Mark Scheme 2825/03
January 2006

MATERIALS

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1. (a) (i) 6 (1)
(ii) 12 (1) [2]

(b) (i) 1 mole contains 6.0×10^{23} atoms / mass of 6.0×10^{23} gold atoms is 0.197 kg (1)
mass of a gold atom = $0.197 / 6.0 \times 10^{23}$ (= 3.3×10^{-25} kg) (1) [2]
[Allow $1.93 \times 10^4 / 5.9 \times 10^{28}$ (= 3.3×10^{-25} kg)]

(ii) Number of moles of gold in 1 m^3 = $1.93 \times 10^4 / 0.197$ = 9.80×10^4
Number of gold atoms in 1 m^3 = $9.80 \times 10^4 \times 6.0 \times 10^{23}$ (= 5.9×10^{28}) (1)
OR
Number of gold atoms in 1 m^3 = density / mass of gold atom
= $1.93 \times 10^4 / 3.3 \times 10^{-25}$ (= 5.9×10^{28}) (1) [1]

(c) (i) Volume of 5.9×10^{28} gold atoms = 0.74 m^3 (1)
Volume of a gold atom = $0.74 / 5.9 \times 10^{28}$ = 1.25×10^{-29} m^3 (1) [2]

(ii) Volume of sphere, $V = 4\pi/3 \times (\text{radius})^3$ (1)
radius = $[(3 \times 1.25 \times 10^{-29}) / 4\pi]^{1/3}$ = 1.44×10^{-10} m (Allow e.c.f.) (1) [2]

[Total: 9]

2. (a) Grains in which atoms are arranged in a repeating pattern; (1)
Separated by grain boundaries; (1)
from other grains with patterns in different orientations. (1) [3]

(b) (i) Atoms are farther apart in graphite (than in diamond). [1]

(ii) (Compared with diamond) atoms in graphite are farther apart so bonds between them are weaker. / Less thermal energy is required to break bonds between atoms in graphite (than in diamond). [1]

(iii) Graphite consists of parallel layers of carbon atoms; (1)
which easily slide over each other / readily undergo plastic deformation. (1) [2]

(iv) Very strong bonds between diamond atoms; (1)
make diamond harder than other materials (and so able to scratch them). (1) [2]

[Total: 9]

3. (a) Area of cross-section = $\pi \times (5.9 \times 10^{-5})^2 = 1.09 \times 10^{-8}$ (m^2) (1)
Conductivity = 1/resistivity (1)
= $L/RA = 0.61/[71 \times \pi \times (5.9 \times 10^{-5})^2]$ = 7.86×10^5 (1)
$\Omega^{-1} m^{-1}$ (1)
Allow 1 mark for resistivity = 1.27×10^{-6} (Ωm) [4]

(b) v = I/nAe; (1)
n: number of free electrons per m^3 / charge carriers per m^3 ;
I: current A: cross-section of filament (e: electron charge). (1) [2]

(c) (i) Fuse-wire has a smaller cross-section than the copper wire; (1)
Fuse wire has lower n / free electron / charge carrier concentration than copper / has fewer electrons in the conduction band. (1) [2]

(ii) In a metal, conducting electrons collide with metal atoms; (1)
increasing their (vibrational) kinetic energy of atoms causing higher temperature; (1)
Energy transfer to atoms is greater in the fuse (than in the copper wire); (1)
because greater speed / k.e.of conducting electrons in the fuse; (1)
outweighs the effect of a larger number of conducting electrons in copper. (1) max

[Total: 12]

4. (a) Graph of correct shape passing through origin; (1)
showing zero gradient at maximum B. (1) [2]

(b) Mention of domains; (1)
Mention of dipoles; (1)
When B is zero / I is zero / at origin, domains are randomly orientated; (1)
Reference to domains orientated in the (general) direction of the magnetising field; (1)
Walls of these domains move / these domains grow (others shrink); (1)
Dipoles (within domains) rotate to be in line with magnetising field; (1)
This occurs where gradient of graph is less steep / This process takes place less readily / requires more energy; (1)
Where graph is horizontal / gradient zero; (1)
B has reached maximum (saturation) value when all dipoles are aligned; (1) max

[Total: 9]

5. (a) Labelled diagram showing: valence band below energy gap; (1)
energy gap labelled 1.1 eV. (1)
conduction band above energy gap. (1) [3]

(b) In the dark few electrons in the conduction band; (1)
9| In daylight light photons provide energy; (1)
to promote (many) more electrons from valence band to conduction band; (1)
High / low resistance related to few / many conduction band electrons. (1) [4]

(c) (i) Circuit with battery connected to LDR; (1)
Ammeter and voltmeter correctly connected. (1) [2]

(ii) Control and measurement of light intensity:
Arrangement to shield LDR from light from unwanted sources / Carry out experiment in darkened room; (1)
Use constant light source placed at variable distance from LDR / Use light source of variable power at fixed distance from LDR; (1)
with light meter to record light intensity at position of LDR. (1) [3]

