Mark Scheme 2825/03
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1. (a) (i) The atoms (of a substance) occupy the minimum possible space /
The atoms have the maximum number of nearest neighbours / or wtte
Suitable diagram. [1]

(b) (i) Volume = mass ÷ density / 1 ÷ 4510 (1)
= 2.21×10^{-4} m^3 (1) [2]

(ii) No. of atoms = 1 / 7.98×10^{-26} (1)
= 1.25×10^{25} (1) [2]

(c) (i) Volume = $4/3\ \pi r^3$ (1)
= $4/3 \times \pi \times (1.46 \times 10^{-10})^3$ (1)
(= 1.30×10^{-29} m^3) [2]

(ii) Vol occupied by atoms = $1.25 \times 10^{25} \times 1.30 \times 10^{-29}$ (= 1.63×10^{-4} m^3) (1)

% = ($1.25 \times 10^{25} \times 1.30 \times 10^{-29}$ / 2.21×10^{-4}) x 100 (= 73.9) (1) [2]

(d) decrease in density (1); due to expansion during rise to 883 °C; (1)

Body-centred cubic is not a close-packed structure, (so change at 883degC) . (1) [3]

2. (a) Graph correct for x less than equilibrium separation; (1)
Graph correct for x greater than equilibrium separation; (1)
Correct regions for attractive and repulsive forces, <u>shown on F-axis</u> . (1) [3]

(b) Attractive force: Attraction between unlike charges; (1)
Ionic, covalent or Van der Waal's bonding; (1)
Increases as separation decreases; (1)
Repulsive force: Repulsion between like charges; (1)
Occurs when electron clouds overlap; (1)
Increases as separation decreases; (1)
Resultant force is (vector) sum of attractive and repulsive forces; (1)
Equilibrium (F=0) when attractive force = repulsive force; (1)
Resultant attractive force when stretching force removed; (1)

Resultant repulsive force when compressing force removed; (1)
max [8]

3. (a) (i) 1. Element is a gas / vapour.
2. Element is a solid / liquid. [1]

(ii) The atoms of the element come closer together; (1)
The outer electrons of the atoms interact; (1)
The sharp levels split into many different energy levels. (1) [3]

(b) (i) Diagram labelled to show valence band; (1)
conduction band; (1)
energy gap. (1) [3]

(ii) Electrons in valence band are bound / do not take part in conduction; (1)
Electrons in conduction band are free / can take part in conduction; (1)

Insulator has empty conduction band and large energy gap; (1)
Electrons do not gain enough energy to cross the gap so no conduction; (1)

Semiconductor has narrow energy gap; (1)
Electrons can gain enough energy to cross into conduction band so semiconductor conducts; (1)
More electrons cross gap as temperature rises so conductivity rises / resistivity falls with increasing temperature; (1)

Metal has a partially filled conduction band/valence & conduction bands overlap (1)
Electrons permanently available to take part in conduction; (1)
No change in number of conduction band electrons with change of temperature. (1)
max [7]

4. (a) No of free electrons in length l of wire = nA l
/Number of free electrons passing a point in 1 s = nAv; (1)
Charge of these electrons, Q = nAve / Q=$nA\,l\,e$ (1)
I = Q/t = nAve/1 (= nAve)/ I = Q/t (=nAve) as v = l/t (1) [3]

(b) (i) v = I/nAe = $0.025/(8.7 \times 10^{28} \times 5.0 \times 10^{-5} \times 8.0 \times 10^{-3} \times 1.6 \times 10^{-19})$ /
correct substitution in I = nAve; (1)
$v = 4.49 \times 10^{-6}$ m s^{-1} (1) [2]

(ii) V_H = Bvd (1)
$= 0.15 \times 4.49 \times 10^{-6} \times 8.0 \times 10^{-3}$ (1)
$= 5.39 \times 10^{-9}$ V (1) [3]

(iii) X and Y marked at sides of strip, opposite each other, by eye. [1]

(c) Semiconductor has (much) smaller concentration of free electrons; (1)
(For same current) drift velocity is (much) higher; (1)

(In same field) Hall voltage is (much) higher so more accurately measurable. (1) [3]

