4.	*(a)*	(i)	$\frac{\text{Total distance}}{\text{[Total] time}}$ [or equiv.] [**Not** rate of change of distance]	1
		(ii)	Time for the whole journey = 3 h + 4 h = 7 h (1) [or 25 200 s] Mean speed $= \frac{480(1)}{7}\left[\frac{480000}{25200}\right] = 68.6$ km h^{-1} (1)[accept 69 – not 70]	3
	(b)	(i)	Forward force labelled Driving / engine force **and** reverse force labelled Friction / drag / air resistance]	1
		(ii)	Maximum at $t = 0$ (s) [accept: starts high at $t = 0$](1) Decreases (1) to zero [after 8 s] (1)	3
		(iii)	$a = \frac{\Delta v(\text{from tangent})}{\Delta t\ (\text{from tangent})}$ (= 2.75 [accept 2.6 – 2.9] m s^{-1}) (1) $\sum F = ma$ / $\sum F = 350 \times 2.75$(ecf) (1)= 962.5 [accept 910 – 1015] N (1)	3
	(c)	(i)	Force × distance (moved) (1) in the direction of the force (1) [or equivalent, e.g. component of force in the direction of motion × distance moved, $Fd\cos\theta$ if symbols defined]	2
		(ii)	Power $P = \frac{\text{work done}}{\text{time}}$ or $P = \frac{Fd}{t}$ (1) d/t <u>identified</u> with v (1) [by impl. if $F \times d$ / t used to define power]	2
		(iii)	$F = \frac{40 \times 10^3}{18}$ [=2200 N]	1
	(d)	(i)	Energy cannot be created or destroyed only changed from one form to another.	1
		(ii)	Brake pads and wheel discs heat up (1) [accept k.e. → heat energy] Reference to particles' gaining energy (1)	2
				[20]

Question			Marking details	Marks Available
6.	*(a)*	(i)	Horizontal arrow [by eye] to right, close to **A**, labelled **D**. (1)	
		(ii)	Vertically downwards arrow at **A** labelled **F**. (1)[NB if other force(s) labelled, s.i.f. $\rightarrow 0$]	2
	(b)	(i)	$U_{\mathrm{H}} = \dfrac{4.50}{1.50}\left(= 3.0\,\mathrm{m\,s^{-1}}\right)$	1
		(ii)	Use of relevant equation, e.g. $v = u + at$ or $v^2 = u^2 + 2ax$ (1) [or by impl.] Correct subst e.g. $0 = u - 9.81 \times 0.75$ or $0 = u^2 - 2 \times 9.81 \times 2.75$ (1) [or by impl.] Answer $U = 7.3$ / 7.35 / 7.4 m s^{-1} (1)	3
		(iii)	$U = \sqrt{3.0^2 + 7.4^2}$ [or $U^2 = 3^2 + 7.4^2$] (1) [e.c.f. on both velocities] = 7.9 – 8.0 m s^{-1} (1)	2
	(c)	(i)	$E_{\mathrm{total}} = mgh + \frac{1}{2}mv_{\mathrm{H}}{}^2$ [or by impl.] [Accept E_{total} = P.E. + K.E.] (1) $= 6.0 \times 9.81 \times 2.75 + \frac{1}{2} \times 6.0 \times 3.0^2$ [e.c.f. on v_{H}] (1) [subst] = 189 J (1) [NB If only PE considered then 0]	3
		(ii)	Extreme points of trajectory **both** marked with a **K**.	1
		(iii)	$\frac{1}{2}mU^2 = 189$ (1) [e.c.f.] [accept KE = 189 J ecf] $U = 7.9$ m s^{-1} (1)	2
				[14]

