RECOGNISING ACHIEVEMENT

A2 MATERIALS

Mark Scheme 2825/03

June 2004

1. (a) (i) No. = $1.5 / 3.0 \times 10^{-10}$ (= 5.0×10^{9}) [1]

(ii) Diameter or side of square = 3.0×10^{-10} m / radius = 1.5×10^{-10} m; (1)

No. = $1.6 \times 10^{-7} / [\pi \times (1.5 \times 10^{-10})^2]$ (= 2.3×10^{12})
OR $1.6 \times 10^{-7} / [(3.0 \times 10^{-10})^2]$ (= 1.8×10^{12}) (1) [2]

(b) e.g. Packing arrangement not taken into account / atoms are not square / circular; (1)
Plane of atoms contains grain boundaries; (1)
Plane of atoms contains vacancies / impurity atoms; (1)
Plane of atoms contains dislocations. (1) max [2]

(c) (i) strain = $2.8 \times 10^{-3} / 1.5 = 1.87 \times 10^{-3}$ [1]

(ii) stress = E x strain; (1)
= $1.9 \times 10^{11} \times 1.87 \times 10^{-3} = 3.55 \times 10^{8}$ Pa
OR $1.9 \times 10^{11} \times 2 \times 10^{-3} = 3.8 \times 10^{8}$ Pa (1) [2]

(iii) tension = $1.6 \times 10^{-7} \times 3.55 \times 10^{8} = 56.8$ N (e.c.f.)
OR $1.6 \times 10^{-7} \times 3.8 \times 10^{8} = 60.8$ N (e.c.f.) [1]

(d) (i) increase in separation = $2.8 \times 10^{-3} / 5.0 \times 10^{9} = 5.6 \times 10^{-13}$ m [1]

(ii) force causing increased separation = $56.8 / 2.3 \times 10^{12} = 2.5 \times 10^{-11}$ N (e.c.f.)
OR $56.8 / 1.8 \times 10^{12} = 3.2 \times 10^{-11}$ N (e.c.f.)
OR $56.8 / 2 \times 10^{12} = 2.8 \times 10^{-11}$ N (e.c.f.)
OR 60.8 used instead of 56.8 [1]

2. (a) Allow tolerance of 0.05 in reading logs with consequent variations in answers.

(i) log σ = log 8.0×10^{7} (= 7.90) (1)
T = 24.5 K Allow +/- 0.5 K (1) [2]

(ii) 7 K [1]

(b) (i) Use of reading of 8.8 (1)
$\sigma_{max} = 6.31 \times 10^{8}\ \Omega^{-1}\ m^{-1}$ (1) [2]

(ii) $\rho_{min} = 1/6.31 \times 10^{8} = 1.58 \times 10^{-9}$ (e.c.f.) (1); Ω m. (1) [2]

3. (a) (i) Diagram showing at least a single circle surrounded by 6 equal circles. [1]

(b) (i) Amorphous: No pattern / random arrangement <u>of atoms</u>; (1)
Single crystal: a regular array <u>of atoms</u> (extending throughout a body). (1) [2]

(ii) e.g. the silicon used to make a 'chip';
the quartz crystal in a watch or clock;
a diamond for appropriate use e.g. cutting. [1]

(c) Metallic glass <u>has an amorphous structure</u> (like glass). [1]

is a metal / contains metal atoms; (1)
is easy to magnetise in any direction / easy to change the direction of magnetisation / is magnetically soft; (1)
minimises energy loss / heat generation in the core; (1)
has high resistivity / eddy currents are small; (1)
has hysteresis loop of (very) small area; (1)
has a high value of magnetic saturation / does not reach magnetic saturation; (1) max [4]

4. (a) (i) Reference to photons and energy; (1)
Energy levels in the conduction band of a metal are very closely spaced; (1)
The energy of visible light photons is sufficient to raise an electron in the conduction band of the metal to a higher level, (so is absorbed). (1) max [2]
[Reference to overlapping valence and conduction bands not sufficient.]

