

2) a) IONIC BONDING IS THE PROCESS OF ELECTRONS TRANSFERRING BETWEEN ATOMS TO BECOME BALANCED.

BALANCE IS ACHIEVED BY HAVING A COMPLETE OUTER SHELL.

IN ORDER TO TRANSFER ~~AT~~ ELECTRONS, ONE ATOM MUST BE A DONOR (UNSTABLE, INCOMPLETE OUTER SHELLS) AND A RECEPTOR (ALMOST COMPLETE OUTER SHELLS). THIS IS A PERMANENT

EXCHANGE BETWEEN METALS AND NON-METALS.

COVALENT BONDING IS TEMPORARY AND OFTEN BETWEEN ~~NON METALS~~ ^{NON METALS} AND NON METALS. ATOMS HERE SHARE ELECTRONS IN THE OUTER SHELL.

THIS CAN HAPPEN WITH A METAL AND NON METAL BUT IS UNCOMMON.

~~METALLIC~~ BONDING

METALLIC BONDING HAPPENS WHEN ELECTRONS FROM THE OUTER SHELL OF A METAL ATOM ARE MOVED. THIS RESULTS IN STRUCTURED POSITIVE CHARGE IONS AND THE ELECTRONS ARE FREE TO MOVE - CALLED DELOCALISED. THESE ELECTRONS FILL THE GAPS IN THE IONS STRUCTURE.

VACENCY IS THE ATOMS ABILITY TO BOND WITH HYDROGEN ATOMS, MEASURED AS A NUMBER OF FREE SPACES ON THE OUTER SHELL.

b) $a = 0.362 \text{ nm}$ COPPER IS FCC SO $a = 2\sqrt{2} R$

$$0.362 = 2\sqrt{2} R$$

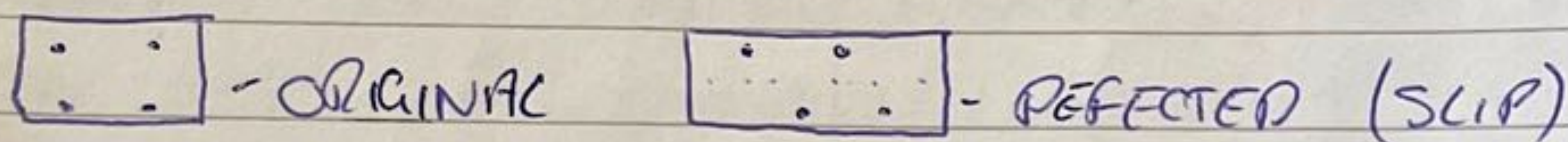
$$\frac{0.362}{2\sqrt{2}} = R$$

$$0.128 = R$$

$$R = 0.128 \text{ nm}$$

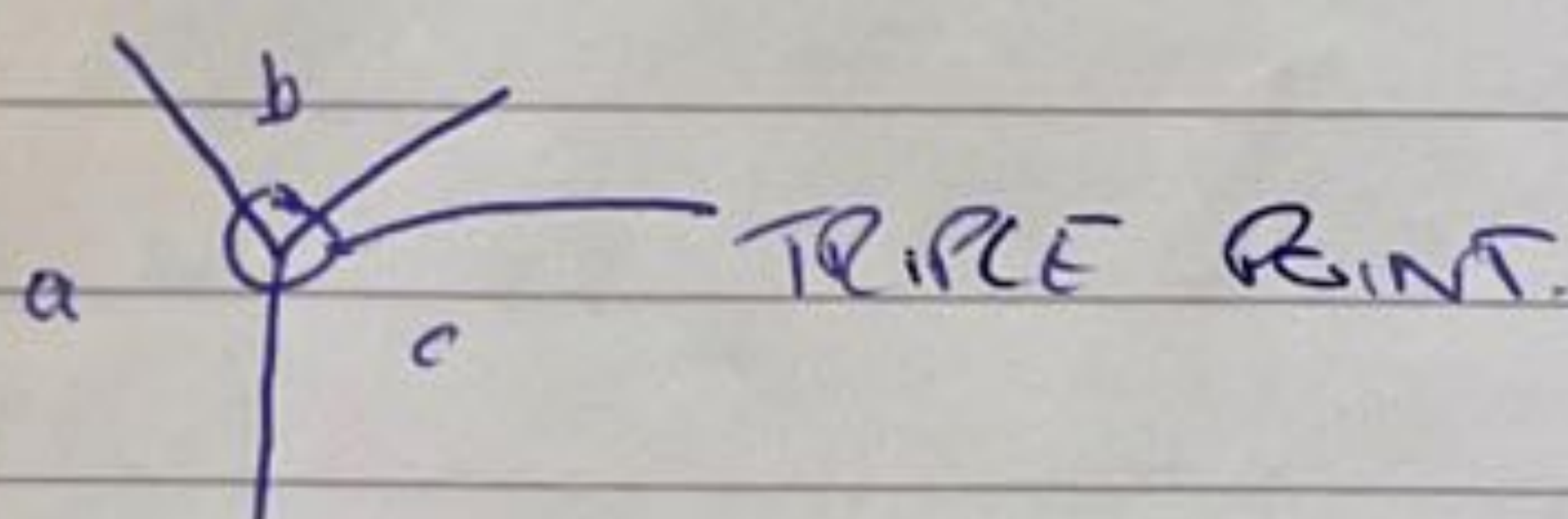
- c) POINT DEFECTS ARE ATOMS WHICH ARE NOT BEHAVING AS PART OF THE STRUCTURE.
- VACANCIES OCCUR NATURALLY AND RESULTS IN MISSING ATOMS AND THUS DISTORTION. THIS IS AFFECTED BY TEMPERATURE WITH VACANCIES INCREASING CLOSE TO MELTING POINT.
- SELF-INTERSTITIALS ARE THE OPPOSITE WHERE AN EXTRA ATOM IS SITUATED BETWEEN STRUCTURED ATOMS.
- SUBSTITUTIONAL DEFECT IS A ORIGINAL ATOM BEING REPLACED WITH A DIFFERENT TYPE - MAINTAINING LATTICE FORMATION.

