L-3/T-1/MME Date : 29/10/2019

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B.Sc. Engineering Examinations 2018-2019

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

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. Consider yourself as a materials engineer. You are working in an R&D division of a renowned local non-ferrous industry, specialised in manufacturing refrigerator compressor and related parts. Some of the parts were failed during fabrication. You are investigating the alloys to determine the root causes. As part of your inspection work, you have done some uniaxial tensile tests. To prepare samples for tensile test, you have used standard dog-bone shaped samples of gauge length 50.80 mm. Draw a typical engineering stress-strain curve representative of your material. Now, point out the proof stress by offsetting at 0.002 engineering strain. Mark the UTS of the material. Put two more points: one between proof stress and UTS, and another one at the fraction (breaking stress), Finally, mark one point between UTS and failure (breaking) stress. Label these five points as A, B, C, D and E. Draw a schematic elongation vs gauge length (or, gauge length vs elongation) plot to show variation of elongation throughout the gauge length of the material. **(5+5+7½)**

Note: You do not need to make any explanatory writing of the plots/graphs.

2. Consider yourself still working in that industry. After successful identification of the first problem, as mentioned earlier, you are now a lead engineer in the R&D division. Your work is more focused on ductile fracture behaviour of materials used in your plant. After conducting research on those materials for a few months, and reading of peer-reviewed original research articles on steels and nickel-based alloys, you have reached the following conclusion.

"*In practice, materials generally contain a large quantity of dispersed phases. These can be very small particles (1 to 20 nm) such as carbides of alloy elements, particles of intermediate size (50 to 500 nm) such as alloy element compounds (carbides, nitrides, carbonitrides) in steels, or dispersions such as Al_2O_2 in aluminium and ThO_2 in nickel. Precipitate particles obtained by appropriate heat treatment also form part of this class (e.g., on Al–Cu–Mg system), as do inclusion of large size (on the order of milimetres) – for example, oxides and sulphides.*" From this conclusion, you have decided that you can identify fracture mode (ductile or not) by looking at the SEM mircrographs. One such micrograph is shown in Figure 1.

How can you correlate the micrograph shown in Figure 1 and the statement made above? **(17½)**

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3. The industry you are working (as mentioned above) has become a large enterprise by attracting a good number of investors. You have been asked to enhance your knowledge on fracture by understanding brittle fracture, since your company now not only works on FCC metals, they are planning to expand their business in BCC and HCP metals (which typically fall in brittle manner). You've been sent to a European research lab to carry out some research works on brittle fracture. After one month of hard study on brittle fracture, your line manager in that European lab has shown you two SEM micrographs, as given in Figure 2. River-markings, typical of brittle fracture, are evident in the micrographs. He also has given you a schematic, as shown in Figure 3, to explain the appearance of brittle fracture. What was his explanation? **(17½)**

4. Derive the following expression, where symbols have their usual meanings. **(17½)**

$$\sigma_{max} = \sqrt{\frac{E\gamma}{a_0}}$$

5. What is fatigue? Why is fatigue important in engineering materials? Draw a typical fatigue for a low-carbon steel at two different frequencies of cycling. Explain the difference in fatigue life due to difference in frequencies of cycling. **(4+4+5+4½)**

6. A micro-alloyed 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. You may assume Palmgren-Miner's rule. **(17½)**

7. What is creep? Draw a typical creep curve, and explain the differences in slopes (or, creep rate) in different regions. **(5+5+7½)**

8. Diffusion creep be of three types: Nabarro and Herring creep, Coble creep and Harper and Dorn creep. Figure 4 shows these three types of diffusion creep mechanisms. Identify those mechanisms and write down in your answer script as 'a', 'b' or 'c', next to the name of the mechanisms. Now, briefly discuss those mechanisms, and why these diffusion mechanisms are considered in creep. **(2½ + (3*5))**

SECTION – B

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

9. (a) Derive Schmid law and state condition for the maximum shear component value. **(12+3)**

   (b) How critical resolved shear stress (CRSS) is effected by purity of element and addition of alloying elements? **(8)**

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(c) Describe the processes of climb and cross-slip for edge and screw dislocation respectively. **(12)**

10. (a) Differentiate between slip and twinning. Describe the mechanism of twinning. **(15)**

(b) Draw a typical stress-strain curve for a twinned single crystal. **(5)**

(c) Consider the following BCC dislocation reaction:

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

Determine if this reaction will occur or not. What type of crystal imperfection may result from this reaction if occurs? **(15)**

11. (a) Write short note on sessile dislocation, Frank sessile dislocation and Lomer-cottress barrier. **(15)**

(b) With neat sketches explain how both intrinsic and extrinsic stacking faults can be introduced in FCC structure. **(10)**

(c) Determine whether the following dislocation reaction is feasible. **(10)**

$$\frac{a}{2}[0\bar{1}1] = \frac{a}{6}[1\bar{2}1] + \frac{a}{6}[\bar{1}\,\bar{1}\,2]$$

12. (a) Describe the stages of a generic shear-stress-strain curve for FCC single crystal. What happen when shear stress is less than critical resolved shear stress value? **(15)**

(b) Draw a typical stress-strain curve for Al-Cu alloy for various strengthening mechanisms. **(5)**

(c) Consider dislocations are 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 the crystal when it is deformed to a point where the resolved shear stress in the slip plane is 42 MPa. Take G = 50 GPa. For copper, $b = 2.55 \times 10^{-10}$ m. **(15)**

