Engineering Questions by Topic

Higher Level

Question 3

Iron & Steel

50 Marks

1996 Question 3

(a) (i) State **two** factors that affect the state of the carbon in cast iron.

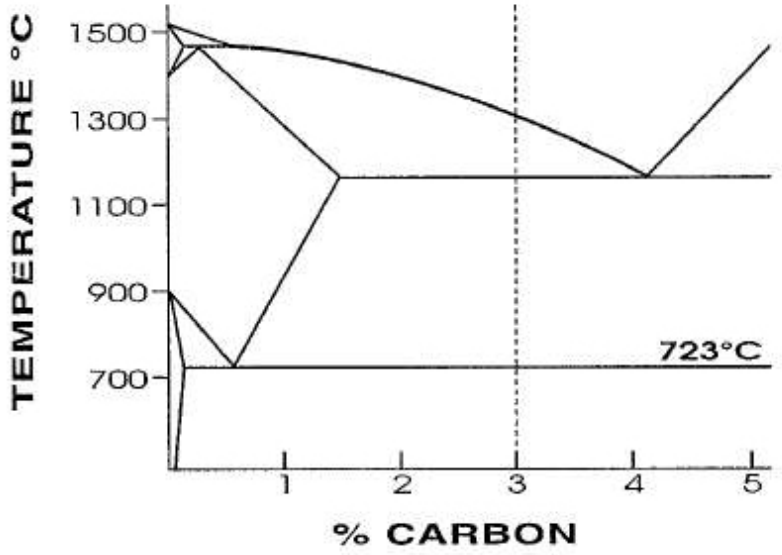
(ii) Explain any **two** of the following:

white cast iron; grey cast iron; spheroidal graphite cast iron.

(b) With reference to the given iron-carbon diagram:

(i) Explain the solidification of cast iron with 3% carbon under quick cooling conditions from 1400°C.

(ii) Indicate clearly on a diagram the phases of ferrite, pearlite and austenite.



1996 Question 3 cont.

(c) (i) Describe, with the aid of diagrams, **two** methods for the surface hardening of plain carbon steels.

(ii) Why do these steels become hard when quenched rapidly?

(iii) State **two** factors that affect the depth of hardening of a steel.

1997 Question 3

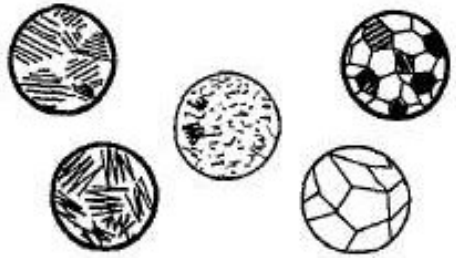
(a) Select the most suitable microstructure shown to illustrate an explanation of the following structures:

(i) Martensite;

(ii) Ferrite and Pearlite;

(iii) Ferrite;

(iv) Pearlite and Cementite.



(b) Redraw the given iron - carbon diagram into your answer book.

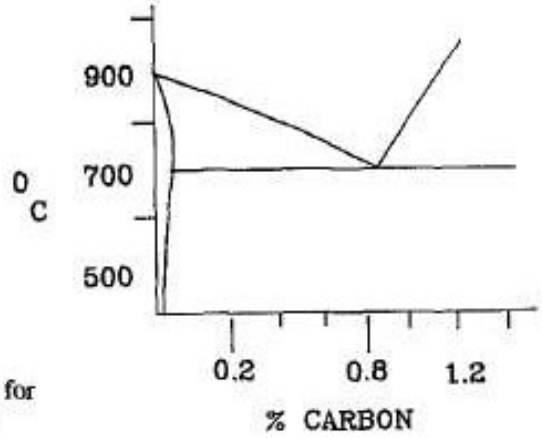
Define the terms:

(i) Stress relieving;

(ii) Normalising;

(iii) Annealing.

Indicate the temperature zones for each process on your diagram.



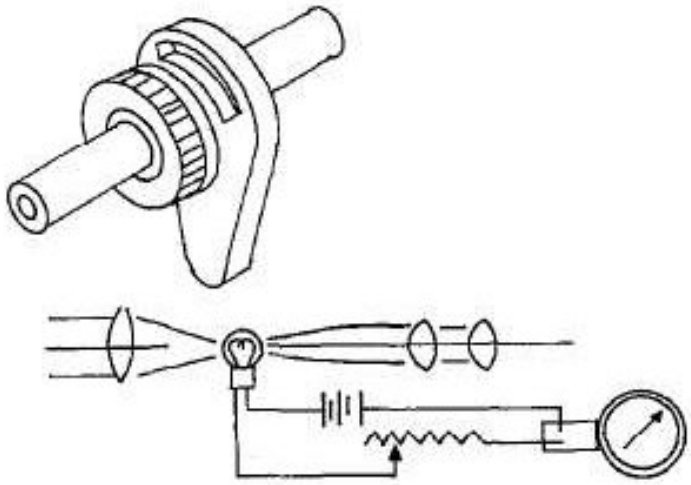
1997 Question 3 cont.

(c) With reference to the instrument shown below, discuss its characteristics under the following headings:

(i) Name and function;

(ii) Method of operation;

(iii) Advantages/Limitations.



1998 Question 3

(a) The microstructures of grey and white cast iron are shown. Distinguish between the two. Reference must be made to microstructures, properties and uses.

