City & Guilds

9210-131
Level 6 Graduate Diploma in Engineering
Materials

Sample Paper

You should have the following for this examination
- one answer booklet
- drawing instruments
- non programmable calculator

No additional data is attached

General instructions
- This examination paper is of **three hours** duration.
- This paper contains **nine** questions.
- Answer **any five** questions.
- All questions carry equal marks. The maximum marks for each section within a question are given against that section.
- An electronic, non-programmable calculator may be used but candidates **must** show clearly the steps prior to obtaining final numerical values.
- Drawings should be clear, in good proportion and in pencil. Do **not** use red ink.

1 a) State the **four** factors that affect solubility in the formation of substitutional solid solutions.
Part of the Iron-carbon phase diagram is shown in Figure Q(1). (4 marks)

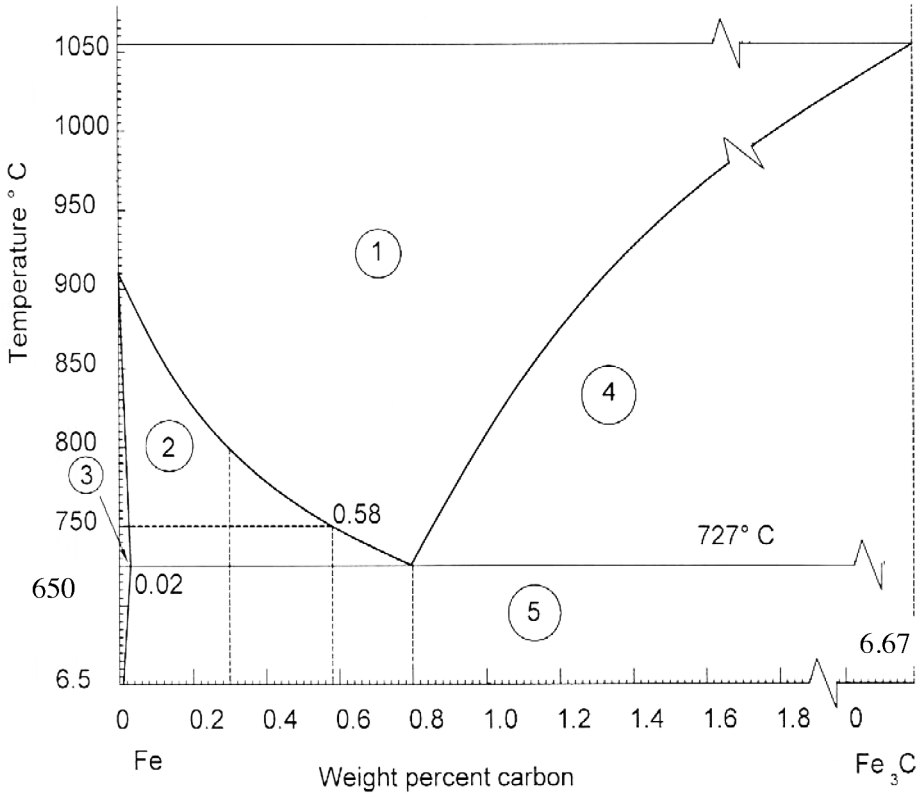


Figure Q(1)

b) Label the phase/s in areas marked 1-5 in the phase diagram.
A sample of plain carbon steel containing 0.3 wt% carbon is heated in a furnace to a temperature of 1000°C. It is then cooled down slowly to 700°C in air.
Answer the following questions using the phase diagram given above. (5 marks)

c) i) Make a phase analysis of the material when the sample is cooling down to 700°C. (6 marks)

ii) Calculate the amount of phases present at 750°C. Name the phases. (5 marks)

2 a) Distinguish the difference between following two major polymer categories with the aid of diagrams showing their microstructure.

i) Thermoplastics. (4 marks)

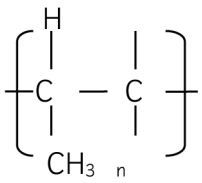
ii) Thermosetting plastics. (4 marks)

b) The molecular weight data for a polypropylene material is tabulated below.

Molecular weight range (g/mole)	Xi	Wi
8000-16000	0.05	0.02
16000-24000	0.16	0.10
24000-32000	0.24	0.20
32000-40000	0.28	0.30
40000-48000	0.20	0.27
48000-56000	0.07	0.11

Where X_i and W_i are mole fractions and weight fractions respectively.
The atomic weights of C and H are respectively 12.01 & 1.01.

