NITDGP/BTECH/Reg/Odd/2023-24

# NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

## Odd Semester Mid-Term Examination, 2023-24

**Course Code:** ~~MEC301~~ MMC301 Full Marks: 25

**Course Name:** METALLURGICAL THERMODYNAMICS AND KINETICS Time: 90 Minutes

Instructions: Answer all the questions.

Materials to be supplied: **Graph paper shall be supplied, if required.**

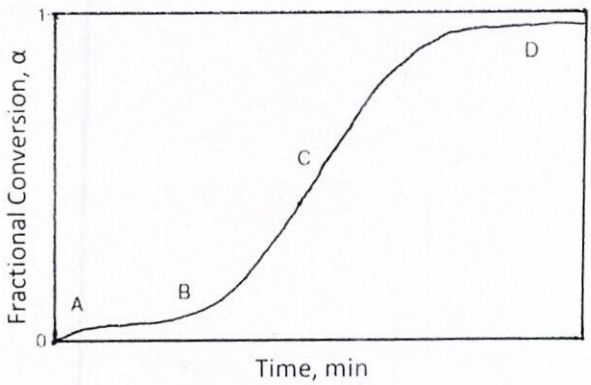
| Question No. | Body of the Question | Marks | Mapped CO |
|---|---|---|---|
| 1 | Calculate the work required (*kJ*) to compress 453.6 g of air reversibly and isothermally at 300 K from 1 atm to 5 atm pressure. The equivalent molecular weight of air is 29. | 2 | CO1 |
| 2 | Use the following data to calculate the standard enthalpy change for the formation of ethane ($C_2H_6$) at 298 K.<br>$C(s) + O_2(g) = CO_2(g)$ $\quad \Delta H^0_{f,298} = -393\ kJ/mole$<br>$H_2(g) + \frac{1}{2}O_2(g) = H_2O(l)$ $\quad \Delta H^0_{f,298} = -286\ kJ/mole$<br>$C_2H_6(g) + 7/2O_2(g) = 2CO_2(g) + 3H_2O(l)$ $\quad \Delta H^0_{f,298} = -1561\ kJ/mole$ | 2 | CO2 |
| 3 | Find the enthalpy change at 800°K for the reaction<br>$CaO(s) + CO_2(g) = CaCO_3(s)$<br>The following data are given<br>\| | $\Delta H^0_f$ at 298°K (*kJ/mole*) \| $C_P$ (*J/mole. °K*) \|<br>\| $CaO(s)$ \| −634.3 \| $49.62 + (4.52 \times 10^{-3}\ T) - (6.95 \times 10^5\ T^{-2})$ \|<br>\| $CO_2(g)$ \| −393.5 \| $44.14 + (9.04 \times 10^{-3}\ T) - (8.54 \times 10^5\ T^{-2})$ \|<br>\| $CaCO_3(s)$ \| −1206.7 \| $104.52 + (21.92 \times 10^{-3}\ T) - (25.94 \times 10^5\ T^{-2})$ \|<br>OR<br>For the reaction: $CO(g) + \frac{1}{2}O_2(g) = CO_2(g)$<br>Calculate the enthalpy change for the above reaction at 473°K.<br>The following data are given<br>\| | $\Delta H^0_f$ at 298°K (*kJ/mole*) \| $C_P$ (*J/mole. °K*) \|<br>\| $CO(g)$ \| −110.5 \| 30.00 + 0.0041 T \|<br>\| $O_2(g)$ \| 0 \| 28.5 +0.0042 T \|<br>\| $CO_2(g)$ \| −393.5 \| 44.2 + 0.0088 T \| | 3 | CO2 |
| 4 | Write the first law of thermodynamics. Prove that internal energy is a state function. Calculate the value of the universal gas constant in the SI unit. | 4 | CO1 |
| 5 | A Carnot heat engine operates between reservoirs at 1200 °C and 200 °C. The isothermal process at the hotter reservoirs consists of expansion (reversible) from an initial pressure of $5 \times 10^5\ N/m^2$ to $4 \times 10^4\ N/m^2$. Assuming that the working substance is a kilogram of ideal gas, calculate. (a) the efficiency of the heat engine and (b) heat absorbed from the hotter reservoir. | 2 | CO1 |

Course Outcomes

CO1: Acquire the knowledge of thermodynamic laws to apply in metallurgical processes and materials.

