NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

DEPARTMENT OF CIVIL, MINING AND PROCESS ENGINEERING

QUALIFICATION: BACHELOR OF ENGINEERING IN METALLURGY	
QUALIFICATION CODE: 08BEMT	**LEVEL: 8**
COURSE CODE: HTM 811S	**COURSE NAME: HEAT TREATMENT OF METALS 414**
SESSION: June 2023	**PAPER: THEORY**
DURATION: 3 HOURS	**MARKS: 100**

FIRST OPPORTUNITY QUESTION PAPER	
EXAMINER(S)	**Mrs Jaquiline T. Kurasha**
MODERATOR:	**Prof Josias Van der Merwe**

INSTRUCTIONS
1. Answer all questions. 2. Read all the questions carefully before answering. 3. Marks for each questions are indicated at the end of each question. 4. Please ensure that your writing is legible, neat and presentable.

PERMISSIBLE MATERIALS

1. Examination paper.
2. Non-programmable calculator.

THIS QUESTION PAPER CONSISTS OF 6 PAGES (Including this front page and appendix)

Question 1 [25 marks]

(a)Two samples of steel contain 95% pearlite. With the aid of Fe-Fe_3C Equilibrium Diagram (see Appendix 1) and Lever rule, estimate the carbon content of each sample if one is known to be:

(i) hypoeutectoid and the other [10]

(ii) hypereutectoid. [10]

(b) Figure Q1 features a Time Temperature Transformation (TTT) diagram for a hypoeutectoid plain carbon steel. The A1 critical temperature and A3 critical temperature can be clearly distinguished in the TTT diagram. With the aid of the Fe-C Equilibrium diagram (see Appendix 1) determine the carbon content (wt. %) in the steel grade featured in Figure Q1. [5]

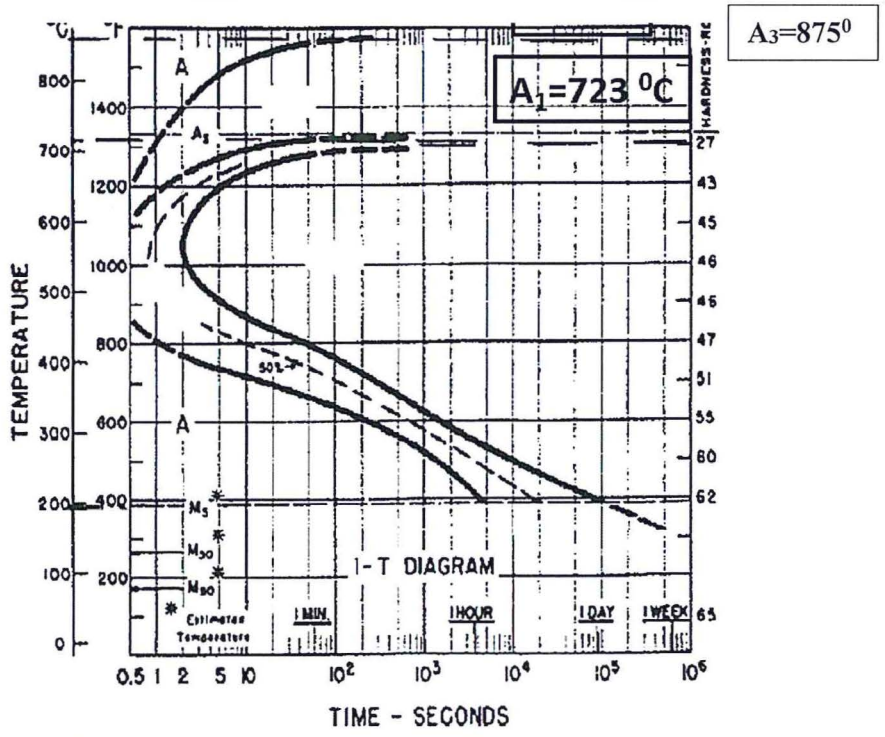


Figure Q1. A Time Temperature Transformation (TTT) diagram for a hypoeutectoid plain carbon steel.