Polypropylene mer unit -



Calculate

i) The number average molecular weight. (4 marks)

ii) The weight average molecular weight. (4 marks)

iii) The number average degree of polymerization. (4 marks)

3 a) i) List the types of stainless steels available. (3 marks)

ii) Explain each type briefly. (6 marks)

b) Why do stainless steels have corrosion resistant properties? (5 marks)

c) i) Explain the welding problems commonly experienced with different types of stainless steels. (3 marks)

ii) How do you prevent the occurrence of such problems? (3 marks)

4 a) i) What are the types of point defects and line defects found in materials? (6 marks)

ii) Explain each briefly. (8 marks)

b) Using Hall-Petch equation, explain how the grain size affects the strength of a material. (6 marks)

5 a) Explain briefly the following types of failures found in materials in service.

i) Fatigue. (3 marks)

ii) Creep. (3 marks)

iii) Yielding. (3 marks)

b) Illustrate the main characteristic features found in the following.

i) Fatigue fracture surface. (3 marks)

ii) Fractured surfaces due to yielding. (3 marks)

c) What is meant by Fatigue limit or the Endurance limit of a fatigue failure? (5 marks)

See next page

6 a) i) Differentiate the deformation process of Rolling from Extrusion. (4 marks)
ii) Give **one** example for the application of each process. (2 marks)
iii) Describe the effects of above deformation processes on mechanical properties. (2 marks)
b) Explain the process of work hardening or strain hardening. (3 marks)
c) i) List the primary bonds present in materials. (3 marks)
ii) Explain briefly the above bonding mechanisms using examples. (6 marks)

7 a) i) Briefly explain the precipitation hardening heat treatment process. (3 marks)
ii) Explain how the precipitate affects the properties of an alloy. (3 marks)
b) i) Classify cast iron into different categories. (3 marks)
ii) Differentiate grey cast iron from nodular cast iron. (3 marks)
c) i) List the types of fibres and matrix materials used in making fibre reinforced plastics. (5 marks)
ii) Give **one** application for each type of fibre reinforced plastic. (3 marks)

8 a) i) Explain briefly what a nanomaterial is. (3 marks)
ii) What are the important physical and chemical properties of nanomaterials? (3 marks)
b) i) Describe briefly the process of casting of metals. (3 marks)
ii) With the aid of a sketch, explain the internal structure of a casting. (3 marks)
c) i) Categorize the casting defects found due to different causes into **five** main types. (5 marks)
ii) Explain them briefly. (3 marks)

9 a) List the important Physical and Mechanical properties of materials used for aircraft construction. (5 marks)
b) Explain briefly, how you would measure **three** of these mechanical properties experimentally. (3 marks)
c) From the tensile stress-strain behaviour for a Brass specimen as shown above in Figure Q(9), determine the following.

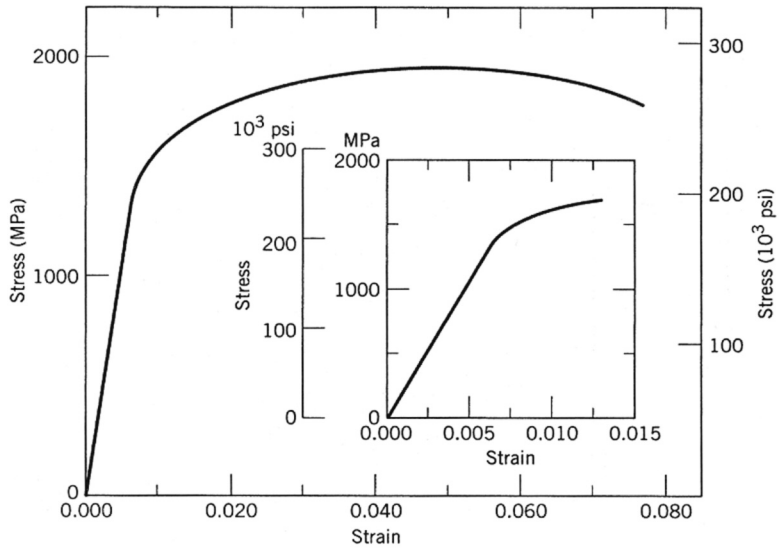


Figure Q(9)

i) The Young's modulus. (3 marks)
ii) The proof stress at a strain offset of 0.2%. (3 marks)
iii) The maximum load that can be sustained by a cylindrical specimen having an original diameter of 12.8 mm. (3 marks)
iv) The change in length of a specimen originally 250 mm long when subjected to a tensile stress of 345 MPa. (3 marks)