Roll No.													

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd Sem. 2019-20

Course Code: MEC 205

Course Name: MATERIAL SCIENCE & METALLURGY

Program & Sem: B.Tech, (MEC) & III

Date: 30.09.2019

Time: 11:00AM to 12PM

Max Marks: 40

Weightage: 20%

Instructions:

i. Answer the questions to the point.
ii. All the questions are compulsory.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries two marks. (4Qx2M=8M)

1. Define the following (C.O.NO.1) [Knowledge]
   (a) Unit cell
   (b) Space lattice
2. Complete the following (C.O.NO.1) [Knowledge]
   (a) As grain size of metal increases, Strength of metal .....
   (b) Ceramics & Glasses are thermally and electrically .....
3. Match the following, Group 1 (crystal structure) with group 2(average number of atoms per unit cell) and select the correct option (C.O.NO.1) [Knowledge]

Group 1	Group 2
1. Simple cubic	A. Two
2. Body centered	B. Six
3. Face centered	C. One
4. Hexagonal close packed	D. Four

   a. 1-A, 2-C, 3-D, 4-D
   b. 1-C, 2-A, 3-D, 4-B
   c. 1-B, 2-A, 3-C, 4-D
   d. 1-D, 2-A, 3-B, 4-C

4. Match the following, Group 1 with group 2 and select the correct option.

Group 1	Group 2
1. Pair of cation and anion is missing	A. Vacancy defect
2. One or more atom sites are vacant	B. Line imperfection
3. Substitution of foreign atom in site of parent atom	C. Schottky defect
4. Edge dislocation	D. Substitution defect

a. 1-A, 2-C, 3-D, 4-D
b. 1-C, 2-A, 3-D, 4-B
c. 1-B, 2-A, 3-C, 4-D
d. 1-D, 2-A, 3-B, 4-C (C.O.NO.1) [Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries six marks. (2Qx6M=12M)

5. What do you understand by crystal structure? Show the arrangement of atoms in cubic crystal system. Drive the relation between unit cell edge length (a) and atomic radius (r) for the body-centered cubic crystal structure. Also calculate the Atomic packing factor (APF) for the same. (C.O.NO.1) [Knowledge]

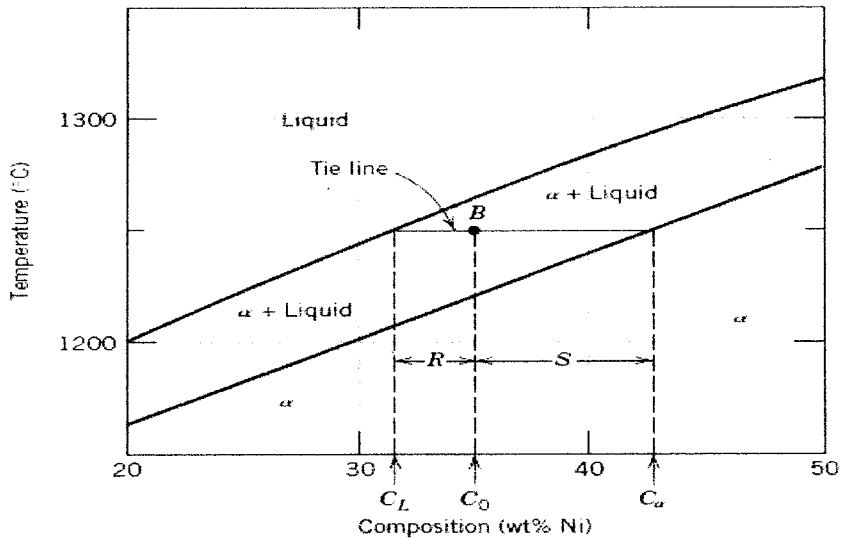
6. What do you understand by diffusion? Distinguish between steady-state and non-steady state diffusion. Write Fick's first and second laws in equation form and define all parameter (C.O.NO.1) [Knowledge]

Part C [Problem Solving Questions]

Answer both the Questions. Each Question carries ten marks. (2Qx10M=20M)

7. Write the expression of theoretical density of crystal and define all the parameters. How co-ordination number of crystal, affects it's the theoretical density. Iron has a BCC crystal structure, an atomic radius of 0.124 nm, and an atomic weight of 55.85 g/mol. Compute its theoretical density. (C.O.NO. 1, 2) [Comprehension]

8. State Gibbs phase rule and Lever rule with a suitable example. Calculate the amount of alpha phase and Liquid phase present in a Cu - 40% Ni alloy at 1250 C (refer the figure below). (C.O.NO. 1, 2) [Comprehension]



SCHOOL OF ENGINEERING

Semester: ODD

Course Code: MEC 205

Course Name: Material Science & Metallurgy

Date: 30-09-2019

Time: 1 HOUR

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels				Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K				C			A			
1,2,3,4	1	1 Module Title	2	2	2	2							8
5,6	1	1					6	6					12
8,9	2									10	10		20
	Total Marks												40

K =Knowledge Level C = Comprehension Level, A = Application Level

1

2

3

4

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

[I hereby certify that All the questions are set as per the above guide lines. Ms.Rupali Baghel]

Reviewers' Comments

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

SOLUTION

Semester: 3rd

Course Code: MEC 205

Course Name:

