Engineering Questions by Topic

Higher Level

Question 4

Thermal Equilibrium Diagrams

50 Marks

1996 Question 4

(a) (i) What basic information can be obtained from a thermal equilibrium diagram?

(ii) Explain, using diagrams, the various stages of solidification of a metal from the liquid phase.

(b) The melting points of two metals A and B are 500°C and 700°C respectively. The given table shows the solidification temperatures for various alloys of the two metals.

Amount of B in alloy (%)	0	10	30	50	70	90	100
Temperature at start of solidification (°C)	500	545	610	650	670	690	700
Temperature at end of solidification (°C)	500	510	530	550	585	650	700

(i) Using the graph paper supplied, draw the thermal equilibrium diagram according to the given data.

(ii) Label the diagram and discuss its main features.

(c) For the alloy with 40% B at 590°C, determine from the diagram:

(i) the composition;

(ii) the ratio of the phases which exist.

1997 Question 4

(a) Describe one of the following:

(i) Age hardening;

(ii) Slip in crystals.

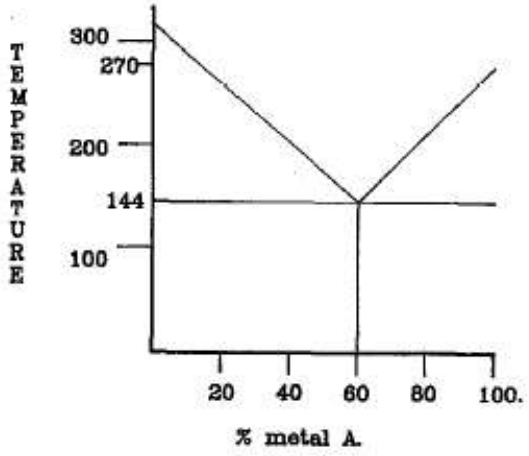
(b) Simplified thermal equilibrium diagrams for two different Alloy systems are shown.

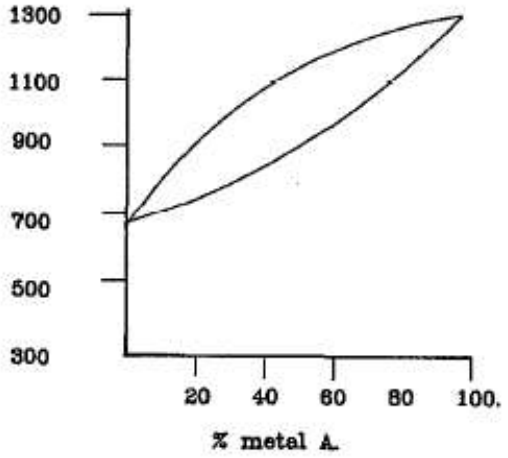
Copy the given diagrams into your answer book and compare both systems under the following headings:

(i) Degrees of solubility;

(ii) Regions and features;

(iii) Typical alloying elements.

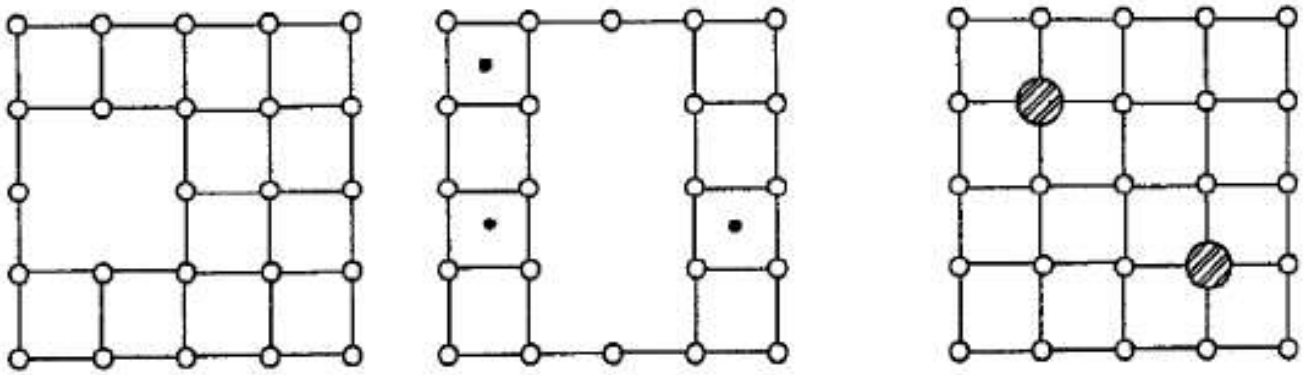




(c) With reference to the diagram on the right hand side above, determine for a 40% metal A, the ratio of the phases at 900°.