(b) With reference to the cubic form of crystallisation, discuss:

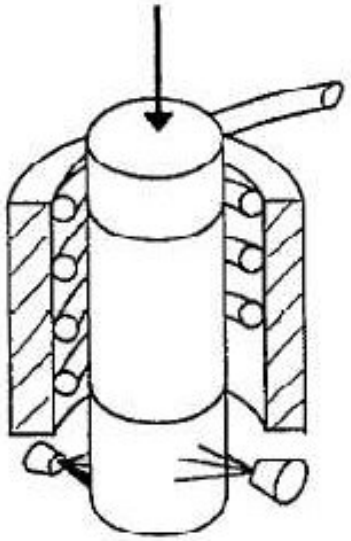
- **(i)** The two common forms;
- **(ii)** Characteristics and properties;
- **(iii)** Slip planes.

In the normal crystal structure of metals what is the ***ability to exist in two forms*** called?

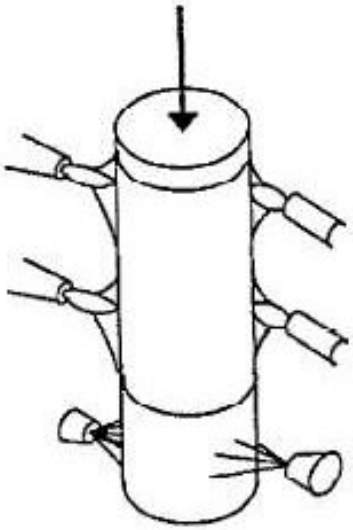
1998 Question 3 cont.

(c) Select <u>one</u> of the heat treatment processes shown and describe it.

(i)

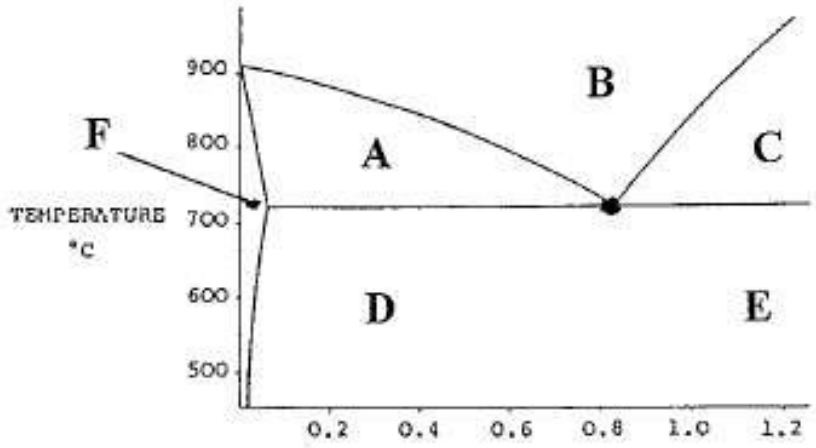


(ii)



1999 Question 3

(a) (i) The diagram shows a simplified iron-carbon equilibrium diagram. Redraw the diagram into you answerbook and insert the names of the microstructures at A, B, C, D, E and F.



(ii) Identify and explain the meaning of the *Eutectic* point.

1999 Question 3 cont.

(b) The diagrams represent the microstructures of medium carbon steel (0.5%) when quenched rapidly from 870°C and slowly cooled from 870°C. Describe both structures and explain their differences.

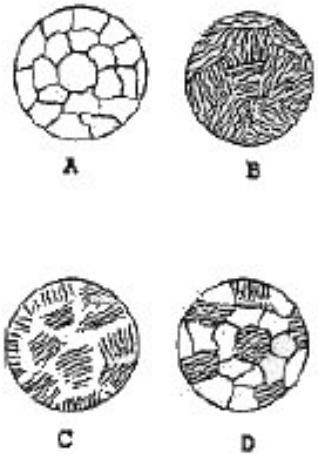
(i)

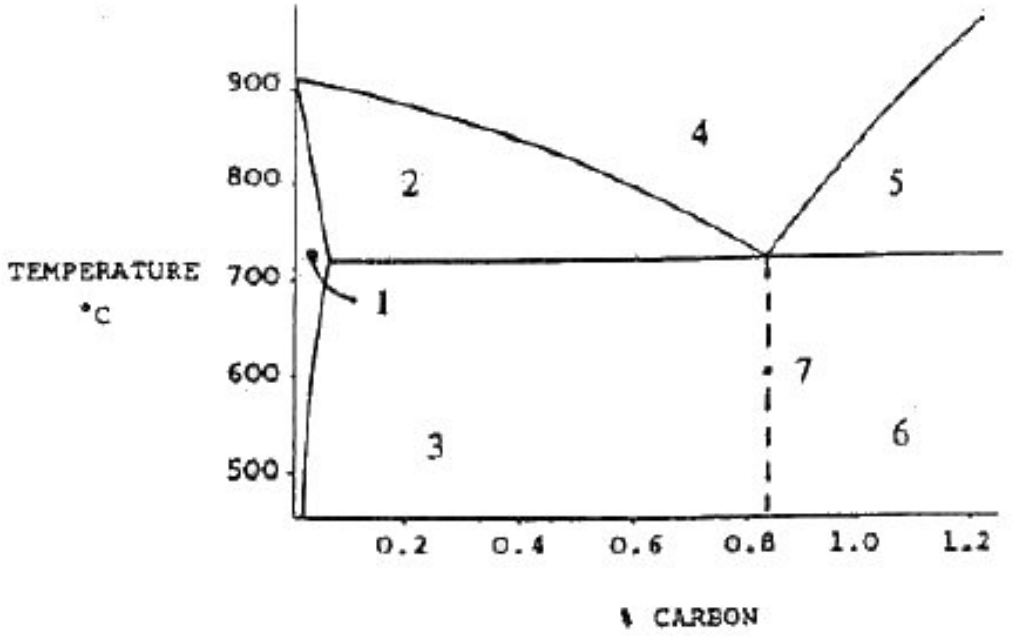
(ii)

(c) Describe how high temperatures are measured in heat treatment furnaces.

