RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE **2825/03**

Materials

Mark Scheme for June 2010

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1	**(a)**	**(i)**	Polycrystalline: many small crystals / grains;	(1)	
			with different orientations of planes of atoms;	(1)	**Max**
			separated by grain boundaries.	(1)	**[2]**
			Amorphous: random placement of atoms / no regular repeating pattern.		**[1]**
		(ii)	Example of polycrystalline solid: eg metal / example of metal or alloy;	(1)	
			Example of amorphous solid: eg glass.	(1)	**[2]**
	(b)	**(i)**	equilibrium separation $d = 3.0 \times 10^{-10}$ m.		**[1]**
		(ii)	separation = 2.2×10^{-10} m.		**[1]**
		(iii)	force to separate atoms $F_s = 8.0 \times 10^{-9}$ N		**[1]**
	(c)	**(i)**	Atoms in a cross-section = $A / [\pi (d/2)^2]$ OR A / d^2		**[1]**
			Force required to break wire = F_s x answer above.		**[1]**
			Breaking stress = breaking force / area of cross-section;	(1)	
			$= F_s / [\pi (d/2)^2]$ OR F_s / d^2	(1)	**[2]**
		(ii)	Breaking stress = $F_s / [\pi (d/2)^2] = 8 \times 10^{-9} / 7.07 \times 10^{-20} = 1.1 \times 10^{11}$ Pa OR $F_s / d^2 = 8 \times 10^{-9} / (3 \times 10^{-10})^2 = 8.9 \times 10^{10}$ Pa		**[1]**
					Total: [13]
2	**(a)**		Hexagonal close-packing / hcc;	(1)	
			Cubic close-packing / ccp / face-centred cubic / fcc.	(1)	**[2]**
	(b)		Sketches: close-packing of atoms in a layer;	(1)	
			Sketch or description to show placement of atoms in layer Y relative to layer X;	(1)	
			Sketch or description of one method of adding layer Z;	(1)	
			Name of this arrangement;	(1)	
			Sketch or description of second method of adding layer Z;	(1)	**[6]**
			Name of this arrangement.	(1)	
					Total: [8]

3 (a) (i) Atoms (of the alloy) vibrate with smaller amplitude as temperature falls; (1)
Free / current-carrying electrons travel farther between collisions with lattice atoms; (1)
Drift velocity of electrons increases so current increases; (1)
Increased current (with same voltage) means less resistance / resistivity (1) **[4]**

(ii) At 10 K, (sudden) drop (of resistivity) to zero; (1)
From 10 K to 5 K resistivity stays at zero. (1) **[2]**

(b) (i) Copper carries negligible / zero current because its resistivity is very much / infinitely greater than the Ni-Ti alloy. **[1]**

(ii) Resistivity of Nb -Ti alloy is (now) much / 40 times greater than resistivity of copper; (1)
Cross-sectional area of copper is greater than / twice that of the Nb-Ti wire; (1)
Resistance = resistivity x length / cross-section; (1)
Resistance of copper is (now) much less than that of the Nb -Ti alloy. (1) **Max [3]**
[Allow 3 marks if resistance of copper given as 1/80 that of Nb –Ti alloy]

Total: [10]

4 (a) Mention of valence band, conduction band and energy gap anywhere in answer; (1)
Electrons in the conduction band carry current; (1)
Valence band electrons do not take part in conduction; (1)
Resistivity decreases as number of conduction band electrons increases; (1)

At 20 °C copper has many more conduction band electrons than silicon (so resistivity much less). (1)

Silicon has an energy gap between the valence band and the conduction band; (1)
Energy is required to promote electrons in the valence band to the conduction band; (1)
As temperature increases more electrons in the valence band gain enough energy to be promoted. (1) **Max [7]**

Total: [7]

5 (a) $V_H = Bvd$ / $v = V_H$ / (Bd; (1)
$v = 0.28 \times 10^{-3} / (0.24 \times 0.065) = 0.018 \text{ m s}^{-1} = 1.8 \text{ cm s}^{-1}$ (1) **[2]**

