Birla Institute of Technology & Science, Pilani
Work Integrated Learning Programmes Division
First Semester 2022-2023

Comprehensive Exam
(EC-3 Regular)

Course No.	: DE ZG631
Course Title	: Materials Technology and Testing
Nature of Exam	: Open Book
Weightage	: 40%
Duration	: 2 Hours
Date of Exam	: 26/11/2022 FN

No. of Pages = 7
No. of Questions = 6

Note to Students:
1. Please follow all the *Instructions to Candidates* given on the cover page of the answer book.
2. All parts of a question should be answered consecutively. Each answer should start from a fresh page.
3. Assumptions made if any, should be stated clearly at the beginning of your answer.
4. **Answer very brief and to the point taking not more than 15-20 minutes for each question.**

Q.1 Set. (A) **[7 Marks]**

Fractography of three components failed are shown in Figure A, Figure B and Figure C given below. Identify the component which has failed due to Ductile Fracture among the three, name the fracture surface. Also explain the features lead to your decision. When do such fracture occurs?

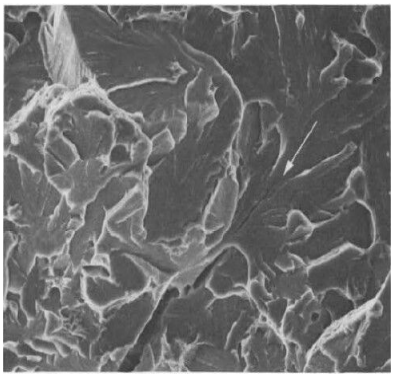


Figure A

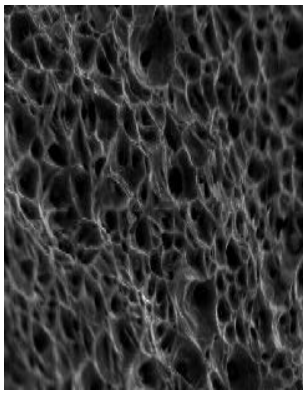


Figure B

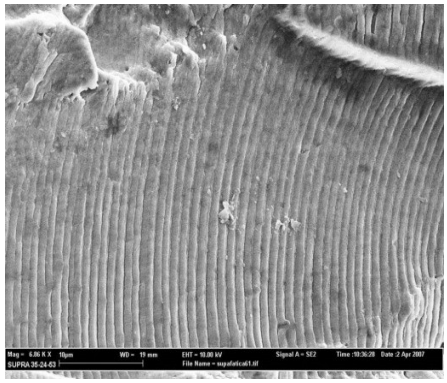


Figure C

Q.1 Set. (B) **[7 Marks]**

Fractography of three components failed are shown in Figure A, Figure B and Figure C given below. Identify the component which has failed due to Brittle Fracture among the three, name the fracture surface. Also explain the features lead to your decision. When do such fracture occurs?

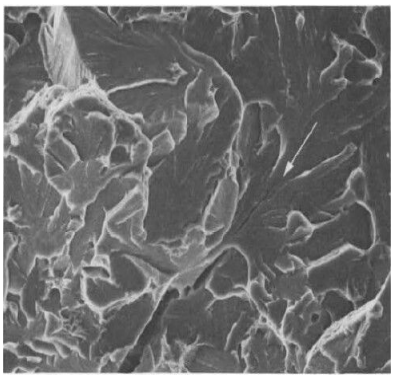
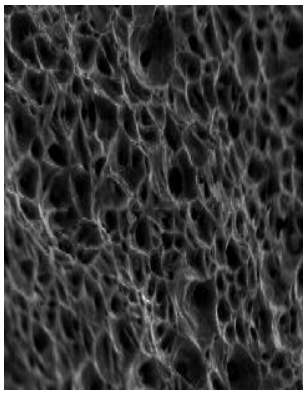
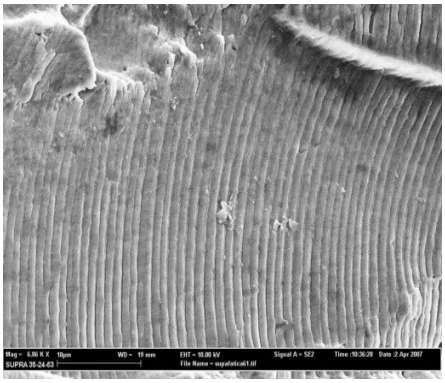




