20.5

The University of Jordan

School of Engineering

Materials Science **Midterm Exam (30 Marks)** **Time: 50 Minutes**

Student Name احمد علي راتب ابو عليا **I.D. number:** 0139136

Q1: Explain why metals are good conductors of electricity while materials such as sodium chloride are considered as electrical insulators? **(2 Marks)**

because metals have Valance electron (free electrons) can transmit the energy betwee atoms oppistte the insulation dont have Valenc electrons

Q2: Determine the carburizing time necessary to achieve a carbon concentration of 0.30 wt% at a position 4 mm into an iron–carbon alloy that initially contains 0.10 wt% C. The surface concentration is to be maintained at 0.90 wt% C, and the treatment is to be conducted at C. Use the diffusion data for γ-Fe **(4 Marks)**

3.5

Table 5.2 A Tabulation of Diffusion Data

Diffusing Species	Host Metal	$D_0 (m^2/s)$	Activation Energy Q_d kJ/mol	Activation Energy Q_d eV/atom	Calculated Values T(°C)	Calculated Values $D (m^2/s)$
Fe	α-Fe (BCC)	2.8×10^{-4}	251	2.60	500	3.0×10^{-21}
					900	1.8×10^{-15}
Fe	γ-Fe (FCC)	5.0×10^{-5}	284	2.94	900	1.1×10^{-17}
					1100	7.8×10^{-16}
C	α-Fe	6.2×10^{-7}	80	0.83	500	2.4×10^{-12}
					900	1.7×10^{-10}
[illegible]	γ-Fe	2.3×10^{-5}	148	1.53	900	5.9×10^{-12}
					1100	5.3×10^{-11}

z	erf(z)
0.70	0.6778
0.75	0.7112
0.80	0.7421
0.85	0.7707
0.90	0.7970
0.95	0.8209
1.0	0.8427

$$\frac{C_x - C_o}{C_s - C_o} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right)$$

$$\frac{0.3 - 0.1}{0.9 - 0.1} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right)$$

$$erf\left(\frac{4*10^{-3}}{2\sqrt{Dt}}\right) = 0.75$$

$$\frac{4*10^{-3}}{2\sqrt{5.349*10^{-11} t}} = 0.8138$$

$$t = 112913.833 \ s$$

$$D = D_o \exp\left(\frac{-Q_d}{RT}\right)$$

$$= 2.3*10^{-5} \exp\left(\frac{-148000}{(8.31)(1100+273)}\right)$$

$$= 5.34906*10^{-11}$$

0.8 — 0.7421

z — 0.75

0.85 — 0.7707

$$z = 0.8138$$

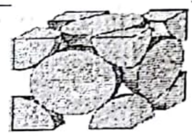
Q3) Choose the correct answer-show the calculation/work when required.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
a	f	a	e	d	e	a	b	a	a	d	d	d	d	d	c	c	b	f	a	a

1. The distance between the centers of adjacent atoms along the [010] direction in the shown crystal structure, where R is the atomic radius:

a. $4R/\sqrt{3}$
b. 2R
c. 4R
d. $R\sqrt{2}$
e. $2R\sqrt{2}$
f. R/2

2. The linear density of the [111] direction in the shown crystal structure, where R is the atomic radius:

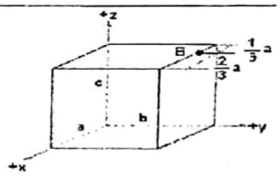


a. $1/R\sqrt{96}$
b. $\sqrt{3}/4R$
c. $1/R\sqrt{24}$
d. $1/R\sqrt{6}$
e. $1/4R$
f. $\sqrt{2}/4R$

3. The planar density of the (110) plane in the shown crystal structure, where R is the atomic radius:

a. $3/16R^2$
b. $1/4R^2$
c. $3/\sqrt{32}\,R^2$
d. $3/8R^2$
e. $3/\sqrt{128}\,R^2$
f. $1/2\sqrt{2}R^2$

4. The crystallographic point coordinates for point B:



a. 3 1 1
b. 1 3 3
c. $\frac{2}{3}$ 1 0
d. $\{\frac{2}{3},1,1\}$
e. $\frac{1}{3}$ 1 1
f. $\{1,\frac{1}{2},1\}$

5. The crystal structure for a metal with lattice parameter, a = 0.3302 nm and atomic diameter = 0.286 nm is:

a. simple cubic
b. hexagonal close packed
c. face centered cubic (FCC)
d. body centered cubic (BCC)
e. FCC or BCC
f. none

6. Gold (Au) forms a substitutional solid solution with silver (Ag). If a new Au-Ag alloy having a density of 11.55 g/cm3 is desired for a novel application, the required concentration of Au (in wt%) is:

a. 10
b. 20
c. 30
d. 80
e. 90
f. 60

7. An alloy consists of 75 gram lead (Pb) and 130 gram tin (Sn). the concentration of Pb in at% is:

a. 36.59
b. 24.84
c. 11.74
d. 63.41
e. 75.16
f. 2035

8. Which one of the following crystal structures has the fewest slip directions and therefore the metals with this structure are generally more difficult to deform at room temperature?
a. BCC b. FCC c. HCP d. all of them