LINE DEFECTS ARE STRINGS OF POINTS DEFECTING AS A LINE, AFFECTING LATTICE FORMATION. THESE DEFECTS RESULT IN PERMANENT DEFORMATION. SLIP DEFECT IS AN OFFSETTING OF A PART OF THE STRUCTURE TO ANOTHER.



AREA DEFECTS OCCUR WHEN THE OUTER ATOMS OF A STRUCTURE - BOUNDARIES RECOGNISING DUE TO A CHANGE IN CRYSTAL STRUCTURE

- d) THE SECOND STAGE OF CREEP IS CONTROLLED BY DISLOCATION MOVEMENT - WHERE CRYSTALLINE STRUCTURE DEFORMATIONS MOVES TOWARD GRAIN BOUNDARIES. DUE TO APPLIED STRESSES, THIS DEFORMATION IS PREDICTABLE AS THE MOVEMENT IS DIRECTED TO THE WEAKEST AREA, THE GRAIN BOUNDARY TRIPLE POINTS (INTERSECTION OF GRAIN BOUNDARIES)



4)a: STEEL ALLOY GROUP 7XXX UTILISES ZINC AS A MAIN ALLOY - IN THE HEAT TREATABLE CATEGORY.

ZINC ACCOUNTS FOR MATERIAL HARDENING THROUGH HEAT TO INCREASE STRENGTH. THIS REDUCES MALLEABILITY AND RESULTS IN A BRITTLE ALLOY.

ii 1045 STEEL 1 = CARBON STEEL

4,5 = 0.45% CARBON CONTENT

b)

THREE COMPOSITE CLASSIFICATIONS ARE STRUCTURAL, PARTICLE REINFORCED AND ~~STRUCTURAL~~ FIBER-REINFORCED.

STRUCTURAL COMPOSITES ARE COMBINATIONS OF COMPOSITES AND HOMOGENEOUS MATERIALS. THIS HAS THE BENEFITS OF COMBINING PROPERTIES FROM BOTH MATERIAL TYPES. FOR EXAMPLE A SANDWICH COMPOSITE WILL HAVE A STRONGER SOLID MATERIAL SURROUNDING A MORE CATHWEIGHT, INDIVIDUALLY WEAKER MATERIAL. A BENEFIT TO THIS IS THE ABILITY TO OPPOSE STRESS ACTING FACES TO INCREASE LATERAL RIGIDITY, AND SAVE WEIGHT.

PARTICLE REINFORCED COMPOSITES WORK BY ADDING VERY SMALL BUT HARDER, STIFFER PARTICLES.

SPLIT INTO LARGE PARTICLE AND DISPERSION STRENGTHENED GROUPS - DEFINED BY STRENGTHENING MECHANISMS.

'LARGE' PARTICLE IS DECATIVE BUT JUST MEANS THE PARTICLES ARE NOT ATOMIC SCALE. DISPERSION STRENGTHENED PARTICLES OFTEN < 0.1 MICRONS. AND WORK BY ATOMICALLY BONDING MATERIALS. THIS LEADS TO DECREASED PLASTIC DEFORMATION.

CONCRETE IS AN EXAMPLE OF LARGE PARTICLE
WHEREAS ~~STRENGTHENED~~ STRENGTHENED
GLASS IS IS DISPERSION STRENGTHENED THROUGH THE
ADDITION OF ZIRCONIA FOR EXAMPLE.