Figure A Figure B Figure C

Q.1 Set. (C) **[7 Marks]**

Fractography of three components failed are shown in Figure A, Figure B and Figure C given below. Identify the component which has failed due to Fatigue Fracture among the three, name the fracture surface. Also explain the features lead to your decision. When do such fracture occurs?

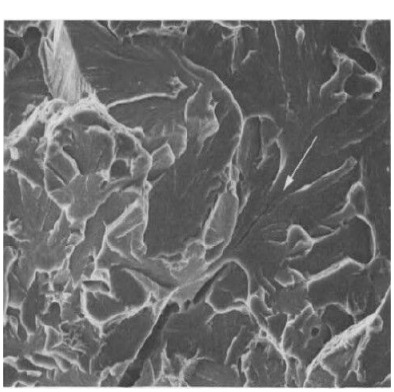
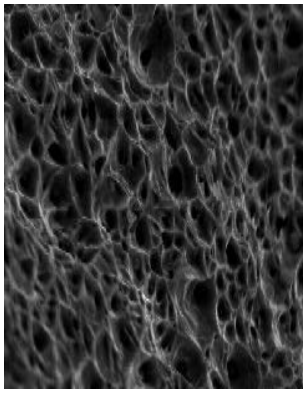
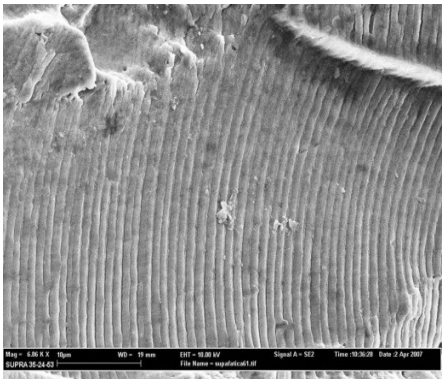
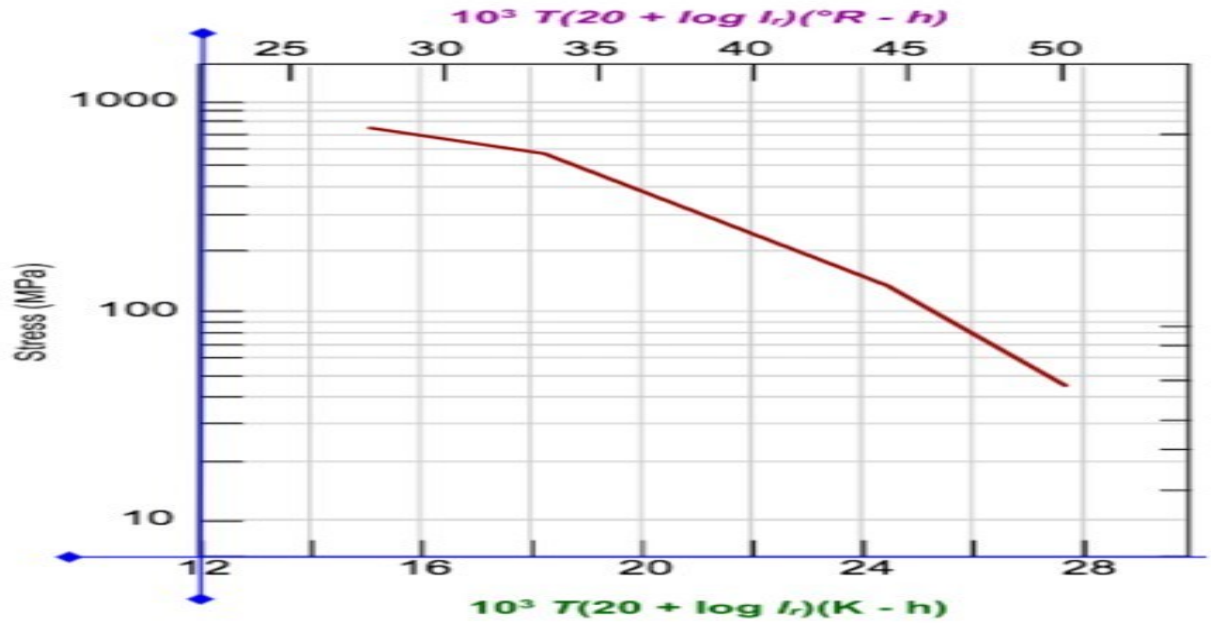




