L-3/T-1/MME **Date : 28/06/2015**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2013-2014

Sub : **MME 449** (Ferrous Production Metallurgy)

Full Marks : 280 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Discuss the mechanism of formation of fusion zone within an iron blast furnace. Where this zone is formed and how does it interfere with blast furnace operation? Explain with necessary sketches. **(26⅔)**

   (b) Temperature and gas composition within an iron blast furnace change with the change of height from tuyere level. Give this temperature and gas composition profiles of a blast furnace and explain the reasons of such variations. **(20)**

2. (a) List major irregularities in blast furnace operation. What are the possible causes of these irregularities? **(26⅔)**

   (b) Giving appropriate reactions describe the technology of ferrosilicon production. **(20)**

3. (a) Using imported iron ores and locally available reductants (natural gas and coal) propose a sponge iron production process which you think will be most suitable for Bangladesh. **(30)**

   Give reasoning to your answer and describe the process in detail.

   (b) With a neat sketch of the hot blast stove, discuss the preheating system of the air used in the blast furnace. **(16⅔)**

4. Kinetic data for isothermal reduction of iron ore by coal char for three temperature levels is given in Fig. 1. **(46⅔)**

   Examine if these data fit any one of the reaction mechanisms mentioned below:

   (a) $1-(1-\alpha)^{1/3} = kt$

   (b) $-\ln(1-\alpha) = kt$

   (c) $1-\frac{2}{3}\alpha-(1-\alpha)^{2/3} = kt$

   Values of $\alpha$ and $t/t_{0.5}$ for the above three equations are given in Table 1.

   (Use graph paper and show all the necessary calculations)

Contd ..... P/2

**MME 449**

## SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Compare and contrast vertical type continuous casting process with vertical mould-bend discharge type continuous casting process, in terms of production process and product quality. **(26⅔)**

   (b) Mention the causes of defects that are generally formed in a continuous cast steel billet. **(20)**

6. (a) What are the four types of refining that are done in a ladle refining process. **(8)**

   (b) Discuss ladle degassing, circulation degassing, and batch degassing processes. **(30)**

   (c) Hydrogen gas may create problems during steelmaking – why? **(8⅔)**

7. (a) Explain electric arc furnace steel making process. Mention its advantages and disadvantages over induction furnace steel making process. **(30⅔)**

   (b) Differentiate between electric arc furnace and electric arc furnace-argon oxygen decarburization steel making processes. **(16)**

8. (a) Sketch and identify different parts of a modern open-hearth furnace. **(14)**

   (b) Describe the refining process of an open-hearth furnace. **(18⅔)**

   (c) Mention seven characteristics of LD steelmaking process. **(14)**

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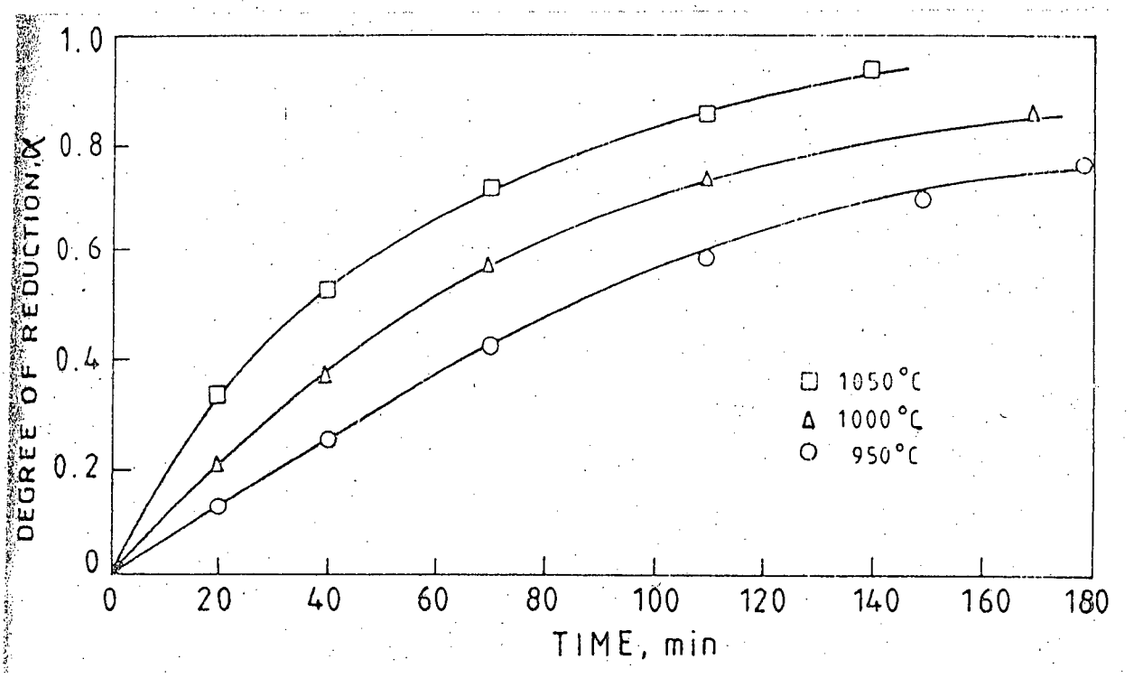