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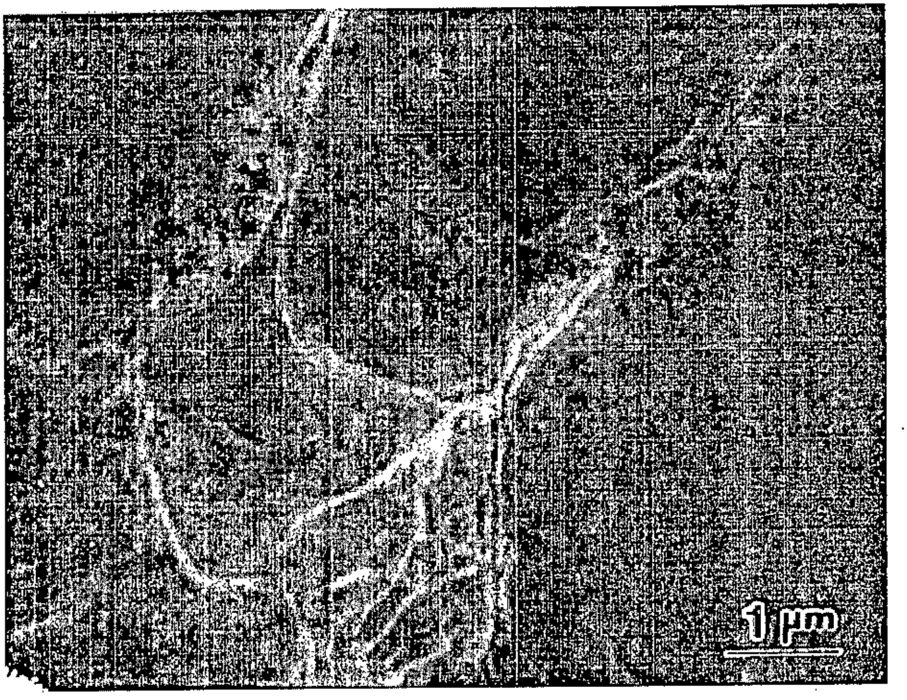

Scanning electron micrograph of dimple fracture resulting from the nucleation, growth, and coalescence of microcavities. The micrograph shows an inclusion, which served as the microcavity nucleation site.

Figure 1 for Question No. 2

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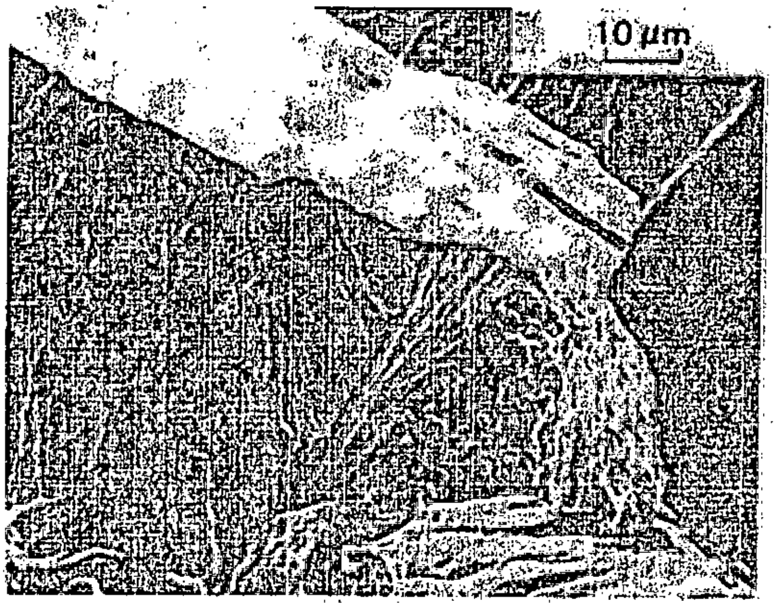
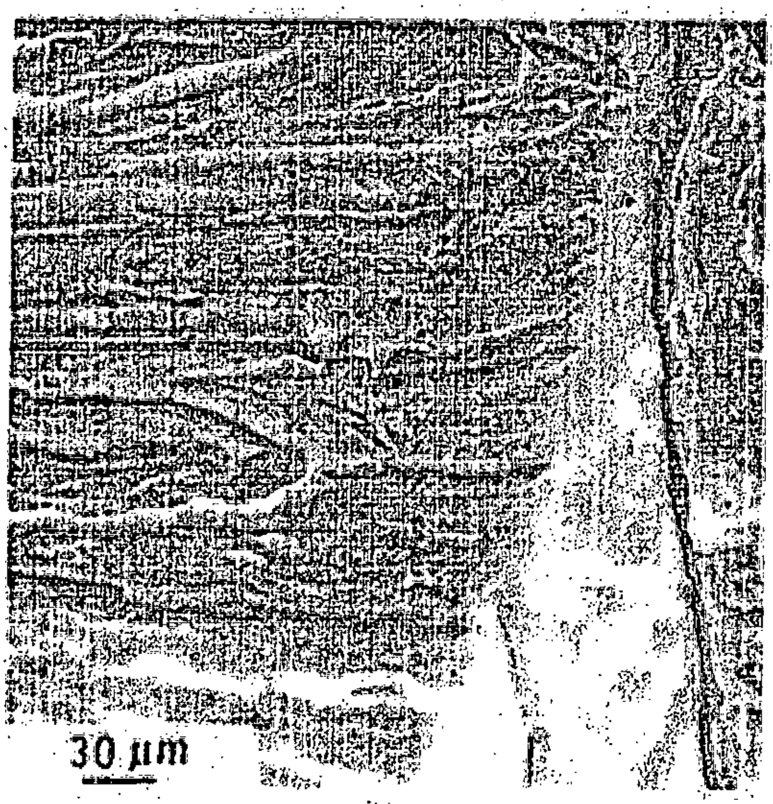


