L-3/T-1/MME **Date: 01/09/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2017-2018

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

SECTION – A

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

1. (a) With the help of Fe-O-C equilibrium diagram, briefly discuss the iron oxide reduction that occurs in the blast furnace. **(20)**

   (b) Explain how and where impurities (Si, Mn, P and S) are picked up in liquid iron in a blast furnace. **($26\frac{2}{3}$)**

2. (a) Discuss the advances that have been made in modern blast furnaces to reduce coke consumption and to increase their productivity. **(20)**

   (b) There are different processes available for the production of liquid iron in small quantities in the world. Out of these which one do you think most suitable for Bangladesh? Justify your answer and explain how liquid iron can be produced by your proposed process. **($26\frac{2}{3}$)**

3. (a) Distinguish between the mechanism of iron oxide reduction in coal-based process and gas-based process of DR process. **($24\frac{2}{3}$)**

   (b) What are the processes used for the production of carbon bearing ferromanganese? Which one do you consider to be better? Justify your answer and briefly explain the process. **(22)**

4. A blast furnace produces pig iron of composition of Fe- 93.0%, C-3.6%, Si- 2.0%, Mn- 0.5%, P- 0.9%. The flux amounts to one-fourth the weight of the ore. Consumption of coke is 780 kg/ton of pig iron. The gases carry 2 parts CO to 1 part CO_2. Assume that 99.0% of the iron is reduced and 1.0% iron is slagged.

   Calculate:

   (a) the weight of the ore required to produce one ton (1000 kg) pig iron

   (b) the weight of slag made from one ton pig iron and its composition, and

   (c) volume and composition of the blast furnace gas. **($46\frac{2}{3}$)**

Iron ore composition (wt.%)	Fe_2O_3- 79, SiO_2- 7.4, MnO- 0.6, Al_2O_3- 4.5, P_2O_5- 1.7, MgO- 1.7, H_2O- 5.1
Flux composition (wt.%)	$CaCO_3$- 95, $MgCO_3$- 3, SiO_2- 2
Coke composition (wt.%)	C- 89, SiO_2- 8, Al_2O_3- 1, H_2O- 2

Contd P/2

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SECTION – B

There are **NINE** questions in this section. Answer any **SEVEN**.

5. Explain how the physico-chemical properties of slag (slag basicity, oxidation and reduction potential, and slag viscosity) influence the steelmaking process. **(20)**

6. (a) Rewrite the following rate equation in terms of reduced time ($t_{0.5}$): **(5)**

$$g(\alpha)=1-2\alpha/3-(1-\alpha)^{2/3}=\left(k/r^2\right)t$$

(b) The ($\alpha - t$) values for a reaction are as follows: **(15)**

α :	0.53	0.67	0.78	0.86	0.90
t (min):	0.50	1.00	1.50	2.00	2.50

Plot the data using reduced time $\theta = t/t_{0.5}$ and check whether or not the above data follows the kinetic model mentioned in (a).

7. Using thermodynamic consideration, establish the conditions for phosphorous removal from liquid iron and explain how bath and slag compositions influence effective phosphorous removal process. **(10+5+5=20)**

8. A basic Bessemer converter is charged with 20 metric ton of pig iron, together with a flux of CaO, and is blown until it has 17.0 tons of Fe and 5720 kg of slag analyzing 13% SiO_2, 5 MnO, 19 P_2O_5, 27 FeO, 36 CaO. Assume that the iron is oxidised at a uniform rate throughout the blow. The carbon goes two-thirds to CO and one-third to CO_2. The total blowing time is 28 min. Determine: (i) The total volume of air required for the blow, and (ii) the time of each period. **(10+10=20)**

9. Using schematic diagram, discuss how carbon, silicon, manganese, phosphorous and sulphur are removed in the BOS process. **(20)**

10. Explain why and how pre-treatment of B/F liquid iron is performed before charging into the BOF for making steel. **(20)**

11. Analyse the potential of using pig iron and sponge iron as an alternate charge material to steel scrap in the EAF steelmaking process. **(20)**

12. Analyse the suitability of using induction furnace route as an alternate to the EAF steelmaking process and discuss how you can solve the limitations, if any, of this process. **(15+5=20)**