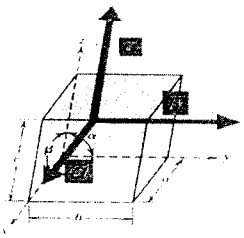
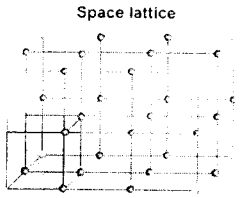
Date: 30-09-2019

Time: 1 hour

Max Marks: 40

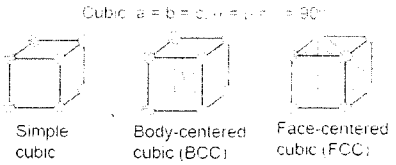
Weightage: 20%

Part A (4 x 2 = 8)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1, 2, 3, 4	A.1: Define the following (a) Unit cell: Small repeating entity of the atomic structure. It is the basic building block of the crystal structure that defines the entire crystal structure with the atom position within.  (b) Space lattice: Space lattice is an array of points showing the arrangement of atoms or groups of atoms in a three dimensional spaces.  	To the point, 2+2+2+2	8
2	~~Q.2~~: Complete the following		

	(a) As grain size of metal increases, Strength of metal **decrease**..... (b) Ceramics & Glasses are thermally and electrically ...**Insulating**..... Q.3: Match the following. **Answer: (C) 1-C, 2-A, 3-D, 4-B** **Q.4: Answer: (b) 1-C, 2-A, 3-D, 4-B**		

Part B (2 x 6 = 12)

Q. 5 No	Solution	Scheme of Marking	Max. Time required for each Question
	Answer 5.: Crystal structure is a description of the ordered arrangement of atoms, ions or molecules in a crystalline material. Ordered structures occur from the intrinsic nature of the constituent particles to form symmetric patterns that repeat along the principal directions of three-dimensional space in matter. • ordered special arrangement • Atoms, ions & molecules. • Decides properties of materials.  **Body centered cubic (BCC):** In BCC, one on each corner of the cube and one atom in the center. Because the volume of each of the eight corner atoms is shared between eight adjacent cells, each BCC cell contains the equivalent volume of two atoms (one central and one on the corner). **The value of diagonal on one side will be**  $a^2 + a^2 = X^2$ $X=\sqrt{2}a$ Each corner atom touches the center atom. A line that is drawn from one corner of the cube through the center and to the other corner passes through $4r$. where r is the radius of an atom.	2+2+2	6

$$\sqrt{2}a^2 + a^2 = (4r)^2$$

$$\mathbf{a} = \frac{4r}{\sqrt{3}}$$

Where a= edge of the unit cell
r =radius of atom

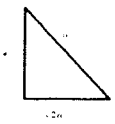
APF calculation

$$\text{APF} = \frac{number\ of\ atom \times volume\ of\ the\ atom}{volume\ of\ the\ unit\ cell}$$

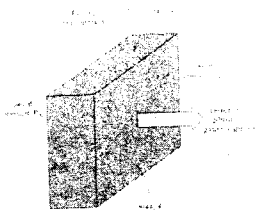
No of atoms =2

Volume of the atoms =2 $*\frac{4}{3}\pi r^3$

Volume of unit cell (cubic) = a^3



$$= \frac{\frac{8\pi r^3}{3}}{\left(\frac{4r}{\sqrt{3}}\right)^3} = \frac{\frac{8\pi r^3}{3}}{\frac{64}{3\sqrt{3}}r^3} = \frac{\sqrt{3}\pi}{8} = 68\%$$

6	Diffusion: Phenomenon of material transport by atomic motion. If M is the number of atoms diffusing through the cross sectional area A, then diffusion flux occurring in time t is given by $$J = \frac{M}{At}$$ Steady state diffusion: Concentration profile is maintained same throughout the process. Non-Steady state diffusion: Diffusion is under un steady condition; i.e. flux is function of both space and time. Ficks first law **Flux of atoms moving is proportional to concentration gradient**  That is, $\frac{dC}{dx}$ $J \propto -\frac{dC}{dx}$ or $J = -D\frac{dC}{dx}$ D is called diffusion coefficient • **Ficks second Law** In this case, flux is a function of both space and time. That is, flux varies from section to section and varies with time at a given section.	2+2+2	6

Assuming diffusion coefficient is independent of concentration

$$\frac{\delta C}{\delta t} = D\frac{\delta^2 C}{\delta x^2}$$

Part C (2 x 10 = 20)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
7	**Theoretical density:** # atoms/unit cell; Atomic weight; Volume/unit cell (cm^3/unit cell); Avogadro's number (6.023×10^{23} atoms/mol) $\rho = \frac{n A}{V_c N_A}$ Problem: Compute the density of Copper Given: Atomic radius of Cu = 0.128 nm (1.28×10^{-8} cm) Atomic Weight of Cu = 63.5 g/mol Crystal structure of Cu is FCC Solution: $\rho = n A / V_c N_A$ $n = 4$ $V_c = a^3 = (2R\sqrt{2})^3 = 16 R^3 \sqrt{2}$ $N_A = 6.023 \times 10^{23}$ atoms/mol $\rho = 4 \times 63.5$ g/mol / $16\sqrt{2}(1.28 \times 10^{-8}$ cm$)^3 \times 6.023 \times 10^{23}$ atoms/mol $\rho = 8.98$ g/cm^3	3+7	10

