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University of Choice

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2021/2022 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER

COURSE CODE: **MIE 213/RET 214**

COURSE TITLE: **MATERIAL SCIENCE I**

DATE:22/4/2022 **TIME: 12.00-2.00 PM**

INSTRUCTIONS TO CANDIDATES

- This paper consists of **FOUR** questions
- ANSWER QUSTION **ONE** and any other **TWO** QUESTIONS
- Graph Papers are provided
- ALL symbols have their usual scientific meanings unless stated otherwise

This paper consists of 7 printed pages Please Turn Over→

Question 1 (30 Marks)

a) In Fig Q1(a) is a plane marked A.

i) Write down the miller indices of the plane. (1 marks)

ii) Leaving out the brackets and using the numerical values contained in your answer to Q 1(a)(i), differentiate between a family of planes and a family of directions. (4 marks)

iii) With suitable sketches differentiate between equi-axed grains and dendritic grains (4 marks)

b) Determine the first three diffraction angles (2θ) for copper metal. Take λ of the radiation as 0.154nm. (8 marks)

c) Sketch using only straight lines a eutectic phase diagram of metals X and Y . Metal X has a higher melting point than metal Y. Take eutectic point as 60% of metal Y and that metal X can dissolve a maximum of 10% Y and Y a maximum of 5 % metal X. Indicate any salient points. Using 30 % of metal Y, determine the phases present, composition and relative amounts of each phase at the midpoint of the solidus and liquidus lines (6 marks)

d) On 11/01/2022 Kenya witnessed the worst vandalism of Kenya Power and Lighting Company limited (KPLC) infrastructure plunging many Kenyans into darkness and a lot of businesses were lost. Following this occurrence, the Kenya's President, his Excellency Uhuru Muigai Kenyatta banned the sale of all scrap metals. From materials science point of view. What contribution can graduates of the program you are pursuing make to help Kenya never to be plunged into such a darkness again in future. **(7 marks**

Question 2 **20 marks**

a) In Fig Q 2(a) are some photographs, Study the diagrams and mention any TWO materials used in each photograph giving suitable reasons for their use,

b) Aluminium is one metal that has versatile applications. Briefly describe its manufacture, its properties and uses giving reasons for the use.

Question 3 (20 Marks)

Study Fig. Q3 and use it to answer the following question.

a) State the scientific names of the invariant points marked S,U and V **(3 marks**

b) State any TWO factors that would influences the type of phase diagram formed. **(2 mrks)**

c) Choosing the alloy with 3 wt % Carbon and by the help of an appropriate table, state the phases present and determine the composition of these phases, their relative amounts and finally sketch the approximate microstructure that would be obtained for the following temperature points (°C) ; 1400,1200, 1148, 1146, 728 and 726 **(15mrks)**

Question 4 (20 Marks)

a) Materials Science is a course being taught to both Electrical and Communications Engineering and Renewable energy technology students. Mention any three reasons why this course should be offered to students pursuing your program. **(3mks)**

b) The following materials are part of the broad groupings of material science

i) Ceramics

ii) Composites

Mention any two materials belonging to these groupings and stating any Two application of each with respect to your profession. **(7marks)**