CO2: Identify the feasibility of metallurgical processes and reactions.

CO3: Learn to analyze the kinetics of metallurgical processes and design the alloy systems by applying the concepts of thermodynamics.

| | | | |
|---|---|---|---|
| 6 | a) Derive the expression for rate constant of a second order reaction where two reactants are involved with different initial concentration.<br>b) Discuss negative order reaction with an example.<br>c) Does the oxidation kinetics of metal obeying parabolic law is an example of negative order reaction? Explain.<br>d) Does a metal which is following a linear oxidation kinetics suitable for structural application? Explain. | 4 | CO3 |
| 7 | The reduction experiments of iron ore-coal composite pellet were conducted at both 1000°C and 1100°C. The 95% reduction for both the cases was completed in 60 min and 35 min, respectively. Calculate the activation energy. | 2 | CO3 |
| 8 | Explain the figure:<br>  <br> | 2 | CO3 |
| 9 | The oxidation kinetics study of a metal was conducted at 800°C. The experimental data are as follows:<br>Time min / Weight gain, mg/cm²<br>20 — 53.61<br>60 — 96.26<br>100 — 123.85<br>120 — 145.64<br>180 — 175.21<br>Determine the rate constant. Assume that it follows parabolic law. | 2 | CO3 |
| 10 | What is zero order reaction? For a zero order reaction 40% completed in 20min. Calculate the time required to complete 90% reaction. | 2 | CO3 |

Course Outcomes
CO1: Acquire the knowledge of thermodynamic laws to apply in metallurgical processes and materials.
CO2: Identify the feasibility of metallurgical processes and reactions.
CO3: Learn to analyze the kinetics of metallurgical processes and design the alloy systems by applying the concepts of thermodynamics.

# NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

## Odd Semester Mid-Term Examination, 2023-24

**Course Code:** MMC 302 Full Marks: 25

**Course Name:**-Introduction to Metallurgy and Materials Time: 90 Minutes

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Instructions: Answer any five questions.

| Question No. | Body of the Question | Marks | Mapped CO |
|---|---|---|---|
| 1. | (a) "The universe consists of fermions and Bosons"- explain.<br><br>(b) "Although both neutron and proton consist of similar kind of fundamental particle; neutron is neutral, while proton has a positive charge"- explain. | 2.5<br><br>2.5 | CO1 |
| 2. | Briefly explain the role of different quantum numbers to quantize certain inevitable parameters pertaining to electron in an atom. | 5 | CO1 |
| 3. | Show that the role of principal quantum number may be mathematically explained through solution of one dimensional Schrödinger wave equation. | 5 | CO1 |
| 4. | Draw a BCC unit cell.<br>Calculate its effective number of atom/unit cell and derive the relation between radius of the atom and lattice parameter. | 3<br>2 | CO1 |
| 5. | Draw a HCP unit cell and show the $[11\bar{2}0]$ direction.<br>Also show the (0001) plane in it. | 5 | CO1 |
| 6. | In a BCC unit cell which of the following directions has highest atomic density (in terms of number of atom/lattice parameter) [111], [011] and [010]?<br>Show the calculation. | 5 | CO1 |

Course Outcomes

CO1: To correlate atomic structure, periodic table, elemental properties, chemical bonding and material properties.

CO2: To interpret crystal structure in view of translational periodicity and symmetry and as well as to introspect different kinds of defects in a crystal.

CO3: To study the binary phase diagrams and a brief introduction to different engineering materials.

# NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

## Odd Semester Mid-Term Examination, 2023-24

**Course Code:** MMC 303 Full Marks: 25

**Course Name:** Non - Ferrous Process Metallurgy Time: 90 minutes

Instructions: Answer all questions

| Question No. | Body of the Question | Marks | Mapped CO |
|---|---|---|---|
| 1 | What are the properties useful for extraction of metal from its ore ? Why does an oxide ore preferred with respect to chloride ore for extraction? | 3 | CO1 |
| 2 | What is the most common method for detection of an ore? How did Tata Steel Plant got established in Jamshedpur? | 3 | CO1 |
| 3 | Assam Coal is not selected for Extraction in metallurgical industry. Explain with reasons . Zinc Blende has lead and cadmium present in the ore. What will be the best process for extaction of Zinc from its ore ? | 3 | CO3 |
| 4 | What is the difference between a jaw crusher and Hammer mill ? What rotational speed in revolution per minute would be recommended for a ball mill of 1200 mm diameter charged with 75 mm balls ? ( Assume industrial operating speed) | 4 | CO3 |
| 5 | What are the advantages and limitations of the *Bayer-Hall Heroult* route of aluminium production? | 3 | CO2 |
| 6 | Why *Carbothermic* route is not feasible for production of Aluminium from Alumina | 3 | CO2 |
| 7 | What are the benefits of using *cryolite* during the electrolytic decomposition of alumina in H-H Cell? | 3 | CO3 |
| 8 | Why *fluidized bed roaster* having the potentiality for replacing *multiple hearth roaster* in future roasting process in industry? | 3 | CO3 |

Course Outcomes
CO1: Understand fundamentals and unit operations of Mineral Beneficiation (MB).
CO2: Understand developments in processing of non-ferrous metals
CO3: Identify and solve the problems of industrial applications of MB unit

# NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

## Odd Semester (5th SEM) Mid-Term Examination, 2023-24

**Course Code:** MMC 501 Full Marks: 25

**Course Name:** Manufacturing Processes Time: 90 Minutes

Instructions: Answer all the questions.

**Group A** *(Answers all questions)*

| Question No. | Body of the Question | Marks | Mapped CO |
|---|---|---|---|
| 1 | Classify manufacturing processes. | 2 | CO1 |
| 2 | How powder metallurgy is different from other manufacturing processes. | 2 | CO1 |
| 3 | Give examples of P/M components. | 2 | CO2 |
| 4 | Explain mechanical alloying. | 2 | CO2 |
| 5 | Explain the factors governing the green density of a P/M component. | 2 | CO3 |
| 6 | Explain the chemical routes of powder production. | 2.5 | CO1 |

**Group B** *(Answers all questions)*

| Question No. | Body of the Question | Marks | Mapped CO |
|---|---|---|---|
| 1 | What is slush Casting ? | 2 | CO1 |
| 2 | How do you determine the efficiency of a Cupola furnace? | 2 | CO1 |
| 3 | A cupola 75 cm in diameter has a melting ratio of 10:1. How much iron is melted per hour? How much coke is consumed per hour? Assume a melting rate of 0.562 kg/hr/cm$^2$. | 3 | CO3 |
| 4 | Steel castings are to be produced from a brass pattern which is to be made from a wooden pattern. If one dimension of the component part as taken from its drawing is 75 mm, calculate the correct dimension on the wooden pattern considering the shrinkage only. (Shrinkage allowance for steel : 20.8 mm/meter and brass : 15.3 mm /meter. ) | 3.5 | CO3 |
| 5 | What is AFS number of sand grain ? Does it vary with type of sand? | 2 | CO2 |

Course Outcomes
CO1:
CO2:
CO3:

# NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

## Odd Semester Mid-Term Examination, 2023-24

**Course Code:** MMC 502
**Course Name:** Heat Treatment of Materials

Full Marks: 25
Time: 90 Minutes

Instructions: Answer all the questions.
Materials to be supplied: Graph paper shall be supplied, if required.

| Q. No. | Body of the Question | Marks | Mapped CO |
|---|---|---|---|
| 1 | Answer with Justification | 10 | CO1 |
| (i) | A steel is heated just below the $A_1$ temperature and hold for a long time. The steel over tempers and large $Fe_3C$ spheres form in a ferrite matrix. We then estimate the amount of $Fe_3C$ spheres is 16%. Calculate the carbon content in this steel. | 2 | |
| (ii) | Irrespective of carbon content, in annealed plain carbon hypo-eutectoid steels, the relative amounts of ferrite and cementite in pearlite remain same – justify. | 2 | |
| (iii) | For a given carbon content of hypo-eutectoid steel, normalized structure is harder than annealed steel. | 2 | |
| (iv) | Fully bainitic structure cannot be obtained in plain carbon steel upon continuous cooling | 2 | |
| (v) | Tempering results in a reduction of toughness is known as … | 1 | |
| (vi) | How does cooling rate affect the hardness of the plain carbon steels? | 1 | |
| 2 | Indicate the temperature range of various heat treatment processes of steels on the basis of Fe-$Fe_3C$ phase diagram. State the significance of $A_3$ and $A_{cm}$ lines. | 3 | CO2, CO3 |
| 3 | Briefly explain with proper sketching Martempering treatment, explain the final microstructure formation | 3 | CO3 |
| 4 | Discuss critically austenetisation of steel. | 4 | CO2 |
| 5 | Superimpose CCT curve on the TTT diagram and state the differences. | 3 | CO1, CO2 |
| 6 | State the purpose of post carburising treatment. | 2 | CO1 |