13. (a) What do you mean by clean steel? List the type and morphology of inclusions usually present in liquid steel. Explain how an assessment of inclusions can be performed to determine the cleanliness of steel. **(2+5+3=10)**
(b) What is inclusion engineering? List the requirements for inclusion engineering. Explain how this concept is used for aluminium oxide inclusion. **(3+2+5=10)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2017-2018

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

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 a recuperative burner. **(17)**

3. (a) A furnace consists of two large parallel plates separated by 0.75 m. A gas mixture comprised of O_2, N_2, CO_2, and water vapor, with mole fractions of 0.20, 0.50, 0.15, and 0.15, respectively, flows between the plates at a total pressure of 2 atm and a temperature of 1300 K. If the plates may be approximated as blackbodies and are maintained at 600 K, what is the net radiative heat flux to the plates? Assume reasonable values of any missing data. Use figures [Figure 1 to Figure 5] and Table 1 if necessary. **(20)**

   (b) Explain briefly: **(15)**

   (i) How are luminous flames generated?

   (ii) Why are luminous flames preferred in large industrial furnaces over clear flames?

4. (a) Give a neat sketch showing the flow of steel through different components during secondary refining of steel. Also mention the types of refractories that are used in each of those different components. Outline the main types of interactions that occur between steel and refractories during secondary refining. **(15)**

   (b) 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 after recuperator = 770°C

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

MME 341

Contd... Q. No. 4(b)

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) are as follows
Air = 0.301
B.F. gas = 0.310
Flue gas = 0.358
Steel = 0.180 (kcal/kg.°C)
(All volumes are measured at 1 atm, 20°C)
Scale formation = 1.5% (by weight)
Scale formation reaction is

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

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.

SECTION – B

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

5. (a) What is firing shrinkage? Why is it desirable to have a low firing shrinkage? How this shrinkage can be minimized? **(20)**
(b) What are the principal properties those are considered in selecting a refractory material for a particular use? Describe them in brief. **(15)**

6. (a) What are the raw materials for silica refractories? Explain how can silica refractories be produced from raw materials mentioning every steps with their effects on the properties of final products. **(20)**
(b) What are fusion cast refractories? Give a flow sheet and explain the manufacturing process of fusion cast refractories. **(15)**

7. (a) Illustrate the effect of various factors on spalling. Describe the spalling fractures that are found in service. **(20)**
(b) Describe the changes that occur during firing of fireclay brick. **(15)**

8. (a) Mention the differences between a compartment kiln and tunnel kiln. In your opinion, which one is more thermally efficient for a large scale refractory industry. Give reasoning. **(22)**
(b) Write in brief the working principle of periodic kiln. **(13)**

