RECOGNISING ACHIEVEMENT

MATERIALS

Mark Scheme 2825/03
January 2003

1. (a) (i) 1. example (e.g. quartz); (1)
2. example (e.g. glass). (1) [2]

(ii) Crystalline: atoms in regular repeated patterns; (1)
Amorphous: atoms randomly placed / no pattern. (1) [2]

(b) Diagram [2]
1 mark only if atoms in lower layer shown vertically below atoms in upper layer.

(c) (i) Number of atoms in $1m^3$ = $7300 / 2.0 \times 10^{-25}$ = 3.7×10^{28}. [1]

(ii) Volume per atom, $V = 1/3.7 \times 10^{28}$ = 2.7×10^{-29} m^3 (1)

Calculation based on $V = \frac{4}{3}\pi r^3$ to give separation of 3.6×10^{-10} m
or $V = L^3$ to give separation of 3.0×10^{-10} m. (1) [2]

(iii) Atoms are closer together / more closely packed in white tin. [1]

2. (a) Attractive and repulsive forces between A and B are equal / the system is in equilibrium. [1]

(b) Repulsive force between atoms is now greater than attractive force; (1)
External force pushing atoms together = repulsive force – attractive force (or wtte). (1) [2]

(c) (i) All points plotted correctly; (1)
Correct graph drawn: straight section through origin and curve. (1) [2]

(ii) Use of point on straight line / gradient of straight line used; (1)
Correct data from graph; (1)
Young modulus between 1.2×10^{11} Pa and 1.3×10^{11} Pa. (1) [3]

(d) (i) Permanent change of shape (1)
after removal of stress / force. (1) [2]

(ii) Slip occurs (1)
between adjacent layers of atoms (1) [2]

3. (a) (i) Free electrons move in random directions; (1)
with a range of speeds. (1) [2]

(ii) Free electrons move in the opposite direction to the current; (1)
accelerating between collisions with / undergoing collisions with copper ions / atoms; (1)
This motion superimposed on random motion of (I). (1) [3]

(b) (i) nAv [1]

(ii) I = Q/t (1)
= nAve/1 (1) [2]

(c) $v = I/nAe = 0.25/(8.0 \times 10^{28} \times 1.5 \times 10^{-6} \times 1.6 \times 10^{-19})$ (1)

$= 1.3 \times 10^{-5}\ m\ s^{-1}$ (1) [2]

(d) The filament of the bulb is thinner than the copper wire; (1)
Tungsten contains fewer free electrons per m^3 than copper. (1) [2]

4. (a) (i) Resistivity = RA/L (1)
symbols explained (1) [2]

(ii) conductivity = 1/resistivity [1]

(b) (i) Mention of conduction band and valence bands (of energy levels); (1)
Electrons in conduction band are free / can take part in conduction; (1)
Electrons in valence band do not take part in conduction; (1)
In metals conduction and valence bands overlap so free electrons are always present; (1)
Temperature increase of metal has no effect on number of electrons in conduction band; (1)
Resistance increases / conductivity falls because of increased obstruction to flow (of electrons) as amplitude of vibration of atoms / ions increases; (1)
In semiconductors, energy gap between valence and conduction bands; (1)
Thermal energy can promote electrons from valence to conduction band; (1)
At room / normal temperatures few electrons in conduction band so resistance high / conductivity low; (1)
Temperature rise promotes more electrons to conduction band so resistance falls / conductivity rises. (1) max [8]

(ii) Diamond has wide energy gap between valence and conduction bands; (1)
At normal temperatures no electrons are in the conduction band so no current can flow / no free electrons; (1)
Very high temperatures give sufficient energy for some electrons to transfer into the conduction band / become free so conduction can take place. (1) [3]