9. Average atomic energy due to thermal excitation is of order
a. k_b T b. $(k_b T)^2$ c. $(k_b T)^{0.5}$ d. $(k_b T)^{-2}$

10. The imperfection in the crystal structure of metal is called
a) Vacancy b. cleavage c. fracture d. slip

11. Following is not a 2-dimensional imperfection
a. Twin boundary b. Dislocation c. Surface d. Grain boundary

12. Thermodynamically stable defects
a. Point defects b. Line defects c. Surface defects d. Volume defects

13. Internal dislocations of a material is, generally, examined by
a. naked eye b. optical microscope c. TEM d. SEM

14. Fine grain size, usually, **cannot** be obtained during the following process
a. Slow cooling b. increasing nucleation rate c. retarding grain growth d. fast cooling

15. Plastic deformation results from the following
a. Slip b. Twinning c. Both d. None

16. Typical density of dislocations in a solid
a. 10^{8}-10^{10} μm^{-2} b. 10^{8}-10^{10} mm^{-2} c. 10^{8}-10^{10} cm^{-2} d. 10^{8}-10^{10} m^{-2}

17. Burger's vector changes with
a. Kind of dislocation b. Length of dislocation c. Both kind and length of dislocation d. None

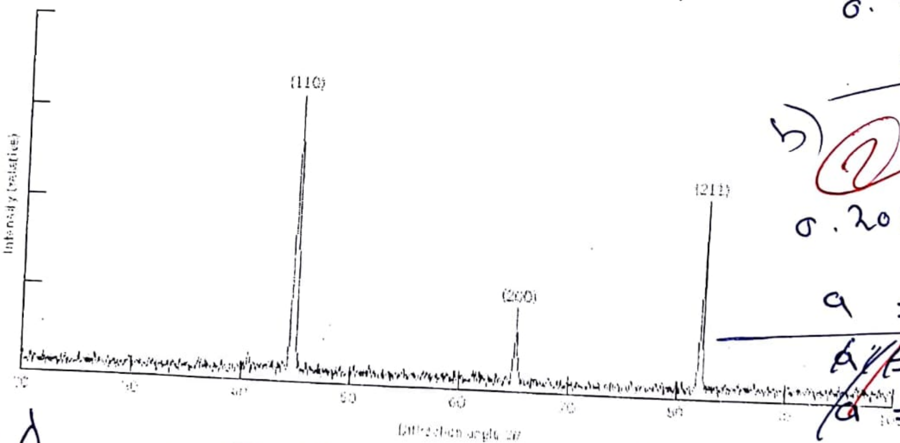
18. How many atoms or molecules are there in a mole of a substance?
a) 6.023 x 10^{19} b) 6.023 x 10^{23} c) 6.32 x 10^{19} d) 6.023 x 10^{-19}

19. What type(s) of electron subshell(s) does an *L* shell (2^{nd} shell) contain?
a. d b. p c. f d. s f) s and p

20. An element with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6$ has how many electrons?--
a) 18 b) 16 c) 11 d) s f) 12

21. Which of the following materials may form crystalline solids?
a) Polymers b) metals c) ceramics d) all of them e) none of the them

Q4) The figure below shows an x-ray diffraction pattern for α-iron taken using a diffractometer and monochromatic x-radiation having a wavelength of 0.154 nm; each diffraction peak on the pattern has been indexed. Find the following:
a) The interplanar spacing for (110) plane **(2 Marks)**
b) The lattice parameter of Fe **(2 Marks)**



19

UNIVERSITYOF JORDAN
SCHOOL OF ENGINEERING

Materials Science | | **Midterm Exam**
Student Name: احمد علي ابو عليان | **Time: 40 Minutes**
Serial Number: 0139136

Q1: choose the correct answer and summarize your answer in the following table. **(12 Marks)**

i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii
a	a	d	d	b	a	c	c	a	a	c	c

10

i. Cleavage fracture appears
   a. a) Bright b) Dull c) Difficult to identify d) None

ii. Usually materials with following crystal structure fail in ductile mode
   a. a) FCC b) BCC c) HCP d) None

iii. Brittle fracture is more dangerous than ductile fracture because ________________.
   a. a) No warning sign b) Crack propagates at very high speeds
   b. c) No need for extra stress during crack propagation d) All

iv. Fracture stress (σf) is proportional to
   a. a) crack length b) 1/crack length c) $(\text{crack length})^{1/2}$ d) $(\text{crack length})^{-1/2}$

v. Fracture toughness, KIC, decreases with
   a. a) increasing temperature b) increasing strain rate c) increase in yield strength d) increase in grain size

vi. If the surface crack causing fracture in a brittle material is made twice as deep, the fracture strength will
   a. a) decrease by a factor of $\sqrt{2}$ b) decrease by a factor of 2 c) decrease by a factor of 22 d) No change

vii. Which hardness method can be used to measure hardness of a single grain ?
   a. a) Rockwell b) Knoop c) Vickers d) Shore