2000 Question 3

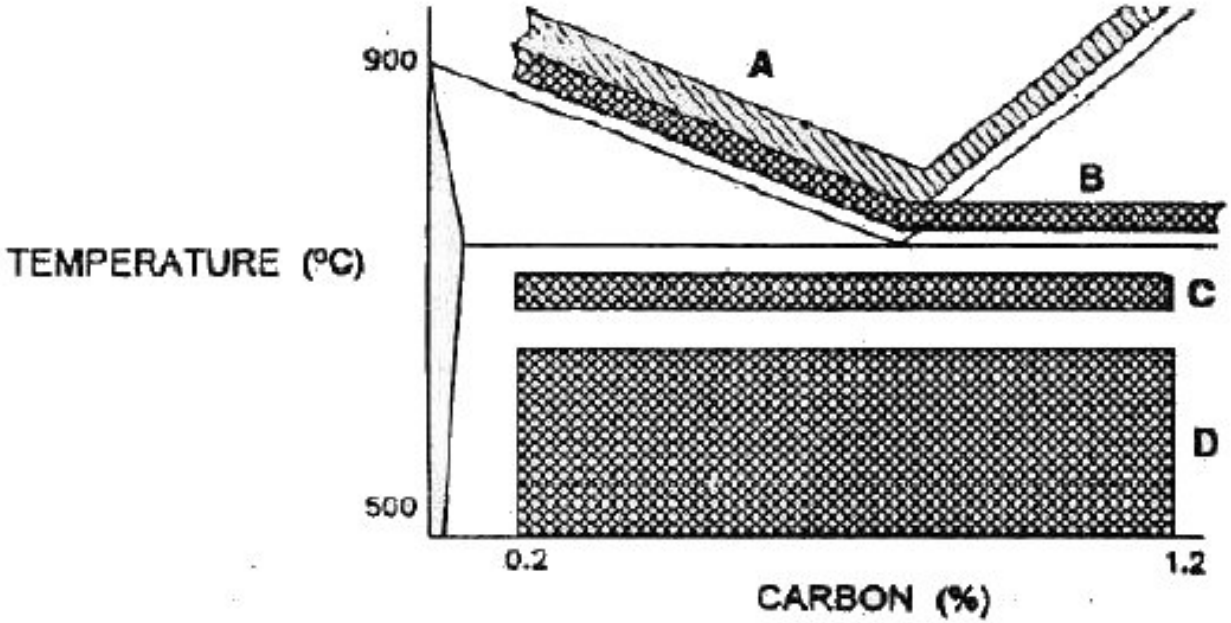
(a) Various microstructures of carbon steel are marked A, B, C and D as shown below.
Relate **each** microstructure to the most suitable numbered position on the given equilibrium diagram and name these **four** microstructures.





2000 Question 3 cont.

(b) Temperature zones for various heat-treatment processes for carbon steel are marked A,B,C and D as shown below. Select any two zones and explain the heat treatment processes that are represented.

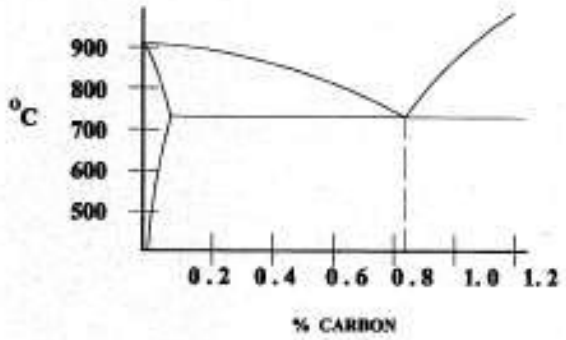


(c) Outline the principles of induction hardening or the flame hardening process.

2001 Question 3

(a) Redraw the given iron-carbon diagram into your answer book and label the following phases.

(i) Ferrite;
(ii) Ferrite and Austenite;
(iii) Ferrite and Pearlite;
(iv) Austenite;
(v) Austenite and Cementite;
(vi) Cementite and Pearlite.

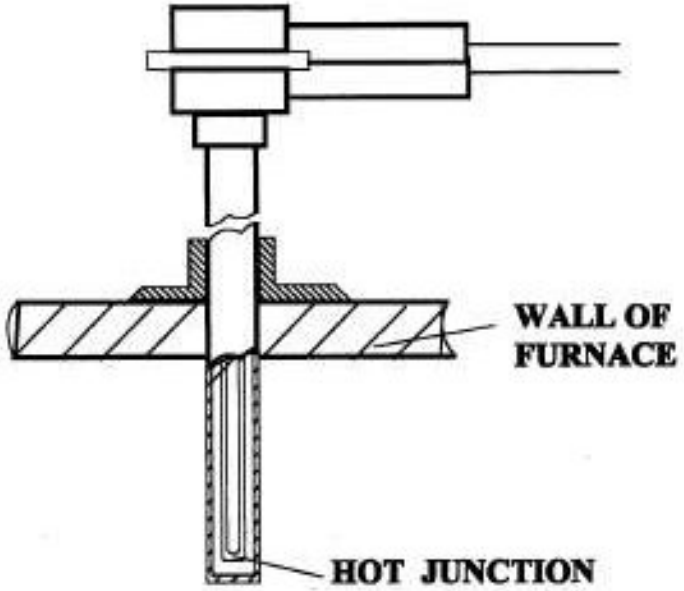


(b) (i) Define <u>any two</u> of the following terms.
Ferrite; Pearlite; Cementite.