c) Describe the procedure for the recycling of plastics **(10marks)**

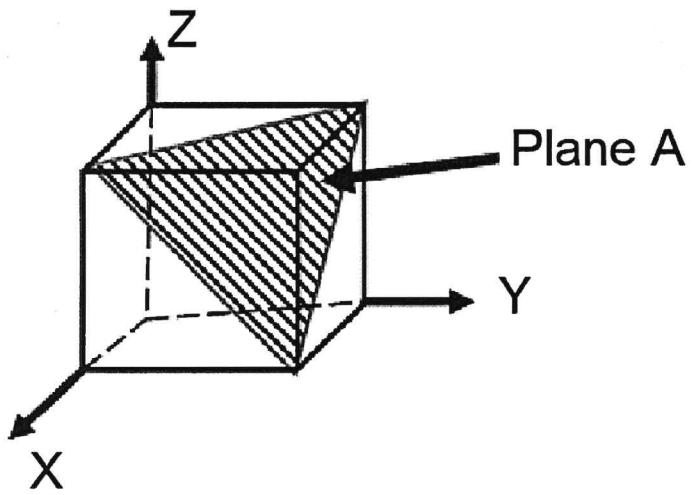
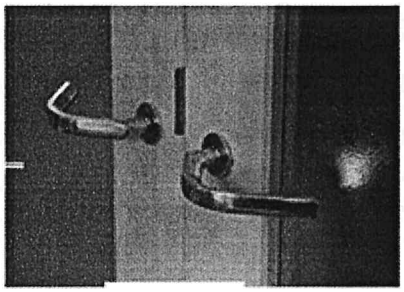
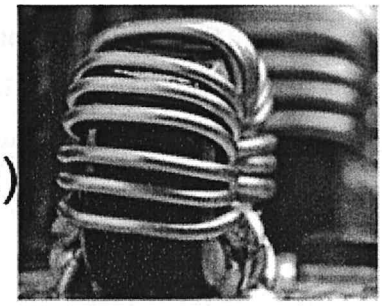
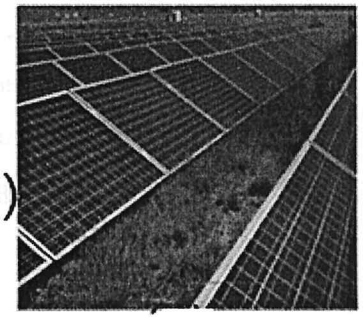


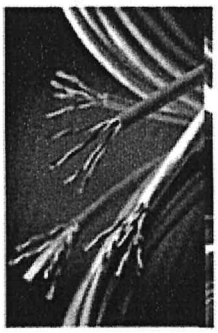
Fig. Q1 (a)

(1) 

(2) 

(3) 

(4) 

(5) 

(6) 

