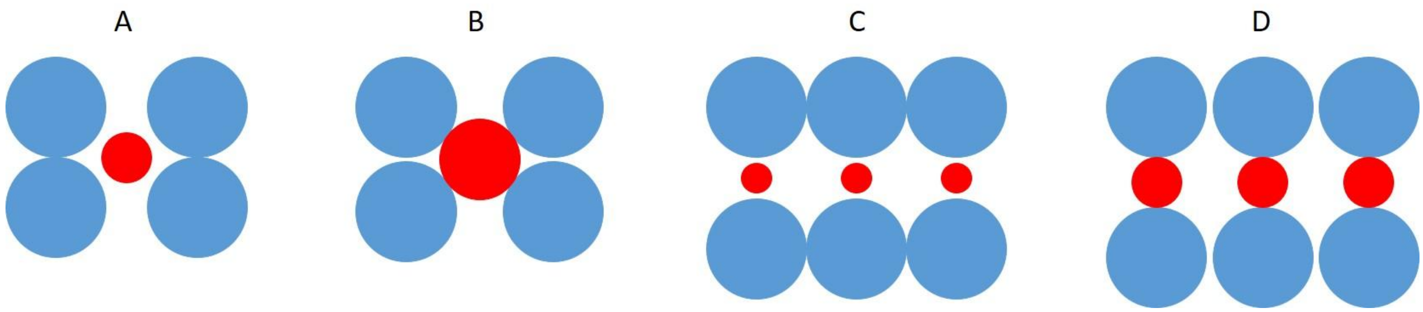
41680 F22 Introduction to advanced materials exam (adjustet for F23)

Der anvendes en scoringsalgoritme, som er baseret på "One best answer"

Dette betyder følgende:
Der er altid netop ét svar som er mere rigtigt end de andre
Studerende kan kun vælge ét svar per spørgsmål
Hvert rigtigt svar giver 1 point
Hvert forkert svar giver 0 point (der benyttes IKKE negative point)

The following approach to scoring responses is implemented and is based on "One best answer"
There is always only one correct answer – a response that is more correct than the rest
Students are only able to select one answer per question
Every correct answer corresponds to 1 point
Every incorrect answer corresponds to 0 points (incorrect answers do not result in subtraction of points)

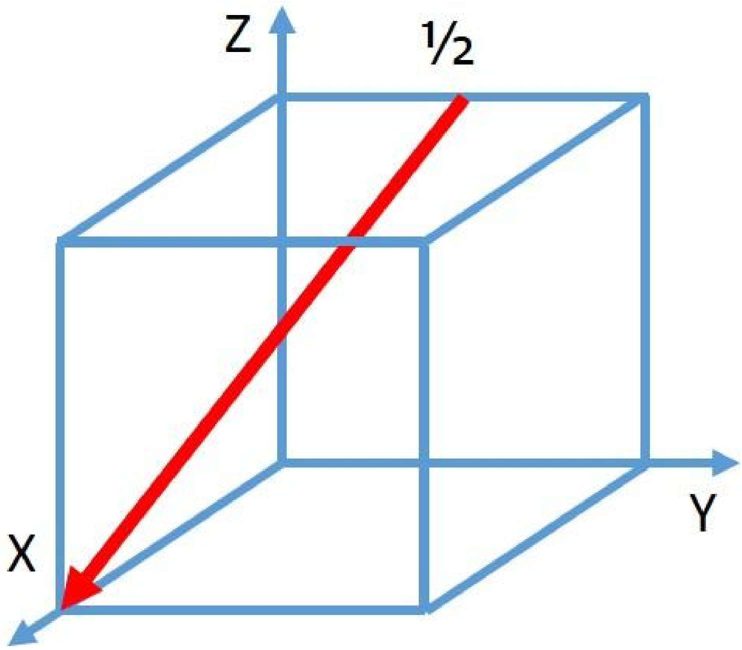
Which of the lattice planes illustrated in the figure (blue anions and red cations are properly scaled) represent a {110} plane in a stable cesium chloride structure?