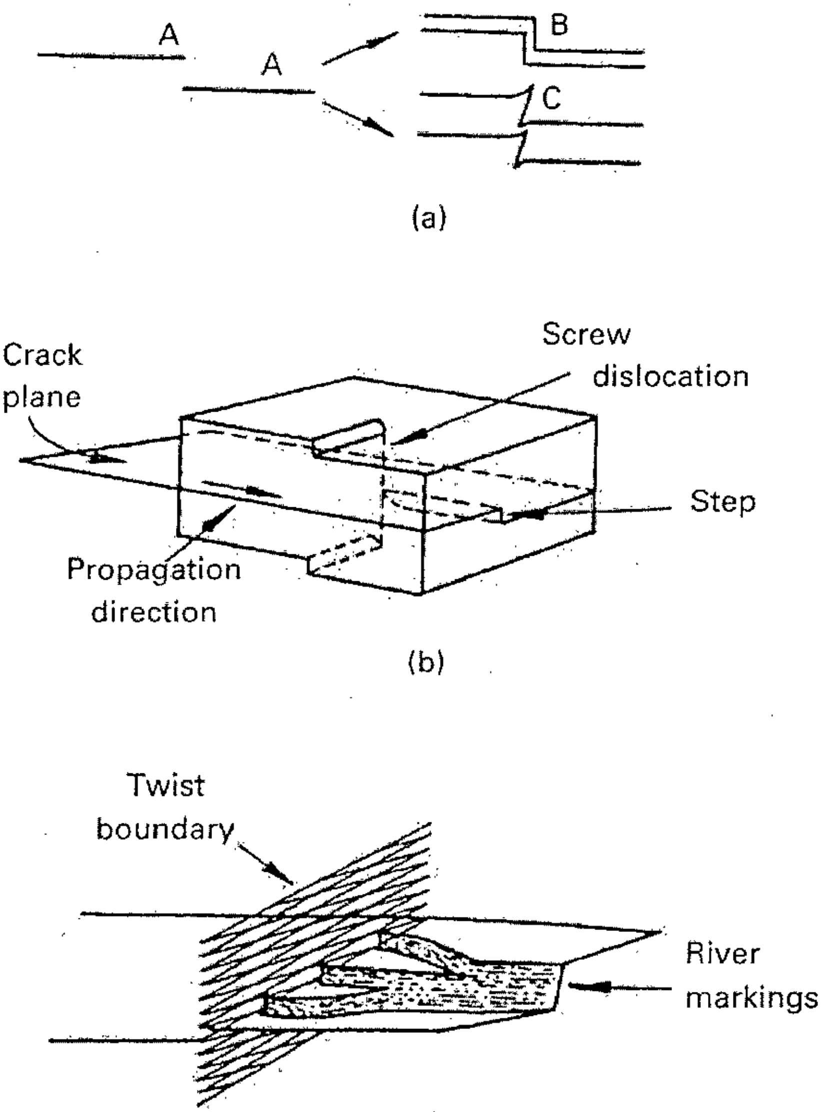
(a)



(b)

(a) Cleavage facets in 300-M steel (scanning electron micrograph). (b) River markings on a cleavage facet in 300-M steel (scanning electron micrograph).

Figure 2 for Question No. 3



Formation of cleavage steps. (a) Parallel cracks (A, A) join together by cleavage (B) or shear (C). (b) Cleavage step initiation by the passage of a screw dislocation. (c) Formation of river markings after the passage of a grain boundary. (Adapted from D. Broek, Elementary Engineering Fracture Mechanics, 3rd ed. (The Hague, Netherlands: Martinus Nijhoff, 1982), p. 33.)