(ii) Explain the effects on a 0.7% carbon steel when quenched rapidly from 900° C <u>and</u> cooled slowly from 900° C.

2001 Question 3 cont.

(c) Explain the operation of the thermoelectric pyrometer shown below.



2002 Question 3

(a) Explain **any two** of the following terms used in the heat treatment of steel.

(i) Recalescence;
(ii) Annealing;
(iii) Critical range;
(iv) Martensite.

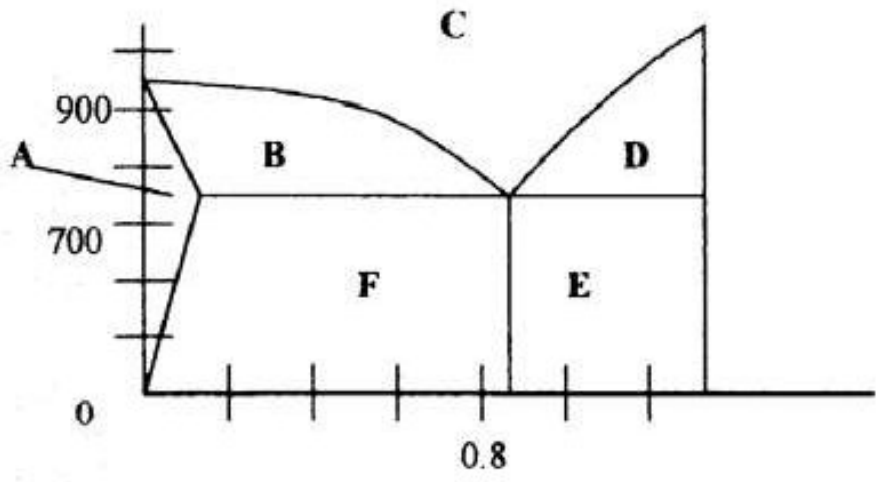
(b) Differentiate between **any two** of the following:

(i) Flame hardening and induction hardening;
(ii) Ferrite and pearlite;
(iii) Grey cast iron and white cast iron;
(iv) Eutectic and eutectoid.

2002 Question 3 cont.

(c) The diagram represents a simplified equilibrium diagram for iron and carbon.

(i) Name the regions labelled;
(ii) Redraw the given diagram into your answer-book and highlight the temperature zones for hardening and stress relieving;
(iii) For a structure containing 0.6% carbon at 870°C, distinguish between the effects of rapid cooling and slow cooling.



2003 Question 3

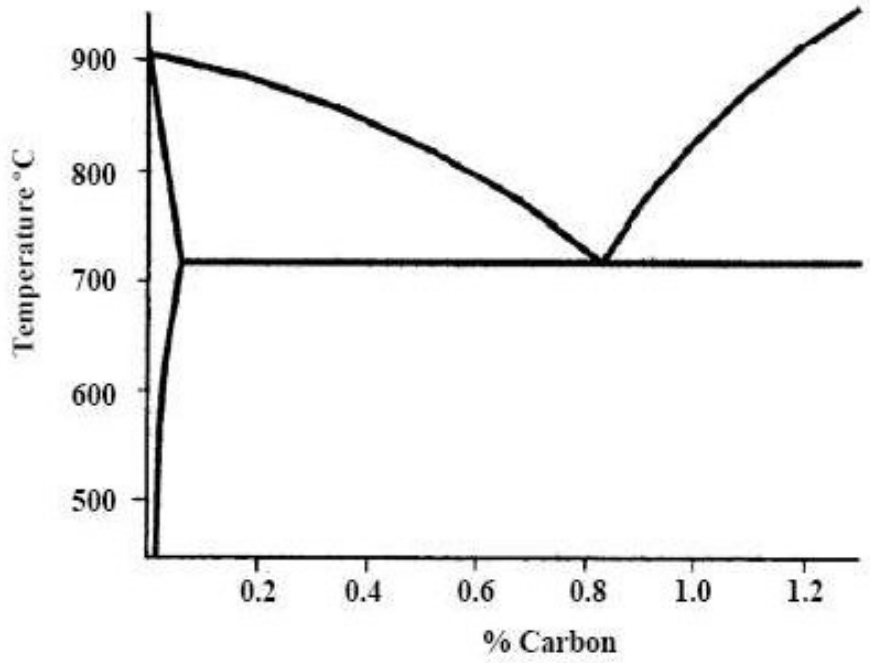
(a) Explain **any two** of the following terms used in the heat treatment of steel.

(i) Ferrite;
(ii) Cementite;
(iii) Martensite;
(iv) Tempering;
(v) Normalising.

2003 Question 3 cont.

(b) Copy the simplified iron-carbon equilibrium diagram into your answer book.
With reference to the diagram, describe how 0.5% carbon steel may be heat treated to produce:

(i) A soft condition;
(ii) A tough condition.



2003 Question 3 cont.

(c) (i) Name **two** methods of measuring furnace temperature.

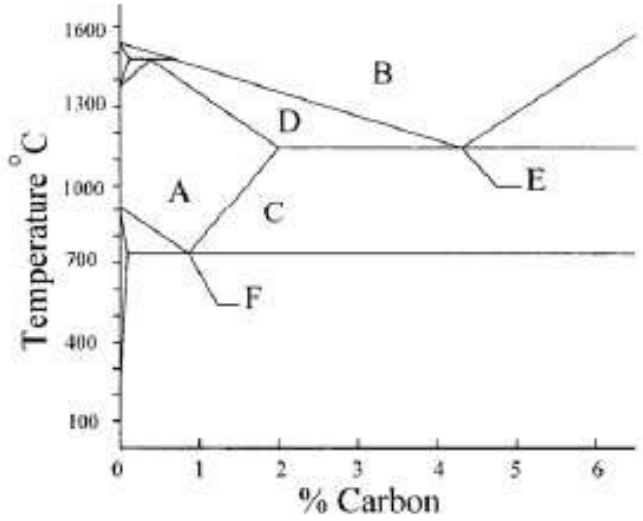
(ii) Describe the principle of operation and give a suitable application for **one** method.