Ranges of meters:
Voltmeter with range applicable to battery voltage / say 0 - 10 V scale; (1)
For maximum light conditions use milliammeter; (1)
and for minimum light conditions use microammeter. (1)
OR
Reference to multimeter to read current (1) with appropriate change of scale. [3]

Readings and calculations:
For each position of light source / power value of light source, measure (and record) readings from light meter; (1)
Read (and record) readings from voltmeter and ammeter and calculate resistance using R = V/I. (1) [2]

[Total: 17]

6. (a) (i) Speed v = c/n (1)
$= 3.0 \times 10^8 / 1.47 = 2.04(1) \times 10^8$ m s^{-1} (1) [2]

(ii) Time for the mean wavelength = s/v (1)
$= 1000 / 2.04 \times 10^8 = 4.9(00) \times 10^{-6}$ s (e.c.f.) (1) [2]

(b) Speed of the maximum wavelength $= 2.041 \times 10^8 \times 1.001$ (e.c.f.)
$= 2.042(9) \times 10^8$ m s^{-1} (1)

Time for the maximum wavelength $= 1000 / 2.043 \times 10^6 = 4.8951 \times 10^{-6}$ s (e.c.f.) (1)
Time difference $= 4.9 \times 10^{-6} - 4.8951 \times 10^{-6} = 5.0 \times 10^{-9}$ s (1) [3]

(c) (i) [Do not accept multipath dispersion without explanation]
A pulse of radiation spreads out as it travels through the fibre; (1)
Causing a signal to be distorted; (1)
Imposing a limit to the number of pulses able to be transmitted per second. (1) max

(ii) Use infra-red from a laser; (1)
The band of wavelength / frequency from a laser is narrower, so less variation in speed / smaller time difference. (1) [2]

(d) Between 1.35 μm and 1.45 μm photons are absorbed by (hydoxyl ion) impurities in the glass; (1)
At λ = 1.5 μm the amount of Rayleigh scattering is low, and absorption by other processes is minimal; (1)
Above 1.5 μm photons are (increasingly) absorbed by vibrating bonds in the glass structure. (1) [3]

[Total: 14]

Question	Expected Answers		Marks	
7 (a)	*either* (If in parallel) when one bulb fails, other bulbs stay on *or* (If in parallel) can identify which bulb has failed;		1	[1]
(b)(i)	$P = VI$ $0.5 = 240\,I$ $I = 2.1 \times 10^{-3}$ A 1 s.f. in answer (-1) once only		1 1	 [2]
(ii)	$R = V/I$ $= 240/(2.1 \times 10^{-3})$ $= 1.14 \times 10^{5}\,\Omega$ or $1.15 \times 10^{5}\,\Omega$ accept $(1.1 \text{ to } 1.2) \times 10^{5}\,\Omega$	 ans	1 1	 [2]
(iii)	$A = \rho l / R$ $= 1.1 \times 10^{-6} \times 6.0 \times 10^{-3} / (1.14 \times 10^{5})$ $(= 5.79 \times 10^{-14}\,m^2)$ $A = \pi r^2$ $5.79 \times 10^{-14} = \pi r^2$ so $r = 1.4 \times 10^{-7}$ m		1 1 1	 [3]
(iv)	filament too thin / fragile to be manufactured / used without damage; allow ecf from **(iii)**.		1	[1]
(c)	**P**: 0 V **Q**: 0 V; **R**: 240 V **S**: 240 V		1 1	
	current is zero (1) p.d. across (any intact) bulb becomes zero (1) so all 240 V across Y (1)	 any 2	 2	 [4]

d(i) *either* set B bulb(s) have less resistance (than set A bulbs)
or adding (each) set B bulb lowers circuit resistance; 1

either so current increases (when set B bulb inserted)
or p.d. across (each) bulb increases
or any valid argument using V^2/R; 1

so power dissipation (in any bulb) increases; 1 [3]

(ii) set A bulbs fail first; 1

Then
either Failure current for set A bulb $I_f = \sqrt{P/R} = \sqrt{0.75/200} = 0.0612$ A; 1
When failure occurs <u>total</u> resistance of set = 240 / 0.0612 (= 3920); 1
Let X be number of 50 Ω bulbs substituted
3920 = 50X + 200(24 - X) ; 1
so X = 5.87 bulbs , so 5 or 6 bulbs;

or Total initial resistance = 24 x 200 = 4800 Ω
After substituting X set B bulbs, resistance = 4800 - 150 X (1)
Current = 240/(4800 - 150 X) (1)
So power in a set A bulb,
$P = I^2 R = [240/(4800 - 150X)]^2 \times 200 = 0.75$ for failure (1)
This gives X = 5.87 i.e. 5 or 6 bulbs [4]