Figure 3 for Question No. 3

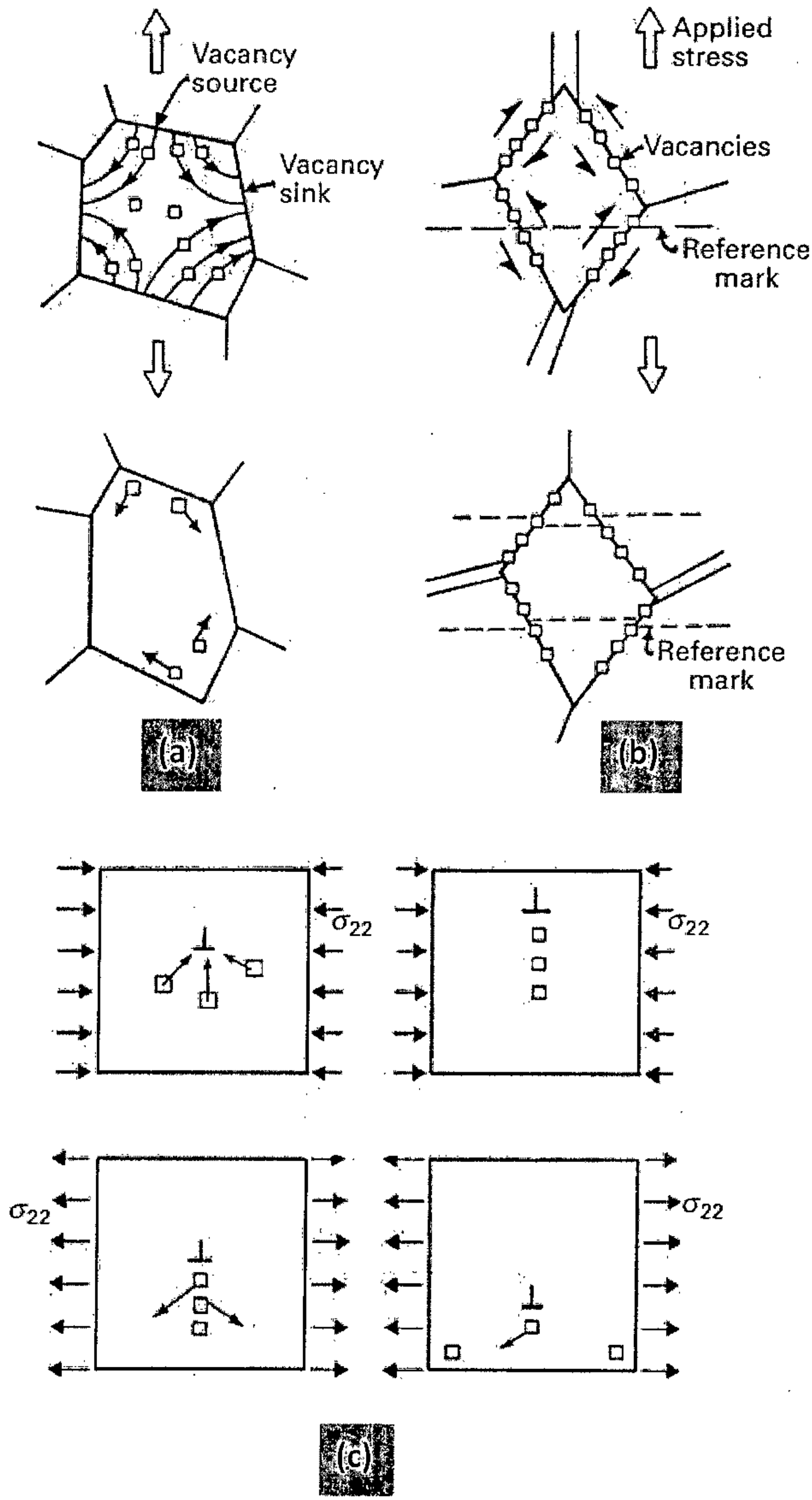


Figure 4 for Question No. 8

L-3/T-1/MME **Date : 02/11/2019**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2018-2019

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

SECTION – A

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

1. (a) With suitable examples draw n-type and ρ-type oxide defect structures. How can oxidation be decreased by doping n-type semiconductors? **(18)**

   (b) When does catastrophic oxidation of metal occur? Name metals and oxides that are susceptible to catastrophic oxidation. What is the remedy? **(8)**

   (c) How does Pilling-Bedworth ratio assess the corrosion protection of metals and alloys? **(9)**

2. (a) Mixed potential theory of two simple hypotheses. - Write the hypotheses. . **(5)**

   (b) Three possible cases when an active-passive metal is exposed to an acid solution. Which one is the most desirable and which one is the least desirable and why? Answer with necessary diagram and examples. Hence prove that a metal/alloy will more rapidly passivate if it has small I_C & E_{PP} values. **(25)**

   (c) What is Synergistic effect during use of inhibitors? **(5)**

3. (a) Amount of oxidizer concentration required to cause passivation is greater than that required to maintain passivity. - Justify the assertion with necessary figures. **(25)**

   (b) The corrosion rate of a metal in diffusion-controlled system is a function of solution velocity at low velocity regime but it becomes independent of solution velocity at very high velocities. - Explain with necessary figure/(s). **(10)**

4. (a) Figure 1 shows the effect of galvanically coupling Zn to Pt in an air-free acid solution. Write the conventional notations and their meanings used to define the six points indicated by 1 to 6 arrowheads. Also illustrate the corrosion of Zn-Pt system with the help of mixed potential theory. **(18)**

   (b) Ti is more active to Pt. Corrosion of Ti will decrease upon coupling to an equal area of Pt which is completely contrary to classic corrosion theory. - Prove with necessary figure. Mention the condition for which this happens. **(17)**

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SECTION – B

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

5. (a) "Economy would be drastically changed if there is no corrosion" - Explain this assertion. **(7)**

(b) Two steel electrodes are immersed in dilute hydrochloric acid solution and electrically connected. The electrolyte around one electrode is building by air. In this case what type of corrosion cell occurs and explain the corrosion mechanism of the cell? **(10)**

(c) Calculate the emf of the cell Sn;Sn^{2+}, Ti^{2+}; Ti at 25°C and also show the polarity of the cell from the free energy change with the help of schematic diagram. The standard potential of $Sn^{+} + 2e \rightarrow Sn$ and $Ti^{2+} + 2e \rightarrow Ti$ are -0.136 and -1.630 volt respectively. Given R = 8.314 j/deg-mol and F = 96,500 C/eq. **(18)**

6. (a) What type of corrosion attack occurs under the non-metallic dirt deposits on corrugated galvanized roof sheet? Explain the corrosion mechanism. **(18)**

(b) Filiform corrosion does not destroy the metallic component, however it is a major problem in the canning industry-why? **(5)**

(c) Explain how metallurgical variables affect the pitting corrosion and what measures can be taken for the prevention of pitting damage? **(12)**