2004 Question 3

(a) With reference to the given iron-carbon equilibrium diagram, answer **each** of the following:

(i) Identify the phases represented by A, B, C and D.

(ii) Name points E and F **and** describe what **each** represents.



2004 Question 3 cont.

(b) Describe, with the aid of suitable diagrams, **any two** of the following heat treatment processes:

(i) Induction hardening;

(ii) Flame hardening;

(iii) Carburising.

(c) Outline the significance of allotropy in relation to carbon steel.

2005 Question 3

(a) Answer **any two** of the following:

(i) Compare eutectic and eutectoid reactions, stating any temperature and structural changes;

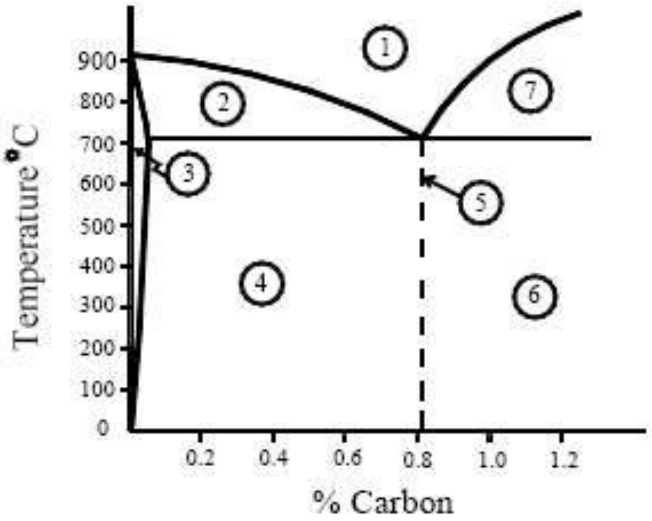
(ii) Describe **one** method of measuring temperature in heat treatment furnaces;

(iii) Differentiate between grey and white cast iron;

(iv) Explain the term recrystallisation in relation to heat treatment.

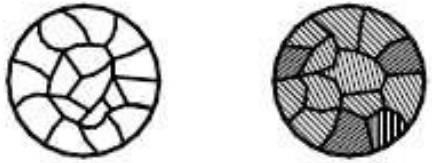
2005 Question 3 cont.

(b) A simplified portion of the iron-carbon equilibrium diagram is shown.



(i) Name the regions 1, 2, 3, 4, 5, 6 and 7.

(ii) Identify the region most suited to each of the microstructures shown below.



A B

2005 Question 3 cont.

(c) Describe **any two** of the following heat treatment processes:

(i) Annealing;

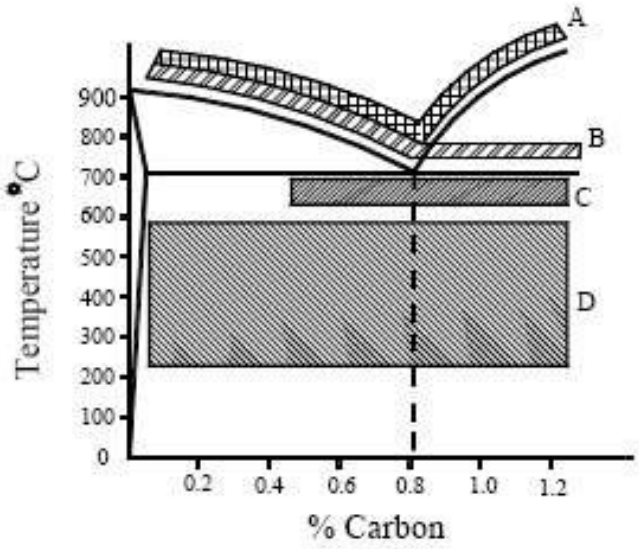
(ii) Normalising;

(iii) Stress Relieving.

2006 Question 3

(a) Temperature zones, A, B, C and D, for a range of heat-treatment processes for carbon steel are shown below.

Select **any two** zones and explain the heat-treatment process that they represent.



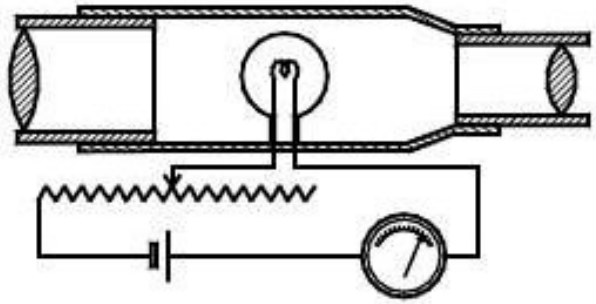
2006 Question 3 cont.

(b) For **any two** of the following, differentiate between the terms:

- **(i)** Ferrite and martensite;
- **(ii)** Upper critical temperature and lower critical temperature;
- **(iii)** Stainless steel and high speed steel;
- **(iv)** Eutectic and eutectoid point.

(c) With reference to the diagram shown below:

- **(i)** Name the instrument;
- **(ii)** State its function;
- **(iii)** Outline the method of operation.



