UNIVERSITY OF JORDAN
ENGINEERING SCHOOL
INDUSTRIAL ENGINEERING DEPARTMENT
Material science

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Seat No. 32

6/8

- Time duration: **50 minutes**
- closed book & closed notes exam….
- **All constants you need are shown in the last paper**

Solve Q1 and Q2 on the same paper while answer the rest on the answer sheet

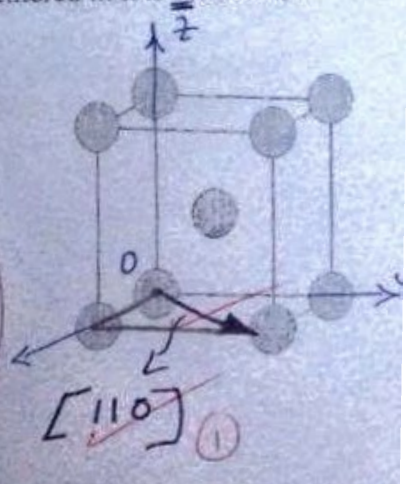
Q 1 Fill in the tables below: (8 marks)

	Ceramics	polymers	Smart materials
Example of material	SiC / silicon carbide	Rubber	semiconductors (not exact)
Objects made of / application	Glass vase	polyester polyethlen	electrons computer Industries.

	Ionic	covalent	Van der waals
Type	primary	primary	secondary
Bond energy	Hard, brittle, large bond energy	ductile, low bond energy	weak
One example	NaCl	AlP	HCl, molecules

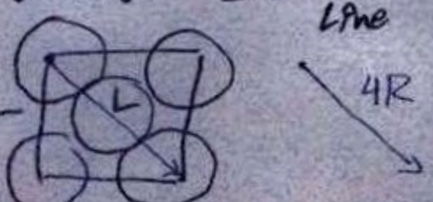
	Description	Why would it occur
Edge dislocation	dislocation line ⊥ burger vector	resulting from an extra portion of plane of atoms or half plane
screw	dislocation line // burger vector	Resulting from shear stress.
Twin boundaries	one side of atoms is a mirror image of the atoms on the other side.	Resulting from shear stress.

Q 2 Draw the direction [110] which passes through 2 corner atoms on the unit cell shown to the right and calculate its linear density (in terms of R) assuming that the number of atoms centered in it is $\frac{1}{2}$ atom? (4 marks)



* linear density = $\frac{\text{No. of atoms on the line}}{\text{Line vector length}}$

* Length.



$a = \frac{4R}{\sqrt{3}}$

$L.D = \frac{1}{\frac{8\sqrt{3}R}{3}}$

3/4

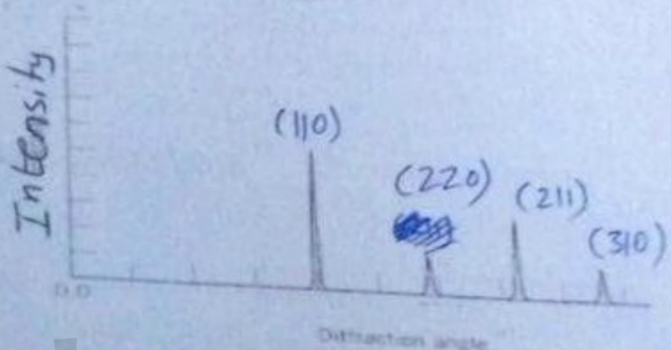
Q 3 Complete the four components of the discipline of material science? (1 marks)

Q 4 Compute the percent ionic character of the bond for the compound ZnTe , given that the electro negativities are 1.6 and 2.1 for Zn and Te respectively. (1 mark)

Q 5 If a monochromatic radiation wave with a length of 0.071 nm was subjected to a sample (that have a BCC crystal structure and an atomic radius of 0.1241 nm) , answer the following: (5 marks)

a) which set of planes will a first-order diffraction peak occur at a diffraction angle of 46.21°

b) cite the plane indices of the 4 diffraction peaks shown below for the same question