1998 Question 4

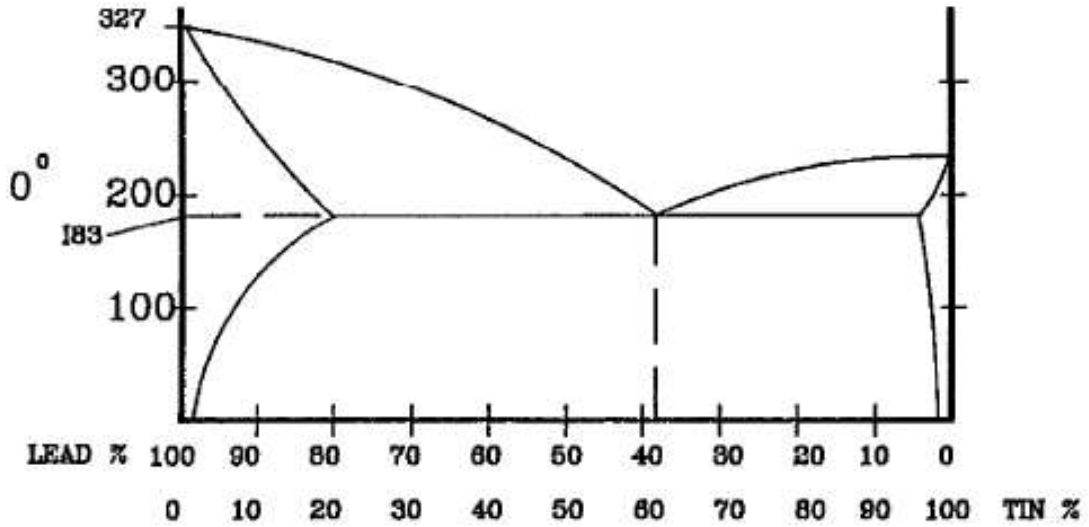
(a) Name **any three** crystal defects shown below:



Suggest how any **one** defect is used to maximum advantage.

1998 Question 4 cont.

(b) Copy the given equilibrium diagram into your answer book and answer each of the questions below:



(i) Identify and explain the liquidus, solidus, solvus and the eutectic points;

(ii) Referring to the diagram identify tinmans solder and state its melting temperature.

(c) For an alloy with 30% tin, determine from the diagram the following:

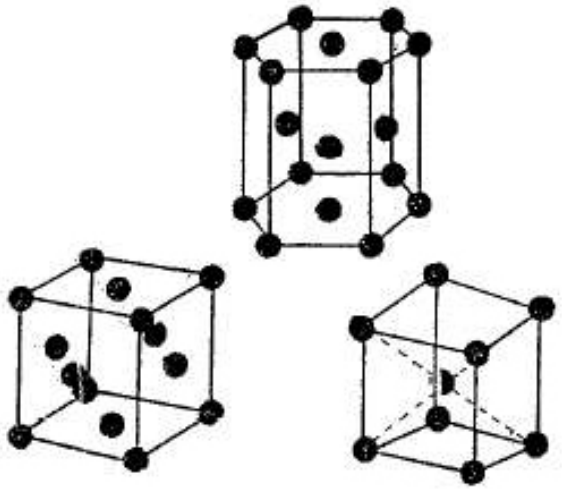
(i) the composition of the phase at 250°C;

(ii) the ratio of the phases at 250°C.

1999 Question 4

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

(i) Name the **three** unit cells represented.



(ii) Which structure is most associated with brittleness in metals?

(iii) Explain the term *allotropic*.