Vælg en svarmulighed

- A
- B
- C
- D

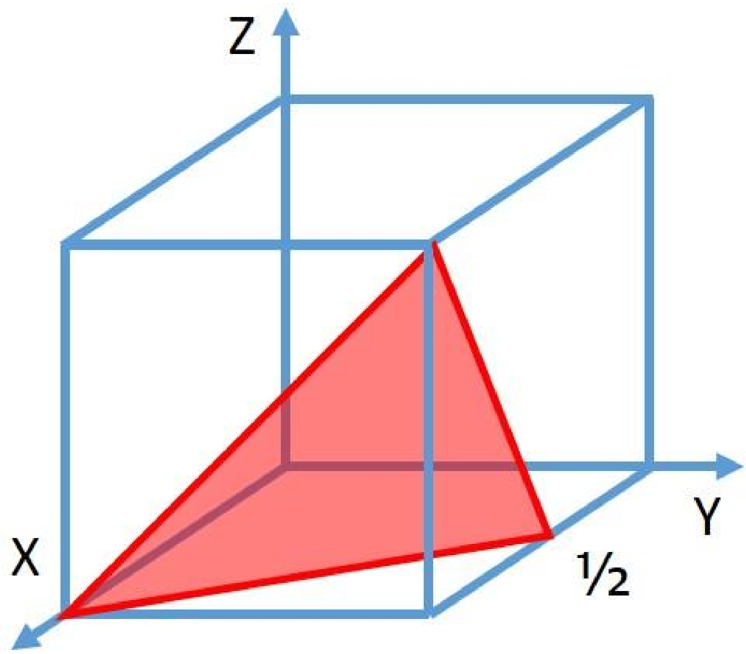
Which is the proper notation for the crystallographic direction shown in the unit cell in the figure?



Vælg en svarmulighed

- $[\bar{2}12]$
- $[2\bar{1}\bar{2}]$
- $[\bar{1}21]$
- $[1\bar{2}\bar{1}]$

What is shown in red in the unit cell in the figure?



Vælg en svarmulighed

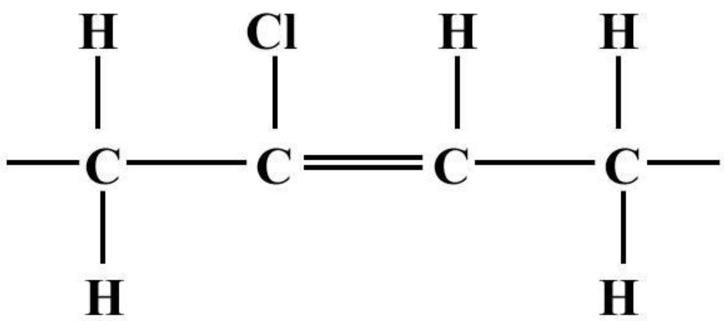
- One of the {211} planes.
- One of the {221} planes.
- A (121) plane.
- A (212) plane.

Praseodymium has a molar mass of 140.9 g/mol, its atoms have a radius of 0.179 nm. What is the density of ß-praseodymium, which crystallizes with body-centered cubic lattice?

Vælg en svarmulighed

- About 3.3 g/cm^3.
- About 5.1 g/cm^3.
- About 6.6 g/cm^3.
- About 7.2 g/cm^3.
- About 9.7 g/cm^3.

The graph shows the repeating unit of polychloroprene.



Compare a batch of polychloroprene (CR) with a batch of polybutadiene (BR) having the same molar mass. Which statement is correct?

Vælg en svarmulighed

- CR has a higher degree of polymerization and a higher glass transition temperature than BR.
- CR has a higher degree of polymerization than BR, but BR has a higher glass transition temperature than CR.
- BR has a higher degree of polymerization and a higher glass transition temperature than CR.
- BR has a higher degree of polymerization than CR, but CR has a higher glass transition temperature than BR.

An increase in crystallinity of a semi-crystalline polymer causes a reduction of …

Vælg en svarmulighed

- … its yield strength.
- … its melting temperature.
- … its transparency.
- … its degree of polymerization.

Semi-crystalline polypropylene cannot have a crystallinity much higher than 80 %. Why?

Vælg en svarmulighed

- Because the polymer chains must be folded and cannot be arranged in perfect order.
- Because even a perfectly ordered arrangement will have open space between the chains.
- Because the hydrogen atoms are making up 14 % of the entire mass.
- Because polypropylene always shows atactic sections along the chain.

The density of polyethylene depends on its crystallinity. Amorphous regions with mass density 0.870 g/cm^3 are less dense than crystalline regions with 0.998 g/cm^3. What is the density of semi-crystalline polyethylene with a crystallinity of 70 %?

Vælg en svarmulighed

- 0.960 g/cm^3
- 0.956 g/cm^3
- 0.930 g/cm^3
- 0.934 g/cm^3
- 0.908 g/cm^3
- 0.905 g/cm^3

At room temperature, a nickel specimen contains the equilibrium vacancy concentration. The specimen is heated to a temperature just below the melting temperature and – after establishing thermal equilibrium – quenched. Compared to the original specimen, the quenched specimen is …

Vælg en svarmulighed

- ○ … a better electrical conductor.
- ○ … stronger.
- ○ … slightly larger.
- ○ … stiffer.