FIBRE REINFORCED COMPOSITES USE FIBRES OF
VARYING SIZES TO MODIFY A MATERIALS CHARACTERISTICS,
E.G. FIBREGLASS, CARBON FIBRE. FIBRE GROUPS ARE
SPLIT TO ALIGNED, RANDOM AND WOVEN.

ALIGNED FIBRES INCREASE STRENGTH IN A SINGLE DIRECTION
AND CAN DRASTICALLY INCREASE LOAD STRENGTH UP TO
15x. RANDOM FIBRES ARE CHEAP ~~BUT~~ ^{AND} EASY TO PRODUCE
BUT DO NOT PROVIDE THE SAME LEVEL OF INCREASED
STRENGTH. THE FINAL COMPOSITE WILL BE ISOTROPIC.
OFTEN USED IN CONSTRUCTION TO EASILY INCREASE CONCRETE
STRENGTH.

WOVEN ~~ALIGNED~~ FIBRES ARE THE MOST EXPENSIVE AND PROVIDE
BEST INCREASED LOAD STRENGTH ON AVERAGE BUT NOT
AS STRONG AS ALIGNED FIBRES IN A SINGLE DIRECTION.

$$\begin{aligned} c) \quad 30 \text{ MPa} &= 30 \times 10^6 \text{ Pa} \\ \cancel{0.45} V_f &= 0.45 \\ E_f &= 65 \times 10^9 \text{ Pa} \\ E_m &= 3.2 \times 10^9 \text{ Pa} \\ A_c &= 300 \times 10^{-6} \\ V_m &= (1 - 0.45) = 0.55 \end{aligned}$$

$$\begin{aligned} E_{CL} &= E_m V_m + E_f V_f = (3.2 \times 10^9 \cdot 0.55) + (65 \times 10^9 \cdot 0.45) \\ &= 31.01 \times 10^9 \text{ Pa} \end{aligned}$$

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$$\frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m} = \frac{65 \times 10^9 \cdot 5.2 \times 10^{-6} \cdot 0.45}{3.2 \times 10^9 \cdot 0.55} = 16.61$$

$$F_f = 16.61 F_m$$

$$\sigma = 30 \times 10^6$$

$$A_c = 300 \times 10^{-6}$$

$$F_c = \sigma A_c = (30 \times 10^6) \times (300 \times 10^{-6}) = 9000 \text{ N}$$

$$F_c = F_f + F_m$$

$$F_c = 16.61 F_m + F_m = 17.61 F_m$$

$$9000 = 17.61 F_m \quad \therefore \quad \frac{9000}{17.61} = F_m \quad \therefore \quad \underline{F_m = 511.07 \text{ N}}$$

$$F_f = 16.61 F_m \quad \therefore \quad \underline{F_f = 511.07 \times 16.61 = 8488.87 \text{ N}}$$

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1) a) HYDROGEN AND BIOETHANOL ARE OPTIONS FOR FUTURE FUELS.

HYDROGEN IS THE MOST ABUNDANT ELEMENT AND PRODUCES ONLY H_2O WHEN COMBUSTED. BIOETHANOL IS A RENEWABLE SOURCE OF ENERGY AND IS ALREADY BEING ADDED TO PETROL TO REDUCE GREENHOUSE EMISSIONS IN F10 FUEL.

b) USERS OF HYDROGEN WILL NEED DRASTICALLY DIFFERENT STORAGE CAPACITY THAN PETROL AS IT NEEDS TO BE STORED SAFELY AS A COMPRESSED LIQUID. PURE ETHANOL HAS A SIMILAR PROBLEM AS IT HAS A MUCH LOWER ENERGY DENSITY THAN PETROL, AND AS SUCH, WILL REQUIRE MORE FUEL TO BE BURNED TO ACHIEVE THE SAME PERFORMANCE, RESULTING IN WORSE FUEL ECONOMY. ETHANOL IS ALSO POOR IN TERMS OF COLD START CAPABILITIES SO CONSUMERS IN COLD TEMPERATURE CLIMATES MAY STRUGGLE.

c) SAFETY STANDARDS AND MEASURES WILL NEED UPDATING TO MAKE THE USE OF CARRYING COMPRESSED HYDROGEN FUEL REALISTIC AND APPEALING FOR THE CONSUMER. IT IS ALSO NOTORIOUSLY DIFFICULT TO PRODUCE PURE HYDROGEN AND AS SUCH CURRENTLY EXPENSIVE TO ACQUIRE.

BOTH FUELS WILL NEED INCREASED DISTRIBUTION SO THAT EVERYONE HAS ACCESS TO IT.