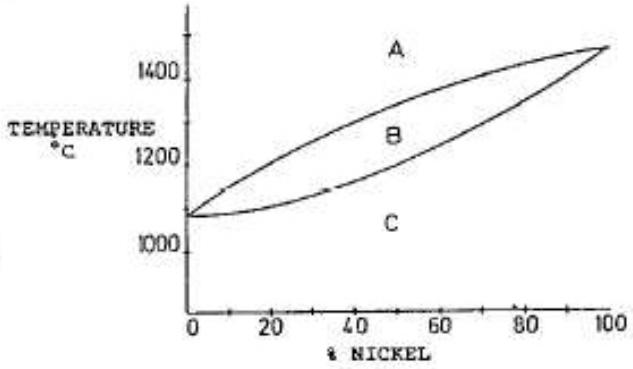
(iv) Name a metal based on each structure, under normal conditions.

(v) Distinguish between *crystalline* and *amorphous* structures.

(b) A thermal equilibrium diagram for a copper / nickel alloy system is shown.

(i) Name the upper and lower curves and explain what the areas at A, B and C represent;

(ii) With reference to the alloy containing 40% nickel, determine from the diagram the compositions of the phases at 1200°C.



(c) Distinguish between a *substitutional* solid solution and an *interstitial* solid solution.

2000 Question 4

(a) Select **any two** of the following terms and give a definition for each selected:

(i) Eutectic Alloys;

(ii) Solid Solution;

(iii) Partial solubility.

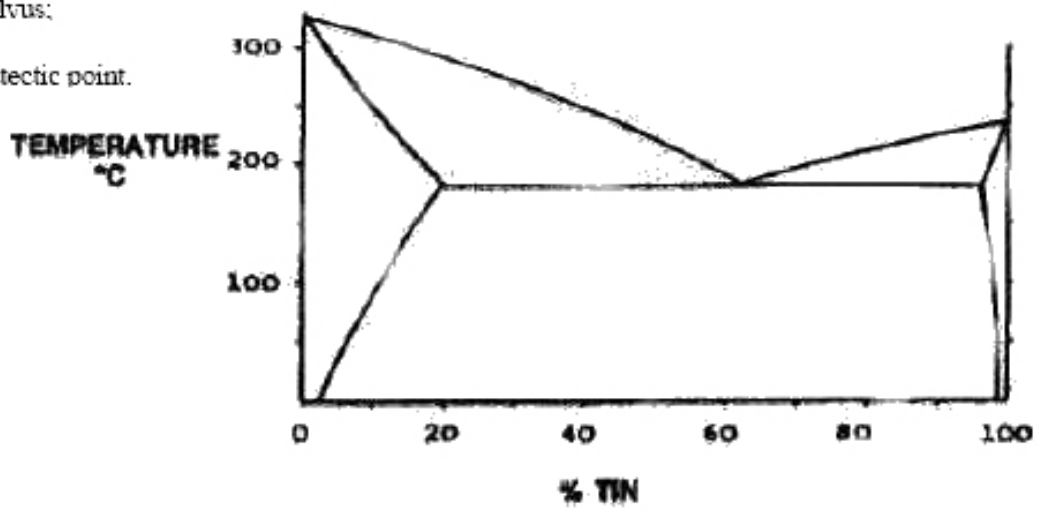
(b) Transfer the Lead – Tin equilibrium diagram, given below, into your answer book and identify and explain each of the following terms:

(i) Liquidus;

(ii) Solidus;

(iii) Solvus;

(iv) Eutectic point.



2000 Question 4 cont.

(c) Describe, with the aid of diagrams, **any three** of the following terms:

(i) Dislocation;

(ii) Vacancy;

(iii) Substitutional alloy;

(iv) Interstitial solid solution.

2001 Question 4

(a) Select <u>any two</u> of the following terms and give a definition for each selected.