When the Young's modulus of a material depends on the loading direction, the material is …

Vælg en svarmulighed

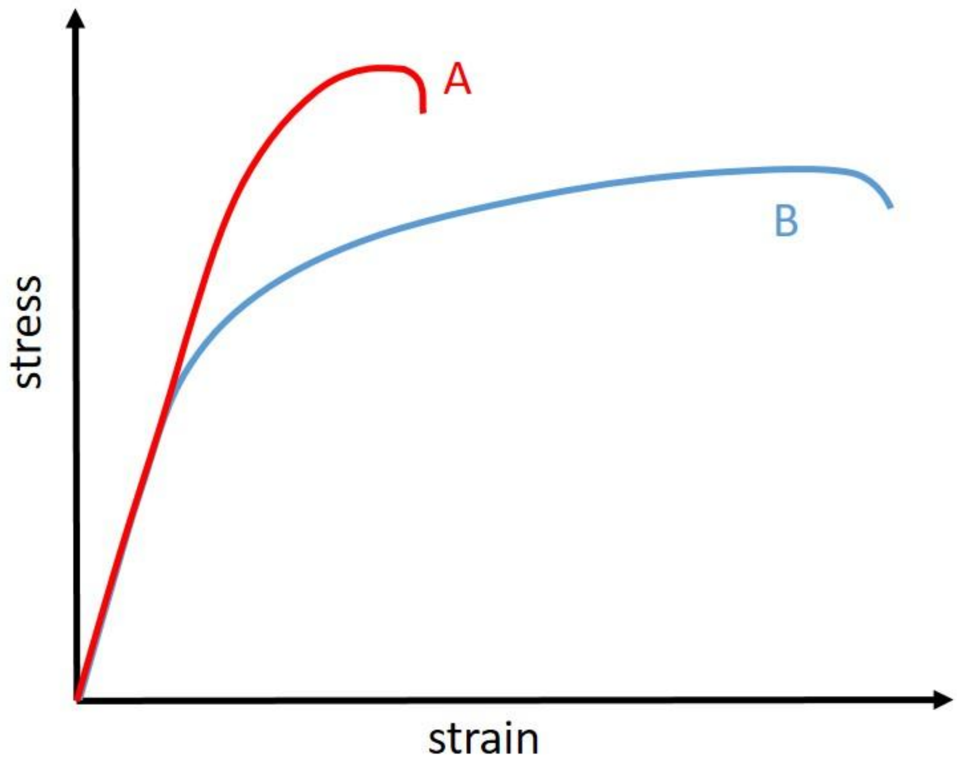
- … anelastic.
- … anisotropic.
- … allotropic.
- … auxetic.
- … atactic.
- … amorphous.

Which lattice defects can cause a higher stiffness?

Vælg en svarmulighed

- ○ Interstitial atoms
- ○ Dislocations
- ○ Grain boundaries
- ○ Pores

Compare the stress strain curves from two specimens A and B as shown in the figure.



Which statement is correct?

Vælg en svarmulighed

- ◯ Specimen B is stiffer than specimen A.
- ◯ Specimen B is stronger than specimen A.
- ◯ Specimen B is less ductile than specimen A.
- ◯ Specimen B is tougher than specimen A.

Large plastic deformation of aluminium leads to substantial changes in several of its properties. Which change does <u>**not**</u> arise as a consequence of plastic deformation by compression?

Vælg en svarmulighed

- ○ A decrease in ductility.
- ○ An increase in strength.
- ○ A decrease in electrical conductivity.
- ○ An increase in density.

Two molybdenum specimens have rather different yield stresses (1680 MPa and 300 MPa) due to their different grain sizes (0.2 µm and 500 µm). Which grain size will cause a yield stress of 600 MPa in molybdenum?

Vælg en svarmulighed

- ○ About 0.9 µm
- ○ About 3.7 µm
- ○ About 9.6 µm
- ○ About 310 µm

Compare the properties of binary alloys formed by two completely miscible metallic elements with the properties of the two pure elements. Which statement is correct? There exists always an alloy composition for which the binary alloy has …

Vælg en svarmulighed

- ○ … a higher mass density than both elements.
- ○ … a higher compliance than both elements.
- ○ … a lower melting point than both elements.
- ○ … a lower ductility than both elements.

Molybdenum and tungsten are completely miscible in each other. Which defects are responsible for the superior strength of some of the Mo-W alloys compared to the pure elements?

Vælg en svarmulighed

- ○ Interstitial atoms
- ○ Substitutional atoms
- ○ Phase boundaries
- ○ Small particles

Molybdenum and tungsten are completely miscible in each other. Which of the three primary types of atomic bonds (metallic bonds, ionic bonds and covalent bonds) are present in binary molybdenum-tungsten alloys?