8	**Gibbs phase rule:** Establishes the number of thermodynamic variables that must be experimentally fixed in order to fully define the properties of an equilibrium chemical system Mathematically $F = C - P + 2$ F= number of degrees of freedom or variance C= number of components P= number of phases present at equilibrium Constant 2=non-compositional thermodynamic variables (usually T and P). **Lever rule:** The Lever Rule is used to calculate the weight % of the phase in any two-phase region of the Phase diagram (and only the two phase region!) In general: • Phase percent = opposite arm of lever / total length of the tie line x 100 Numerical part: W% of Liquid= (42.5-35)/(42.5-31.5) = 0.68 W% of solid =(35-31.5)/(42.5-31.5) =0.32	2+2+6	10

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GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem 2019-20 | **Date**: 18.11.2019

Course Code: MEC 205 | **Time**: 11.00 AM to 12.00 PM

Course Name: MATERIAL SCIENCE & METALLURGY | **Max Marks**: 40

Program : B.Tech & III | **Weightage**: 20%

Instructions:

1. **Draw diagrams neatly and label**
2. **SI Systems to be followed.**

Part A [Memory Recall Questions]

Answer following Questions. **(3Qx3M=9M)**

1. Explain Austenite, Perlite and Ferrite [3 M] (CO 2) [Knowledge Level]
2. Classify heat treatment process. [3 M] (C0 3) [Knowledge Level]
3. Draw cooling curve for pure iron. [3 M] (C0 2) [Knowledge Level]

Part B [Problem Solving Questions]

Answer all the Questions. Each Question carries seven marks. **(3Qx7M=21M)**

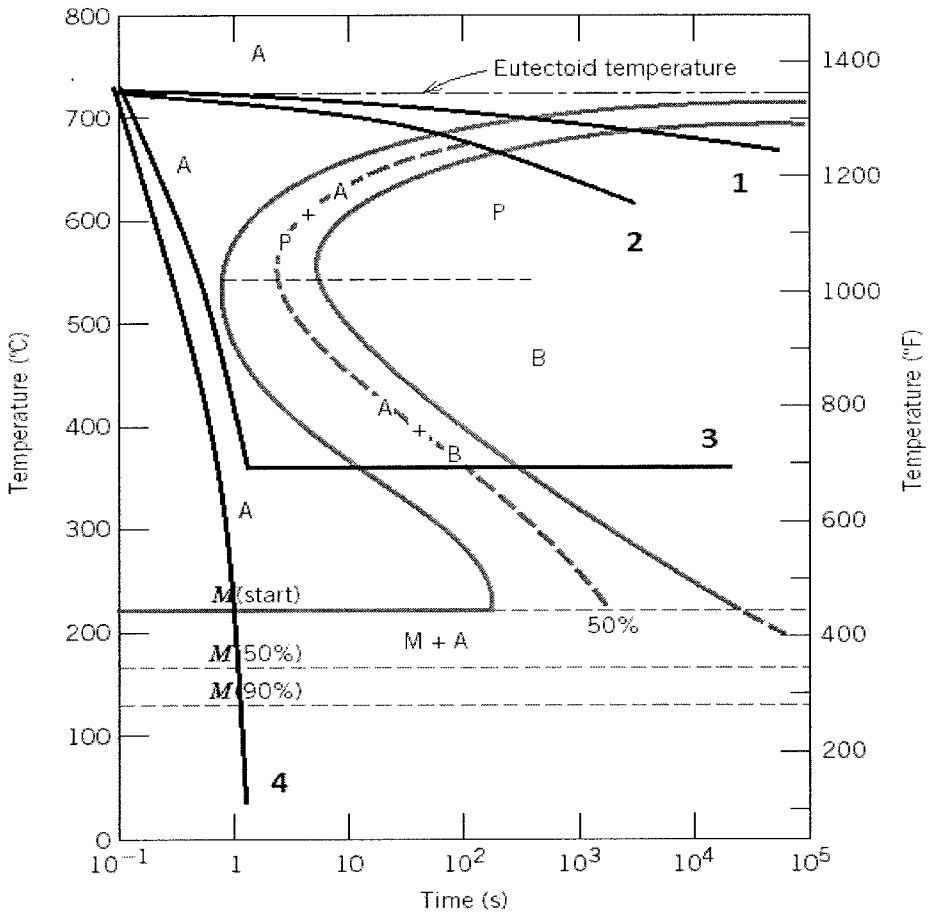
4. Explain Austemering and martempering with the help of TTT diagram. [7M] (CO 3) [Application Level]
5. Explain in detail annealing and quenching process. [7M] (CO 3) [Application Level]
6. Write note on Peritectic, Eutectic and Eutectoid invariant reactions. [7M] (CO 2) [Comprehension Level]

Part C [Problem Solving Questions]

Answer the Question. The Question carries ten marks **(1Qx10M=10M)**

7. Describe in your own words the 4 different cooling curves superimposed on the TTT diagram. Mention the type of microstructure developed at the end of each process. Draw the microstructure at the end of cooling process 1 and mention its micro-constituents. [10M]

(C.O.NO 3) [Application Level]



SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Semester: : III
Course Code: MEC 205
Course Name: Material Science & Metallurgy
Program : B.TECH.