viii. In a tensile test, necking starts at
   a. a) lower yield stress b) upper yield stress c) ultimate tensile stress d) just before fracture

ix. The property of a material due to which it breaks with little permanent distortion, is called
   a. a) brittleness b) ductility c) malleability d) plasticity

x. Most often machine components fail by
   a. a) Buckling b) Creep c) Fatigue d) All

xi. Which hardness method can be used to measure hardness of a single grain ?
   a. a) Rockwell b) Knoop c) Vickers d) Shore

xii. In secondary creep the (select two options)
   a. recovery rate is greater than the work hardening rate
   b. recovery rate is equal to the work hardening rate
   c. creep strain ε is given by ε = Kt, where K is constant and t is the time
   d. creep strain is given by $\varepsilon = Kt^{1/3}$
   e. creep rate is independent of temperature.

Q2: Answer the following with either True or False. **(8 Marks)**

4

i	ii	iii	iv	v	vi	vii	viii
T	F	T	T	F	F	F	T

i) The material crystal structure plays an important role in the brittle to ductile transition phenomenon.
ii) Rough fracture surface is an indication of a brittle fracture
iii) Cup-and-cone fracture is a term refers to brittle fracture where an angle of 45° with tensile axes takes place.
iv) Corrosive environment enhances the materials fatigue resistance.
v) A material creep resistance becomes an important factor for designers when the designed component operates in an environmental temperature exceed 0.4 of the material melting temperature.
vi) Rough fracture surface is an indication of a brittle fracture
vii) Surface grains orientation has no effect on the material fatigue resistance
viii) Materials resistance to creep decreases with larger grain sizes.

Q3: Mention the factors that affect fatigue life and discuss how they affect fatigue strength. **(3 Marks)**

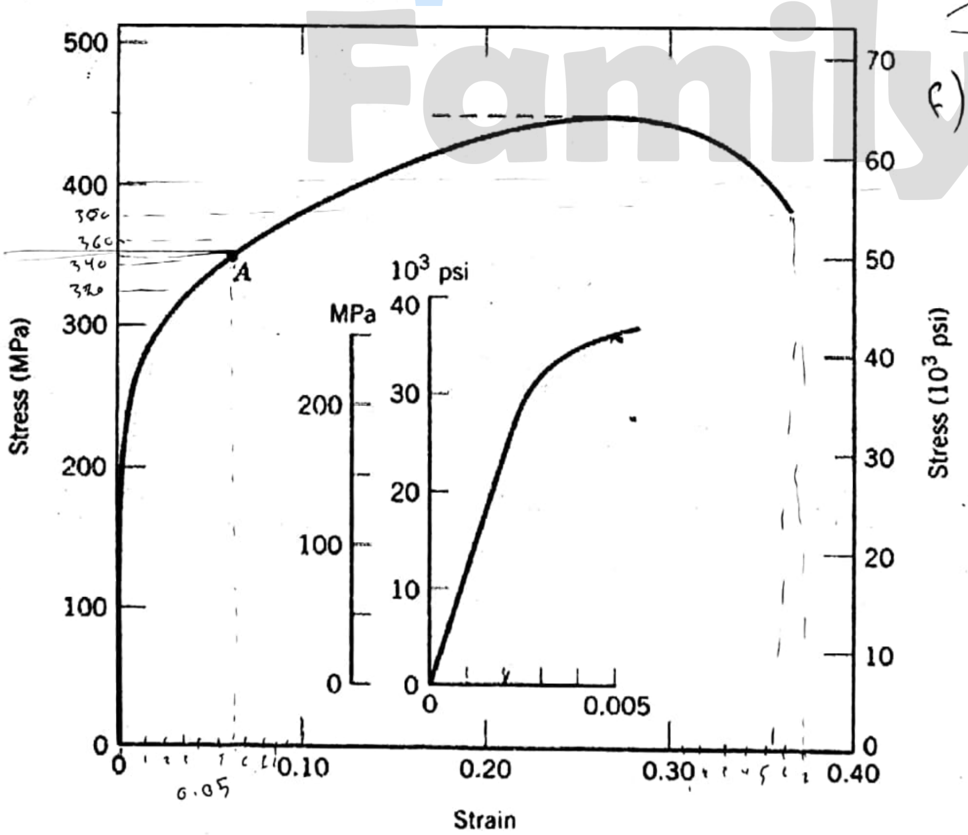
1. heat treatment and mechanical treatment used to reduce fatigue:
2. corrosion enviroment we solve it by use coating (طبقة عازلة)
3. surface

2

Q4: The following diagram shows the stress-strain curve for some material. Use the curve to find a numerical value for: (7 Marks)

a. yield stress 350 MPA
b. ultimate tensile stress 450 MPA
c. fracture stress 380 MPA
d. elastic deformation region 0 – 0.055
e. plastic deformation region 0.055 – 0.37
f) modulus of resilience. 1.066×10^{-5}
g) proportional limit 250 MPA

3



f) $E = \frac{150 - 0}{0.016 - 0} = 93750$

Moduls of resilience $= \frac{1}{E} = \frac{1}{93750}$

$= 1.066 \times 10^{-5}$