Vælg en svarmulighed

- ○ Solely metallic bonds.
- ○ Metallic bonds and ionic bonds.
- ○ Metallic bonds and covalent bonds.
- ○ Metallic bonds, ionic bonds and covalent bonds.

The semiconductor InSb crystallizes in the zinc blende (ZnS) structure. The table summarizes some properties of the elements.

Element	Electronegativity	Atomic radius
In	1.7	0.155 nm
Sb	1.9	0.145 nm

What could be the reason for the zinc blende structure?

Vælg en svarmulighed

- The similar ratio between the atomic radii of In and Sb.
- The large difference in electronegativity between In and Sb.
- The dominating ionic bonding in InSb.
- The dominating covalent bonding in InSb.

The ionic ceramics CaS, CuI, KBr, and TlCl show distinctively different crystal structures and fractions of ionic bonding. The table summarizes the properties of the elements.

Element	Valence	Electronegativity (Pauling)	Atomic radius / nm	Ionic radius / nm
Br	-1	2.8	0.115	0.196
Ca	+2	1.0	0.180	0.100
Cl	-1	3.0	0.100	0.181
Cu	+1	1.9	0.135	0.077
I	-1	2.5	0.140	0.220
K	+1	0.8	0.220	0.138
Tl	+1	1.8	0.144	0.173
S	-2	2.5	0.100	0.184

Which of the four compounds crystallizes in sodium chloride structure (rock salt structure) and has the smallest fraction of ionic bonding?

