

BRADLEY BURTON 1803066

AUTOMOTIVE MATERIALS & SUSTAINABILITY ACMAG012

13TH MAY 2022

QUESTION 1

A) TWO ALTERNATIVE FUELS THAT HAVE THE POTENTIAL TO ^{HELP} MEET NEW EMISSION STANDARDS ARE HYDROGEN & BIOETHANOL. HYDROGEN WILL MEET STANDARDS DUE TO THE REMOVAL IN CARBON EMISSIONS FROM THE END USE PHASE, WHEREBY FUEL CELL ELECTRIC PRODUCES ^{HARMFUL} NO ¹ EMISSIONS & COMBUSTION PRODUCES ONLY NOX WHICH CAN BE MINIMISED OR REMOVED THROUGH LEAN MIX CONTROL OR NITROGEN PRE OR POST FILTRATION. BIOETHANOL DOES PRODUCE CO₂ AS A RESULT OF COMBUSTION, HOWEVER, IT PRODUCES 55 - 75% LESS CO₂ AND CAN BE PRODUCED BY SUSTAINABLE METHOD. HYDROGEN IS SIMILARLY GREEN AS IT CAN BE DISSOCIATED BY ELECTROLYSIS USING RENEWABLES TO SUPPLY ENERGY REQUIRED.

B) HYDROGEN HAS A REDUCTION IN PRACTICALITY FOR THE END USER DUE TO A NUMBER OF CURRENT RESTRICTIONS. AT PRESENT THE FUEL INFRASTRUCTURE IS NOT IN PLACE TO PRODUCE LARGE QUANTITIES OF RENEWABLE HYDROGEN READY FOR END USE, WITH ONLY A HANDFUL OF FILLING STATIONS AVAILABLE IN THE UK. ALSO DUE TO HYDROGEN'S DIFFUSAL CHARACTERISTICS IT

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IS DIFFICULT TO STORE AND MAINTAIN A QUANTITY IN THE TANK AS IT HAS A TENDENCY TO ESCAPE TO ATMOSPHERE. THIS MAY BE DANGEROUS IF STORED FOR ANY PERIOD IN A CONFINED WELL SEALED AREA FOR A LARGE LENGTH OF TIME. THIS DISSIPATION WILL RESULT IN EMPTY FUEL TANKS AND NO MEANS OF TRANSPORTATION FOR REFUEL.

BIOETHANOL WILL IMPACT END USERS BY REDUCING RANGE ABILITY OF A TANK COMPARED WITH PETROL AS IT HAS A LOWER VOLUMETRIC ENERGY DENSITY. HOWEVER, SHOULD COST LESS DUE TO THE ABILITY TO MANUFACTURE LOCALLY WHICH REMOVES HIGH COSTS OF TRANSPORTATION AND EXTRACTION ASSOCIATED WITH FOSSIL FUEL HYDROCARBON PRODUCTION.

- C) A GREAT DEAL OF WORK IS REQUIRED TO DEVELOP THE INFRASTRUCTURE FOR ~~THIS~~ THIS TO BECOME A VIABLE GREEN ALTERNATIVE. THESE INCLUDE, PLACEMENT OF ELECTROLYSERS AT FUEL STATIONS WITH SUSTAINABLE POWER SUPPLY WHICH WILL ENABLE THE PRODUCTION AND DISTRIBUTION OF LOCALLY GENERATED FUEL, REMOVING THE CARBON FOOTPRINT OF INDUSTRIAL PRODUCTION & TRANSPORTATION.

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IN ADDITION, STORAGE METHODS FOR EACH USE NEED TO BE IMPLEMENTED TO ENSURE EVERY LOSS IS MINIMISED FROM DISPERSAL. FINALLY THE ENVIRONMENTAL ASPECTS OF HYDROGEN INCREASE IN ATMOSPHERE NEED TO BE UNDERSTOOD TO ENSURE THAT UPTAKE DOES NOT NEGATIVELY EFFECT THE PLANETS ATMOSPHERIC COMPOSITION.

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QUESTION 2

A) IONIC BONDING OCCURS WHEN ATOMS TRANSFER ELECTRONS FROM ONE TO ANOTHER IN AN EFFORT TO BECOME BALANCED, ~~FOR~~ ONE ATOM IS THE DONOR AND THE OTHER A RECEIVER.

COVALENT BONDING IS WHEN ATOMS SHARE ELECTRONS BUT THE TRANSFER IS NOT PERMANENT.

METALLIC BONDS OCCUR IS WHEN ATOMS SHARE ELECTRONS FREELY FROM THEIR OUTER SHELL, WHEREBY IONS FORM A LATTICE & ELECTRONS FILL THE GAPS. ~~THE~~

AN ATOM'S VALENCY IS DEFINED AS ~~THE~~ ITS ABILITY TO COMBINE & VARIES DEPENDANT ON THE NUMBER OF ~~ATOMS~~ ELECTRONS IN ITS OUTER SHELL, IF INCOMPLETE IT HAS A TENDENCY TO FILL THE OUTER SHELL THROUGH ELECTRON SHARING WITH OTHER ATOMS.

B) $a = 2\sqrt{2}R$ FOR FACE CENTERED CUBIC AS COPPER HAS 4 ATOMS PER UNIT CELL

$$a = 0.362 \text{ nm} \quad \text{SO} \quad R = \frac{\left(\frac{a}{2}\right)^2}{2}$$

$$R = \frac{\left(\frac{0.362}{2}\right)^2}{2} = \boxed{0.016 \text{ nm}}$$

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c) DEFECTS COVERED BY POINTS :

VACANCIES - MISSING ATOMS WITHIN THE LATTICE
CREATE DISTORTION OF SURROUNDING
AREA

SELF-INTERSTITIALS - OCCURS WHEN AN ATOM IS
POSITIONED WITHIN A NORMAL
LATTICE STRUCTURE,

SUBSTITUTIONAL - OCCURS WHEN AN ORIGINAL ATOM
IS REPLACED BY ANOTHER ATOM
WITHIN LATTICE STRUCTURE.