Fig. 1 Kinetics of isothermal reduction of iron ore by coal char.

Figure 1 for Q. No. 4

**Table-1** Values of α and $t/t_{0.5}$ for some commonly used solid state reaction equations

| α | $D_1(\alpha)$ | $D_2(\alpha)$ | $D_3(\alpha)$ | $D_4(\alpha)$ (c) | $F_1(\alpha)$ (b) | $R_2(\alpha)$ | $R_3(\alpha)$ (a) | $A_2(\alpha)$ | $A_3(\alpha)$ |
|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.040 | 0.033 | 0.028 | 0.032 | 0.152 | 0.174 | 0.165 | 0.390 | 0.533 |
| 0.2 | 0.160 | 0.140 | 0.121 | 0.135 | 0.322 | 0.362 | 0.349 | 0.567 | 0.685 |
| 0.3 | 0.360 | 0.328 | 0.295 | 0.324 | 0.515 | 0.556 | 0.544 | 0.717 | 0.801 |
| 0.4 | 0.640 | 0.609 | 0.576 | 0.595 | 0.737 | 0.768 | 0.762 | 0.858 | 0.903 |
| 0.5 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.6 | 1.440 | 1.521 | 1.628 | 1.541 | 1.322 | 1.253 | 1.277 | 1.150 | 1.097 |
| 0.7 | 1.960 | 2.207 | 2.568 | 2.297 | 1.737 | 1.543 | 1.607 | 1.318 | 1.198 |
| 0.8 | 2.560 | 3.115 | 4.051 | 3.378 | 2.322 | 1.887 | 2.014 | 1.524 | 1.322 |
| 0.9 | 3.240 | 4.363 | 6.747 | 5.028 | 3.322 | 2.334 | 2.602 | 1.822 | 1.492 |

Where $D_1(\alpha) = \alpha^2 = (k/r^2)t$

$D_2(\alpha) = (1-\alpha)\ln(1-\alpha) + \alpha = (k/r^2)t$

$D_3(\alpha) = [1-(1-\alpha)^{1/3}]^2 = (k/r^2)t$

(c) $D_4(\alpha) = (1-2/3\alpha) - (1-\alpha)^{2/3} = (k/r^2)t = kt$

(b) $F_1(\alpha) = \ln(1-\alpha) = kt$

$R_2(\alpha) = [1-(1-\alpha)^{1/2}] = (k/r)t$

(a) $R_3(\alpha) = [1-(1-\alpha)^{1/3}] = (k/r)t = kt$

$A_2(\alpha) = [-\ln(1-\alpha)]^{-1/2} = kt$

$A_3(\alpha) = [-\ln(1-\alpha)]^{-1/3} = kt$

Table-1 for Q. No. 4

L-3/T-1/MME Date : 05/07/2015

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2013-2014

Sub : **MME 325** (Corrosion and Degradation of Materials)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Discuss the factors that affect the corrosion resistance of a metal. **(10)**

   (b) Explain differential temperature cell. "Corrosion will not occur unless the spontaneous direction of the reaction indicates metal oxidation" – Explain. **(5+10)**

   (c) Silver is connected to zinc and then immersed in a solution containing both $Ag^{2+}$ and $Zn^{2+}$ ions. Standard potential values are given in Table 1. **(10)**

   (i) Which metal corrodes?

   (ii) Calculate the maximum possible potential of the resulting corrosion cell.