Date: 18.11.2019
Time: 1 HOUR
Max Marks: 40
Weightage: 20%

TEST 2

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	CO2	Module: 2: PHASE DIAGRAM:	3									3
2	CO3	Module: 3: HEAT TREATMENT:	3									3
3	CO3	Module: 3: HEAT TREATMENT:	3									3
4	CO3	Module: 3: HEAT TREATMENT:							7			7
5	CO3	Module: 3: HEAT TREATMENT:				7						7

6	CO2	Module: 2: PHASE DIAGRAM:							7			7
7	CO3	Module: 3: HEAT TREATMENT:							10			10
	Total Marks		9			7			24			40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SOLUTION

Semester: : III
Course Code: MEC 205
Course Name: Material Science & Metallurgy
Program : B.TECH.

Date: 18.11.2019
Time: 1 HOUR
Max Marks: 40
Weightage: 20%

TEST 2

Part A (3Q x 3M =9 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**Austenite** is an interstitial solid solution of Carbon dissolved in □ (F.C.C.) iron. Maximum solubility is 2.0 % C at 1130°C. High formability, most of heat treatments begin with this single phase. It is normally not stable at room temperature. But, under certain conditions it is possible to obtain austenite at room temperature. **Pearlite** is the eutectoid mixture containing 0.80 % C and is formed at 723°C on very slow cooling. It is a very fine platelike or lamellar mixture of ferrite and cementite. The white ferritic background or matrix contains thin plates of cementite (dark). **Ferrite** is known as α solid solution. It is an interstitial solid solution of a small amount of carbon dissolved in α (BCC) iron. stable form of iron below 912 deg.C. The maximum solubility is 0.025 % C at 723°C and it dissolves only 0.008 % C at room temperature. It is the softest structure that appears on the diagram.	Each phase 1 mark X 3 phases **Total 3 marks**	**5 mins.**
2	**Classification of heat treatment** • When the metal or an alloy is heat treated the microstructure of its entire volume is altered. • But in some situation microstructure of surface is need to be alter. • Based on this heat treatment is classified into – Full heat treatment – Surface heat treatment	**3 marks**	**5 mins.**

Full heat treatment

1 Annealing
- Recrystallization annealing
- full annealing
- Partial annealing
- Process annealing
- Spherodising annealing

2 Normalising

3 Hardening

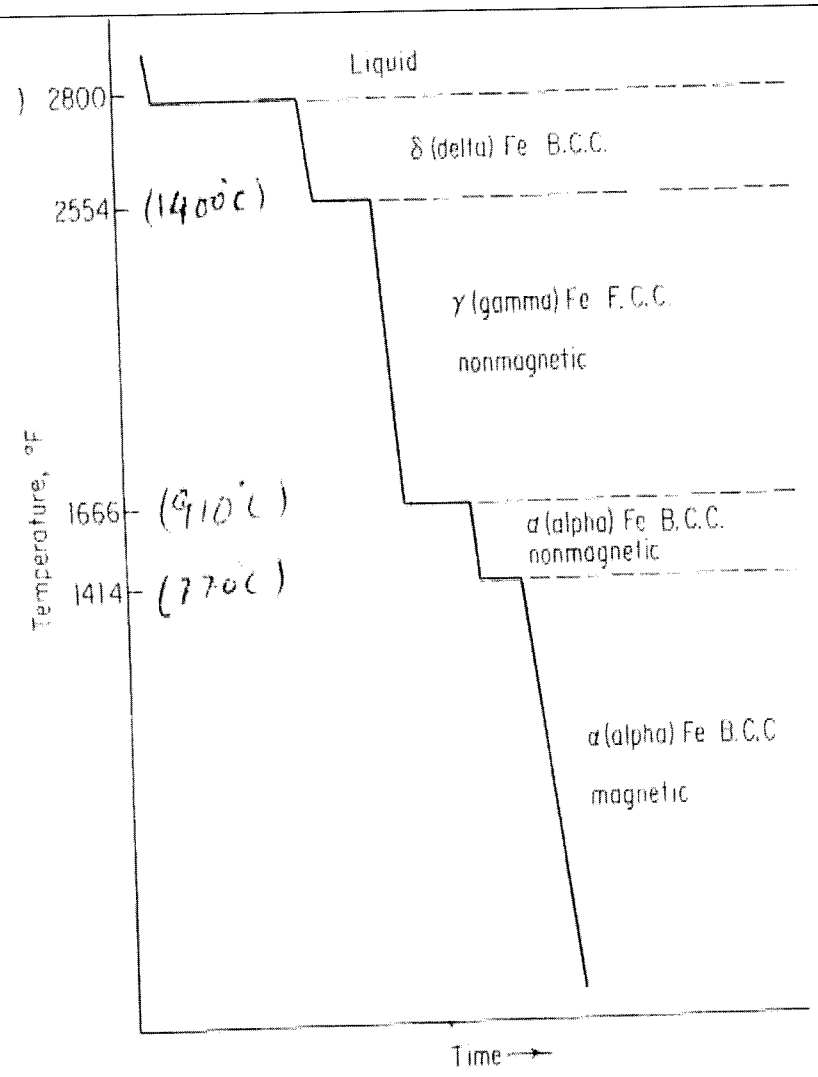
4 Tempering
- Austempering
- martempering