Figure A Figure B Figure C

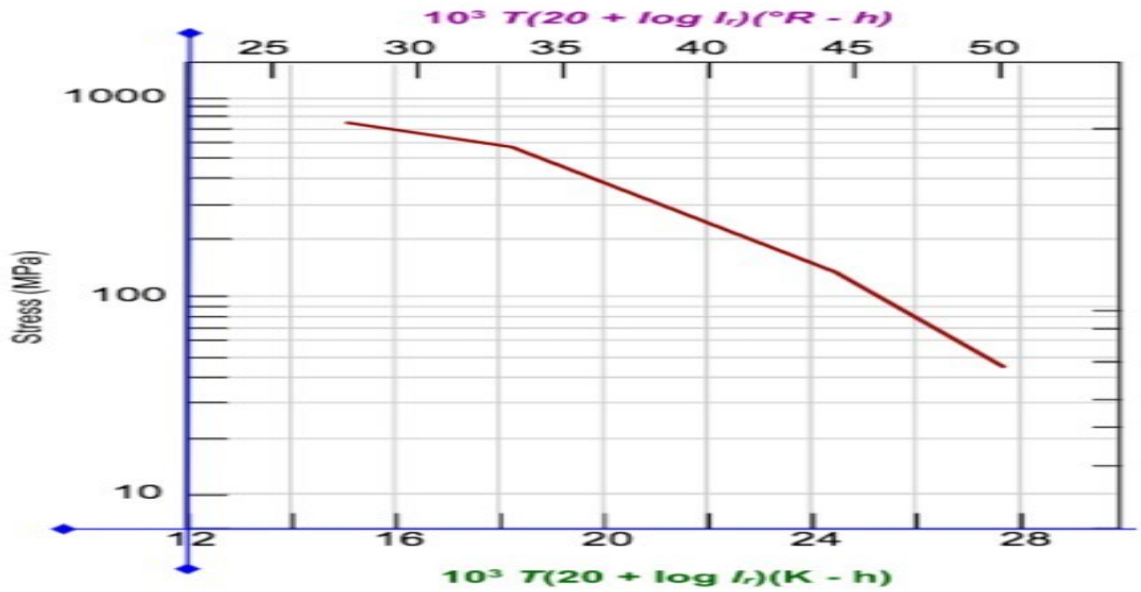
Q2 Set A

LMP of a material is given below. Find the Rupture time for the material at 100 MPa stress if exposed to 800K. Also find the reduction in life if the stress level is increased to 200MPa. **(7 Marks)**