2007 Question 3

(a) Answer **any two** of the following:

(i) Identify **two** methods of measuring furnace temperature;

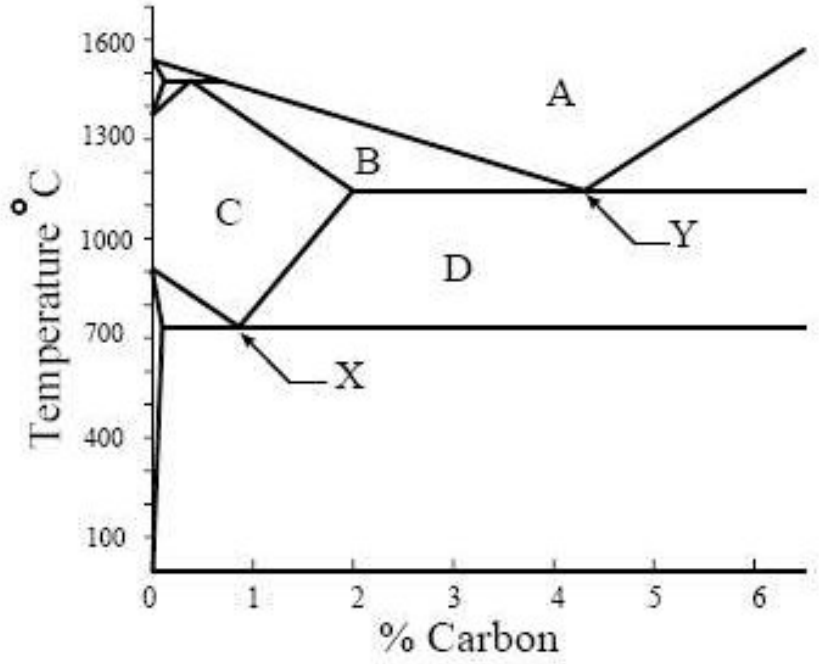
(ii) Describe the influence of *allotropy* in carbon steel;

(iii) Explain the term *soaking* in relation to the annealing process;

(iv) Distinguish between the properties of grey cast iron and white cast iron.

2007 Question 3 cont.

(b) A simplified portion of the iron-carbon equilibrium diagram is shown.



(i) Name the regions A, B, C and D.

(ii) Identify and describe the significance of points X and Y.

2007 Question 3 cont.

(c) **(i)** The rate of cooling in heat treatment is dependent on the quenching medium.
Name **three** quenching media and order them in terms of speed of cooling.

(ii) Outline, with the aid of a suitable diagram, the principle of induction hardening.

2008 Question 3

(a) Answer **any two** of the following:

(i) Differentiate between the eutectic point and the eutectoid point;

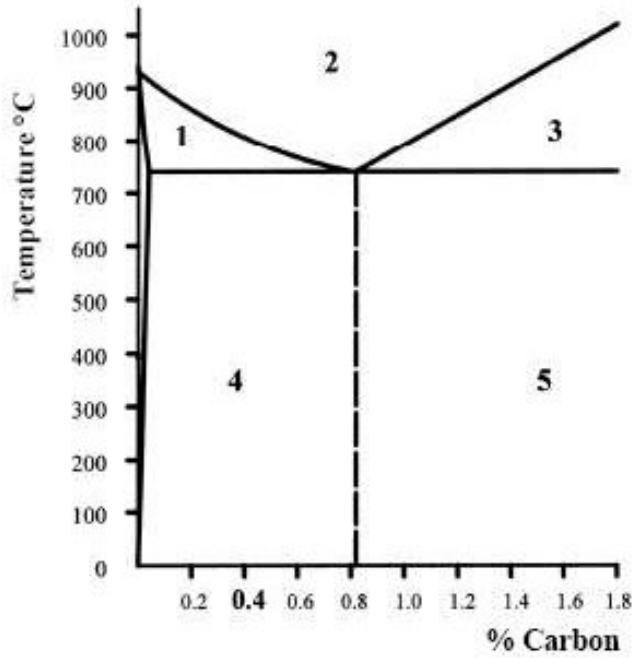
(ii) Describe **one** method of measuring furnace temperature;

(iii) Compare the microstructures of martensite and ferrite;

(iv) Explain the term recrystallisation in terms of heat treatments.

2008 Question 3 cont.

(b) A simplified section of the iron-carbon equilibrium diagram is shown.



(i) Name the regions represented at 1, 2, 3, 4 and 5.

(ii) Describe the structural changes that occur in **0.4%** carbon steel as it cooled slowly from 900 °C.

2008 Question 3 cont.

(c) (i) Describe the principle of pack carburising.

(ii) Outline, with the aid of a suitable diagram, the process of flame hardening.

2009 Question 3

(a) Answer **any two** of the following:

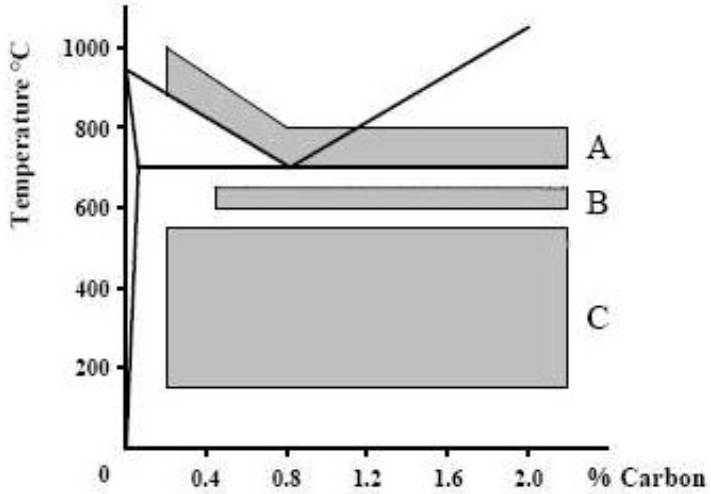
(i) Identify **any three** quenching media used in heat treatments;

(ii) Discuss the safety hazards associated with the process of case hardening;

(iii) Describe the principle of induction hardening;

(iv) What is pearlite?