DEFECTS COVERED BY LINE :

DISLOCATIONS - OCCUR AS A DEFECT IN THE
STRUCTURE WHEREBY LAYERS SLIP
RELATIVE TO ADJACENT LAYERS, BREAKING
ORIGINAL BONDS TO FORM NEW,
RESULTING IN PERMANENT PLASTIC
DEFORMATION.

DEFECTS COVERED BY AREAS :

GRAIN BOUNDARIES - CREATE DEFECTS IN CRYSTALLINE
STRUCTURE, ORIENTATION OF WHICH

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PREVENTS DISLOCATION AS
ORIENTATION OF BOUNDARIES & CRYSTALS
IS RANDOM.

D) THE CREEP FAILURE MECHANISM THAT CONTROLS
THE SPEED OF CREEP IN THE SECONDARY
STAGE IS DISLOCATION OF THE CRYSTALLINE
STRUCTURE, WHEREBY, THE STRESS APPLIED
CAUSES DISLOCATIONS TO MOVE AS THE
STRUCTURE SETTLES, ~~CAUSED~~ BY THE
INTERSECTION OF THREE POINTS WITHIN
THE GRAIN BOUNDARIES, AS IT IS
THE WEAKEST STRUCTURE, WHICH HAS A
PREDICTABLE DEFORMATION.

QUESTION 4

A) I) • THE MAIN ALLOYING ELEMENT IN 7000
SERIES ALUMINIUM IS ZINC

ITS BENEFITS ARE IT IS HEAT TREATABLE
TO INCREASE STRENGTH

ITS LIMITATIONS ARE THAT IT BECOMES
BRITTLE & IS THEREFORE RARELY USED ALONE

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II) STEEL 1045

1 = STATES STEEL TYPE IS CARBON

0 = STATES IT HAS NOT BEEN RE-SULPHURIZED

45 = THE PERCENTAGE CARBON CONTENT = 0.45%

B) THE THREE GROUPS USED TO CLASSIFY COMPOSITES ARE;
FIBRE REINFORCED, PARTICLE REINFORCED,
& STRUCTURAL.

FIBRE REINFORCED - PROMOTES HIGH STIFFNESS /
STRENGTH TO WEIGHT RATIO;
SUBCATEGORISED BY FIBRE LENGTH
WHEREBY SMALL FIBRE IMPLEMENTATION
REDUCES STRENGTH & LONGER FIBRES
PROMOTE STRENGTH. ~~AND~~ STRENGTH
IS INFLUENCED BY FIBRE ORIENTATION,
WHICH INCLUDE ALIGNED FIBRES,
RANDOM FIBRES OR WOVEN FIBRES
MOST COMMON FIBRE REINFORCED
MATERIALS ARE CARBON FIBRE
& FIBERGLASS.

PARTICLE REINFORCED - MADE UP OF LARGE PARTICLES &
DISPERSED STRENGTHENING PARTICLES
WHEREBY SMALLER PARTICLES FORM
BONDS ON MOLECULAR OR ATOMIC
LEVEL RESISTING PLASTIC DEFORMATION

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LARGE PARTICLES INTERACT WITH THE MATRIX MATERIAL IS NOT ON A MOLECULAR LEVEL, AN EXAMPLE OF WHICH IS CONCRETE.

STRUCTURAL - COMBINED COMPOSITE & HOMOGENEOUS MATERIALS CREATING MATERIALS WITH PROPERTIES FROM BOTH. THE GEOMETRIC CONSTRUCTION AFFECTS THE COMPOSITE PROPERTIES AS A RESULT. THIS CAN BE ACHIEVED THROUGH STRUCTURAL, SANDWICH CONSTRUCTION, WHEREBY CORE IS LESS DENSE THAN FACE PLATES, OR LAMINAR COMPOSITES WHEREBY IDENTICAL SHEETS ARE STACKED IN VARIOUS ORIENTATIONS TO PROMOTE TAILORED STRENGTH CHARACTERISTICS.

c)

$$\begin{aligned}V_F &= 0.45 \% \\V_M &= 0.55 \% \\E_F &= 65 \times 10^9 \text{ Pa} \\E_M &= 3.2 \times 10^9 \text{ Pa} \\A &= 300 \text{ mm}^2 \text{ OR } 300 \times 10^{-6} \text{ m}^2 \\ \sigma &= 30 \times 10^6 \text{ Pa}\end{aligned}$$

$$\frac{F_F}{F_M} = \frac{(65 \times 10^9)(0.45)}{(3.2 \times 10^9)(0.55)} = 16.62 \text{ N}$$

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$$\sigma = \frac{F}{A} \quad \text{so} \quad F_c = \sigma A$$

F_c
↓

$$\text{so} \quad (30 \times 10^6)(300 \times 10^{-6}) = 9000 \text{ N}$$

$$F_c = F_F + F_M$$

so ✓ SUB IN

$$9000 = 16.62 F_M + F_M$$

so

$$9000 = 17.62 F_M$$

so

$$F_M = \frac{9000}{17.62} = 510.78 \text{ N}$$

$$F_c - F_M = F_F$$

so

$$9000 - 510.78 = 8489.22 \text{ N}$$

$$F_M = 510.78 \text{ N}$$

$$F_F = 8489.22 \text{ N}$$