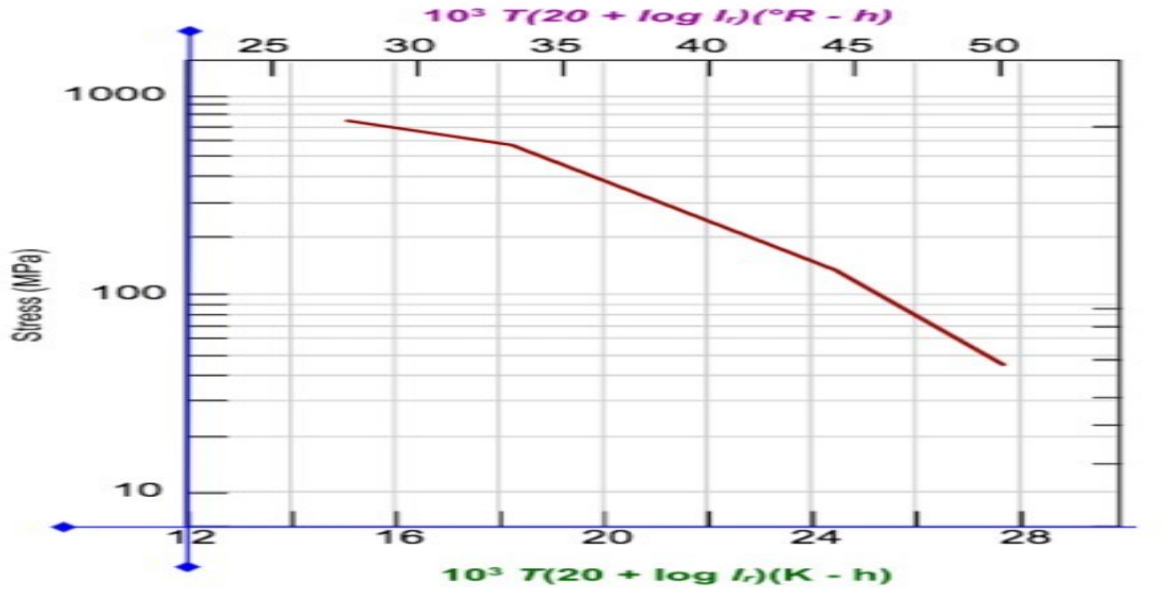
Q2 Set B

LMP of a material is given below. Find the Rupture time for the material at 50 MPa stress if exposed to 900K. Also find the reduction in life if the stress level is increased to 100MPa. **(7 Marks)**



Q2 Set C

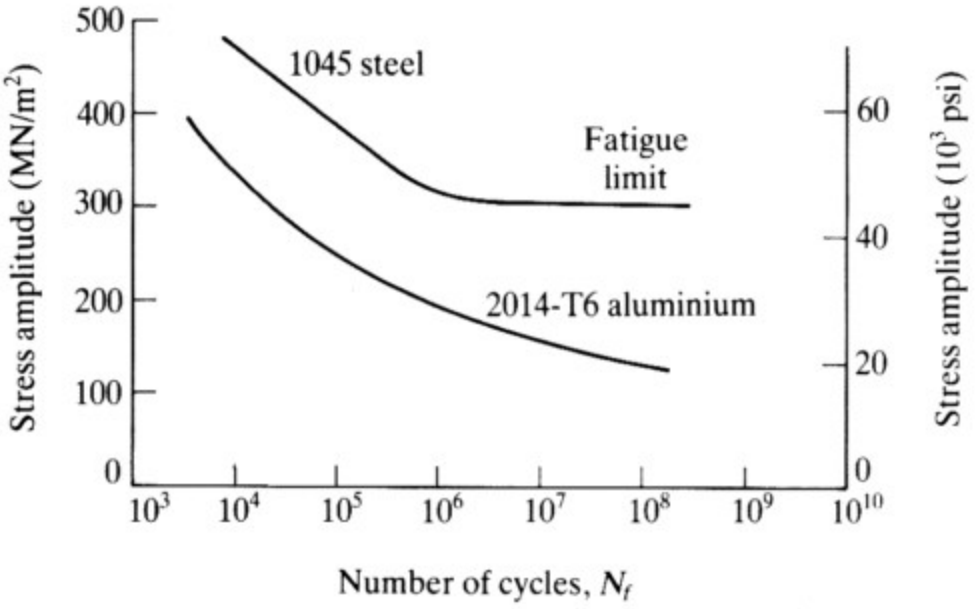
LMP of a material is given below. Find the Rupture time for the material at 200 MPa stress if exposed to 600K. Also find the reduction in life if the stress level is increased to 600MPa. **(7 Marks)**