Fig Q 2

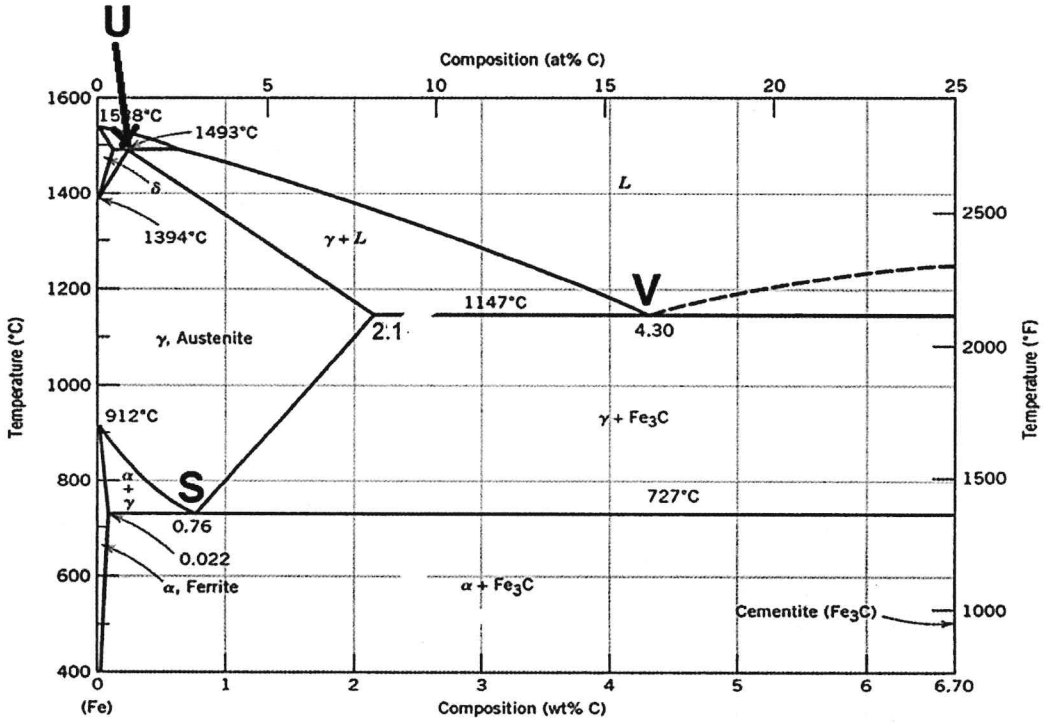

U
Composition (at% C)
0
5
10
15
20
25
1600
1538°C
1493°C
1400
δ
1394°C
γ + L
L
2500
1200
1147°C
V
4.30
γ, Austenite
2:1
2000
1000
912°C
γ + Fe3C
Temperature (°C)
Temperature (°F)
800
α + γ
S
727°C
1500
0.76
0.022
600
α, Ferrite
α + Fe3C
Cementite (Fe3C)
1000
400
0
1
2
3
4
5
6
6.70
(Fe)
Composition (wt% C)

Fig Q 3

Miller Indices	Q^2		
	$h^2+k^2+l^2$	**BCC**	FCC
(100)	1	X	X
(110)	2	√	X
(111)	3	X	√
(200)	4	√	√
(210)	5	X	X
(211)	6	√	X
(220)	8	√	√
(300), (221)	9	X	X
(310)	10	√	X
(311)	11	X	√
(222)	12	√	√
(320)	13	X	X
(321)	14	√	X
(400)	16	√	√
(410),(322)	17	X	X
(411),(330)	18	√	X
(331)	19	X	√
(420)	20	√	√
(421)	21	X	X
(332)	22	√	X

Fig Q 1(b) Miller indices for the cubic crystal structure

Metal	Symbol	Density at 25 °C (g/cm^3)	Crystal Structure	Lattice Parameter (Å)	Closest Approach of atom (Å)	Atomic Mass units
Aluminum	Al	2.699	F.c.c	4.0491	2.862	26.98
Antimony	Sb	6.7	Rhombohedral	4.5065	2.904	121.75
Berrylium	Be	1.85	C.P.H	a=2.2858 c=3.5842	2.221	9.01
Carbon Graphite	C	2.25	Hexagonal	a=2.4614 c=6.7041	1.42	12.011
Chromium	Cr	7.19	B.C.C	2.884	2.498	52.0
Copper	Cu	8.93	F.C.C	3.6153	2.556	63.54
Gold	Au	19.3	F.C.C	4.078	2.882	197
Iron (α)	Fe	7.89	B.C.C	2.8664	2.4824	55.85
Lead	Pb	11.381	F.C.C	4.9489	3.499	207.2
Magnesium	Mg	1.74	C.P.H	a=3.2088 c=5.2095	3.196	24.31
Manganese	Mn	7.47	Cubic(complex)	8.912	2.24	54.94
Nickel	Ni	8.90	F.C.C	3.5238	2.491	58.71
Silicon	Si	2.33	Diamond Cubic	5.428	2.351	28.09
Silver	Ag	10.5	F.C.C	4.086	2.888	107.87
Tin	Sn	7.17	B.C.T	a=5.8314 c=3.1815	3.016	118.69
Titanium	Ti	4.51	C.P.H	a=2.9503 c=4.683	2.91	47.90
Tungsten	W	19.25	B.C.C	3.1585	2.734	183.9
Vanadium	V	6.05	B.C.C	3.039	2.632	
Zinc	Zn	7.13	C.P.H	a=2.6649 c=4.9470	2.6648	65.38

Source: Metals Handbook (1961 ed.) American Society for Metals Park, Ohio
One Angstrom=10^{-8} cm