(i) Eutectoid point;

(ii) Dendritic growth;

(iii) Vacancy;

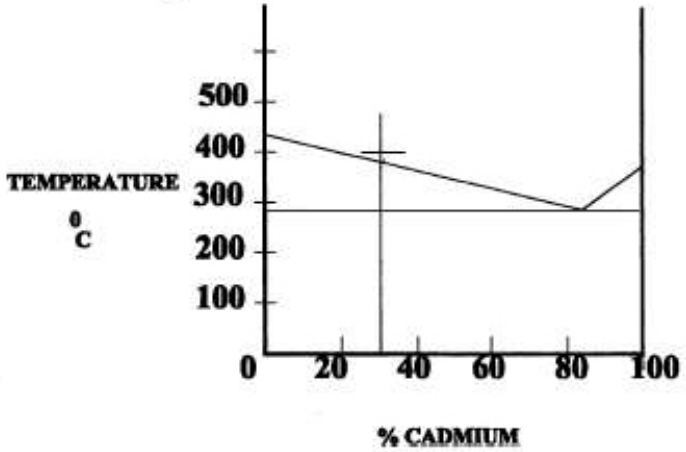
(iv) Solid solution.

(b) Redraw the Cadmium - Zinc equilibrium diagram, given below, into your answer book and identify and explain each of the following terms.

(i) Liquidus;

(ii) Solidus;

(iii) Eutectic point.



(c) Using the above diagram explain the solidification process from 400° C for an alloy with 30% cadmium.

2002 Question 4

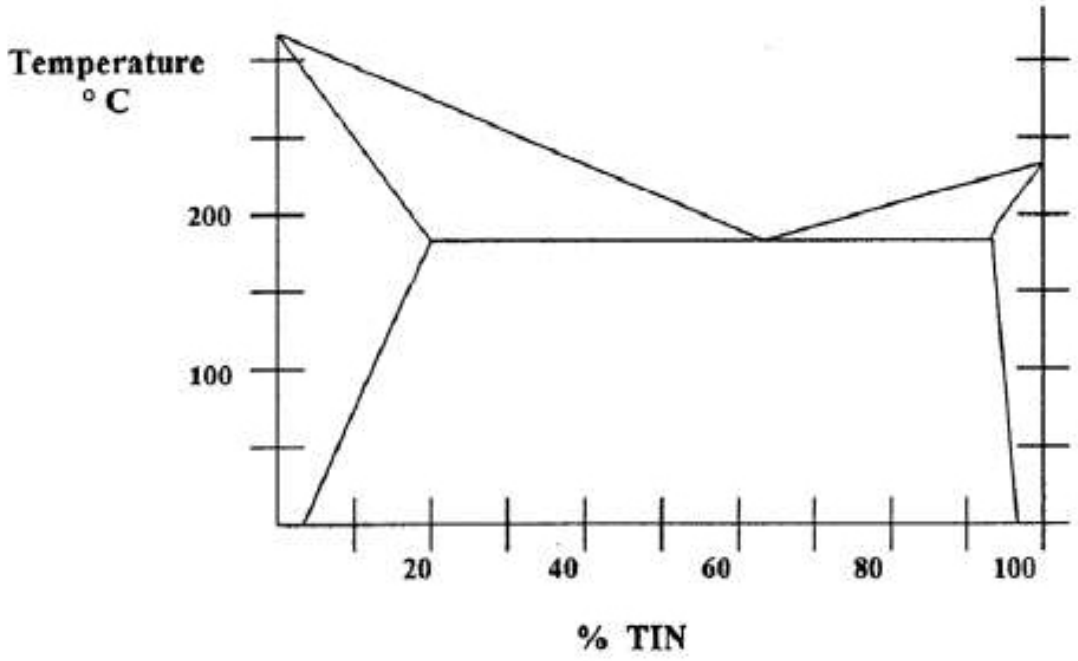
(a) With reference to aluminium, answer **any four** of the following:

(i) Name the ore used to manufacture aluminium;
(ii) How is aluminium refined?
(iii) Describe its resistence to oxidation;
(iv) Outline **five** important properties of aluminium;
(v) Where in Ireland is aluminium refined?
(vi) Outline age hardening in the Y-alloy.

(b) Distinguish between a solid solution and a simple eutectic.

2002 Question 4 cont.

(c) Copy the given lead-tin diagram into your answer book.
Identify (i) liquidus, (ii) solidus and (iii) solvus on your diagram and explain clearly what each term represents.



2003 Question 4

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

(i) Interstitial solid solution and substitutional solid solution;
(ii) Crystalline and amorphous structures;
(iii) Solvus and solidus;
(iv) Body centred cubic and face centred cubic;
(v) Simple eutectic and a solid solution.