Vælg en svarmulighed

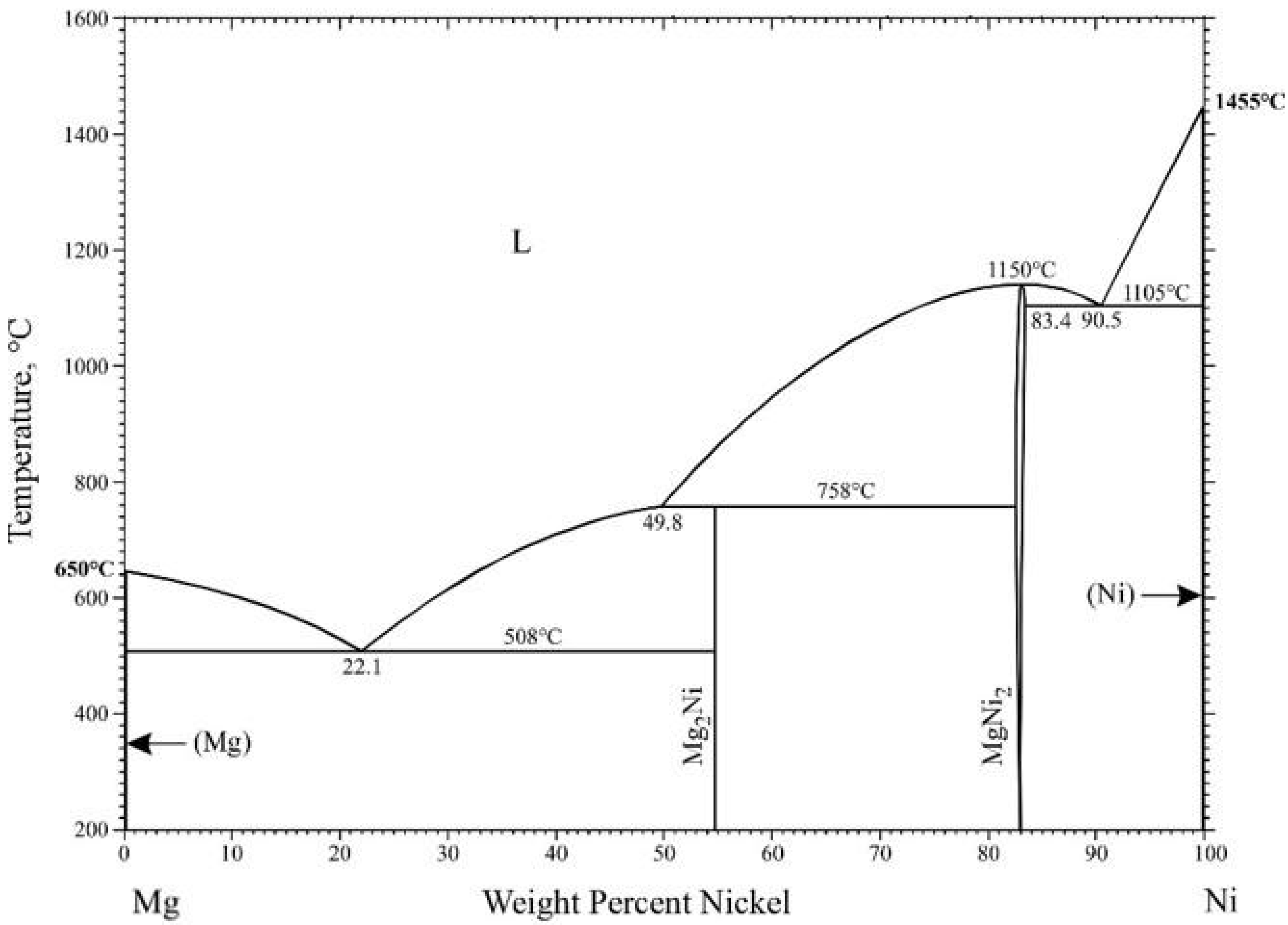
- CaS
- CuI
- KBr
- TlCl

The tensile strength of a ceramic material becomes higher, …

Vælg en svarmulighed

- … when the porosity is increased.
- … when the temperature is increased.
- … when the mass density is increased.
- … when the grain size is increased.

The figure shows the phase diagram of the binary alloy system magnesium-nickel (Mg-Ni). No changes occur between 200 °C and room temperature.

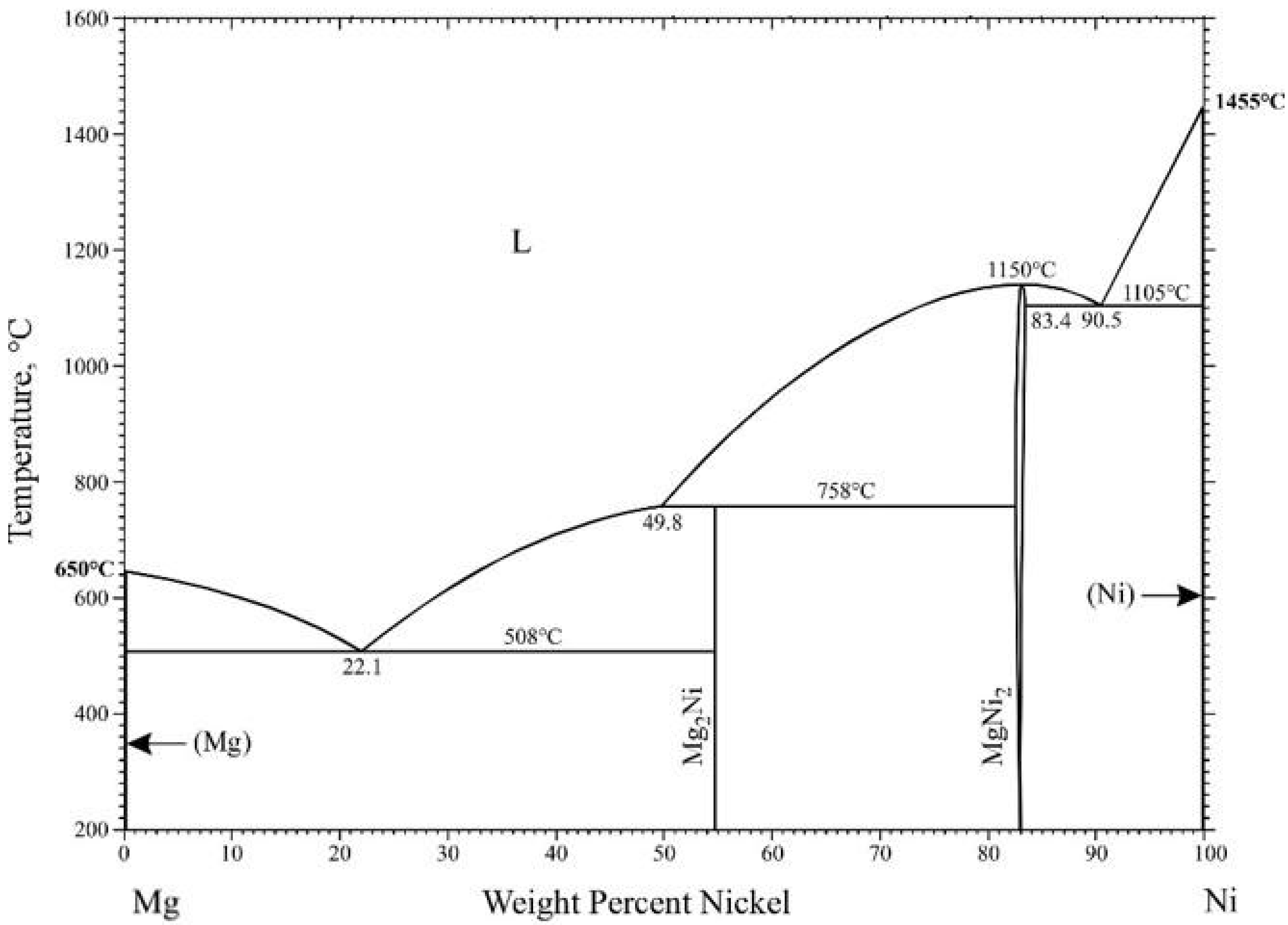


A melt of a magnesium-nickel alloy with 52 wt.% Ni is cooled slowly from 1500 °C to room temperature. How many different solid phases of the four solid phases (Mg), Mg_2Ni, $MgNi_2$, and (Ni) in the phase diagram are formed at some instant during the solidification process?