2. (a) Define limiting diffusion current density. Deduce an equation for the combined polarization of an electro-chemical cell. **(3+7)**

   (b) Cite two hypothesis of mixed-potential theory. With the help of appropriate diagram, explain the corrosion behavior of a metal when it is immersed in acid solution containing ferric salts. **(4+10)**

   (c) Discuss the comparison of Zn-Pt and Zn-Au galvanic couples, with the help of a suitable diagram. **(11)**

3. (a) Describe the mixed potential theory of velocity effect of a normal metal and an active-passive metal. **(15)**

   (b) What are the differences between anodic and cathodic protection? **(5)**

   (c) Explain that the anodic protection is much more efficient than the cathodic protection in acid solutions. **(15)**

4. (a) Explain how you would reduce corrosion by the selection of proper materials. **(15)**

   (b) Classify the corrosion tests. How would you clean a specimen after corrosion tests? **(10)**

   (c) Discuss briefly how polymers are degraded. **(10)**

Contd ..... P/2

**MME 325**

## SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Discuss the three common types of oxidation kinetics in metals. **(10)**

   (b) 'Li has virtually no resistance to oxidation but Li improves the oxidation resistance of Ni when added in small amounts. On the contrary, Cr is invariably present in oxidation resistant alloys but small additions of Cr in Ni deteriorates its oxidation resistance' – Justify with necessary figures. **(25)**

6. (a) Two specimens are riveted plates of copper and steel both exposed in the ocean for15 months at the same time. One specimen is steel plate with copper rivets; another specimen is copper plates with steel rivets. Which one will you prefer and why? **(15)**

   (b) Define 'a pit'. Describe with necessary figures, how pit depth and specimen area would affect the evaluation of pitting damage. **(20)**

7. (a) What is meant by 'selective leaching'? Outline the commonly accepted mechanism of 'dezincification'. **(15)**

   (b) Discuss the differences between stress corrosion cracking and hydrogen embrittlement. Cite four measures for both cases that may be taken to prevent or control them. **(20)**

8. (a) Mention where and under which condition crevice corrosion usually occurs. With schematic diagram explain the mechanism of crevice corrosion. **(25)**

   (b) Cite the most frequent example of filiform corrosion. 'Interaction between corrosion filaments is most interesting' – Explain with necessary schematic diagrams. **(10)**

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**Table 1: Standard emf series of metals (for question 1c)**

| Metal-metal ion equilibrium (unit activity) | Electrode potential vs. normal hydrogen electrode at 25°C, volts |
|---|---|
| $Au\text{-}Au^{+3}$ | +1.498 |
| $Pt\text{-}Pt^{+2}$ | +1.2 |
| $Pd\text{-}Pd^{+2}$ | +0.987 |
| $Ag\text{-}Ag^{+}$ | +0.799 |
| $Hg\text{-}Hg_2^{+2}$ | +0.788 |
| $Cu\text{-}Cu^{+2}$ | +0.337 |
| $H_2\text{-}H^{+}$ | 0.000 |
| $Pb\text{-}Pb^{+2}$ | −0.126 |
| $Sn\text{-}Sn^{+2}$ | −0.136 |
| $Ni\text{-}Ni^{+2}$ | −0.250 |
| $Co\text{-}Co^{+2}$ | −0.277 |
| $Cd\text{-}Cd^{+2}$ | −0.403 |
| $Fe\text{-}Fe^{+2}$ | −0.440 |
| $Cr\text{-}Cr^{+3}$ | −0.744 |
| $Zn\text{-}Zn^{+2}$ | −0.763 |
| $Al\text{-}Al^{+3}$ | −1.662 |
| $Mg\text{-}Mg^{+2}$ | −2.363 |
| $Na\text{-}Na^{+}$ | −2.714 |
| $K\text{-}K^{+}$ | −2.925 |

L-3/T-1/MME **Date : 30/07/2015**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2013-2014

Sub : **MME 321** (Crystal Defects, Deformation and Fracture)

Full Marks : 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

There are **EIGHT** questions in this section. Answer any **SIX**.

The figures in the margin indicate full marks.