(b) Temperature zones for heat treatment processes are shown:

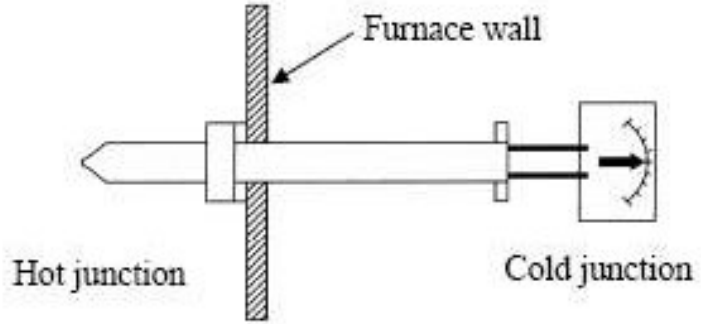


(i) Identify **any two** of the heat treatment processes at A, B or C.

(ii) Explain allotropy in carbon steel.

2009 Question 3 cont.

(c) The diagram represents a pyrometer for measuring furnace temperature.



(i) Identify this instrument.

(ii) Outline the principle of operation for this instrument.

2010 Question 3

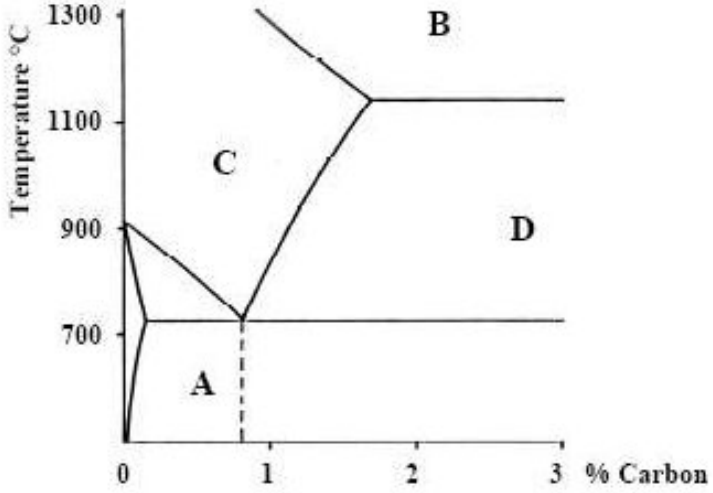
(a) Select **any two** of the following:

(i) Compare the impact of soaking with the impact of water cooling in heat treatment;

(ii) Distinguish between the optical pyrometer and the thermo-electric pyrometer;

(iii) Describe the normalising process.

(b) A simplified section of the iron-carbon equilibrium diagram is shown:



(i) Identify the regions labelled **A**, **B**, **C** and **D**.

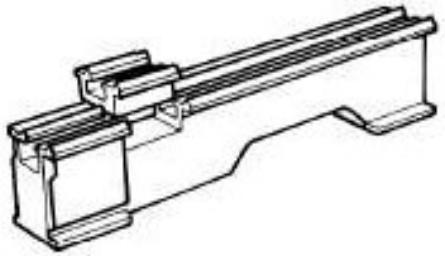
(ii) Describe, with the aid of a diagram, the crystal structure of martensite.

2010 Question 3 cont.

(c) The machined guideways of the lathe bed shown will be subjected to wear.

(i) Identify a suitable heat treatment process to prevent wear on the guideways.

(ii) Describe, with the aid of suitable diagrams, this heat treatment process.



2011 Question 3

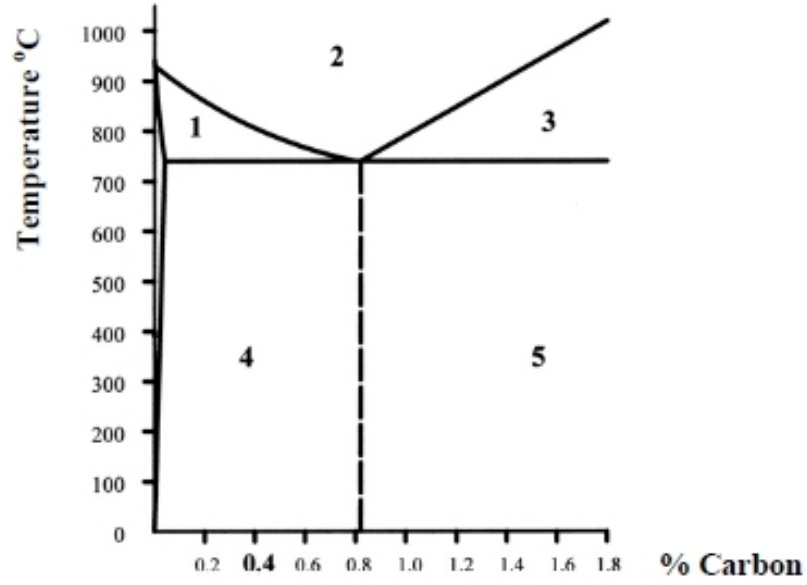
(a) Answer **any two** of the following:

(i) Describe, with the aid of a suitable diagram, the induction hardening process;

(ii) Distinguish between the properties of grey cast iron and white cast iron;

(iii) Explain the function of stress relieving in metals.