Question 2 [25 marks]

Excellent combinations of hardness, strength, and toughness are provided by bainite. With the aid of heat treatment facility available, you austenitized a eutectoid steel at 750°C, quenched it to 250°C and held the steel at 250°C for two hours, and finally permitted the steel to cool to room temperature. With the aid of the time-temperature diagram (Figure Q2), answer the following questions:

(i) Was the required bainitic structure produced in the eutectoid steel? Briefly explain. Sketch the relevant time-temperature path line. [5]

(ii) Briefly indicate the phase transformations observed in the steel upon cooling. [5]

(iii) Indicate the structural phases that will be available in steel at the end of the treatment. [5]

(iv) Explain the meaning of the figures (from 14 to 66) on the right vertical axis of the diagram. How can these figures be used? [10]

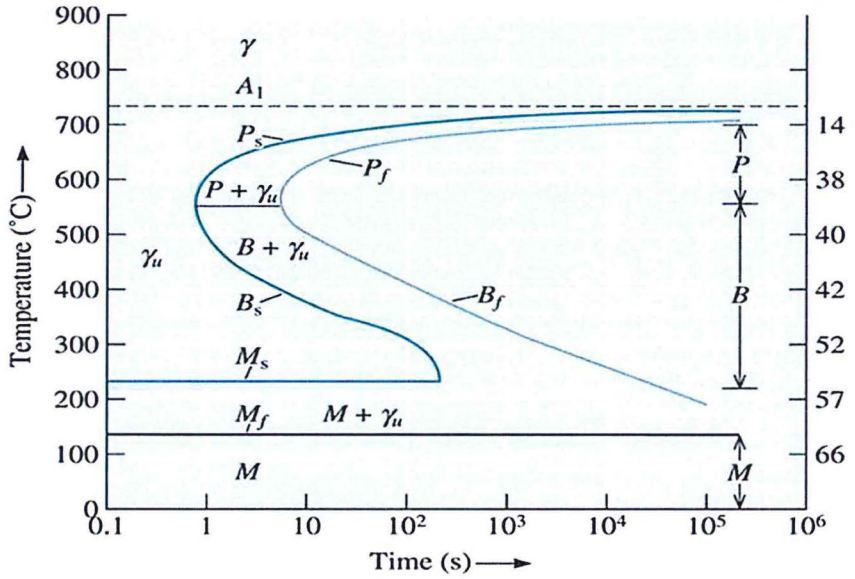
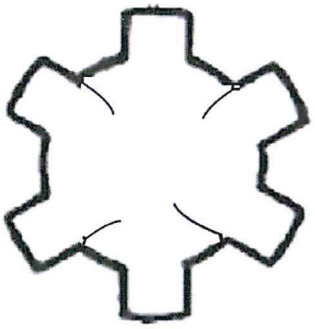


Figure Q2. TTT diagram for a eutectoid steel. Note: Yu – is unprocessed (retained) austenite.

Question 3 [25 marks]

(a) A batch of quenched and tempered steel gears was rejected by the customer because of surface cracks (see a gear after the heat treatment in Figure Q3). The gears were made of 1080 steel grade and quenched in water. With the aid of Time-Temperature Transformation Diagram in Figure Q3, suggest at least five ways to minimize the risk of cracking upon treatment. [15]