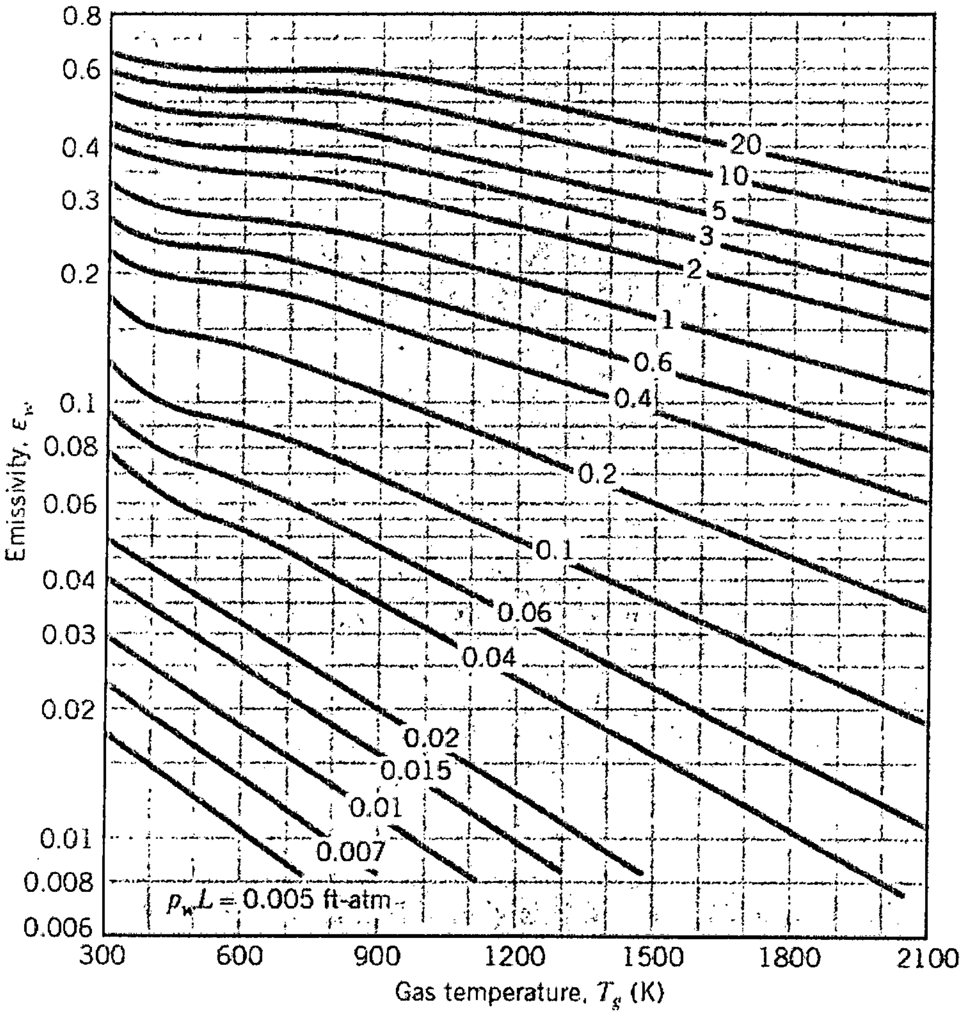


FIGURE 1. Emissivity of water vapor in a mixture with nonradiating gases at 1-atm total pressure and of hemispherical shape [13]. Used with permission.

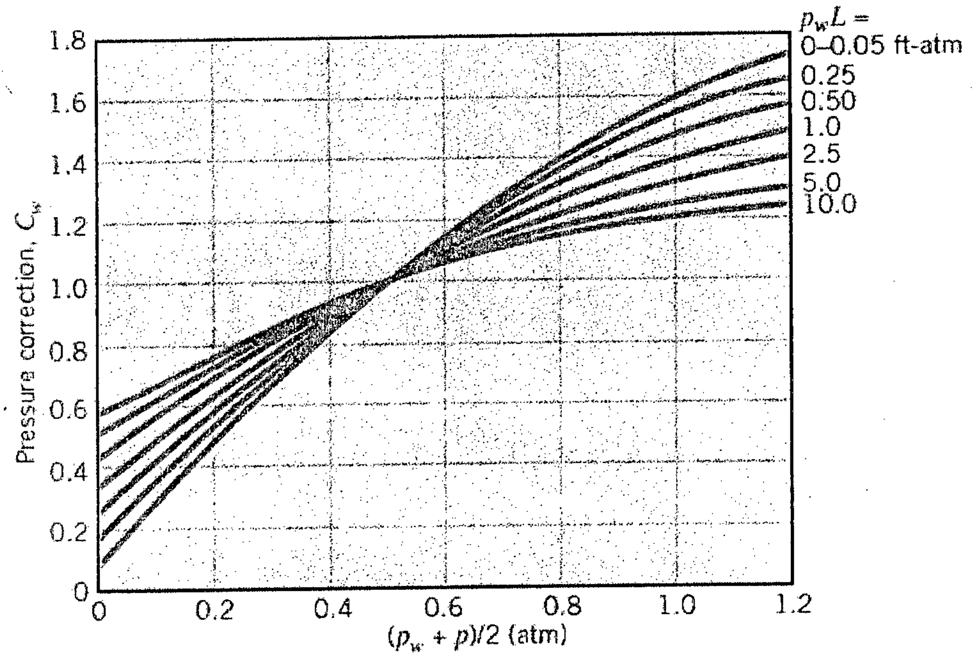


FIGURE 2. Correction factor for obtaining water vapor emissivities at pressures other than $(\varepsilon_{w,p\neq 1atm} = C_w \varepsilon_{w,p=1atm})$ [13]. Used with permission.