Q 6 How many grains per square inch will be at a magnification of 75 if the ASTM grain size number was 4.8? (2 marks)

Q 7 Determine the approximate density of a high-leaded brass that has a composition of 64.5 wt% Cu, 33.5 wt% Zn, and 2.0 wt% Pb (densities 8.94, 7.13 , 11.35 g/cm3 respectively) (2 marks)

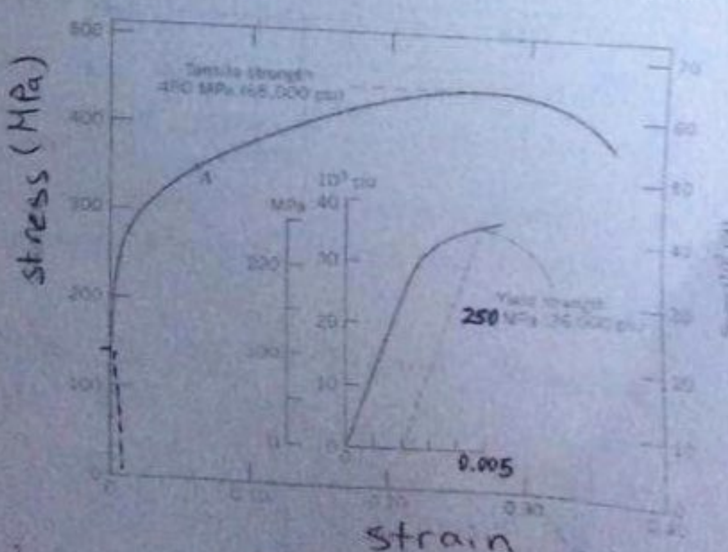
Q 8 Justify why Ni and Copper will form a substitutional solid solution (show calculations when required) (2 marks)

Q 9 Show from first principles that at the point of necking, the value of the true strain equals the value of the strain hardening index "n"? (5 marks)

Q 10 A cylindrical specimen of a brass alloy 7.8 mm in diameter and 95.0 mm long is pulled in tension with a force of 6000 N; the force was then released. The tensile stress – strain behavior of the alloy is shown below , compute : (5 marks)

a) the final length of the specimen after applying the force and then release it

b) the final specimen length when the load is increased to 16,500 N and then released.



Q1 8 Q4 1 Q7 2 Q10 5
Q2 4 Q5 5 Q8 2
Q3 1 Q6 2 Q9 5

Key

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8

Q 1 Fill in the tables below: (8 marks)

	Ceramics	polymers	Smart materials
Example of material	Silicon Carbide	Rubber	SMA
Objects made of / application	Glass vase	bottles. balls	helicopters. sensors--- (ceramic + polymers

	Ionic	covalent	Van der waals
Type	primary	primary.	secondary
Bond energy	Hard, brittle, large bond energy	weak strong	
One example	NaCl	HCL / CH_4	HCL – HCL $H_2O - H_2O$

	Description	Why would it occur
Edge dislocation	extra half plan of atoms	during solidification.
screw	shifted one unit cell or more.	Shear / Mechanical force.
Twin boundaries	mirror	-annealing. - shear force.

Q 2 Draw the direction [110] which passes through 2 corner atoms on the unit cell shown to the right and calculate its linear density (in terms of R) assuming that the number of atoms centered in it is 1 atom? (4 marks)

4

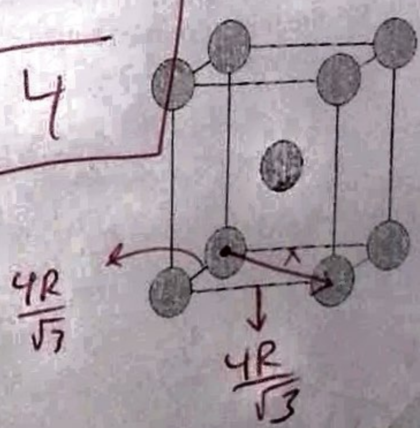
$x^2 = \left(\frac{4R}{\sqrt{3}}\right)^2 + \left(\frac{4R}{\sqrt{3}}\right)^2$

