NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING AND SPATIAL SCIENCES

DEPARTMENT OF CIVIL, MINING AND PROCESS ENGINEERING

QUALIFICATION: BACHELOR OF ENGINEERING IN METALLURGY	
QUALIFICATION CODE: 08BEMT	**LEVEL: 8**
COURSE CODE: HTM811S	**COURSE NAME: HEAT TREATMENT OF METALS 414**
SESSION: June 2023	**PAPER: THEORY**
DURATION: 3 HOURS	**MARKS: 100**

SECOND 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 4 PAGES (Including this front page)

Question 1 [25 marks]

(a) Upon slow cooling a plain carbon steel 1080 contains 100% pearlite at room temperature. Since pearlite is a eutectoid mixture of ferrite and cementite, calculate the weight percentage of cementite and the weight percentage of ferrite in pearlite in a typical steel 1080. Make use of the Lever Rule and the Fe-C Equilibrium Diagram (see Appendix 1) [16]

(b) A Lab technician prepared three samples of steels: (i) a hypoeutectoid plain carbon steel after slow cooling; (ii) a hypereutectoid plain carbon steel after slow cooling under the same conditions; (iii) an austenitic stainless steel. Unfortunately, he failed to label the samples properly. Suggest simple yet effective method to identify which sample is made of which steel, with the aid of a magnet and a hardness tester. Please note that metallographic microscope is out of operation. [9]

Question 2 [25 marks]

A eutectoid plain carbon steel of 1080 type is commonly used for production of rails. It is known that the railroads transporting mining products experience severe loading. In order to produce rails with even higher hardness, wear resistance, and toughness, Japan Steel has developed an advanced heat treatment schedule to form very fine pearlite in steel 1080 . This advanced schedule is featured in Figure Q2 together with two other treatments. With the aid of Figure Q2 answer the following questions:

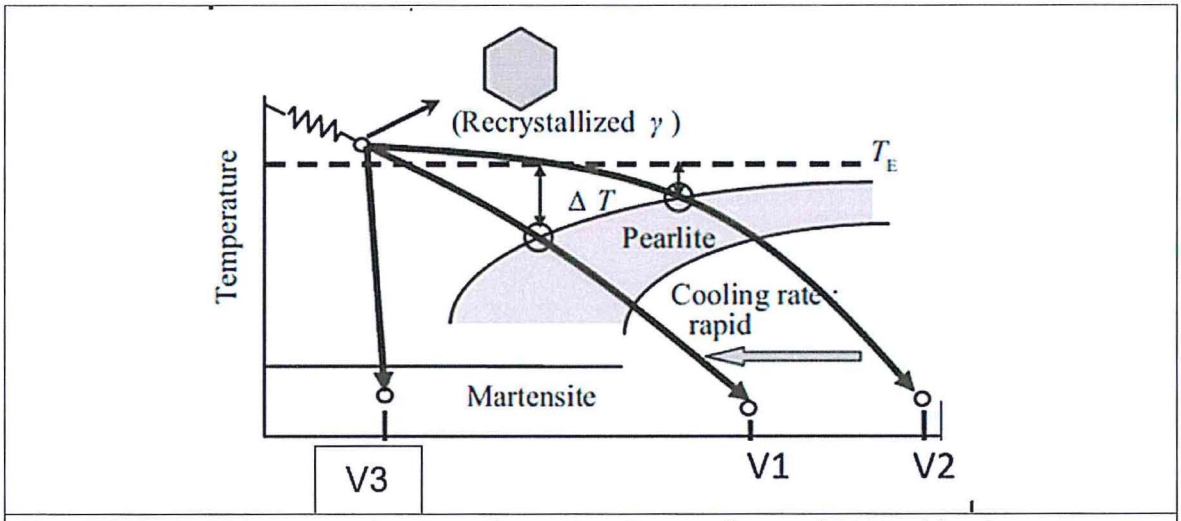


Figure Q2. A Continuous Cooling Transformation diagram for steel 1080 with schematic illustration of three heat treatment schedules: V1, V2, and V3.