(b) A simplified section of the iron-carbon equilibrium diagram is shown.



(i) Identify the regions represented at **1**, **2**, **3**, **4** and **5**.

(ii) Outline the effect of cooling **0.4%** carbon steel quickly from **900 °C**.

2011 Question 3 cont.

(c) The diagrams shown below represent a series of readings from a pyrometer.

A B C

(i) Name this pyrometer and state its function.

(ii) Describe the principle of operation of the pyrometer, making reference to diagrams **A**, **B** and **C**.

2012 Question 3

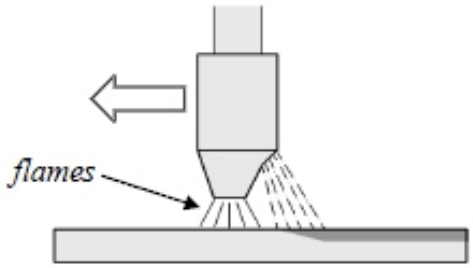
(a) Describe **any two** of the following heat treatment processes:

(i) Annealing;

(ii) Normalising;

(iii) Carburising.

(b) A flame hardening process is shown below.

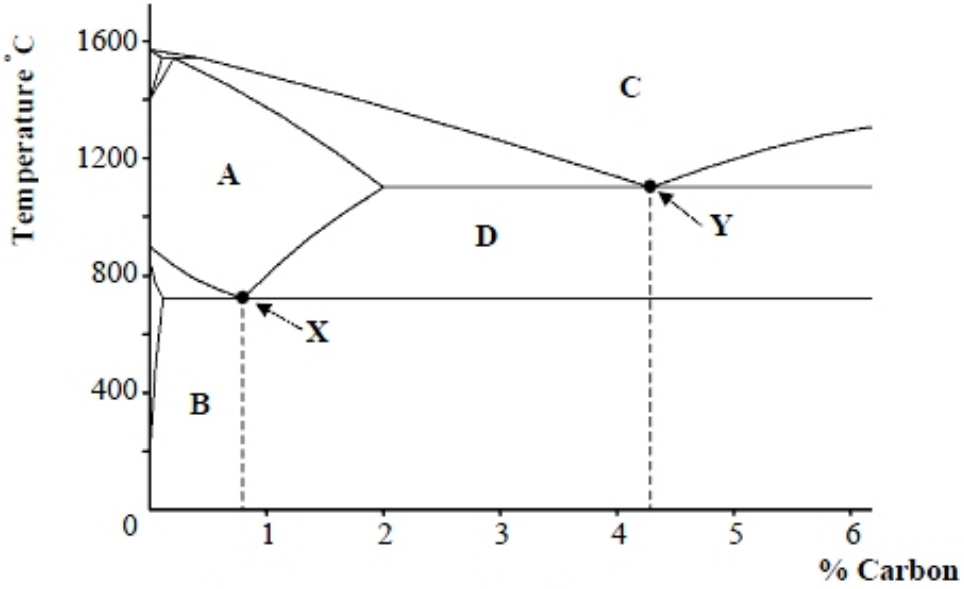


(i) Describe the principle of operation of this flame hardening process.

(ii) Outline **one** application for this process.

2012 Question 3 cont.

(c) A simplified portion of the iron-carbon equilibrium diagram is shown.



(i) Name the regions **A**, **B**, **C** and **D** shown.

(ii) Identify and describe the points **X** and **Y**.

2013 Question 3

(a) The table below describes heat treatments which have been applied to each of the medium-carbon steel screwdrivers **A** and **B**.

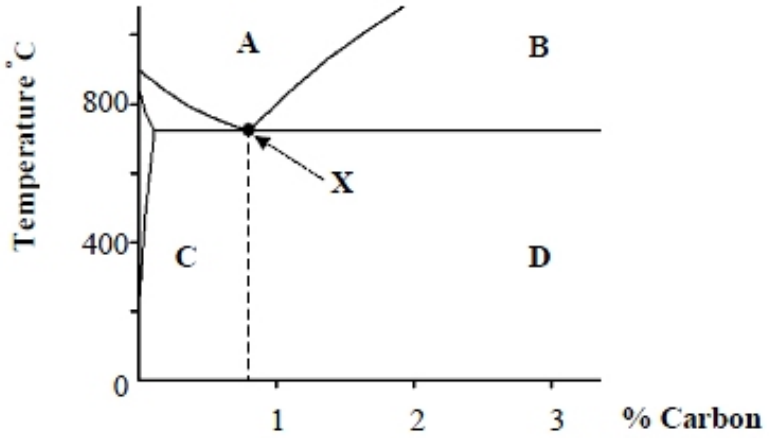
Screwdriver **A**	Heat to 900°C and allow to cool slowly
Screwdriver **B**	Heat to 900°C and quench in cold water

(i) Describe the effect of applying maximum torque to both screwdriver **A** and screwdriver **B** after the above heat treatments.

(ii) Outline the most effective heat treatment process that should be applied to a screwdriver.

2013 Question 3 cont.

(b) A simplified portion of the iron-carbon equilibrium diagram is shown.



(i) Name the regions **A**, **B**, **C**, **D** and the point **X** shown.

(ii) Describe in detail, the point **X** with reference to the following:

- phase change
- composition
- temperature.

2013 Question 3 cont.

(c) Answer **any two** of the following:

(i) Describe the process and applications of induction hardening.

(ii) Name **three** quenching media used in heat treatment.

(iii) Outline the operating principles of an optical pyrometer.

(iv) Explain the properties of *18/10 stainless steel* and outline a suitable use for this steel.