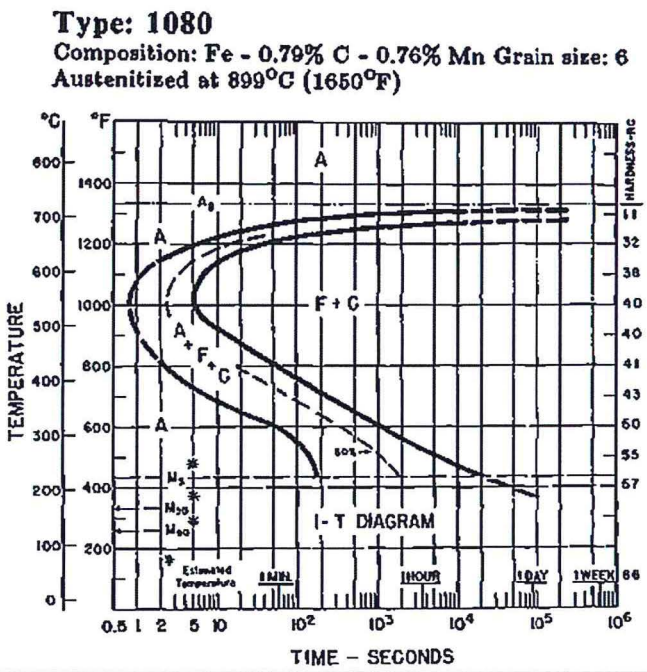


Figure Q3. A 1080 steel gear after heat treatment and the TTT diagram for a 1080 steel.

(b) Another batch of gears was rejected by the customer due to insufficient surface hardness. The gears are made of steel grade 1040, quenched and tempered. You prepare a cross section and examine the harness as a function of distance from the surface (see Table Q3). What is the reason for the heat treatment defect? Is it possible to rectify the problem? (Hint: plot the hardness as a function of distance.) [10]

Table Q3. Hardness distribution along the cross section

Distance from the quenched end, mm	Hardness HRC
1,5	40
3	50
5	55
15	52
20	50

Question 4 [25 marks]

(a) A stainless steel contains 12% Cr, 1.0% Si, and 0.05% C. With the aid of Schaeffler diagram (Figure Q4), estimate the content of nickel required produce paramagnetic steel. [10]