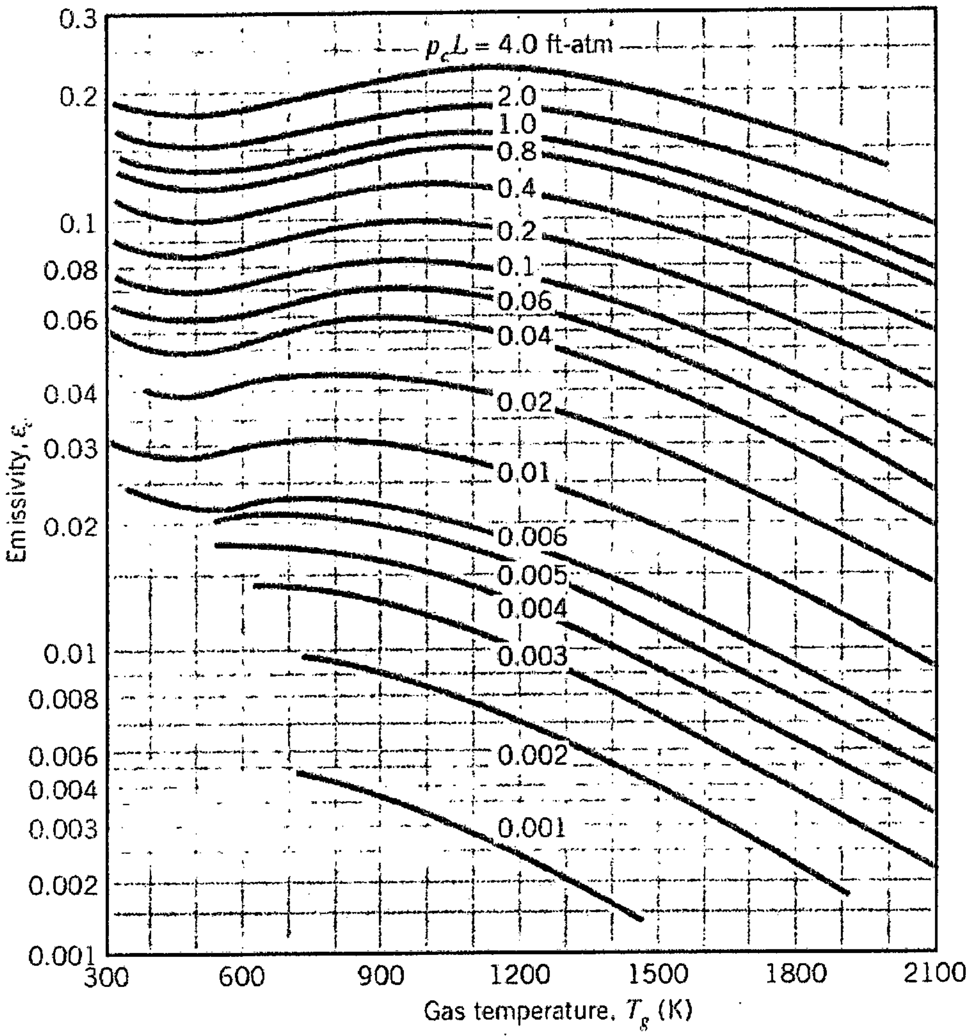


FIGURE 3. Emissivity of carbon dioxide in a mixture with nonradiating gases at 1-atm total pressure and of hemispherical shape [13]. Used with permission.