1. What do you understand by dislocation? Using schematic sketches, discuss dislocation property and relationship for edge and screw types of dislocations. **(17 ½)**

2. What is Burgers vector? Determine the Burgers vectors for simple cubic, face-centred cubic and body-centred cubic unit cells. **(17 ½)**

3. For FCC crystals, using schematic sketches, discuss how you can obtain Schokley partial dislocations from a unit dislocation by valid dislocation dissociation reaction. **(17 ½)**

4. Derive an expression for stress field around screw dislocations using both rectangular and polar coordination systems. **(17 ½)**

5. (a) Define Schmid Law. **(5)**

   (b) Explain the reasons for more ductility of FCC crystals compared to HCP crystals. **(12 ½)**

6. What do you understand by climb of a dislocation? Describe different types of climb processes. **(17 ½)**

7. Draw typical S-N curves for ferrous and non-ferrous metallic materials and explain different features of the curves. **(17 ½)**

8. (a) An infinitely wide (assume) low carbon steel plate is subjected to constant amplitude uniaxial fatigue loads to produce stresses varying from $\sigma_{max}$ = 180 MPa to $\sigma_{min}$ = –40 MPa. If the plate contains an initial through thickness edge crack of 0.50 mm, how many fatigue cycles will be required to fracture the plate? **(10 ½)**

   According to Paris' Law, the relationship in region II of a fatigue crack growth behaviour is assumed to be $\frac{da}{dN}\left(\frac{m}{cycle}\right) = 6.9\times10^{-12}\,(\Delta K)^3\left(MPa\ m^{1/2}\right)^3$.

Contd ..... P/2

**MME 321**

**Contd ... Q. No. 8(a)**

Property data: $\sigma_0$ = 500 MPa, $S_u$ = 600 MPa, E = 207 GPa, $K_c$ = 100 MPa $m^{1/2}$ and

$$N_f = \frac{a_f^{-\left(\frac{p}{2}\right)+1} - a_i^{-\left(\frac{p}{2}\right)+1}}{\left(-\left(\frac{p}{2}\right)+1\right) a \sigma_r^p \pi^{p/2} \alpha^p}.$$

(b) Write a short note on J integral as comprehensive approach to fracture mechanics of low-strength ductile materials. **(7)**

## SECTION – B

There are **EIGHT** questions in this section. Answer any **SIX**.
The questions are of equal value.

9. What is blue brittleness? With suitable examples explain why substitutional solid solutions are more common than the interstitial solid solution.

10. Compare and contrast dispersion and precipitation hardening. Dispersion hardened materials are microstructureally more stable than the precipitation hardened materials at high temperature service – why?

11. Discuss various stages of creep rupture. Grain boundary sliding mechanism usually plays role in the tertiary creep stage. Explain.

12. What is the basis of Monkman-Grant equation for freep failure of materials? With the help of the curve presented in the Fig. for Q. No. 12, explain whether the 0.2 strain rate obeys the Monkman-Grant equation or not.

13. Mention various groups of materials (along with their specific roles) that are necessary to add in superalloys for achieving essential service properties.

14. In a commercially pure iron hydrogen atoms are introduced where the concentration of hydrogen atom is 1 atom per 120 iron cells. Calculate the lattice parameter of the iron cell. Assume reasonable value for any missing data.

15. With necessary sketches discuss the effects of various second phase particles on the tensile properties of steel.

16. Define critical crack length. The fracture stress of a as quenched high carbon steel is 200 MPa and the surface energy is 1 $J/m^2$. Calculate the critical crack length of the steel. Assume reasonable value for any missing data.

