t* in any form (1) $1500 = \frac{2d}{0.50}$ **OR** 2*d* = 1500 × 0.50 (1) 380 m (1)	**3**			
10(b)	distance smaller (first box ticked) **AND** speed of sound lower (in air than liquid)	**1**			
11	rate of change of speed **OR** change of speed / time **OR** Δv / t **OR** (v – u) / t	**1**			

Question	Answer	Marks	AO Element	Notes	Guidance
12	change of distance / change of time **OR** (250 – 70) / (30 – 15) **OR** 180 / 15 (1) 12 m / s (1)	**2**			
13(a)	0 (m/s^2)	**1**			
13(b)	1.4×10^4 N	**1**			
14(a)(i)	(4800 / 120 =) 40 m / s	**1**			
14(a)(ii)	(*v* =) gradient of any part of straight line (1) value between 50 and 60 m / s (1)	**2**			
14(a)(iii)	at *t* = 20 s, acceleration > zero / acceleration is taking place / greater acceleration than at 100 s (1) at *t* = 100 s, acceleration = zero / 0 (1)	**2**			
14(b)(i)	(*F* =) *ma* **OR** $5.6 \times 10^5 \times 0.75$ (1) 4.2×10^5 N (1)	**2**			

Question	Answer	Marks	AO Element	Notes	Guidance
14(b)(ii)	speed / velocity decreases (with time) **OR** slowing down **OR** negative acceleration **OR** rate of decrease of speed / velocity	**1**			
15	tangent on graph **OR** gradient **OR** (a =) $\Delta v \div \Delta t$ or $(v - u) \div t$ (1) gradient increases (1) values from tangent or line 13 to 14 m / s^2 (1)	**3**			**not** gradient decreases
16(a)	gradient changes **OR** graph is curved	**1**			
16(b)	mass of space rocket <u>decreases</u> **OR** gravitational field strength decreases	**1**			
17	towards the centre of the circle / inwards (1) velocity is (continually) changing its direction (1)	**2**			

Question	Answer	Marks	AO Element	Notes	Guidance
18	rate of change of velocity **OR** change of velocity / time **OR** change of velocity over time **OR** (v – u)/t	**1**			
19	straight line from origin to (15, 28) (1) horizontal line {from (15, 28)} to (32, 28) (1) a = (v – u) / t **OR** (t =) (v – u) / a **OR** (0 – 28) / 2.0 (1) = 14 (s) (1) straight line from (32, 28) to (46, 0) (1)	**5**			
20(a)(i)	distance = area under graph **OR** 0.5 × 20 × 13 130 m	**2**			
20(a)(ii)	(*a* =) (*v* – *u*) / *t* **OR** (*a* =) *v* / *t* **OR** 13 / 20 0.65 m / s^2	**2**			
20(a)(iii)	(*F* =) *ma* **OR** 1200 × 0.65 = 780 N	**2**			

Question	Answer	Marks	AO Element	Notes	Guidance
20(b)	acceleration decreases **OR** rate of increase of speed decreases **OR** speed increases at a lower rate	**1**			
21	$v = d / t$ or $2 d / t$ in any form $d = v t / 2$ **OR** $3.0 \times 10^8 \times 2.56 / 2$ 3.84×10^8 m **OR** 3.84×10^5 km	**3**			
22(a)	$F = m a$ in any form **OR** (a =) F / m **OR** (a =) 3500 / 1400 (a =) $2.5\,\text{m/s}^2$	**2**			
22(b)	$a = (v - u) / t$ in any form **OR** (t =) $(v - u) / a$ **OR** (t =) (30 – 0) / 2.5 **OR** 30 / 2.5 (t =) 12 s	**2**			
22(c)	friction / air resistance / drag	**1**			
23(a)	(v =) at **OR** 2.2 x 3.0 6.6 m / s	**2**			