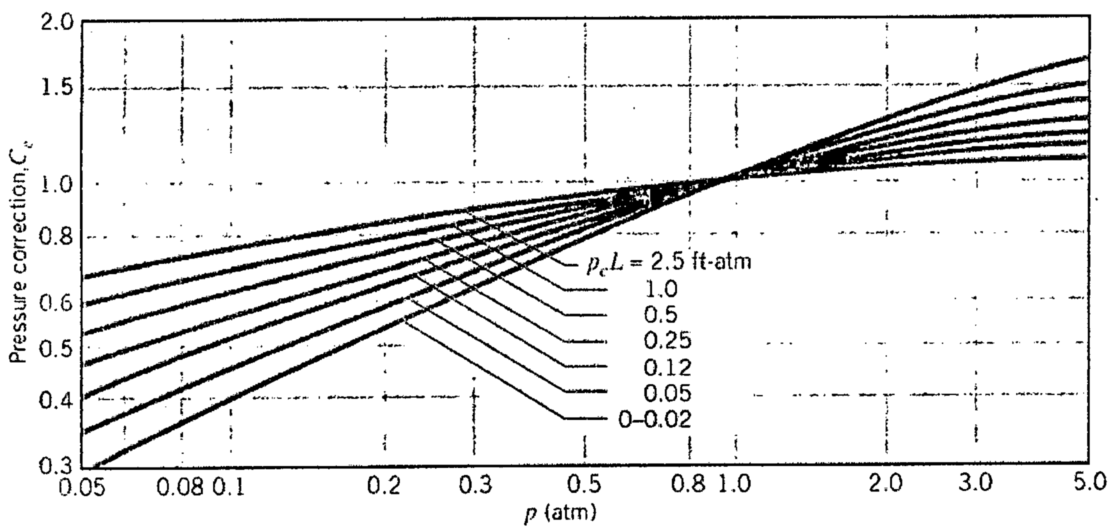


FIGURE 4. Correction factor for obtaining carbon dioxide emissivities at pressures other than 1 atm ($\varepsilon_{c,p\neq 1atm} = C_c\varepsilon_{c,p=1atm}$) [13]. Used with permission.

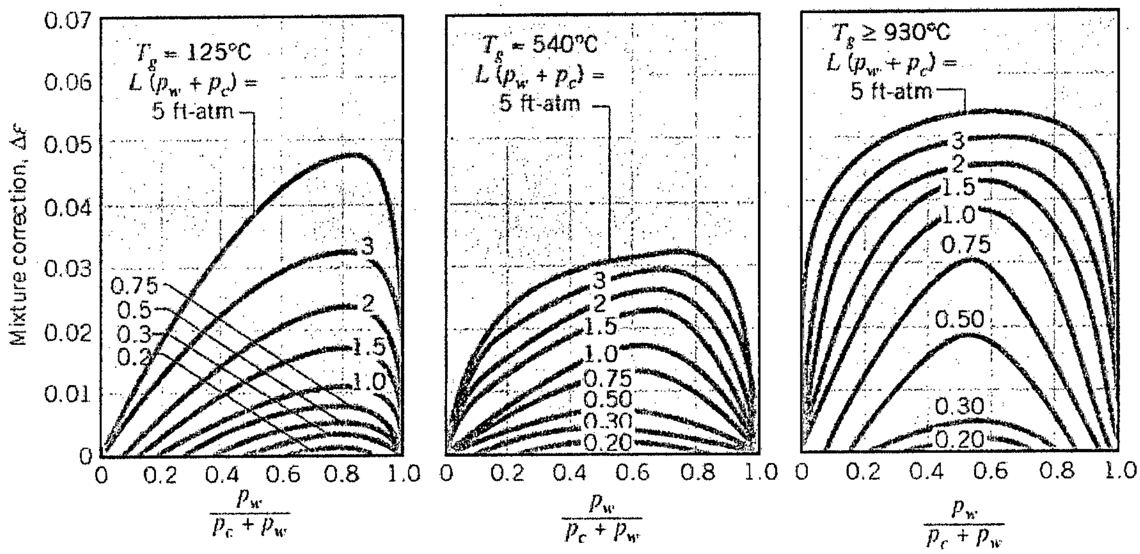


FIGURE 5. Correction factor associated with mixtures of water vapor and carbon dioxide [13]. Used with permission.

TABLE 1: Mean Beam Lengths L_e for Various Gas Geometries

Geometry	Characteristic Length	L_e
Sphere (radiation to surface)	Diameter (D)	$0.65D$
Infinite circular cylinder (radiation to curved surface)	Diameter (D)	$0.95D$
Semi-infinite circular cylinder (radiation to base)	Diameter (D)	$0.65D$
Circular cylinder of equal height and diameter (radiation to entire surface)	Diameter (D)	$0.60D$
Infinite parallel planes (radiation to planes)	Spacing between planes (L)	$1.80L$
Cube (radiation to any surface)	Side (L)	$0.66L$
Arbitrary shape of volume V (radiation to surface of area A)	Volume to area ratio (V/A)	$3.6V/A$

L-3/T-1/MME **Date: 23/09/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2017-2018

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

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

The questions are of equal value.

1. Determine the fatigue strength (fatigue life in terms of total strain) by a superposition of the elastic and plastic strain components of a material. You should use Basquin relationship and Manson-Coffin relationship.