Surface heat treatment

i. Case hardening
1. Carburising
   a) Pack Carburising
   b) Liquid Carburising
   c) Gas Carburising
2. Cyaniding
3. Nitriding
4. Carbo nitriding

ii. Surface hardening
1. Flame hardening
2. Induction hardening

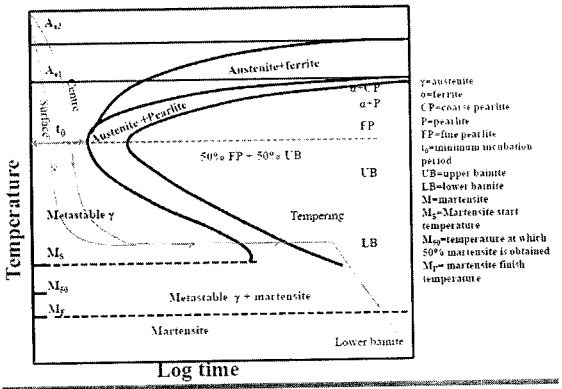
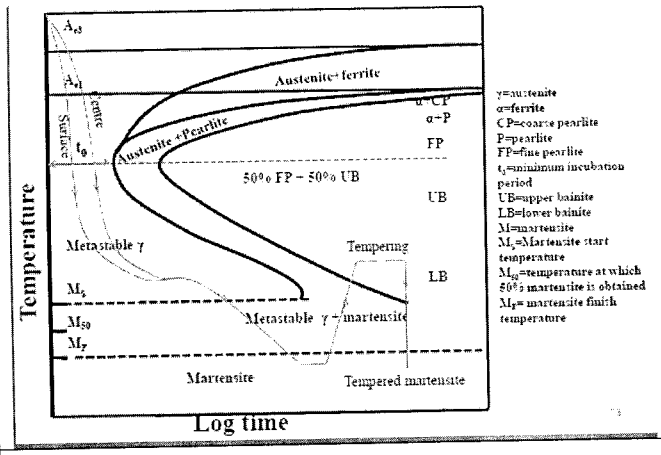
3

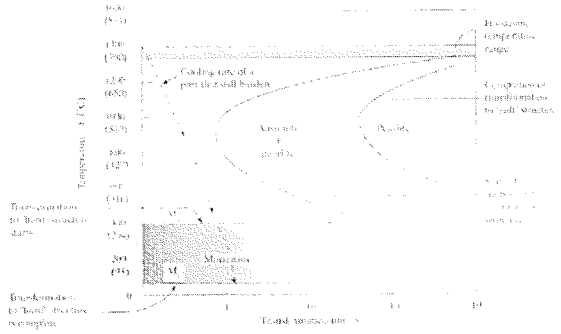
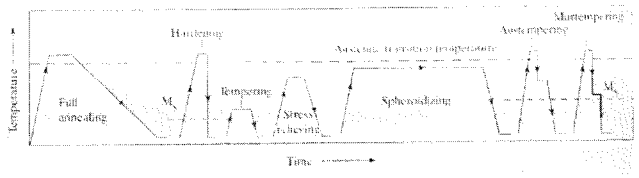


Total 3 marks **5 mins.**

Part B

(3Q x 7M = 21Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
4	Austempering Austempering heat treatment is given to steel to produce lower bainite in high carbon steel without any distortion or cracking to the sample. The heat treatment is cooling of austenite rapidly in a bath maintained at lower bainitic temperature (above M_s) temperature (avoiding the nose of the TTT diagram) and holding it here to equalise surface and centre temperature (**Fig. 45**) and . till bainitic finish time. At the end of bainitic reaction sample is air cooled. The microstructure contains fully lower bainite. This heat treatment is given to 0.5-1.2 wt%C steel and low alloy steel. The product hardness and strength are comparable to hardened and tempered martensite with improved ductility and toughness and uniform mechanical properties. Products donot required to be tempered.  **Martempering :** This heat treatment is given to oil hardenable and air hardenable steels and thin section of water hardenable steel sample to produce martensite with minimal differential thermal and transformation stress to avoid distortion and cracking. The steel should have reasonable incubation period at the nose of its TTT diagram and long bainitic bay. The sample is quenched above M_s temperature in a salt bath to reduce thermal stress (instead of cooling below M_F directly)  	Sketch 3marks Explanation 4 marks. **Total 7 marks.**	**10 mins.**
5	Annealing :	Showing on TTT diagram 3 marks Explaination 7 marks **Total 7 marks.**	**10 mins.**

	• Process Steps: 1. Heat material into the asutenite region (i.e. above 1600F) – rule of thumb: hold steel for one hour for each one inch of thickness 2. Slowly furnace cool the steel – DO NOT QUENCH 3. Key slow cooling allows the C to precipitate out so resulting structure is coarse pearlite with excess ferrite 4. After annealing steel is quite soft and ductile Quenching : • Depending on how fast steel must be quenched (from IT diagram), the heat treater will determine type of quenching required: – Water (most severe) – Oil – Molten Salt – Gas/ Air (least severe) – Many phases in between!!! Ex: add water/polymer to water reduces quench time! Adding 10% sodium hydroxide or salt will have twice the cooling rate!  Figure 10–15 Typical time–temperature–transformation diagram (IT)  Figure 10–33 Heat treating thermal cycles		
6	**Three Phase Reactions** **Peritectic, at 1490 deg.C, with low wt% C alloys (almost no engineering importance).** **Eutectic, at 1130 deg.C, with 4.3wt% C, alloys called cast irons.** **Eutectoid, at 723 deg.C with eutectoid composition of 0.8wt% C, two-phase mixture (ferrite & cementite). They are**	Each reactions 1marks=1X3 marks= 3 marks Presentation of all reactions with clarity and neat explanation = 4 marks. **Total 7 marks.**	**10 mins.**