(b) volume per sec = Av; (1)
$= \pi \times 0.0325^2 \times 0.0185 = 6.0 \times 10^{-5} \text{ m}^3 \text{ s}^{-1}$. (1) **[2]**

Total: [4]

6 (a) (i) 1 Domains walls move; (1)
so that those with magnetisation in the direction of the (external) field grow and other domains shrink. (1) **[2]**

2 Within domains atomic magnets / dipoles rotate to align with the external field. **[1]**

(ii) Saturation / maximum (possible) magnetisation; (1)
when all dipoles are aligned with the external field (1) **[2]**

(b) (i) Magnetism of the specimen / value of *B* when magnetising current is reduced to zero. **[1]**

(ii) (After magnetisation by a current in a given direction,) the current (in the opposite direction) required to demagnetise the specimen. **[1]**

(iii) Area is proportional to / represents work done / energy converted to heat in moving domain walls / rotating dipoles; (1)
in one cycle of magnetising (current). (1) **[2]**

(c) (i) Alternating current in primary sets up alternating magnetic field in core; (1)
Alternating magnetic field induces voltage in core; (1)
Induced voltage causes induced (eddy) current(s) in core; (1)
Eddy currents generate heat due to the resistance of the core. (1) **[4]**

(ii) Core is laminated; (1)
Core is made of high resistivity material; (1) **[2]**

Total: [15]

7 (a) (i) At least 2 points correctly plotted; (1)
All points correctly plotted and reasonable straight line graph. (1) **[2]**

(ii) Triangle drawn under at least half of line plotted; (1)
Values of Δy and Δx from triangle; (1)
Gradient between 2.25×10^{14} and 2.35×10^{14} (1) **[3]**

(iii) gradient = *e* / *h* OR *h* = *e* / gradient; (1)
Value for *h* consistent with gradient found in (ii). (1) **[2]**

(b) (i) 1 12 / 1.8 = 6.7; maximum number of LEDs: 6. **[1]**

2 R = [12 – (6 x 1.8)] / .025 = 48 Ω **[1]**

(ii) Connect 10 sets of 6 LEDs (and a resistor) in series; (1)
Connect these 10 sets in parallel (to the supply). (1) **[2]**

(iii) If one LED fails, the rear light still works but with one set of LEDs off because of parallel connection to the supply; (1)
If a filament bulb fails, the light no longer works. (1)
OR
If engine is not running, less battery energy is used / battery life is prolonged; (1)
because 60 LEDs work at lower total power than a filament bulb. (1) **[2]**

Total: [13]

8

(a) <u>mg Δh</u> / gravitational potential energy / of upper carriage decreases /is converted into.............B1
gravitational energy of lower carriage.............B1
and E_k of carriage(s).............B1
allow for the third mark ref. to heat in brakes / work done against friction

(b) T_1 = mg sinθ
T_1 = 10000 x 9.81 x 150 / 260 or 10000 x 9.81 x sin 35.............B1
T_1 = 5.7 x 10 ^{4} N or 5.66, 5.63, 5.62 x 10^4 N B1

(c)(i) m=F/a , 8.7 x 10^3 / 1.5 ....C1
= 5.8 x 10^3 kg.............C1
m = 10000 – 5800 = 4200 kg.............C1
V = m / ρ
V = 4.2 x 10^3 / 1000 = 4.2 m^3 ....A1

(ii) t = (v-u) / a
t = 6.6 / 1.5 ....C1
t = 4.4 s A1

(iii) s = ut + 0.5 x a x t^2
= 0 + 0.5 x 1.5 x 4.4^2 ....C1
= 14.5 m or 15 m.............A1

(d) (i) 3800 x 9.81 x 150 = change in gpe.............B1
= 5.6 or 5.59 MJ.............B1

(ii) E = m c ΔT.............C1

5.5 x 10^6 = 6 x 25 x 470 x ΔT C1
ΔT = 78 K allow 79 K if 5.6 MJ used A1

(iii) some <u>thermal</u> energy is lost <u>to the surroundings</u> / brakes lose heat.............B1
sensible explanation, ...B1
e.g. mechanism e.g. radiation, by which energy is transferred or
to where the thermal energy might also be transferred e.g. cable or pulley

Total 20

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