(b) The given table shows the solidification temperatures for various alloys of two metals A and B. The melting points of A and B are 270°C and 630°C respectively.

Amount of B in alloy (%)	0	10	20	30	40	50	60	70	80	90	100
Start of solidification (°C)	270	332	400	445	492	524	552	580	603	618	630
End of solidification (°C)	270	272	280	300	318	340	368	404	449	510	630

Using the graph paper supplied:

(i) Draw the equilibrium diagram according to the given data;
(ii) Label the diagram and describe the main features;
(iii) For the alloy of 60% B determine, from the diagram, the ratio of the phases at 450°C.

(c) (i) Describe, with the aid of a diagram, a dislocation defect.

(ii) Suggest **one** method of restricting the movement of a dislocation.

2004 Question 4

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

(i) Differentiate between a vacancy and a dislocation;

(ii) Describe the age hardening process;

(iii) Explain why the body–centred cubic structure is mostly associated with brittleness in metals;

(iv) What is meant by partial solubility ?

(b) The given table shows the solidification temperatures for various alloys of cadmium and bismuth. The melting point of cadmium is 321°C and the melting point of bismuth is 268°C .

Amount of cadmium in alloy (%)	10	20	30	40	50	60	70	80	90
Start of solidification (°C)	237	205	175	140	190	235	265	290	310
End of solidification (°C)	140	140	140	140	140	140	140	140	140

Using the graph paper supplied:

(i) Draw the equilibrium diagram according to the given data;

(ii) Label the diagram and describe the main features;

(iii) For the alloy with 75% cadmium determine, from the diagram, the ratio of the phases at 200°C.

2004 Question 4 cont.

(c) Explain, using diagrams, the various stages of metal solidification during dendritic growth.

2005 Question 4

(a) With reference to thermal equilibrium diagrams, explain **any two** of the following:

(i) Solvus line;

(ii) Simple eutectic solutions;

(iii) Cooling curve;

(iv) Latent heat of fusion;

(v) Substitutional solid solution.

(b) The given table shows the solidification temperatures for various alloys of two metals A and B. The melting points of A and B are 270°C and 630° C respectively.

Amount of B in alloy (%)	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Start of solidification (°C)	**270**	**332**	**400**	**445**	**492**	**524**	**552**	**580**	**603**	**618**	**630**
End of solidification (°C)	**270**	**272**	**280**	**300**	**318**	**340**	**368**	**404**	**449**	**510**	**630**

Using the graph paper supplied:

(i) Draw the equilibrium diagram according to the given data;

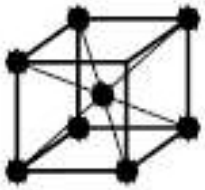
(ii) Label the diagram and describe the main features;

(iii) For the alloy of 50% B determine, from the diagram, the ratio of the phases at 400°C.

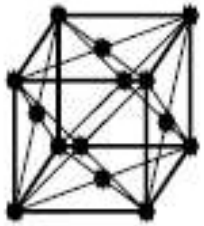
2005 Question 4 cont.

(c) (i) Identify the unit cell structures shown below.

(ii) Explain why structure B is mostly associated with ductility.



A



B

2006 Question 4

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

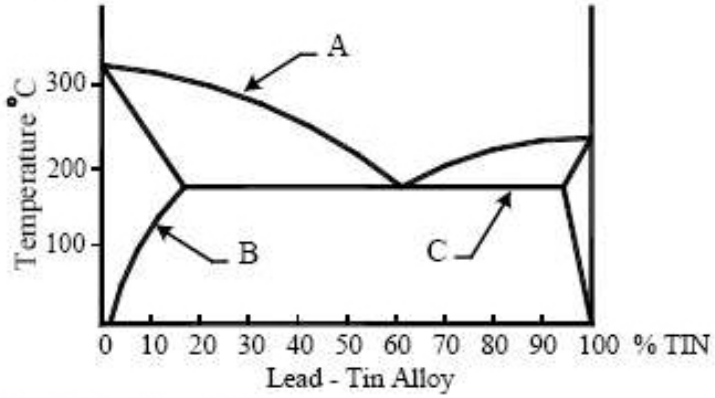
(i) Solid solution alloy;

(ii) Dendritic growth;

(iii) Allotropy;

(iv) Cooling curve.