$x^2 = \frac{16R^2}{3} + \frac{16R^2}{3} = \frac{32R^2}{3}$

$x = 4R\sqrt{\frac{2}{3}}$

1

$L.D = \frac{1}{4R\sqrt{\frac{2}{3}}} = \frac{\sqrt{3}}{4R\sqrt{2}}$



Q3   Processing → Structure → Properties → Performance

Q9   at plastic instabiliy the load is max → slope = 0

* المشتقة عند أعلى نقطة = صفر

at ~~max~~ instability point:

$$\sigma_{max} = \frac{F_{max}}{A} \Rightarrow \boxed{F = \sigma A} \quad ----- (1)$$

↓ derivative

$$dF = \sigma\, dA + A\, d\sigma = 0$$

$$\boxed{\frac{d\sigma}{\sigma} = -\frac{dA}{A} = \frac{dl}{l} = d\varepsilon}$$

$$\boxed{\frac{d\sigma}{d\varepsilon} = \sigma} \quad ---- (2)$$

(3) Now $\sigma = K\varepsilon^n$

$$\frac{d\sigma}{d\varepsilon} = Kn\varepsilon^{n-1}$$

substitute → (4) $Kn\varepsilon^{n-1} = K\varepsilon^n$

$$\boxed{n = \varepsilon}$$

Q10   a. $\sigma = \frac{F}{A_0} = \frac{6000}{47.76} = 126 \text{ MPa}$

Yield point = 250 from the graph ---- $126 < 150$

then it is elastic region ---- the material will return to its dimensions ---- $\boxed{l_f = 95 \text{ mm}}$

Area $= \pi r^2$
$= \pi \left(\frac{7.8}{2}\right)^2$
$= \boxed{47.76 \text{ mm}^2}$

(b) $\sigma = \frac{16500}{47.76} = 345 \text{ MPa} \Rightarrow$ strain at this point from graph is 0.08

$\varepsilon = \frac{\Delta l}{l_0} \Rightarrow 0.08 = \frac{\Delta l}{95} \Rightarrow \boxed{\Delta l = 7.6 \text{ mm}}$

$\boxed{l_f = 95 + 7.6 = 102.6 \text{ mm}}$

Q4. Ionic character:

$$\% = 1 - e^{-.25(X_A - X_B)^2} * 100\%$$

$$= 1 - e^{-0.25(2.1-1.6)^2} * 100\%$$

$$= 6.05\% \text{ or } 6.1\%$$

(1)

Q5

$n\lambda = 2d \sin\theta$

$(1 * 0.071) = 2 * d * \sin\left(\frac{46.21}{2}\right)$

(a)

$d = 0.0904$ nm.

$d = \frac{a}{\sqrt{h^2+K^2+l^2}} \Rightarrow 0.0904 \text{ nm} = \frac{\left[\frac{4*(0.1241)}{\sqrt{3}}\right]}{x}$ (3)

$\sqrt{h^2+K^2+l^2} = x = 3.17 \Rightarrow$ condition all even.

$h^2+K^2+l^2 = (3.17)^2$

$h^2+K^2+l^2 = 10$

(310)

(b) (2) (110), (200), (211), (220), (222), (310)

Q6 $N_m\left(\frac{M}{100}\right)^2 = 2^{n-1}$

$N_m\left(\frac{75}{100}\right)^2 = 2^{(4.8-1)}$ $\Rightarrow N_m = 2$

$N_m * 0.5625 = 2^{3.8}$

$N = 24.7 \approx 25$ grains.

$N_m\left(\frac{M}{100}\right)^2 = 0.155 \times 10^{0.3(n-1)}$

(2) Q7 $\rho_{av} = \frac{100}{\frac{\rho_1}{c_1}+\frac{\rho_2}{c_2}+\frac{\rho_3}{c_3}} \Rightarrow \rho_{av} = 8.27$ g/cm3

$\Delta R = \frac{0.1278 - 0.1246}{0.1278}$

2.5%

0.0032 nm

(2) Q8 Ni and Cu Similar electrones valance

atomic radius FCC