5. (a) (i) $I = V/R = 12/50$ (1)
$= 0.24$ A (1) [2]

(ii) Power in primary = power in secondary / $I_pV_p = I_sV_s$ (1)
$I_p = 0.24 \times 12 / 230 = 0.0125$ A (1) [2]

(b) (i) Laminated structure; (1)
Made of soft iron / material with hysteresis loop of small area; (1)
Core is a complete loop. (1)
max [2]

(ii) Laminated structure:
Induced voltage / current in core proportional to rate of change of flux; (1)
Induced voltage / current increases with frequency; (1)
Energy lost increases with frequency/
Power loss = I^2R / V^2/R (1)
Efficiency decreases as frequency increases. (1) [4]
OR
Hysteresis effect:
Area enclosed by hysteresis loop is a measure of energy lost as heat per cycle of loop; (1)
Heat generated per second increases as number of hysteresis cycles per second increases; (1)
Heat generated per second increases as frequency increases; (1)
Efficiency decreases as frequency increases. (1) [4]
OR
Primary coil produces varying magnetic flux; (1)
This varying flux induces voltage in secondary coil; (1)
Complete loop ensures that maximum possible flux produced by primary coil liks with the secondary coil. (2) [4]

6 (a) Free electrons in the conduction band occupy the lower energy levels; (1)
Energy levels in the conduction band are very close together; (1)
All visible light photons are absorbed by exciting electrons into higher energy levels in the conduction band. (1) [3]

(b) Energy of photon of wavelength 550 nm $= hc/\lambda$ (1)
$= \dfrac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{550 \times 10^{-9}}$
$= 3.62 \times 10^{-19}$ J (1)
$= 3.62 \times 10^{-19} / 1.6 \times 10^{-19}$
$= 2.26$ eV (1)
This energy is less than the energy gap so the photon will not be absorbed / will pass through the insulator. (1) [4]

(c) (i) The amount of Rayleigh scattering is proportional to $1/\lambda^4$ /decreases with λ (1)
Visible light has a smaller wavelength (than infra-red) so loses a bigger proportion of its intensity. (1) [2]

(ii) $\dfrac{\text{\% loss of infra-red}}{\text{\% loss of visible light}} = \dfrac{600^4}{1200^4}$ (1)

% loss of infra-red $= \dfrac{600^4 \times 72}{1200^4} = 4.5$ (1) [2]

7 (a) (i) $s = 2\pi r / t$
$= 2 \times \pi \times 122/2 /(30 \times 60)$ (1)
$= 0.21 \text{ m s}^{-1}$ (1)

(ii) F = 2.5 kN x 16 = 200,000 N or 200 kN (1)

(iii) $W = f \times s$
$= 200 \text{ k} \times 2 \times \pi \times 122 / 2$ (1)
$= 7.67 \times 10^7$ J (1)

(iv) $P = W / t$
$= 7.67 \times 10^7 / (30 \times 60)$ (1)
= 42,600 W or 42.6 kW (1)

(v)
all work is done against friction (1)
as constant k.e. (1)
friction force at bearing opposes rotation, so work done against this (1)
friction force of tyres on rim drives wheel, so useful (1)
electrical energy supplies power to drive wheels (1)
work done by tyres equals work done against bearing friction (1)
some of the electrical energy supplied goes to heating of wires (I^2R) (1)
to max.5

(b) (i) X is bigger than Y as X is under greater tension due to the weight of the bike (1)

(ii) Q is bigger than P due to the weight of the wheel causing compression in P (1)

(c) (i) $k = F / x$
$= 1.8 \times 10^6 / 0.90$ (1)
$= 2.0 \times 10^6 \text{ Nm}^{-1}$ (1)

(ii) $f = 2\pi (k/m)^{0.5}$ (0)
$= 2\pi (2.0 \times 10^6 / 9.5 \times 10^5)^{0.5}$ (1)
= 0.225 Hz (1)

(d) If wind energy causes this frequency in the structure, the amplitude builds up / resonance occurs (1)
damping is necessary / to reduce amplitude or mass change to shift resonant frequency (1)

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