Course Outcomes
CO1:
CO2:
CO3:

# NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

## Odd Semester Mid-Term Examination, 2023-24

**Course Code: MMC503** Full Marks: 25

**Course Name:** Fundamentals of Plastic Deformation and Strengthening of Materials Time: 90 Minutes

Instructions: ***Answer all the questions.***
Materials to be supplied: Graph paper shall be supplied, if required.

| Question no. | Body of the Question | Marks | Mapped CO |
|---|---|---|---|
| 1 | Describe the detailed scheme of classification of lattice imperfections in crystalline materials. | 2 | CO2 |
| 2 | Prove that in a single crystal the most densely packed planes are also most widely spaced. | 2 | CO1 |
| 3 | The tensile axis of a cylindrical single crystal Cu sample is along [2 1 $\bar{3}$] direction. The diameter of the sample is 10 mm. Calculate the critical resolved shear stress of the material, if the sample yields at a tensile load of 12 kN. | 8 | CO1+ CO3 |
| 4 | A 12.8 mm diameter tensile specimen has a 50 mm gage length. The load corresponding to the 0.2 percent offset is 6800 kg and the maximum load is 8400 kg. Fracture occurs at 7300 kg. The diameter after fracture is 8 mm and the gage length at fracture is 65 mm. Calculate UTS, 0.2 percent offset yield strength, breaking stress, elongation and reduction of area. | 5 | CO3 |
| 5 | Draw and describe the engineering stress engineering strain diagram of ductile material | 5 | CO1 |
| 6 | Define the following terms: Yield Strength, Tensile strength and Toughness | 3 | CO1 |

**COURSE OUTCOMES**

CO1: To understand the fundamental concepts of plastic deformation of materials
CO2: To know about various lattice defects and the roles played by these defects in plastic deformation and strengthening of materials
CO3: To correlate the fundamentals ideas of deformation and strengthening with the observations in materials testing and mechanical processing

# NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

## Odd Semester Mid-Term Examination, 2023-24

**Course Code:** MMC504 Full Marks: 25

**Course Name:** Iron Making Time: 90 minutes

Instructions: Answer all questions

| Question No. | Body of the Question | Marks | Mapped CO |
|---|---|---|---|
| 1 | Why is the shaft of Blast Furnace is tapered out ?<br>What is raceway in the Blast Furnace ? How is it important for functioning of Blast Furnace ? | 4 | CO2 |
| 2 | What are the products of Blast Furnace ? Specify the composition and use of each. | 4 | CO2 |
| 3 | Why are there different zones inside Blast Furnace ? Is there any dry and wet zone in Blast Furnace ? | 4 | CO1 |
| 4 | a) Write down the input materials used in conventional blast furnace iron making.<br>c) Why can we not replace coke totally with alternate carbonaceous materials as raw materials in Blast Furnace iron making | 4 | CO2 |
| 5 | Write short notes on the Shatter test. | 3 | CO1 |
| 6 | Explain why the optimum moisture content of the green sinter mix provides uniform sinter quality throughout the sinter bed. | 3 | CO2 |
| 7 | a) Why do Pellets have more Fe content than Sinter?<br>b) What are the *benefits* of LD slag and Pyroxinite as raw materials in Blast Furnace iron making? | 3 | CO3 |

Course Outcomes

CO1: Understand fundamentals of physico-chemical principles of blast furnace iron making

CO2: Understand the design & operational aspects of blast furnace technology.

CO3: Understand the development in alternative iron making processes