Vælg en svarmulighed

- 1
- 2
- 3
- 4

The figure shows the phase diagram of the binary alloy system magnesium-nickel (Mg-Ni). No changes occur between 200 °C and room temperature.

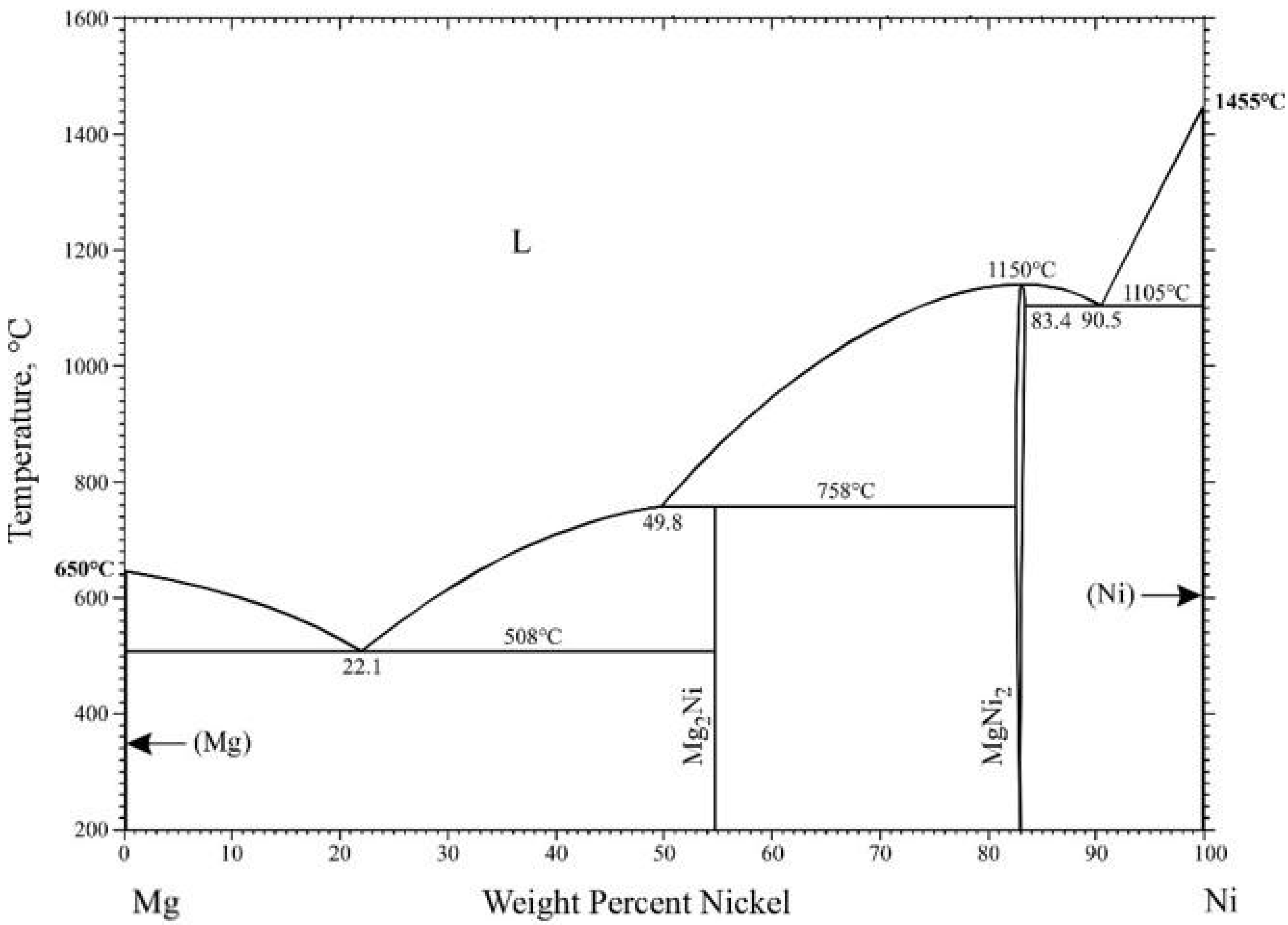


A melt of a magnesium-nickel alloy with 52 wt.% Ni is cooled slowly from 1500 °C to room temperature. What is the lowest Ni content possible in the melt during solidification?