Eutectic, Eutectoid, & Peritectic:

Peritectic - liquid and one solid phase transform to a 2nd solid phase

$Solid_1 + \quad Liquid \leftrightarrow Solid_2$

$\delta + L \underset{heat}{\overset{cool}{\leftrightarrow}} ß$

Eutectic - liquid transforms to two solid phases

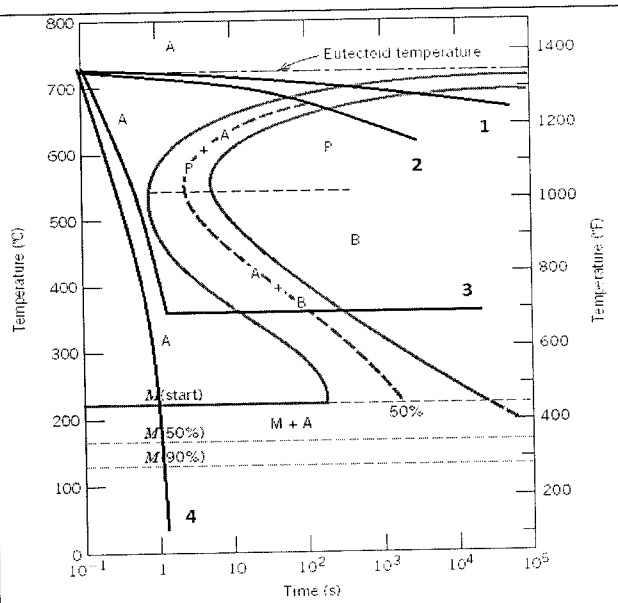
$L \underset{heat}{\overset{cool}{\leftrightarrow}} \alpha + \beta$

Eutectoid – one solid phase transforms to two other solid phases

$Solid_1 \leftrightarrow Solid_2 + Solid_3$

$\gamma \underset{heat}{\overset{cool}{\leftrightarrow}} \alpha + Fe_3C$

Part C (1Q x 10M = 10Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
7		Showing phase present at four points 2 marks Explanation 8 marks **Total 10 marks.**	**15 mins.**

Roll No												

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20
Course Code: MEC 205
Course Name: MATERIAL SCIENCE & METALLURGY
Program & Sem: B.Tech (MEC) & III

Date: 24 December 2019
Time: 1:00 PM to 4:00 PM
Max Marks: 80
Weightage: 40%

Instructions:
(i) Read the all questions carefully and answer accordingly.
(ii) Draw neat and clear diagrams with appropriate labeling.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries 5 marks. **(4Qx5M=20M)**

1. Fill in the blanks. (C.O.No.1,4,1,1,3) [Knowledge]

   a) Co-ordination number for simple cubic structure is _____

   b) In ceramic materials type of bonding present is _____

   c) Atomic packing factor of BCC crystal structure is _____

   d) Crystal structure of Gold is _____

   e) Very slow cooling of 0.8% eutectoid steel gives _____ microstructure phase

2. Match the following. (C.O.No.1,2,2,3,4) [Knowledge]

I. Crystal structure of highly ductile materials	a Quenching
II. Hardest phase in Fe-C diagram	b Ferrite
III. Softest phase in Fe-C diagram	c FCC
IV. Tempering is done after	d α – β Cu alloy
V. Muntz metal	e Martensite

3. Define space lattice and list 14 Bravais space lattice. (C.O.No.1) [Knowledge]

4. List various applications of Ceramic materials. (C.O.No.4) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries 8 marks. **(5Qx8M=40M)**

5. Explain in detail various types of crystal defects. (C.O.No.1) [Comprehension]

6. Draw Iron –Carbon diagram and label it completely. (C.O.No.2) [Comprehension]

7. Explain TTT diagram for 0.8% C eutectoid steel. (C.O.No.3) [Comprehension]

8. Explain different types of Brass and Bronze (composition, properties and applications. (C.O.No.4) [Comprehension]

9. With neat diagram explain any one furnace used for steel making. (C.O.No.4) [Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. Each Question carries 10 marks. **(2Qx10M=20M)**

10. a) What is an Isomorphous system. Explain with diagram any one isomorphous system. [6M]

    b) Write note on Gibb's Phase rule. [4M]

    (C.O.No.2) [Application]

11. Design engineer want to develop a component whose surface has to be hard and wear resistance without compromising the toughness of the component. Suggest suitable heat treatment process and explain the process with neat diagram. (C.O.No.3) [Application]

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO (% age of CO)	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels	Thought provoking type [Marks allotted] Bloom's Levels	Problem Solving type [Marks allotted]	Total Marks
			K	C	A	
1	CO 1 CO 3 CO 4	Module: 1 Module: 3 Module: 4	3 1 1			5
2	CO 1 CO 2 CO 3 CO 4	Module: 1 Module:2 Module: 3 Module: 4	1 2 1 1			5
3	CO 1	Module: 1	5			5
4	CO 4	Module: 4	5			5
5	CO 1	Module: 1		8		8
6	CO 2	Module: 2		8		8
7	CO 3	Module: 3		8		8
8	CO 4	Module: 4		8		8
9	CO 4	Module: 4		8		8
10	CO 2	Module: 2			10	10
11	CO 3	Module: 3			10	10
	Total Marks		20	40	20	80

K =Knowledge Level C = Comprehension Level, A = Application Level

C.O WISE MARKS DISTRIBUTION:

CO 01: 17 MARKS, CO 02: 20 MARKS, CO 03: 20 MARKS, CO 04:23 MARKS

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I hereby certify that all the questions are set as per the above guidelines.