(a) Which line denotes the advanced heat treatment? Is it V1 or V2 or V3? Briefly explain the benefits of this heat treatment. [5]

(b) Briefly explain why the other two treatment schedules are not suitable for the production of heavy loaded rails. [10]

(c) Hadfield steel is distinguished by excellent hardness and toughness. Why is Hadfield steel never used for rails? Give at least two reasons. [10]

Question 3 [25 marks]

(a) Typical media used for quenching include air, brine (10% salt in water), water, and oil.

(ii) Rank the four media in order of the cooling rate from fastest to slowest. [5]

(iii) During quenching in liquid media, very often either the part being cooled, or the bath is agitated. Explain why. [5]

(b) Figure Q3 features a Continuous Cooling Transformation (CCT) diagram for steel 1080. Table Q1 gives the rate of cooling provided by different quenching media. With the aid of Figure Q3 and Table Q3, indicate what phases formed in a 1-inch bar of 1080 steel that is quenched from slightly above the eutectoid temperature using the following quenching media:

(i) oil (without agitation); [3]

(ii) oil (with agitation); [3]

(iii) water (with agitation); [3]

(iv) brine (no agitation). [3]

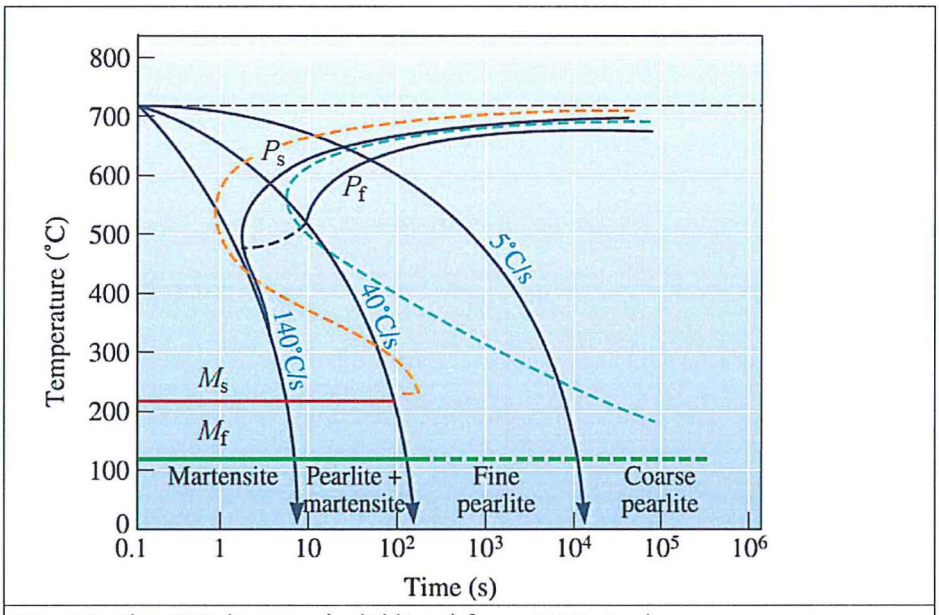


Fig. Q3. The CCT diagram (solid lines) for a 1080 steel.

Table Q3. The quenching power and the cooling rate provided by various cooling media

Medium	H Coefficient	Cooling Rate at the Center of a 1 in. Bar (°C/s)
Oil (no agitation)	0.25	18
Oil (agitation)	1.0	45
H_2O (no agitation)	1.0	45
H_2O (agitation)	4.0	190
Brine (no agitation)	2.0	90
Brine (agitation)	5.0	230

(c) With reference to Figure Q3, recommend a cooling medium to obtain coarse pearlite in steel 1080. [3]

Question 4 [25 marks]