(b) Copy the given lead-tin diagram into your answer book and answer **all** of the following:



(i) Identify the lines labelled A, B and C;

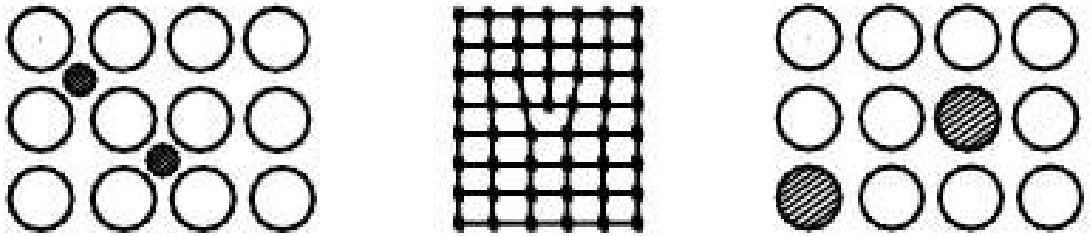
(ii) Explain what **each** line represents;

(iii) For the alloy with 30% tin determine, from the diagram, the composition of the phases at 250°C;

(iv) Indicate clearly on your diagram the eutectic point.

2006 Question 4 cont.

(c) Describe **any two** of the crystal defects shown below.



(i) (ii) (iii)

2007 Question 4

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

(i) Crystalline and amorphous structures;

(ii) The differences between a eutectic alloy and a solid solution alloy;

(iii) Three crystal point defects;

(iv) Age hardening.

(b) The given table shows the solidification temperatures for various alloys of metal A and metal B. The melting point of A is 1083°C and B is 1453°C.

% of metal B in alloy	0	10	20	30	40	50	60	70	80	90	100
Start of solidification (°C)	1083	1160	1220	1270	1320	1350	1380	1400	1430	1440	1453
End of solidification (°C)	1083	1080	1090	1110	1140	1170	1220	1270	1330	1380	1453

Using the graph paper supplied:

(i) Draw the equilibrium diagram according to the given data;

(ii) Label the diagram and describe the main features;

(iii) For the alloy with 50% B determine, from the diagram, the ratio of the phases at 1250°C.

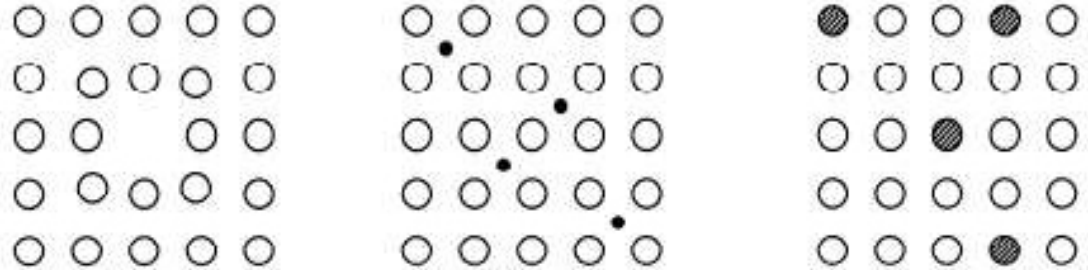
2007 Question 4 cont.

(c) (i) Outline the relationship between cooling curves and the formation of equilibrium diagrams.

(ii) Explain, using diagrams, the stages of dendritic growth as a metal solidifies.

2008 Question 4

(a) Describe **any two** of the crystal defects shown below.



(i) **(ii)** **(iii)**

(b) The table shows the temperatures at which solidification starts and ends as the alloys of cadmium and zinc are cooled from liquid to solid.

Amount of zinc %	0	10	14	20	30	40	50	60	70	80	90	100
Solidification start °C	321	290	266	275	293	310	328	345	362	380	401	410
Solidification end °C	266	266	266	266	266	266	266	266	266	266	266	266

(i) Using the graph paper supplied, draw the thermal equilibrium diagram.

(ii) Label the diagram and describe the main features.