2. Schematically draw Gerber, Goodman, and Soderberg diagrams, showing mean stress effect on fatigue life. A microalloyed steel was subjected to two fatigue tests at ±400 MPa and ±250 MPa. Failure occurred after 2×10^4 and 1.2×10^6 cycles, respectively, at these two stress levels. Making appropriate assumptions, estimate the fatigue life at ±300 MPa of a part made from this steel that has already undergone 2.5×10^4 cycles at ±350 MPa. Follow Palmgren-Miner's rule.

3. Determine theoretical tensile strength of a material following Orowan's model.

4. Consider a brittle material with γ_s = 1 J/m^2 and E = 100 GPa. (a) What is the breaking strength of this material if it contains crack-like defects as long as 1 mm? (b) Should it be possible to increase γ_s to 3,000 J/m^2, what would be the breaking strength for a 1-mm-long crack containing material?

5. Derive a modified expression of Griffith criteria based on crack propagation with plasticity. Explain the underlying reasons for improvement of the fracture toughness of the material by localised plastic deformation at the crack tip.

6. Dislocations and grain boundary sliding can introduce cracks in a ductile material. Explain this statement with schematics and examples.

7. A titanium alloy (Ti-6% Al-4% V) is used for aircraft applications. The NDE methods used cannot detect flaws whose size is smaller than 1 mm. You are asked, as the design engineer, to specify the maximum tensile stress that the part can bear in plane-stress and plane-strain situations. Given: yield stress = 1450 MPa; E = 115 GPa; v = 0.312; G_c = 23.6 kN/m.

8. What is creep? Draw a schematic creep curve for a material and briefly discuss the stages of this curve. From Figure 1 for Zircaloy under two conditions determine the Monkman-Grant rupture strain at three different strain rates. The failure strain is 0.1. Is the Monkman-Grant equation obeyed?

Contd P/2

MME 321

SECTION – B

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

The figures in the margin indicate full marks.

9. (a) Write down the probable defect reactions when NaCl is doped with $CaCl_2$ and identify the defect types. List the types of defects those are usually expected to be observed in un-doped NaCl and write down the defect reactions. If temperature of a $CaCl_2$ doped NaCl crystal is continuously increased, do you expect any change in defect chemistry? **(6+6+3)**

(b) Differentiate between two types of stacking faults. Is it possible to observe both types in both fcc and hcp crystals? — Discuss with necessary sketches. **(4+6)**

(c) Calculate the density of FeO after a heat-treatment resulting in a non-stoichiometric crystal with chemical formula $FeO_{0.85}$. Assume lattice parameter of the crystal to be 0.287 nm. **(10)**

10. (a) Show all possible slip systems in fcc and hcp crystals. Explain which one should be deformed more easily? **(10+2)**

(b) Why movement of a screw dislocation is easier than an edge dislocation if climbing is restricted? **(8)**

(c) Consider the following bcc dislocation reaction: **(15)**

$$\frac{a}{2}[\bar{1}\,\bar{1}\,1] \rightarrow \frac{a}{8}[\bar{1}\,\bar{1}\,0] + \frac{a}{4}[\bar{1}\,\bar{1}\,2] + \frac{a}{8}[\bar{1}\,\bar{1}\,0]$$

Determine if this reaction will occur or not. What type of crystal imperfection may result from this reaction if occurs?