Faculty Signature: 12/12/19

Reviewer Commend:

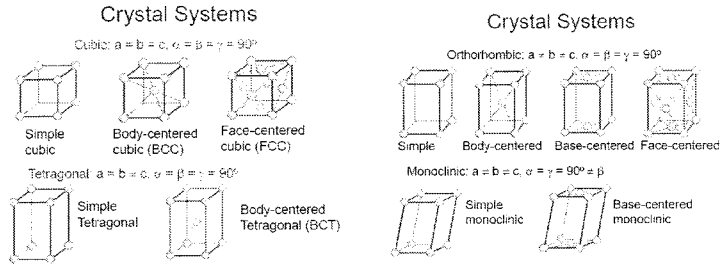
SCHOOL OF ENGINEERING

SOLUTION

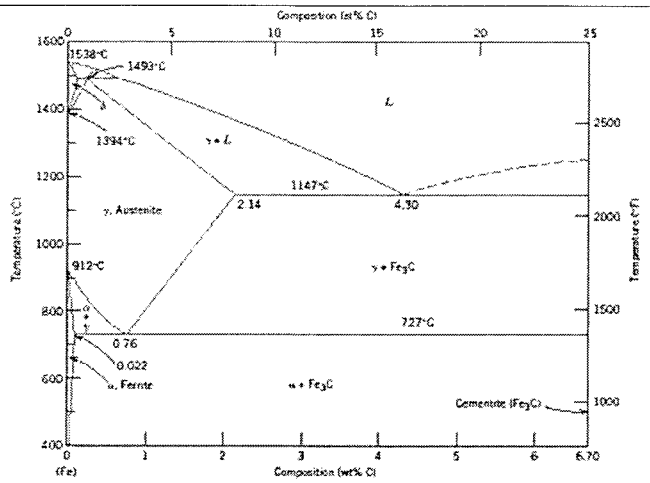
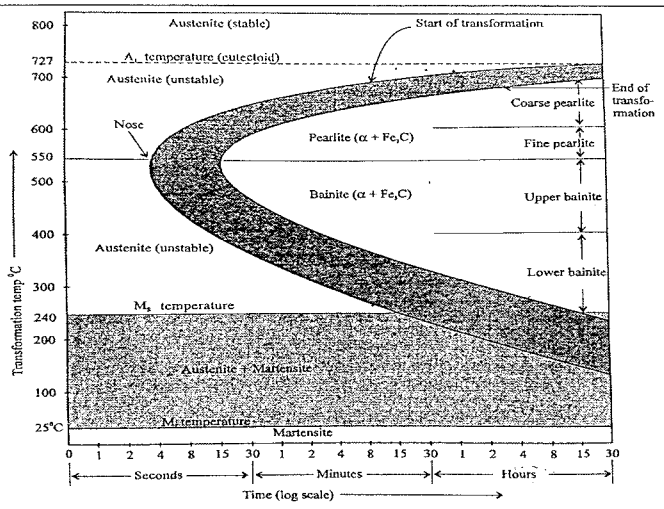
Semester : Odd Semester: 2019 - 20
Course Code: MEC 205
Course Name: Material Science & Metallurgy
Program & Sem: B.Tech. 3rd Sem

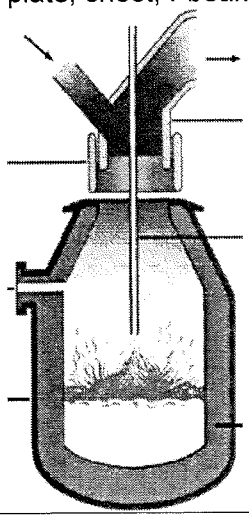
Date: 24-12-2019, Tuesday
Time: 01.00pm to 04.00pm
Max Marks: 80
Weightage: 40 %

Part A (0Q x 0M = 0Marks)