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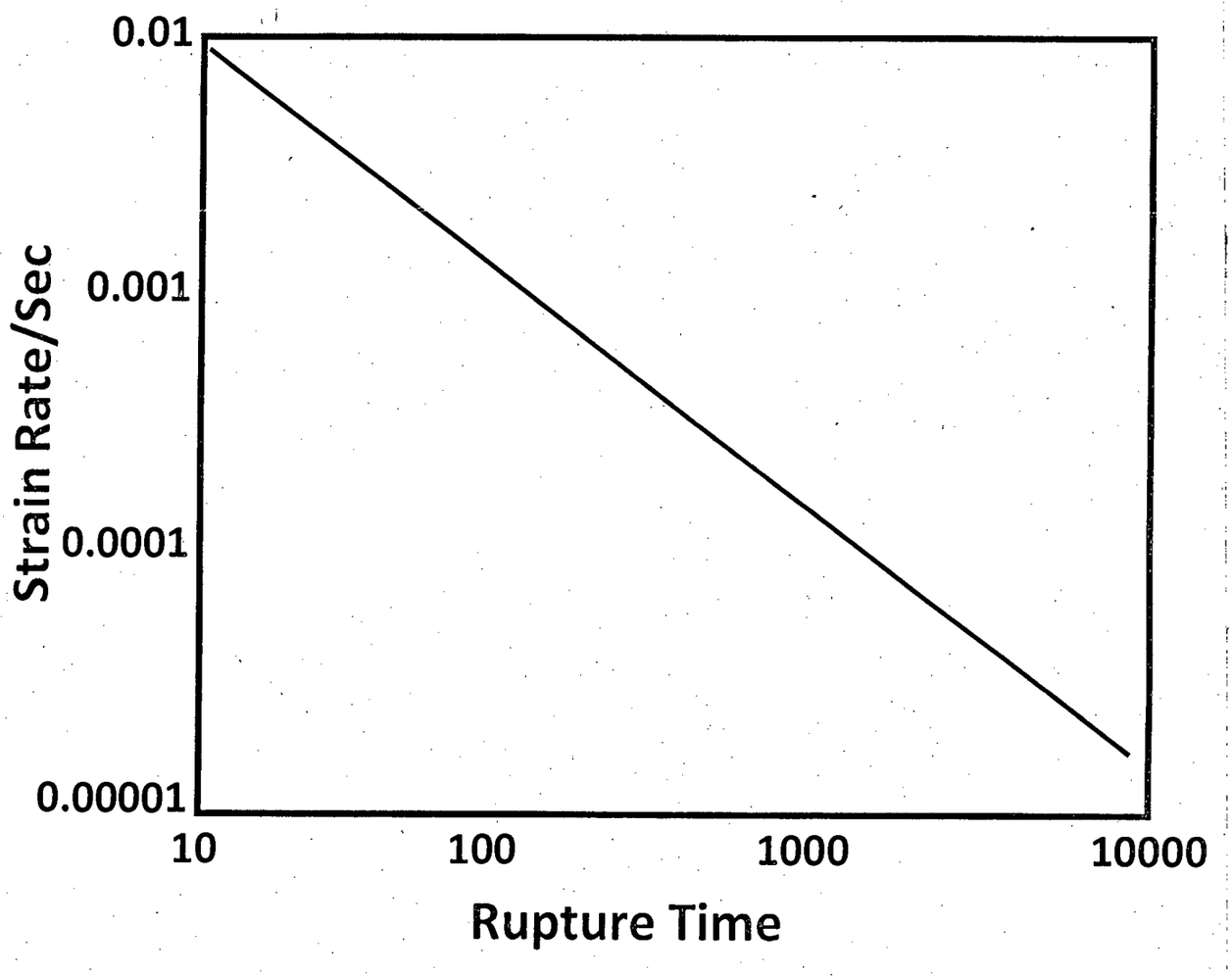


Figure for Question No. ~~A~~ 12.

L-3/T-1/MME **Date : 04/08/2015**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2013-2014

Sub : **MME 341** (Refractories and Furnaces)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) List various types of crucible furnaces and describe them in brief using free hand neat sketches. **(20)**

   (b) What are the main differences between shaft furnaces and hearth furnaces? **(15)**

2. (a) With the help of appropriate diagrams, write in details how waste recovery from the flue gas improves the furnace efficiency in terms of fuel savings. **(18)**

   (b) Give a neat sketch and describe the working principle of recuperative burner. **(17)**

3. (a) Using the following data, draw up a heat balance for a steel ingot soaking pit for a twenty hours test period during which 130 tons of ingots were heated from 20° C to 1220° C. **(20)**

   **Data**:

   Mean temperature of:

   Air after recuperator = 620° C

   Blast furnace gas (fuel) after recuperator = 450° C

   Flue gas after soaking pit = 1050° C

   Flue gas after air recuperator = 770° C

   Flue gas after B.F. gas recuperator = 530° C

   Average B.F. gas consumption = 2805 $m^3$/hr

   Air/fuel gas ratio = 0.8

   Flue gas/fuel gas ratio = 1.65

   Net calorific value of B.F. gas = 860 kcal/$m^3$

   Mean specific heats (kcal/$m^3$ °C):

   Air = 0.301

   B.F. gas = 0.310

   Flue gas = 0.358

   Steel = 0.180

   (All volumes are measured at 1 atm, 20° C)

   Scale formation = 1.5% (by weight)

Contd ..... P/2

## MME 341

**Contd ... Q. No. 3(a)**

Scale formation reaction is

$$3Fe + 2O_2 = Fe_3O_4, \quad \Delta H_{20^\circ C} = -266841 \text{ kcal}$$

Atomic weight of iron = 56

Structural loss = 270 KW

Calculate the thermal efficiency of both the air recuperator and gas recuperator using the above data.