5.	(a)	(i)	In unmagnetised iron domains are randomly arranged.	(1)	
		(ii)	Magnetisation of iron causes domains to become aligned.	(1)	[2]
	(b)	(i)	hysteresis		[1]
		(ii)	1. P and Q show flux density / magnetism left in the steel when the current is switched off.		[1]
			2. R and S show (reverse) current required to demagnetise the steel.		[1]
			3. Shaded area represents / is proportional to heat developed in the steel / energy required	(1)	
			in one hysteresis cycle.	(1)	[2]
	(c)	(i)	Iron can be magnetised to saturation with a smaller current.	(1)	
			Magnetisation of iron more easily reversed.	(1)	
			Other: e.g. comparison of hysteresis loops.	(1)	max [2]
		(ii)	Loop enclosing smaller area;	(1)	
			Correct shape.	(1)	[2]
6.	(a)		An electron in an atom gains energy and is raised to a higher energy level.	(1)	
			The electron falls back to a lower energy level, emitting energy as a photon of electromagnetic radiation.	(1)	[2]
	(b)		Energy of photon = $1.8 \times 1.6 \times 10^{-19}$ J (= 2.88×10^{-19} J)	(1)	
			$h = E\lambda/c$	(1)	
			$= 2.88 \times 10^{-19} \times 650 \times 10^{-9} / 3.0 \times 10^{8} = 6.2 \times 10^{-34}$ J s	(1)	[3]
	(c)	(i)	Process: Rayleigh scattering;	(1)	
			Cause: Presence of small impurity particles / discontinuities.	(1)	
			Process: Absorption of light by the glass;	(1)	
			Cause: Photons have energy suitable to excite electrons in the glass.	(1)	[4]
		(ii)	Rayleigh scattering less for longer wavelength .	(1)	
			Infra-red photons have smaller energy than visible light photons and less likely to cause excitation.	(1)	[2]

7(a)(i) (ii)	1015 N (accept 1010-1020) 130 N (accept 125-135) both correct, no unit penalty	1	[1]
(b)	$F = ma$ written or implicit (1015-130) = 1100a so a = 0.80 ms^{-2} (accept 0.80-0.81, accept 0.8 in place of 0.80) (1015+130) can get only 1 0 0 = 1/3 max)	1 1 1	[3]
(c)	18 ms^{-1} (accept 15-21) find largest difference/distance between force graphs (and note speed) *or* clear from graph 'where lines cross' gets 0/1 'it is the terminal velocity' gets 0/1	1 1	[2]
(d)	49.7 ms^{-1} (accept 49.5 - 50.0) speed is max. when driving force equals/balanced by drag force accept 'speed where forces are equal' if speed has been stated correctly	1 1	[2]
(e)	220 N (accept 220 - 225) work done = force x distance = 220x1000 (=2.2x10^5 J) allow ecf from incorrect graph reading 220 x 1000 only gets 1 0 1 = 2/3 22 x (anything) loses last mark	1 1 1	[3]
(f)	work done = 35(2)x1000 = 3.5(2)x10^5 J accept (3.5 - 3.6)x10^5	1	[1]
(g)	distance travelled on 1 litre at 31 ms^{-1} = 2.2x16/3.5(2) = 10.0 km (9.8 - 10.1) allow (total) energy (in 1 litre of fuel) = 16 x 2.2 x 10^5 for 1/2 reference to 22(ms^{-1}) or 31(m s^{-1}) gets 0/2	1 1	[2]
(h)	ke = ½mv^2 = ½ x 1100x31^2 (= 5.29x10^5 J) subs.	1	[1]
(i)	(ke lost =) heat gained = $mc(\theta_2 - \theta_1)$ 5.3x10^5 =8x460 $\Delta\theta$ either of first two lines correct (1) $\Delta\theta$ = 144 K so θ_2 = 144 + 15 = 159 °C calculation of 144 (1) addition of 15 (1) assumption: brakes initially at 15 °C <u>all</u> heat is dissipated in <u>brakes</u> no heat lost from brakes no air resistance/drag any assumption (1) <u>not</u> Law of Energy assumption without calculation can score 1/3 any 3	3	[3]
(j)	$W = Fd$ *or* $F = ma$ and $v^2 - u^2 = 2as$ (1) 5.3x10^5 = 9300d 9300 = 1100 a so a = 8.45(m s^{-1}) so d = 57 m 31^2 (- 0^2) = 2 x 8.45 s so s = 57 m (1) assumption: no work done against (other) drag forces car is on horizontal road air resistance negligible any valid assumption (1) 'constant braking force' and 'constant deceleration' get 0/1 any 2	2	[2]