7. (a) Discuss the methods that are followed to control the intergranular corrosion of austenitic stainless steel. **(18)**

(b) What type of cast iron is susceptible for selective leaching? Explain the mechanism of the leaching that occurs in cast iron. **(10)**

(c) Suggest a cast iron type that can be used in line pipe for carrying water. Justify your choice. **(7)**

8. (a) Discuss the factors that are directly pertinent to erosion corrosion. **(15)**

(b) Explain the mechanism of the damage that occurs in hydraulic turbines, ship propellers and other surfaces where high velocity liquid flow and pressure are encountered. **(12)**

(c) What measures can be taken to prevent hydrogen blistering? **(8)**

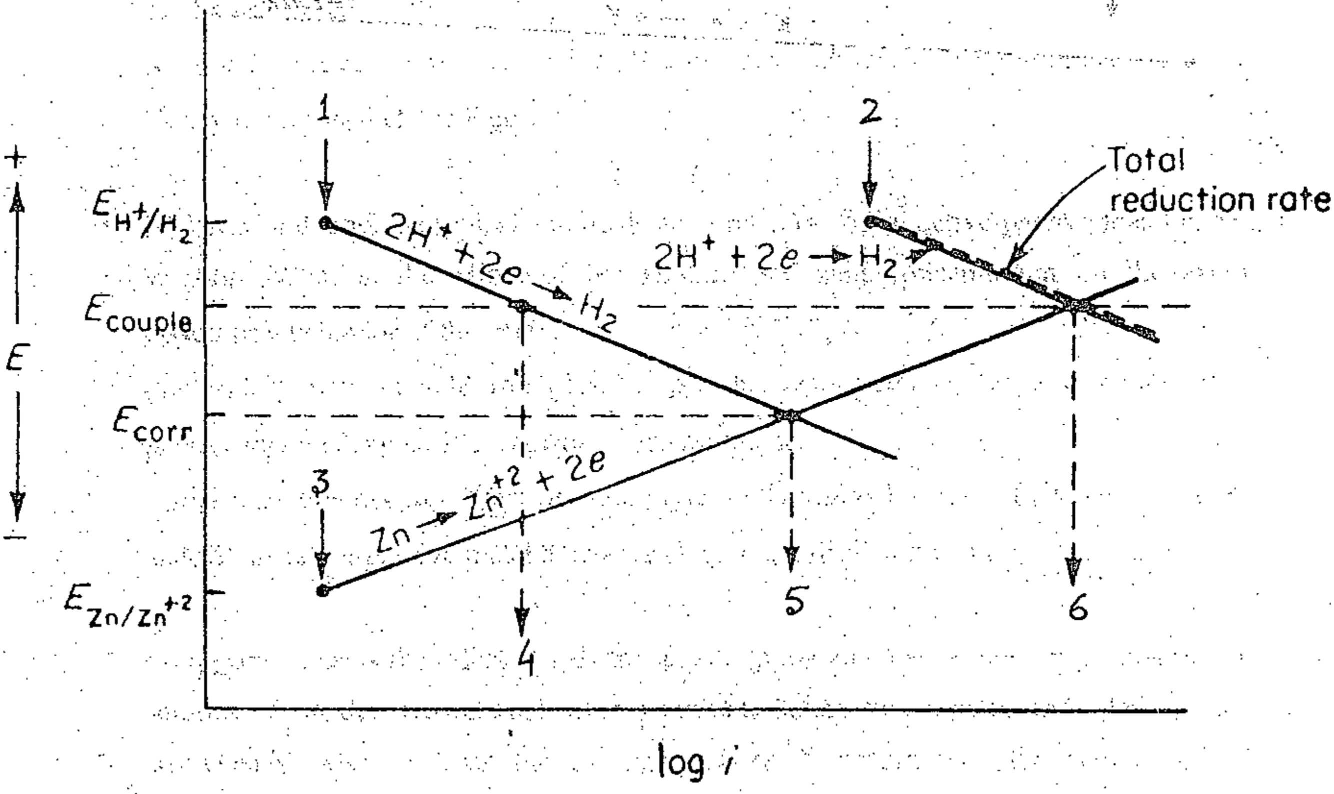

Fig. 1 for question No. 4(7).

L-3/T-1/MME **Date : 24/10/2019**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2018-2019

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

(b) Define 'useful heat' and 'waste heat'. With the help of appropriate diagrams, explain in details how waste heat recovery from the flue gas improves the furnace efficiency in terms of fuel savings. **(20)**

2. (a) List various type of converters and compare their working principles, efficiency and applications in brief using free hand neat sketches. **(18)**

(b) Furnaces can be classified based on several criteria. List those criteria. **(4)**

(c) Compare shaft furnaces and hearth furnaces based on the criteria listed in (b). **(13)**

3. (a) Make a comparison between recuperators and regenerators. **(10)**

(b) Explain how heat is generated and transferred to load from a burner flame inside a fuel fired furnace. Indicate the parameters that affect both the heat generation and transfer processes. **(13)**

(c) Write short notes on (i) radiation recuperator, (ii) Lag time. **(12)**

4. (a) List the different parts used in continuous casting of steel and also mention the types of refractories that are used in those parts. Outline the main types of interactions that occur between steel and refractories of those different parts mentioned above during continuous casting of steel. **(20)**

(b) A steel reheating furnace has 10% external loss and receives 12000 m^3/hr of mixed gas. Waste gas passes through air recuperator and then through mixed gas recuperator. **(15)**