Q3 Set A

Load history of A fatigue loaded component made of 2014-T6 Aluminium is given below. Find the residual life of the component as per the table if it is subjected to 1000rpm. **(6 Marks)**

Sl.No.	Stress Amplitude MPa	Number of cycles	
1	300	100	
2	200	100000	
3	150	?	

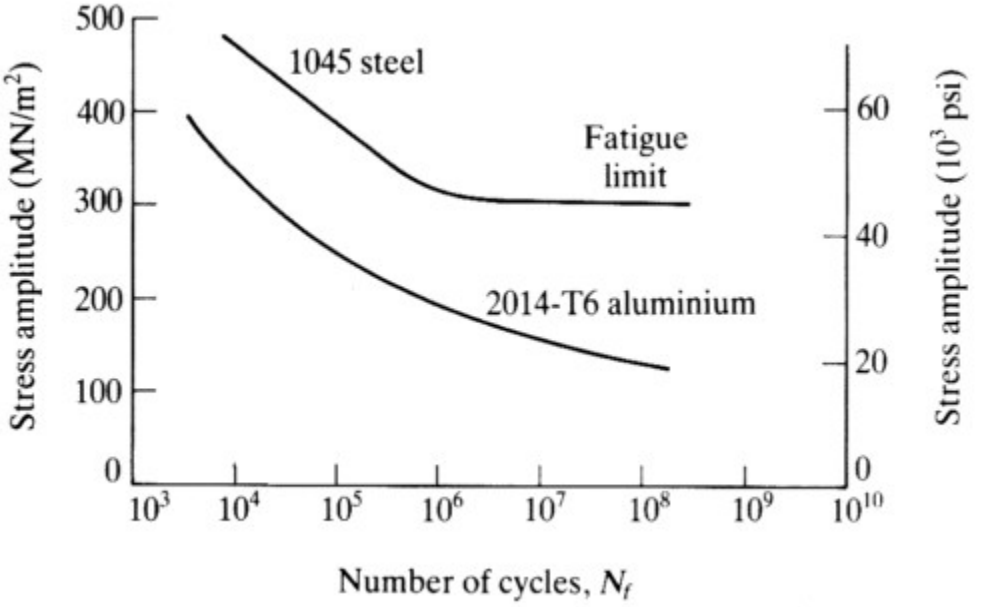


Q3 Set B

Load history of A fatigue loaded component made of 2014-T6 Aluminium is given below. Find the residual life of the component as per the table if it is subjected to 2000rpm. **(6 Marks)**