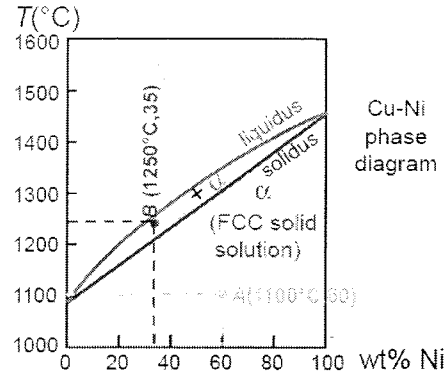
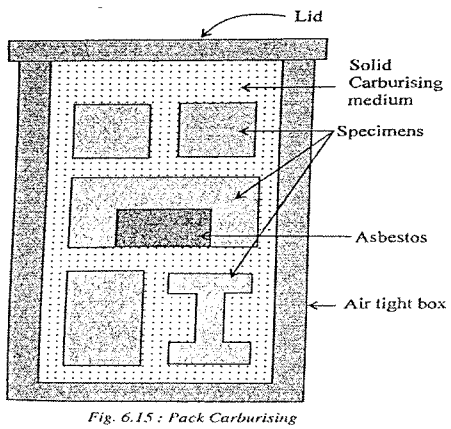
Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	a) 6 b) Ionic c) 68% d) FCC e) Pearlitic	**1MX5= 5M**	10 mins.
2	I – a, II – e, III – b, IV – a, V - d	**1MX5= 5M**	10 mins.
3	**Definition of space lattice:** The three dimensional pattern where the atoms arranged themselves in an orderly manner along various directions is known as Space lattice. 	**Definition – 1M** **Sketch 4 M** **Total - 5M**	10 mins.
4	Applications: Advanced Ceramics Heat Engines • Advantages: • Run at higher temperature • Excellent wear & corrosion resistance • Low frictional losses • Ability to operate without a cooling system • Low density • Disadvantages: – Brittle – Too easy to have voids-weaken the engine – Difficult to machine • Possible parts – engine block, piston coatings, jet engines	**5M**	10 mins.

Part B (0Q x 0M = 0 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
5	**TYPES OF IMPERFECTIONS** • Vacancy atoms • Interstitial atoms • Substitutional atoms — Point defects • Dislocations — Line defects • Grain Boundaries — Area defects	Explanation 5M Sketches 3M **Total – 8M**	16 mins.
6	 Figure 9.22 The iron–iron carbide phase diagram. (Adapted from *Binary Alloy Phase Diagrams*, 2nd edition, Vol. 1, T. B. Massalski, Editor-in-Chief, 1990. Reprinted by permission of ASM International, Materials Park, OH.)	Drawing – 4 M Labeling – 4M Total – 8M	16 mins.
7	 *Fig. 6.2 : T-T-T diagram for 0.8% C eutectoid steel*	Drawing – 4 M Labeling – 4M Total – 8M	16 mins.
8	<u>Brasses</u> Brasses are the alloys of copper and zinc. Brasses are classified as follows 1)α –brasses 2)α-β brasses 3)Red brasses and yellow brasses. α –brasses contain zinc less than 30% and α-β brasses Contain zinc between 30 to 44%. Below 20% zinc, color of brasses is red and above 20% zinc, the color is yellow. 1) α – brasses : Composition: Zinc less than 30% Properties: Ductile, soft, malleable and fairly good corrosion resistance. Application:Cold rolling Wire drawing Press work.	Brass 4M Bronze 4M Total -8M	16 mins.

	A) Cap copper: Composition: zinc between 2 to 5%. If zinc is not added ,copper oxide present in the structure reduces ductility and malleability. Properties: cap copper is very ductile. Application: used as cap detonators in ammunition factories. B)Gilding metal: Composition: zinc from 5 to 15%. Application: bullet envelopes, drawn containers, condenser tubes, coins, needles, emblems and dress jewelry because of color like gold. c)Cartridge brass: Composition: about 30% zinc. Properties: maximum ductility and malleability amongst all the brasses. Application: for forming by deep drawing, stretching, trimming, spinning and press work operations. It is also used for cartridge cases, radiator fins, lamp fixture, rivets and springs. Bronzes: Composition: copper + aluminum Commercial aluminium bronzes contain 4 to 11% aluminium. Other elements such as Fe, Ni, Mn and Si may be added too these bronzes for improvement of certain properties. Properties: Good strength, ductility, toughness.Good bearing properties. Good corrosion resistance.Good fatigue resistance. Applications: jewelry, cigarette cases, heat exchangers, chemical plants, pump castings, valve fittings,propellers, cylinder heads, gears, dies, bearings, spark plug bodies and electrical contacts.		
9	Fastest steelmaking process – can make 250 tons of steel / hour Melted pig iron and scrap are poured (charged) into a vessel. Fluxing agents are added, like limestone. The molten metal is blasted with pure oxygen. This produces iron oxide which then reacts with carbon to produce CO and CO2. The slag floats to the top of the metal. Higher steel quality than open hearth. Used to make plate, sheet, I-beam, tubing and channel. 	Sketch 4 M Explanation 4 M Total 8M	16 mins.

Part C (0Q x 0M = 0Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
10	a)  Cu-Ni phase diagram b) **Gibbs Phase Rule** • *Establishes the number of thermodynamic variables that must be experimentally fixed in order to fully define the properties of an equilibrium chemical system* • *Mathematically* $F = C - P + 2$ *F= number of degrees of freedom or variance* *C= number of components* *P= number of phases present at equilibrium* *Constant 2= non-compositional thermodynamic variables (usually T and P)*	a) Sketch 3M+ explanation 3M= 6M b) 4 M	20 mins. 10 mins.
11	Case hardening ***1)Carburising*** hardness of steels is increased with the presence of martensite in their microstructures amount of martensite can increase only at higher carbon content. In low carbon steel martensite formed is low because of lower carbon content.In such cases more carbon is added to their surface These steel surface are enriched in carbon are further subjected to regular hardening heat treatment as a result more martensite forms on surface and become more harder than interior.*Carburising is the term method of increasing the carbon content at surface*  *Fig. 6.15 : Pack Carburising*	Sketch 4 M Explanation 6 M Total 10M	30 mins.