Mean temperature of:

Air after recuperator = 600° C

Mixed gas after recuperator = 380° C

Flue gas after reheating furnace = 1100° C

Flue gas after Air recuperator = 700° C

Flue gas after mixed gas recuperator = 500° C

Air / mixed gas ratio = 2.9

Flue gas / mixed gas ratio = 3.67

Net calorific value of mixed gas = 2300 kcal/m^3

Contd P/2

MME 341

Contd..... Q. No. 4

Mean specific heats (kcal/m^3 °C) are as follows:

Gases	Air	Mixed gas	Flue Gases		
Temperature, ° C	600	380	1100	700	500
Specific heat, kcal/m^3 ° C	0.325	0.353	0.377	0.36	0.351

Mean specific heat of steel is 0.162 kcal/kg. °C. Steel leaves the furnace at a temperature of 1220°C. Calculate

(i) the useful heat per m^3 of mixed gas

(ii) the thermal efficiency of the furnace

(iii) the throughput of steel.

SECTION – B

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

5. (a) Describe the structural and compositional changes that is observed during heating of a fireclay refractory. **(8)**

   (b) Explain slip-casting method with a schematic diagram. What measures should be taken to obtain a bubble free cast product by this method? **(20)**

   (c) Why does a clay, once having been fired at an elevated temperature, loses its hydroplasticity? **(7)**

6. (a) Is thermal shock more likely to occur on rapid heating or cooling for a ceramic material? Why? **(10)**

   (b) Upon consideration of the $SiO_2 - Al_2O_3$ phase diagram, see figure for question no. 6(b), which one of the following would you judge to be the more desirable refractory? **(15)**
   70 wt% Al_2O_3 – 30 wt% SiO_2 and 74 wt% Al_2O_3 – 26 wt% SiO_2. Justify your choice.

   (c) Distinguish between mechanical spalling and textural spalling. **(10)**

7. (a) Which refractory material, between silicon carbide and zirconia, would you select for blast furnace lining? Explain your selection. **(10)**

   (b) Illustrate the firing schedule of silica brick along with the major structural changes associated with the heating. **(15)**

   (c) What measures may be taken to reduce the likely hood of thermal shock of a ceramic piece? **(10)**

8. (a) How can you obtain equalization of temperature throughout the volume of charge in a kiln? **(15)**

   (b) Compare and contrast between a periodic kiln and a continuous compartment kiln. **(20)**

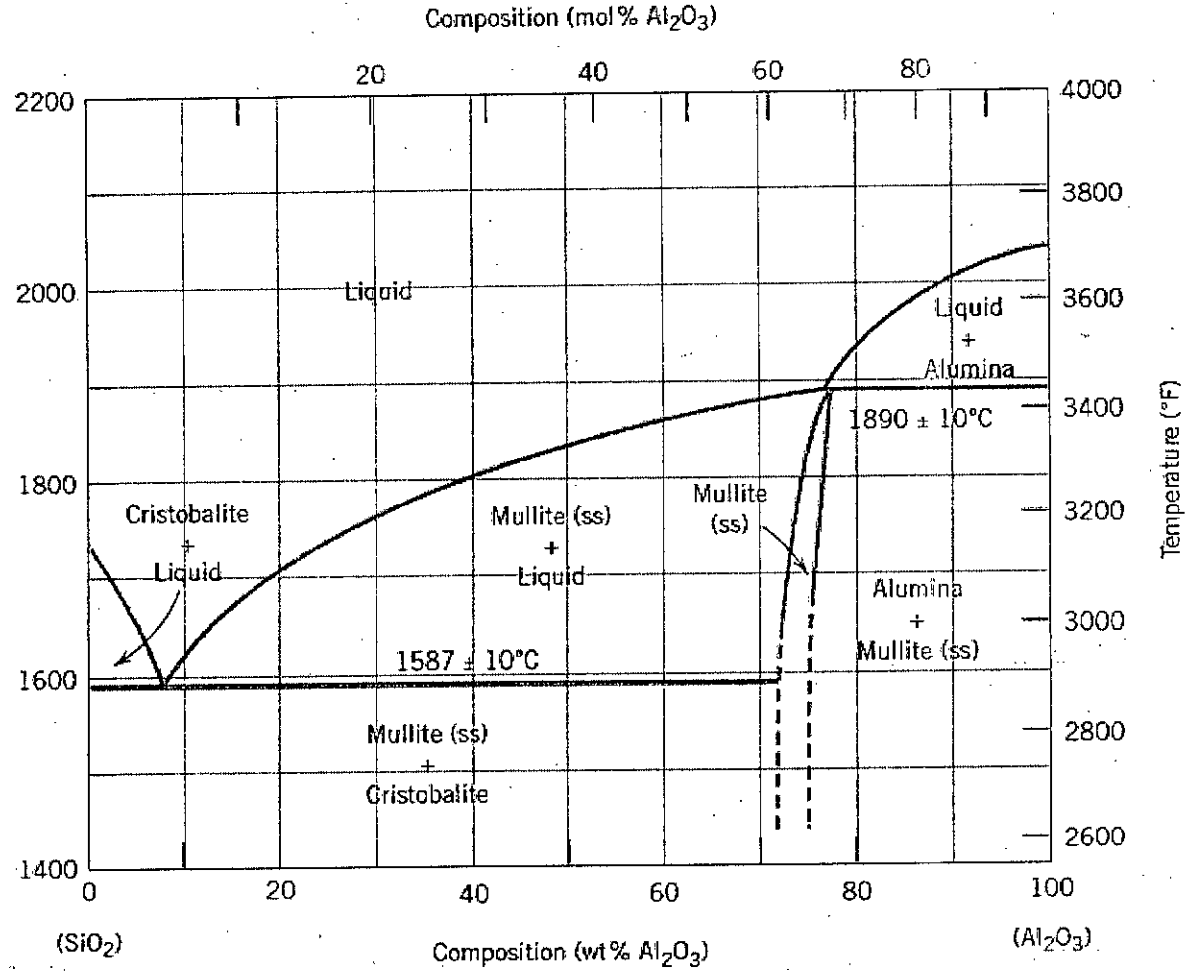

Figure for question no. 6(b)