Sl.No.	Stress Amplitude MPa	Number of cycles	
1	250	10000	
2	200	100000	

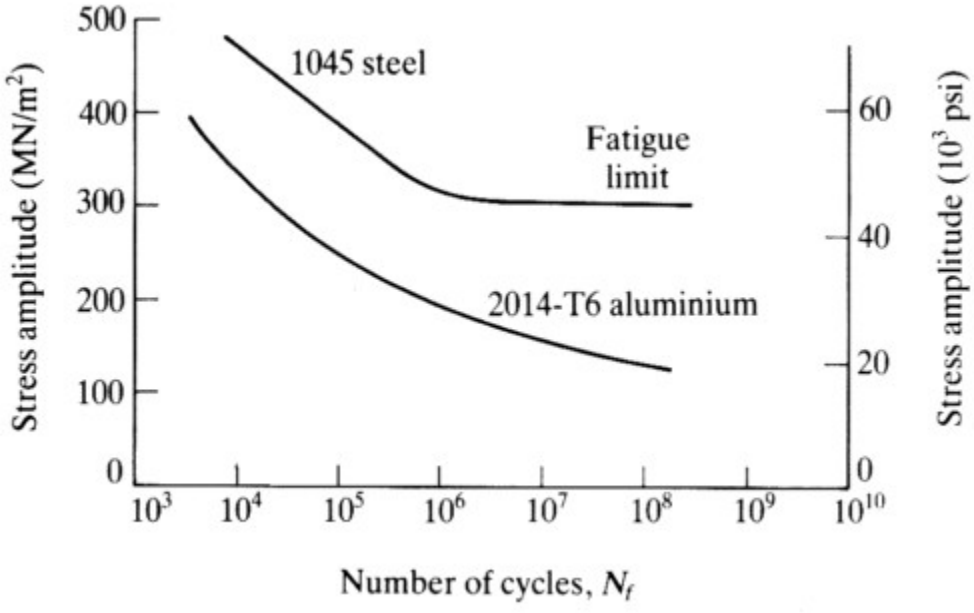
3	150	?	



Q3 Set C

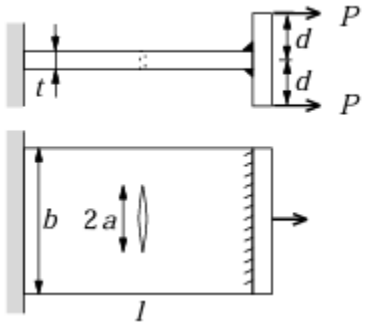
Load history of A fatigue loaded component made of 2014-T6 Aluminium is given below. Find the residual life of the component as per the table if it is subjected to 3000rpm. **(6 Marks)**

Sl.No.	Stress Amplitude MPa	Number of cycles	
1	250	20000	
2	150	200000	
3	100	?	



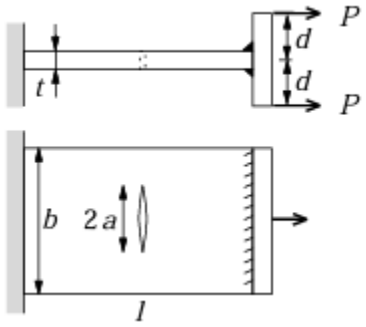
Q.4 Set. (A) **[7 Marks]**

A cantilever beam contains a through-thickness crack. The beam is loaded by a system of forces as shown in the figure. Determine at what value of P failure may be expected. Numerical data: crack length (2a) = 0.04m, beam thickness t = 0.035m, plate width b =0.09m, d=0.07m, l=3.2m, yield strength σ_y =600MPa, and fracture toughness K_{Ic} =50 MPa $m^{1/2}$. The geometrical factor can be taken as 1.12 for fracture toughness calculation. Also, check if the given system plate thickness and crack size satisfy the condition for plain strain fracture toughness test.



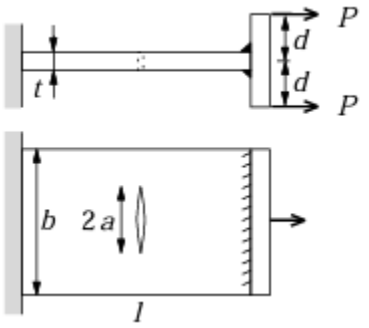
Q.4 Set. (B) **[7 Marks]**

A cantilever beam contains a through-thickness crack. The beam is loaded by a system of forces as shown in the figure. Determine at what value of P failure may be expected. Numerical data: crack length (2a) = 0.05m, beam thickness t = 0.03m, plate width b =0.08m, d=0.06m, l=3.2m, yield strength σ_y =600MPa, and fracture toughness K_{Ic} =50 MPa $m^{1/2}$. The geometrical factor can be taken as 1.12 for fracture toughness calculation. Also, check if the given system plate thickness and crack size satisfy the condition for plain strain fracture toughness test.