2008 Question 4 cont.

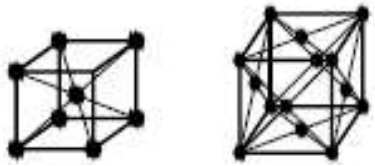
(c) Explain **any two** of the following:

(i) Solvus line;

(ii) Solid solution;

(iii) The stages of metal solidification from the liquid phase;

(iv) The difference between BCC and FCC crystal structures.



2009 Question 4

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

(i) Crystalline and amorphous structures;

(ii) Dendritic growth;

(iii) A cooling curve for an alloy;

(iv) Brittleness in crystal cells.

(b) The given table shows the solidification temperatures for various alloys of metal A and metal B. The melting point of metal A is 270°C and metal B is 630°C.

% of metal B in alloy	0	10	20	30	40	50	60	70	80	90	100
Start of solidification (°C)	270	332	400	445	492	524	552	580	603	618	630
End of solidification (°C)	270	272	280	300	318	340	368	404	449	510	630

Using the graph paper supplied:

(i) Draw the equilibrium diagram according to the given data;

(ii) Label the diagram and describe the main features;

(iii) For the alloy of **50% B** determine, from the diagram, the ratio of phases at **400°C**.

2009 Question 4 cont.

(c) Distinguish, with the aid of suitable diagrams, between the following crystal defects:

(i) a dislocation;

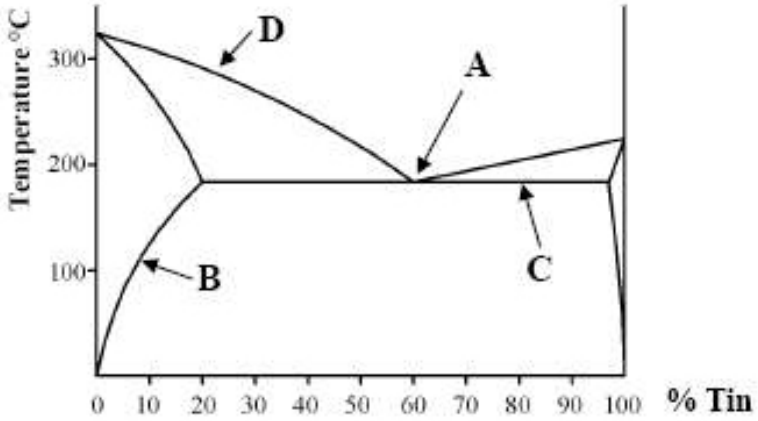
(ii) a substitute defect.

2010 Question 4

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

- **(i)** Dislocation defect;
- **(ii)** Age hardening;
- **(iii)** Intermetallic compound;
- **(iv)** Eutectoid point.

(b) The lead-tin equilibrium diagram is shown below.



- **(i)** Identify the point **A** and the lines **B**, **C** and **D**.
- **(ii)** Describe the main features of the diagram.
- **(iii)** Determine, from the diagram, the composition of the phases at **250°C** for the alloy at **30%** tin.

2010 Question 4 cont.

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

(i) Solid solution alloy;

(ii) Eutectic alloy;

(iii) Partial solubility alloy.

2011 Question 4

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

(i) Allotropy;

(ii) Interstitial solid solution;

(iii) The difference between amorphous structures and crystalline structures;

(iv) The degree of brittleness in body-centred cubic (bcc) structures and the degree of brittleness in face-centred cubic (fcc) structures.

(b) The table shows the solidification temperatures for the various alloys of metal A and metal B. The melting point of **metal A** is **1083 °C** and the melting point of **metal B** is **1453 °C**.

% of metal B in alloy	10	20	30	40	50	60	70	80	90
Start of solidification (°C)	1160	1220	1270	1320	1350	1380	1400	1430	1440
End of solidification (°C)	1080	1090	1110	1140	1170	1220	1270	1330	1380