L-3/T-1/MME **Date : 06/11/2019**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2018-2019

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 do you understand by decomposition voltage? Draw the current-voltage relationship during decomposition of an electrolyte. **(10)**

   (b) Which metallurgical process, pyrometallurgy or hydrometallurgy, is more suitable for treating low-grade ores and why? **(10)**

   (c) Briefly discuss the classes of leaching reagents used in hydrometallurgy process? **(15)**

2. (a) How does sinter roasting operate? Explain with a schematic diagram. **(15)**

   (b) Which process, between agitation leaching and percolation leaching, would you select if the leaching reaction is limited by insufficient diffusion? Describe the process you select. **(20)**

3. (a) What role does hydrogen evolution play during electrolysis in aqueous solutions? **(10)**

   (b) Briefly outline the mechanism of roasting of a sulphide ore. **(13)**

   (c) What are the effects of different kind of impurities in electrolysis? **(12)**

4. (a) Discuss, in reference to the figure 1, why is dissolution of gold more difficult than that of copper? **(15)**

   (b) "The cementation process may be regarded as a process of corrosion" - explain this assertion with an appropriate example. **(20)**

SECTION – B

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

5. (a) Recycling of metals has become an important source of metals-justify. **(10)**

   (b) Classify scrap metals in terms of their availability. What are the metallurgical factors that must be considered in the recycling of scrap metals. **(5+8=13)**

   (c) Discuss, on the basis of the nature of the ores, the importance of ore dressing. **(12)**

6. (a) Define reduction ratio. Why is the actual reduction ratio usually less than the calculated figures? **(2+5=7)**

Contd P/2

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Contd..... Q. No. 6

(b) How does a gyratory crusher differ from a jaw crusher? **(8)**

(c) Draw a neat sketch and explain the movement of charge in a ball mill. **(10)**

(d) What is closed circuit grinding? Discuss its advantages and limitations. **(2+8=10)**

7. (a) Explain, with suitable examples, the need for particle selection. **(08)**

   (b) Define recovery and ratio of concentration. Derive the expression of recovery using two product formula. **(2+10=12)**

   (c) How is gravity concentration done in jigs? What is an artificial bed in jigs? When is it used? **(15)**

8. (a) Explain the principle that is used in the shaking table concentrators. Draw a neat sketch and discuss the functioning of a shaking table. **(5+10)**

   (b) What are frothers, collectors, depressors, activators and conditioners? Explain their role in the separation of particles by froth flotation. **(20)**

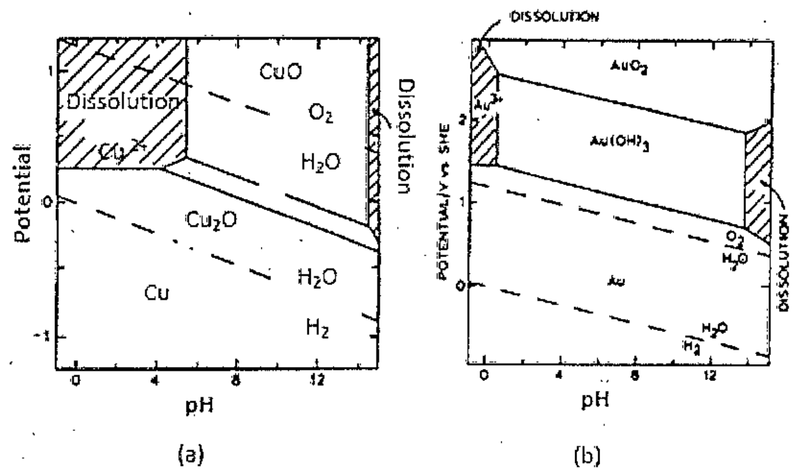

Figure 1 for question no. 4(a)

L-3/T-1/MME Date : 19/10/2019

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2018-2019

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) Explain the electro-chemical nature of slag-metal reaction as metal is non-polar and molten slag is ionic in character. (20)

   (b) Discuss the mechanism of formation of fusion zone within an iron blast furnace. Where is this zone formed and how does it interfere with blast furnace operation? Explain with necessary sketches. $(26\frac{2}{3})$

2. (a) "The system of charging, the level of the charge and the size of the charge are to be selected so as to have maximum utilization of gas, subject to ensuring smooth performance of the blast furnace" - explain this statement. (18)

   (b) Name the sources that are responsible for the blast furnace irregularities. (4)

   (c) Mention the physico-chemical principles of ferro-silicon smelting in electric arc furnace. List the characteristic features indicating smooth operation of the smelting furnace of ferro-silicon. $(24\frac{2}{3})$

3. (a) What are the advantages of submerged electric arc furnace over conventional blast furnace used in liquid iron production? (9)