Q.4 Set. (C) **[7 Marks]**

A cantilever beam contains a through-thickness crack. The beam is loaded by a system of forces as shown in the figure. Determine at what value of P failure may be expected. Numerical data: crack length (2a) = 0.06m, beam thickness t = 0.03m, plate width b =0.09m, d=0.06m, l=3.2m, yield strength σ_y =600MPa, and fracture toughness K_{Ic} =50 MPa $m^{1/2}$. The geometrical factor can be taken as 1.12 for fracture toughness calculation. Also, check if the given system plate thickness and crack size satisfy the condition for plain strain fracture toughness test.



Q.5 Set. (A) **[8 Marks]**

A cylindrical tensile specimen with an initial gage length of 50 mm and initial diameter of 12.5 mm is tested in a universal testing machine as per ASTM specification. The gage length after fracture was observed to be 65 mm and a minimum diameter at fracture was obtained as 10 mm. The measured load corresponding to the 0.2% offset yield is 100 kN, that at the point of the onset of necking is 130 kN and that at the point of fracture is 110 kN, determine the following:

(a) 0.2% offset yield strength and ultimate tensile strength
(b) Fracture strength and applied true fracture strength.
(c) Elongation and true strain at fracture.
(d) Reduction of area and true reduction of area at fracture.

Q.5 Set. (B) **[8 Marks]**

A cylindrical tensile specimen with an initial gage length of 100 mm and initial diameter of 25 mm is tested in a universal testing machine as per ASTM specification. The gage length after fracture was observed to be 125 mm and a minimum diameter at fracture was obtained as 21 mm. The measured load corresponding to the 0.2% offset yield is 150 kN, that at the point of the onset of necking is 210 kN and that at the point of fracture is 175 kN, determine the following:

(a) 0.2% offset yield strength and ultimate tensile strength
(b) Fracture strength and applied true fracture strength.
(c) Elongation and true strain at fracture.
(d) Reduction of area and true reduction of area at fracture.

Q.5 Set. (C) **[8 Marks]**

A cylindrical tensile specimen with an initial gage length of 80 mm and initial diameter of 25 mm is tested in a universal testing machine as per ASTM specification. The gage length after fracture was observed to be 100 mm and a minimum diameter at fracture was obtained as 21 mm. The measured load corresponding to the 0.2% offset yield is 160 kN, that at the point of the onset of necking is 200 kN and that at the point of fracture is 170 kN, determine the following:

(a) 0.2% offset yield strength and ultimate tensile strength
(b) Fracture strength and applied true fracture strength.
(c) Elongation and true strain at fracture.
(d) Reduction of area and true reduction of area at fracture.

Q.6 Set. (A) **[5 Marks]**

A certain material has a Brinell hardness of 157 BHN. Two Brinell hardness tests were conducted on this material, one using a 10mm dia indenter and 3000kg load and another with a 7 mm dia indenter and 1470 kg load. Calculate the diameter of indentation in both cases and comment on the results.

Q.6 Set. (B) **[5 Marks]**

Vickers hardness test was conducted on a certain material using 1000 g load. The observed Vickers hardness is 40 MPa. Calculate the size of the square indentation observed in this test. Why Brinell hardness test is restricted for low and medium hardness material whereas Vickers hardness test can be suitable for all materials?

Q.6 Set. (C) **[5 Marks]**

How do you differentiate an oxidation and reduction electrochemical reactions. With respect to corrosion, briefly mention where these reactions will occur?

A piece of corroded metal alloy plate (density=4.5 g/cm^3) was found submerged in ocean. It was estimated that the original area of the plate was 800 cm^2 and that approximately 7.6 kg had corroded away during the submersion period of 5.3 years. Estimate the corrosion penetration rate for the metal plate.