2011 Question 4 cont.

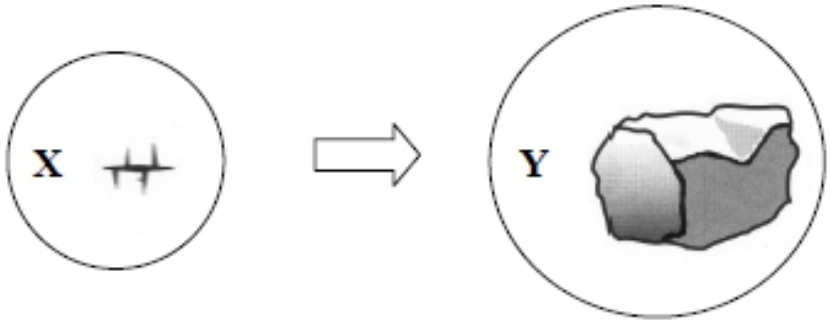
Using the graph paper supplied:

(i) Draw the thermal equilibrium diagram according to the given data;

(ii) Label the main features of the diagram;

(iii) Determine, from the diagram, the ratio of the phases at **1250 °C** for the alloy of **50%** metal B.

(c) Outline the various stages of solidification as a metal cools, from **X** to the crystal at **Y**, as shown below.



2012 Question 4

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

(i) The difference between an interstitial solid solution and a substitutional solid solution;

(ii) A cooling curve for an alloy;

(iii) **One** example of metal refining in Ireland;

(iv) The meaning of the term *solvus*.

2012 Question 4 cont.

(b) The table shows the solidification temperatures for various alloys of Cadmium and Bismuth.

% of Cadmium in alloy	0	10	20	30	40	50	60	70	80	90	100
Start of solidification (˚C)	268	237	205	175	140	190	235	265	290	310	321
End of solidification (˚C)	140	140	140	140	140	140	140	140	140	140	140

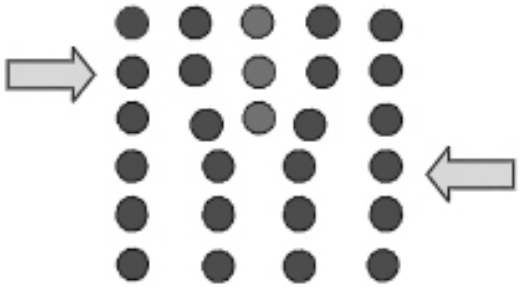
(i) Using the graph paper supplied, draw the thermal equilibrium diagram according to the given data;

(ii) Label and describe the main features of the diagram;

(iii) Explain the term *eutectic alloy*.

2012 Question 4 cont.

(c) A diagram of a crystal-lattice line defect is shown.



(i) Identify and describe this defect.

(ii) Outline the impact of a shear force on the defect shown.

2013 Question 4

(a) Explain in detail **any two** of the following:

(i) Age hardening;

(ii) The differences between *eutectic alloy* and *partial solubility alloy*;

(iii) **Three** crystal point defects;

(iv) Intermetallic compound.

2013 Question 4 cont.

(b) The table shows the solidification temperatures for various alloys of metal **A** and metal **B**.

% of metal B in alloy	0	20	40	60	80	100
Start of solidification (˚C)	270	400	492	552	603	630
End of solidification (˚C)	270	280	318	368	449	630

(i) Using the graph paper supplied, draw the thermal equilibrium diagram according to the given data.

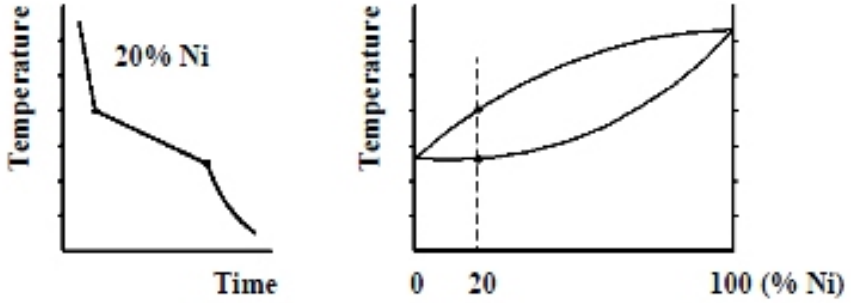
(ii) Label and describe the main features of the diagram.

(iii) Determine the composition of the phases present at **450 ˚C** for the alloy containing **60%** of metal **B**.

2013 Question 4 cont.

(c) (i) Outline the stages of metal solidification from the liquid phase.

(ii) Explain the relationship between cooling curves and the formation of alloy equilibrium diagrams as shown below.



Cooling curve *Equilibrium diagram*