(b) Give a neat sketch and describe the working principles of a rotary heat regenerator. **(15)**

4. (a) Describe a tunnel kiln with the help of a neat sketch. How does it differ from a compartment kiln? **(20)**

   (b) "Kiln efficiency can be more than 100%" – Explain. **(10)**

   (c) Write down the four essentials of a modern kiln. **(5)**

### SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Define the term 'refractory'. List and explain important properties that are considered during its selection for a particular use. **(20)**

   (b) Classify refractory materials and describe any two of them. **(15)**

6. (a) Explain the effect of heat on silica refractories. **(17)**

   (b) Describe the manufacturing process of magnesite refractories. **(18)**

7. (a) What is firing shrinkage? Why must this shrinkage be reduced? How can one reduce it? **(17)**

   (b) What is spalling? Illustrate the effect of various factors on spalling. Describe the spalling fractures that are found in service. **(18)**

8. (a) What do you understand by vitrification? **(10)**

   (b) Explain the changes that occur during firing of fireclay brick. **(15)**

   (c) What are the properties and uses of dolomite refractories? **(10)**

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L-3/T-1/MME Date : 08/08/2015

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2013-2014

Sub : **MME 351** (Principles of Ore Dressing and Extractive Metallurgy)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) What are the advantages of pyrometallurgical processes? **(5)**

   (b) What is roasting? Describe the five stages involved in fluidised bed roasting. **(15)**

   (c) A copper converter receives a charge of 60 tons of matte containing 54 percent FeS which is oxidised by blowing air (21 percent oxygen) onto the converter. Enough $SiO_2$ is made available to form an $FeO.SiO_2$ slag which is subsequently removed. Blowing is continued when cuprous sulphide starts to oxidize. At a certain stage, blowing is stopped and reaction is allowed to occur between the oxide and sulphide of copper forming (blister) copper and sulphur dioxide, no excess of either constituent being left over. Calculate (i) the volume of air necessary for oxidizing FeS, (ii) the total volume of $SO_2$ produced in cubic meters and (iii) the weight of slag formed. **(15)**

2. (a) Draw neat sketches and explain the situations that can arise when a mineral surface dissolves in a leaching reagent. Identify the kinetic steps in each case and explain how the leaching reaction can be accelerated. **(20)**

   (b) Discuss the importance of potential/pH diagrams in leaching operations. What are its limitations? **(15)**

3. (a) Draw a neat sketch and explain how percolation leaching is carried out. **(18)**

   (b) Explain the method of extraction of metals from the leach liquor by the cementation process. **(17)**

4. (a) Differentiate between electrowinning and electrorefining. Mention the basic conditions that an electrolyte must satisfy. **(15)**

   (b) What are the harmful impurities in electrical grade copper and how are they eliminated during copper electrorefining? **(20)**

Contd ..... P/2

**MME 351**

## SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Differentiate between ores and minerals. 'The delineation between ores and minerals is not a fixed division and alters with economic and technological factors change.' – Explain with examples. **(15)**

   (b) Mention the advantages of recycling of materials. **(8)**

   (c) Discuss the metallurgical factors that have to be considered in the recycling of metals. **(12)**

6. (a) Classify crushers with examples. Define mouth, gape and stroke of a crusher. **(12)**

   (b) Compare a jaw crusher with a gyratory crusher. **(8)**

   (c) What is angle of nip for a smooth roll crusher? Derive the equation for expression of angle of nip. **(15)**

7. (a) Draw a neat sketch and explain the movement of change in a ball mill. **(20)**

   (b) Define recovery and ratio of concentration. **(6)**

   (c) In a laboratory floatation test the following data were obtained: **(9)**

| | Weight | Assay |
|---|---|---|
| Head | 2000 g | 2.1% pb |
| Tailings | | 0.1% pb |
| Concentrate | 70 g | 55.1% pb |

   Calculate the ratio of concentration and recovery.

8. (a) Differentiate between free settling and hindered settling. **(6)**

   (b) A pulp consists of galena and quartz suspended in water. The pulp contains 30% galena, 40% quartz and 30% water by weight. Specific gravity of galena is 7.5 and of quartz is 2.7. Determine pulp dilution, pulp density and % of solids. **(9)**

   (c) What is hydrocyclone? Draw a neat sketch and explain the functioning of a hydrocyclone. **(20)**

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