Vælg en svarmulighed

- 0 wt.%
- 22.1 wt.%
- 49.8 wt.%
- 52 wt.%

The figure shows the phase diagram of the binary alloy system magnesium-nickel (Mg-Ni). No changes occur between 200 °C and room temperature.

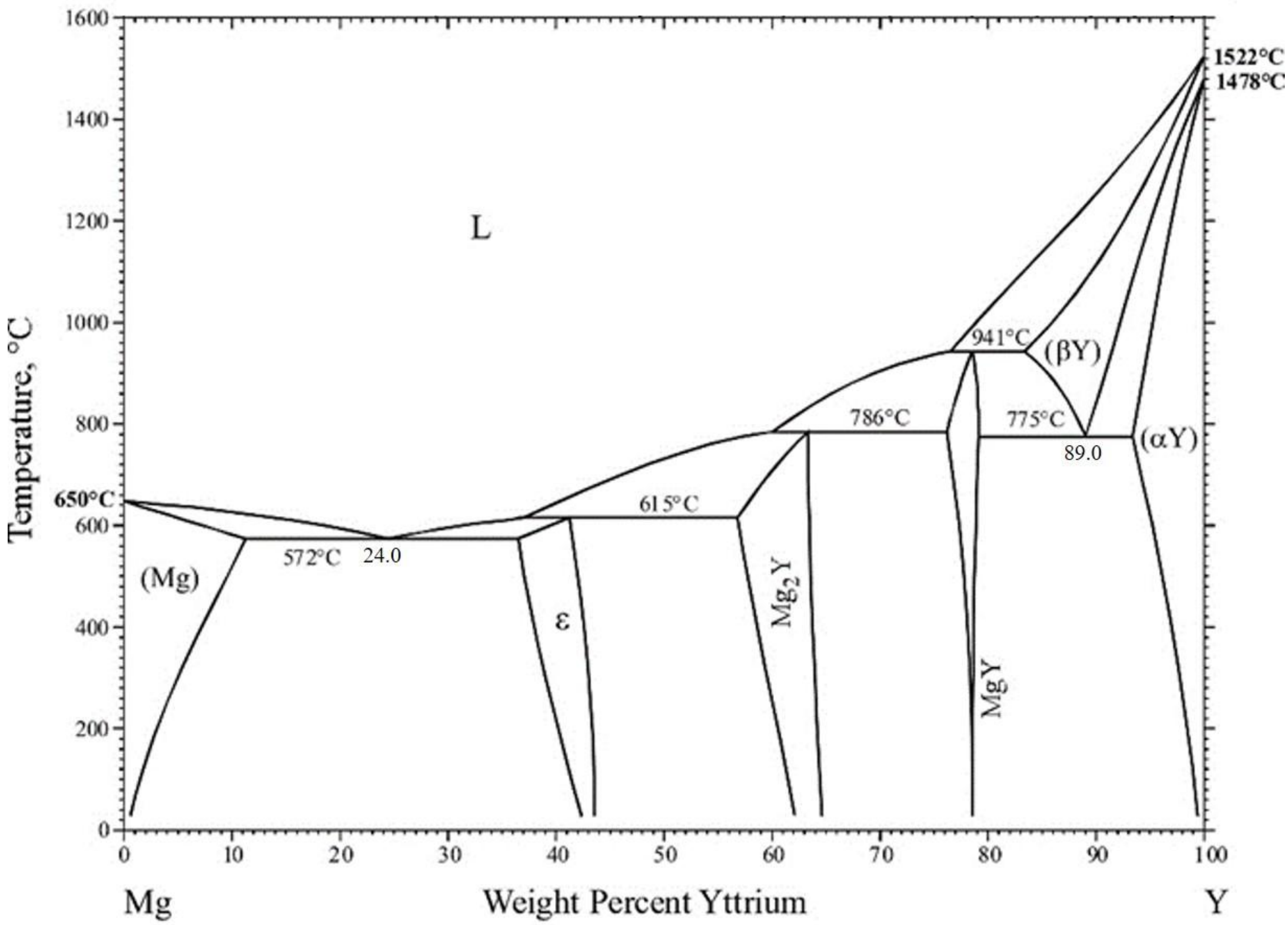


A melt of a magnesium-nickel alloy with 95 wt.% Ni is cooled slowly from 1500 °C to room temperature. What is the mass of (Ni) for a melt of 3.5 kg?

Vælg en svarmulighed

- About 1.0 kg
- About 1.5 kg
- About 2.0 kg
- About 2.5 kg
- About 3.3 kg

The figure shows the phase diagram of the binary alloy system magnesium-yttrium (Mg-Y). The lines end at room temperature.