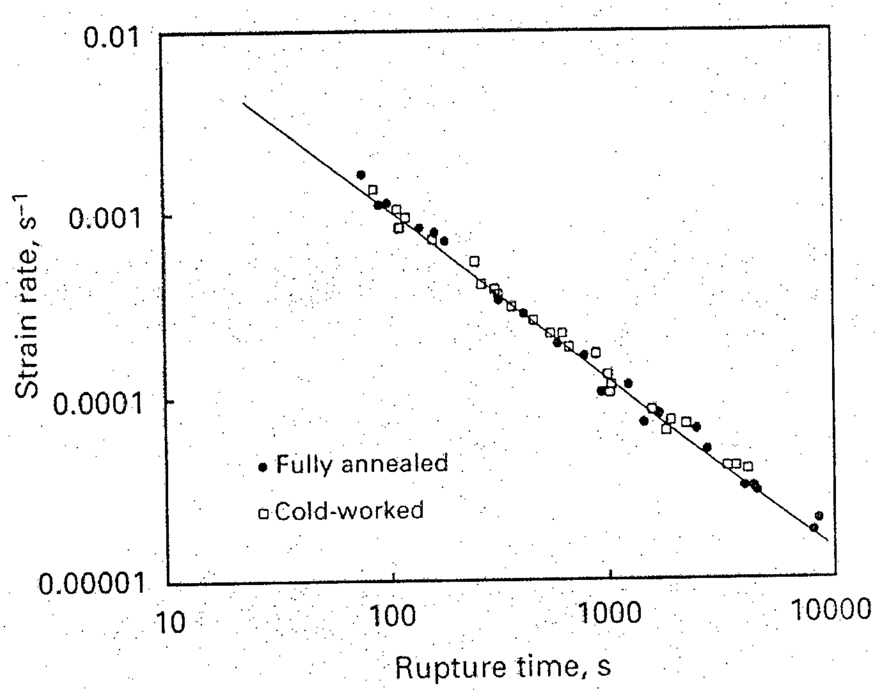
11. (a) Derive Schmid law. List two important conclusions those can be stated using Schmid factor. **(17)**

(b) Describe the characteristics of critical resolved shear stress. **(18)**

12. (a) Draw schematic stress-strain curves for Al-Cu alloy for the cases: pure, solid solution, over aged, aged to form GP zones and aged to peak hardness. **(10)**

(b) Write short note on Cottrell atmosphere, strain ageing and blue brittleness. **(15)**

(c) Consider dislocations blocked in a copper crystal. If the flow stress is controlled by the stress necessary to operate a Frank-Read source, compute the dislocation density in this crystal when it is deformed to a point where the resolved shear stress in the slip plane is 42 MPa. Take G = 50 GPa. **(10)**



Monkman–Grant plot for Zircaloy

Figure 1 for Question 8

L-3/T-1/MME **Date: 29/09/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2017-2018

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

SECTION – A

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

1. (a) What is a predominance area diagram? What are its uses and limitation? **(10)**

   (b) Describe the stages involved in fluidised bed roasting. **(15)**

   (c) Explain, with a suitable phase diagram, the principles of zone refining. **(10)**

2. (a) Discuss the importance of potential/pH diagrams in leaching operations. **(10)**

   (b) 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. **(25)**

3. (a) Draw a neat sketch and explain how leaching is accomplished in a pachuca vat. **(18)**

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

4. (a) List the basic conditions that an electrolyte must satisfy. **(5)**

   (b) Consider the relative activity of metals with respect to hydrogen and explain why all metals are not amenable to electrowinning from aqueous solutions. **(20)**

   (c) What are the harmful impurities in electrical grade copper and how they are eliminated during copper electrorefining. **(10)**

SECTION – B

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

5. (a) Explain the major difficulties in using scrap for metal/alloy production. **(8)**

   (b) Differentiate between ores and minerals. **(5)**

   (c) Define ore dressing. List the importance of ore dressing. Discuss the steps involved in ore dressing. **(12)**

   (d) Relate size of particles produced with the techniques of application of stress in the reduction of the particles. **(10)**

Contd P/2

MME 351

6. (a) Differentiate between crushing machines and revolving mills. **(9)**

(b) How does a jaw crusher work? Explain the important characteristics of a jaw crusher. **(13)**

(c) What are the advantages of toothed roll crusher over smooth roll crusher? **(8)**

(d) List the principal types of size reduction machines. **(5)**

7. (a) In a laboratory floatation test the following data were obtained: **(10)**

Product	Weight	Assay
Head	200 g	2.1% Pb
Tailings	—	0.1% Pb
Concentrate	70 g	55.1% Pb

Calculate the ratio of concentration, recovery and theoretical head assay.

(b) What are the purposes of screening? Discuss the factors that affect the performance of screens. **(12)**

(c) What is classification? Explain the principle of classification. **(13)**

8. (a) 'Compared with thickening and filtration, drying is expensive'. — Explain. Describe the drying operation in a rotary cylindrical dryer. **(17)**

(b) What are frothers, collectors, depressors and activators? Discuss their roles in the separation of particles by froth flotation. **(18)**