   (b) Explain briefly the rate controlling steps of iron oxide reduction that occur during sponge iron production by DRI process. $(22\frac{2}{3})$

   (c) Schematically illustrate the temperature distribution and chemical reactions in the pre-reduction unit and smelting unit of two-stage smelting reduction process. (15)

4. A blast furnace makes pig iron containing Fe-95.0%, C-3.6%, Si-1.4%. The ore was 80% Fe_2O_3, 12% SiO_2, 8% Al_2O_3. The coke (0.95 kg required for per kg pig iron) carried 10% SiO_2, 1% Al_2O_3, 89% C. The flux (0.40 kg required for per kg pig iron) was pure $CaCO_3$. The gases carried 2.33 parts CO to 1 parts CO_2. Assume that 99.0% of the iron is reduced and 1.0% iron is slagged.

   Calculate: $(46\frac{2}{3})$

   (a) the weight of the ore and volume of air required per ton (1000 kg) pig iron, production.

   (b) The weight of slag made from per ton pig iron and its composition.

   (c) volume of the blast-furnace gas.

Contd P/2

MME 449

SECTION – B

There are **FIVE** questions in this section. Answer question No. 5 and any **THREE** from the rest. Question No. 5 is compulsory.

5. **Answer any 2 (two) questions:** $2\times40=80$

(a) (i) The activity coefficient of MnO in slag having a slag basicity of 1.8 is 1.6. The mole fractions of FeO and MnO in slag are 0.25 and 0.05, respectively. Determine the equilibrium contents of Mn and O in steel at 1873K. Given that, at 1873K,

$$[O]_{sat} = 0.233\%$$

$$[Mn] + (FeO) = (MnO) + [Fe];\ \Delta G^0 = -27800 + 11.8T \text{ Joules}$$

$$a_{FeO} = 0.514\ (N_{FeO})^{0.2665}$$

where N_{FeO} is the mole fraction of FeO.

(ii) Calculate the chemical potential of nitrogen gas at equilibrium with liquid steel at 1600 °C. The steel contains 0.01%N, 0.5% C and 0.5% Mn. Given Data:

$$[N]_{ppm\ std.\ state\ in\ iron} = K_{N(pN_2)^{1/2}} = \text{where } \log K_N = -581T + 2.937$$

(Note: 1 wt% = 10^4 ppm).

(b) The times required for different fraction of reactant reduced (alpha) of a chemical reaction at two different temperature are as follows:

Fraction Reduced, Alpha	Time (seconds)	
	600 °C	800 °C
0.1	354	287
0.3	532	542
0.5	665	555
0.7	800	674
0.9	1000	835

Using Table-1, examine whether or not the given data follow any one of the following two kinetic models:

(a) $F_1(\alpha)$ model: $[-\ln(1-\alpha)]^{1/3} = kt$

(b) $R_3(\alpha)$ model: $[1-(1-\alpha)^{1/3}] = kt$

Determine the kinetic parameters E and A.

(c) A Bessemer converter blows a charge of pig iron to steel in 11 minutes. One percent of the Fe in the pig iron is oxidized at a uniform rate and slagged. The slag amounts 1875 kg and analyses SiO_2, 70 per cent; MnO, 20; FeO, 10. In addition to the Si and Mn, the pig iron carries 4.2 per cent C. Three-fourths of the carbon are oxidized to CO, one-fourth to CO_2. Assume that the air is charged cold and the gases leaves the converter at 1500 °C. Given Data:

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Contd ... Q. No. 5

(i) Heat of formation (kcal) per unit weight of metal:

SiO_2 = 7160, MnO = 1757, CO = 2430, CO_2 = 8100, FeO = 1151.

(ii) Heat of formation of slag in the first period: 150 kcal / kg SiO_2.

(iii) Specific heat (kcal/m^3 –°C):

Air/O_2/N_2/CO: 0.302 + 0.000,022 t (here t is temperature in °C)

CO_2 : 0.406 + 0.000,090 t

Determine: (1) The weight of the pig iron charged. (2) The volume of air supplied. (3) The time of each period of blow. (4) Net heat generated per minute in each period.

6. Using thermodynamic considerations, establish the conditions for sulphur removal from liquid iron and explain how these conditions are met in practice. (20)

7. Discuss the salient features of the LDAC process of steelmaking. Using schematic diagram explain how the impurities are removed in this process. (20)

8. (a) Using thermodynamic principles, examine how you could decarburise liquid iron without oxidizing chromium to produce stainless steel. (10)

   (b) Write a short account on the steel production process followed by the steel mill you have visited indicating types of charge used, grades of steel manufactured and the quality control steps they followed. List one important problem they face and mention how you could rectify it if you were given the opportunity. (10)

9. (a) What is secondary metallurgy? Indicate its principal functions. (10)

   (b) What do you mean by the terms killed, semi-killed and rimmed steel? List one ingot steel casting defect you thank the most important, give reasons(s), and discuss how would you rectify it. (10)

Table-1 for Q.5(b): Values of α and $t/t_{0.5}$ for some commonly used solid-state reaction equations.

α	$t/t_{0.5}$								
	$D_1(\alpha)$	$D_2(\alpha)$	$D_3(\alpha)$	$D_4(\alpha)$	$F_1(\alpha)$	$R_2(\alpha)$	$R_3(\alpha)$	$A_2(\alpha)$	$A_3(\alpha)$
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	0.165	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	1.520	1.628	1.541	1.322	1.253	1.227	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