(a) Despite excellent corrosion characteristics of stainless steel 304 grade, this steel is never used in heat exchanger tubes at power plants. Briefly explain the physics behind this decision [10]

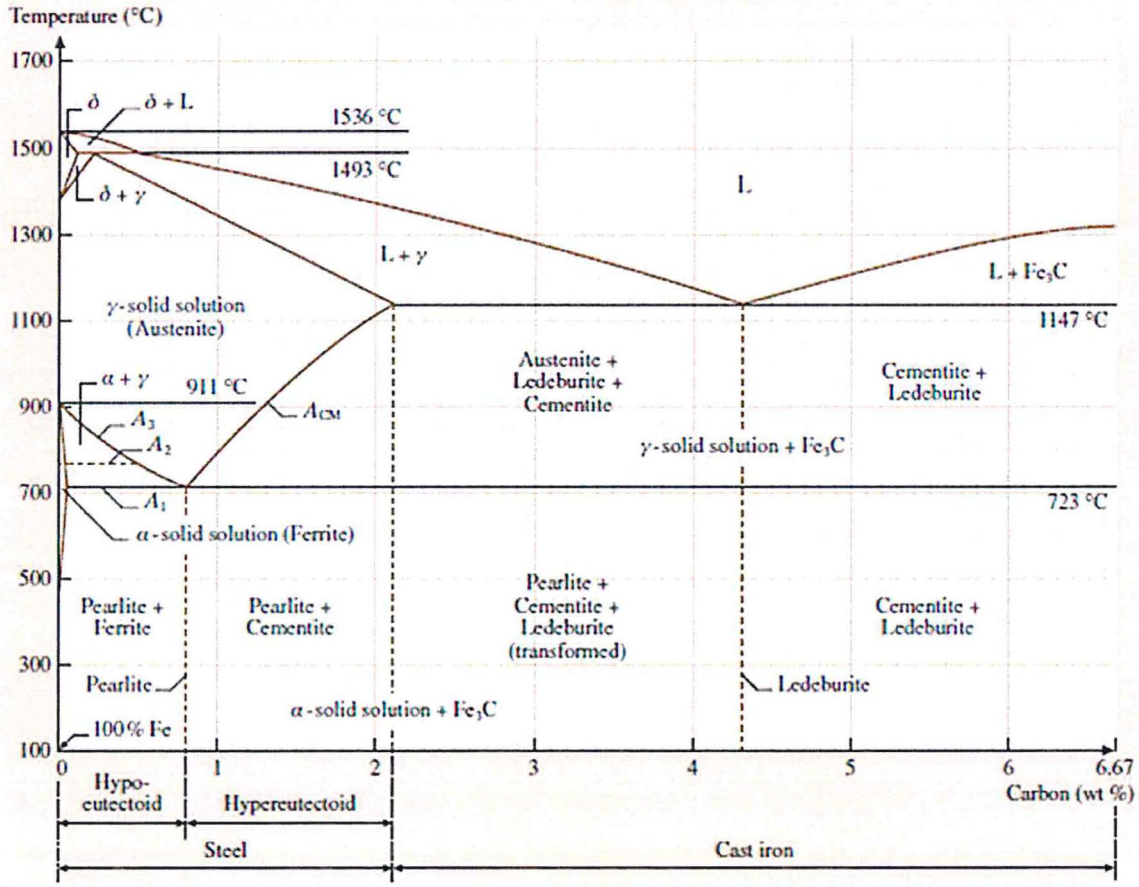
(b) . The principal alloying elements in Hadfield steel are manganese (14 % Mn) and carbon (1,1 % C). This type of steel provides a unique combination of properties and is effectively used in earth-moving equipment (e.g., in excavator teeth).

(i) Specify the key steel properties required for excavator teeth and provided by Hadfield steel .....[5]

(ii) Briefly explain the role of Mn and C as alloying elements in Hadfield steel [10]

.....End.....

Appendix 1



Fe-C Equilibrium Diagram