(ii) Energy of visible light photon not sufficient (1)
to raise an electron in the valence band of the glass to the conduction band, (so is not absorbed). (1) [2]

(b) (i) 1.95 eV = $1.95 \times 1.6 \times 10^{-19}$ = 3.12×10^{-19} J (1)

$E = hf$ / $E = hc/\lambda$ (1)

$\lambda = hc/E = 6.63 \times 10^{-34} \times 3.0 \times 10^{8} / 3.12 \times 10^{-19} = 6.35 \times 10^{-7}$ m = 635 nm (1) [3]

(ii) Red light is not absorbed by the insulator because its wavelength is greater than 635 nm / Photon energies above this wavelength have insufficient energy to promote electrons in the insulator. [1]

5. (a) (i) $A = 0.0024^2$ $I = 0.043$ A (1)
$v = I/nAe = 0.043 / (7.5 \times 10^{20} \times 0.0024^2 \times 1.6 \times 10^{-19})$ (= 62.2 m s^{-1}) (1) [2]

(ii) $V_H = Bvd$ (1)
$= 0.35 \times 62.2 \times 0.0024 = 0.052$ V (0.050 V if 60 m s^{-1} used) (1) [2]

(iii) Lower face of slice marked with X. [1]

(iv) Increased thermal energy so n increases; (1)
more electrons promoted from valence to conduction band of semiconductor; (1)
drift velocity v is reduced because current is constant; [do not accept 'because resistance rises' or 'more atomic vibration'] (1)
Hall voltage is smaller because v reduced. (1) max [3]

(b) (i) Place Hall probe on axis of solenoid; (1)
with narrow dimension of slice perpendicular to field / axis of solenoid;
OR two faces of slab without contacts placed perpendicular to field; (1)
[Both of above 2 marks can be obtained from a clear sketch]
Connect leads from probe to voltmeter / use meter rule to determine position; (1)
Move probe along axis. (1) [4]

(ii) Connect leads from probe to C.R.O. (with suitable settings) / centre-zero (volt)meter if frequency stated as low [1]

6. (a) (i) Domains randomly orientated. [1]

(ii) Domains are aligned (in direction of magnetising field). [1]

(b) (i) 1. Domains already aligned with the (magnetising) field grow due to movement of domain walls. (Other domains shrink.) (1)

2. Domains rotate to align with the (magnetising) field. (1) [2]

(ii) Less steep gradient occurs during stage of domain rotation. (1)
Domain rotation takes place less readily than domain growth. (1)
Gradient zero when domains are fully aligned. (1) max [2]

(iii) At the Curie temperature saturation flux density becomes zero / magnetisation is lost; (1)
There is sufficient thermal energy to disrupt the alignment of domains. (1) [2]

(c) (i) Hysteresis loop encloses a small area; (1)
so energy converted to heat (per cycle due to hysteresis) is small (1) [2]

(ii) Laminations minimise eddy currents; (1)
so energy converted to heat (due to eddy currents) is small. (1) [2]

8 (a) (i)	Mass	= 0.15 × 5 × 60	1
		= 45 kg	1
(ii)	Energy required	= 45 × 4200 × (38 – 8) Must have temperature difference	1
		= 5.67 × 10^6 J	1
(b) (i)	Work done	= Force × distance turned (Allow F.d)	1
		= 80 × 2 π × 0.2	1
		= 100 J	
(ii)	Power produced	= Energy per rev. × Number of rev. per second	
		= 100 × 1.3	
		= 130 W	1
(iii)	Total number of revolutions	= 5.67 × 10^6 / 100	
		= 56700	1
(iv)	Time for pedalling	= 56700 / 1.3	
		= 43615 secs	1
		= 12.1 hours	1
c (i)	Total resistance in heater circuit	= *EMF* / current	1
	Must see some evidence of equation used and physics of problem other than V = IR eg $R_{total} = R_1 + R_2$		
		= 24 / 5	
		= 4.8 Ω	1
	Resistance of element	= 4.8 – 1.2	1
		= 3.6 Ω	
(ii)	Length or wire	= RA / ρ	1
		= 3.6 × 0.32 × 10^{-6} / 1.5 × 10^{-7}	1
		= 7.68 m	1
d	Discussion on energy losses	Work done against friction in bearings etc	1
		Power loss from resistance of generator and connecting wires	1
		Heat radiated from tank	1

In one second student outputs 130 J of which only 120 J to generator
and only 90J to tank
Thus pedalling time will be longer by factor 130 / 90 giving a new time of 17.5 hours. 2
(Any explained energy loss plus extra time calculations scores up to 2 marks)
(Any correct calculation of extra time scores 1 mark)

Maximum 4 marks for question

Up to 3 marks for intelligent discussion (but ignore sound)
Up to 2 marks for calculation **Max 4**