6	*(a)*		Charge = $\frac{2}{3}$ [e] + $-\frac{1}{3}$ [e] + $-\frac{1}{3}$ [e] = 0 [or equiv.] [**or** No other combination of 3 u and d quarks gives zero charge]	1
	(b)	(i)	π^-: $-\frac{1}{3}$ [e] + $-\frac{2}{3}$ [e] [or equiv.] = –e [or –1] (1) Δ^-: 3 × $-\frac{1}{3}$ [e] = –e [or –1] (1)	2
		(ii)	A meson is a quark-antiquark (1) pairing. A baryon is a triplet of quarks [accept antiquarks] (1)	2
	(c)	(i)	I. $0 \rightarrow 1 + (-1)$ or equiv. II. $3 \rightarrow 2 + 1$ or equiv.	2
		(ii)	u and d individually conserved **or** lifetime too short [accept no ν_e involvement]	1
	(d)	(i)	uuu	1
		(ii)	π must be $u\bar{d}$ [because charge must be conserved **or** because u and d numbers are individually conserved].	1
				[9]

Question			Marking details	Marks Available
7	*(a)*		λ_{max} = 950 [± 50] nm [or by impl.] (1) $T = \frac{2.90\times10^{-3}\ \text{m K}}{950\times10^{-9}\ \text{m}}$ (1) [ecf on λ_{max}] = 3050 K (1)	3
	(b)	(i)	Spectral intensity [far] greater at 700 nm [than at 400 nm].	1
		(ii)	Infrared	1
		(iii)	I. peak / around 900 – 950 nm	1
			II. λ_{max} = 550 nm [accept 500 – 600 nm](1) T = 5300 K (1) [e.c.f. from λ_{max} but only if λ_{max} between 400 and 700 nm]	2
	(c)		knowledge of meaning of symbols in $P = \sigma AT^4$ demonstrated (1) $A = 4\pi \times (1.01 \times 10^8\ \text{m})^2$ [$=1.28 \times 10^{17}\ \text{m}^2$] (1) $P = 6.3 \times 10^{23}$ W ((**unit**))(1) [e.c.f. on T from *(a)*] [1 mark lost if answer adrift by a factor of π or 2^n, or if the answer to *(b)*(iii)II used instead of 3000 K]	3
				[11]

Solids under stress

a) Stress on y-axis and strain on x-axis
   Ductile graph can be a typical strain line which then becomes curved at the limit. This can be steel or copper. The steel one is more bendy and wiggly at the limit region.
   Label the limit of proportionality
   The limit of elasticity
   The yield point
   A brittle material could be ceramic or glass
   It is simply a straight line which ends at the limit
b) Shear forces – diagram of opposing forces with material or atomic structure in between.
   This causes bonds around the dislocation to break
   And reform
   We call this the dislocation moving
   Diagram to show the movement occurs
   and a possible end result
   ways to prevent the movement are foreign atoms
   grain boundaries
   other dislocations

SI units

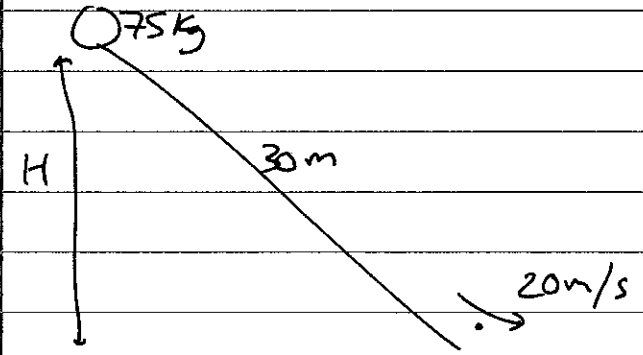
a) $ms^{-2} = \frac{m - ms^{-1} \times s}{s^2}$

$ms^{-2} = ms^{-2} - ms^{-2}$ ✓ correct

b) ~~Kg~~ $= \frac{Kg\, ms^{-2} \times m^2}{(ms^{-1})^2 - (ms^{-1})^2}$

~~Kg~~ $Kg = \frac{Kg\, m^3 s^{-2}}{m^2 s^{-2}}$ × no.

Work & energy

a) 

$mgh = \frac{1}{2}mv^2$

$9.81 \times h = \frac{1}{2} \times 20^2$

$h = \frac{200}{9.81}$

$h = 20.4m$

b) Friction = 20N , $v = 10m/s$.

GPE $= \frac{1}{2}mv^2$ + WD against friction

$75 \times 9.81 \times h = \frac{1}{2} \times 75 \times 10^2 + 20 \times 30$

$735.75 \times h = 3750 + 600$

$h = \frac{4350}{735.75} = 5.91m.$