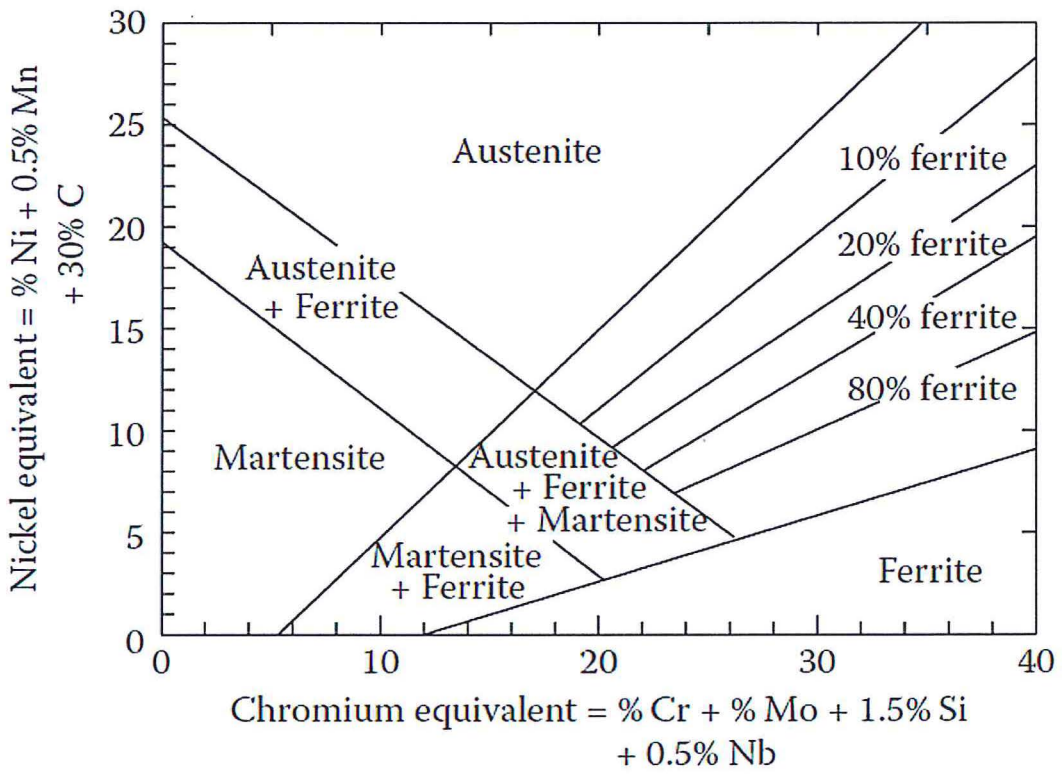


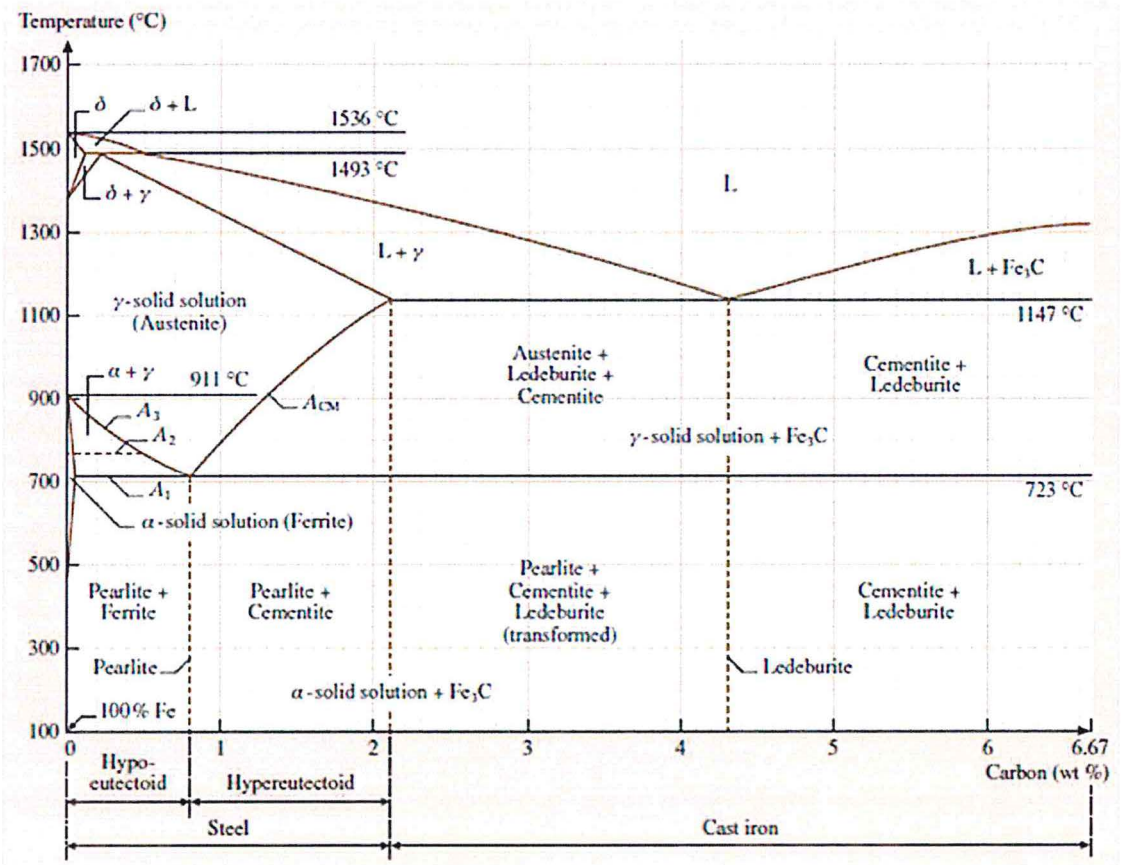
Figure Q4. Schaeffler diagram

(b) Some stainless steels are prone to sensitization due to formation of chromium carbides. You have observed that your grandmother uses a frying pan made of stainless steel 304 with 18%Cr, 8% Ni, and 0,10% C. This is what is indicated in the label. How soon should you expect the failure of the frying pan due to sensitization if your grandmother cooks pancakes for the whole family every other day? [10]

(c) In order to efficiently recycle stainless steel scrap, we wish to separate the high-nickel stainless steel from the low-nickel stainless steel. Design a method for doing this with the aid of Schaeffler diagram (Figure Q4). [5]

.....End.....

Appendix 1



Fe-Fe3C Equilibrium Diagram