Question	Answer	Marks	AO Element	Notes	Guidance
23(b)	3.3 m / s	**1**			
23(c)	curve/line starts at origin initial gradient zero **OR** curve passing through (3.0, 9.9) gradient increasing (with time)	**3**			
24(a)	straight line **and** non-zero gradient	**1**			
24(b)	scale ≥ 1 cm: 1 m / s two arrows/lines and correct resultant **OR** rectangle and correct diagonal (towards bottom left) 7.2→7.6 m / s 26.0° ≤ angle below E–W ≤ 30.5° **OR** 239.5° ≤ bearing ≤ 244°	**4**			
25	*(d =) vt* in any form: words, symbols, numbers	**C1**			
	41 m **or** 40.8 m	**A1**			

Question	Answer	Marks	AO Element	Notes	Guidance
26(a)	less (1st box ticked)	**B1**			
26(b)	any mention of mass/inertia	**B1**			
	well-reasoned explanation involving less mass	**B1**			special case: more weight/heavier **AND** more friction for **B2**
27	(resultant force =) 4000 N	**C1**			
	(M = 50 000/10 =) 5000 kg	**C1**			
	(a = 4000/5000 =) 0.80 m/s^2	**A1**			e.c.f previous lines, accept 1 sig. fig.
28	same area	**B1**			
	area represents distance travelled	**B1**			

Question	Answer	Marks	AO Element	Notes	Guidance
	distance up = distance down **OR** overall displacement = 0 **OR** area above = distance up **AND** area below = distance below	**B1**			
29	any three from: • all of graph below *x*-axis after B • final section horizontal and above CD **AND** gradient always < or equal to 0 • continuous graph from B until time > at DE • new area not clearly different from old	**B3**			
30	(a =) $\Delta v/t$ **OR** $(v–u)/t$ **OR** 10.5 / 1.5	**C1**			
	= 7.0 m / s^2	**A1**			

Question	Answer	Marks	AO Element	Notes	Guidance
31(a)	(a =)$\Delta v/t$ **OR** 30 / 1 **OR** 15 / 0.5 etc. **OR** triangle on graph / tangent	**C1**			
	25 m / s^2 < a < 35 m / s^2	**A1**			(**ignore** – sign)
31(b)	*(F =)ma* **OR** 750 × 30	**C1**			e.c.f. from **(a)**
	2.2 / 2.25 / 2.3 × 10^4 N	**A1**			e.c.f. from **(a)**
32	uses $v = d / t$ in any form or d / t	**C1**			
	(av. vel = 50 / 40 =) 1.3 m / s or 1.25 m / s	**A1**			
33	(distance travelled =) area under line (of speed-time graph) (1) 45 x 10 (1) 450 (m) (1)	**3**			

Question	Answer	Marks	AO Element	Notes	Guidance
34(a)	6.5 (s)	**1**			
34(b)	(resultant force is) zero (1) (because the) speed (of parachute) is constant / steady / uniform (1)	**2**			
35	speed = distance ÷ time (1) 25 ÷ 0.2(0) (1) 125 (cm / s) (1)	**3**			
36(a)	same distance travelled in same time / 0.02 s / dots equally spaced	**1**			
36(b)	trolley accelerates **OR** trolley increases speed / velocity (1) a resultant force is acting on the trolley (1)	**2**			
37	it / velocity / speed changes / increases (with time) (1) it / velocity / speed <u>increases</u> at constant rate / steadily (1)	**2**			

Question	Answer	Marks	AO Element	Notes	Guidance
38	distance = area under graph stated in any form (1) (distance = $\frac{0.5 \times 0.75}{2}$ =) 0.19 m (1)	**2**			
39	(average speed =) $\frac{\textit{initial speed} + \textit{final speed}}{2}$ words, symbols or numbers **OR** (average speed =) $\frac{\textit{distance (from area)}}{\textit{time}}$ words, symbols or numbers (1) (average speed = 40 / 2 =) 20 m / s **OR** (average speed = 80 / 4 =) 20 m / s (1)	**2**			
40	any **three** from : initially velocity increases **OR** the metal ball is accelerating **OR** (downwards) resultant force resistance (of liquid) has increased (as velocity increases) downwards force (on metal ball) = upwards force (on metal ball) (at point X) (metal ball) travels at constant velocity / speed	**3**			

Question	Answer	Marks	AO Element	Notes	Guidance
					[Total: 127]