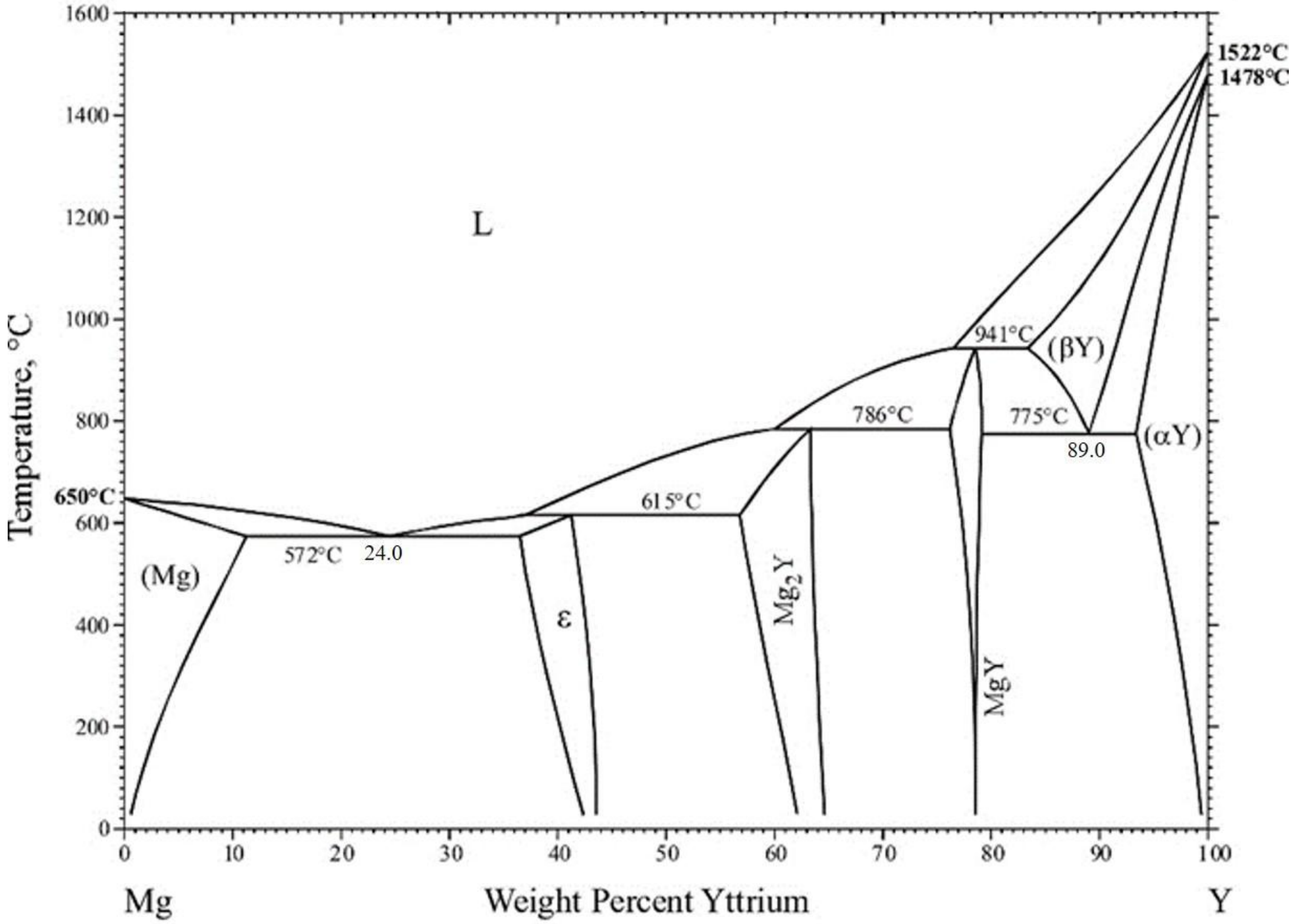


Does the phase diagram contain eutectic points?

Vælg en svarmulighed

- Yes, one at 775 °C for 89.0 wt.% Y.
- Yes, one at 572 °C for 24.0 wt.% Y.
- Yes, several for different temperatures and compositions.
- No, there is no eutectic point.

The figure shows the phase diagram of the binary alloy system magnesium-yttrium (Mg-Y). The lines end at room temperature.



What is the maximum solubility of Mg in solid yttrium?

Vælg en svarmulighed

- About 7 wt.% Mg
- About 11 wt.% Mg
- About 16 wt.% Mg
- About 84 wt.% Mg
- About 89 wt.% Mg
- About 93 wt.% Mg

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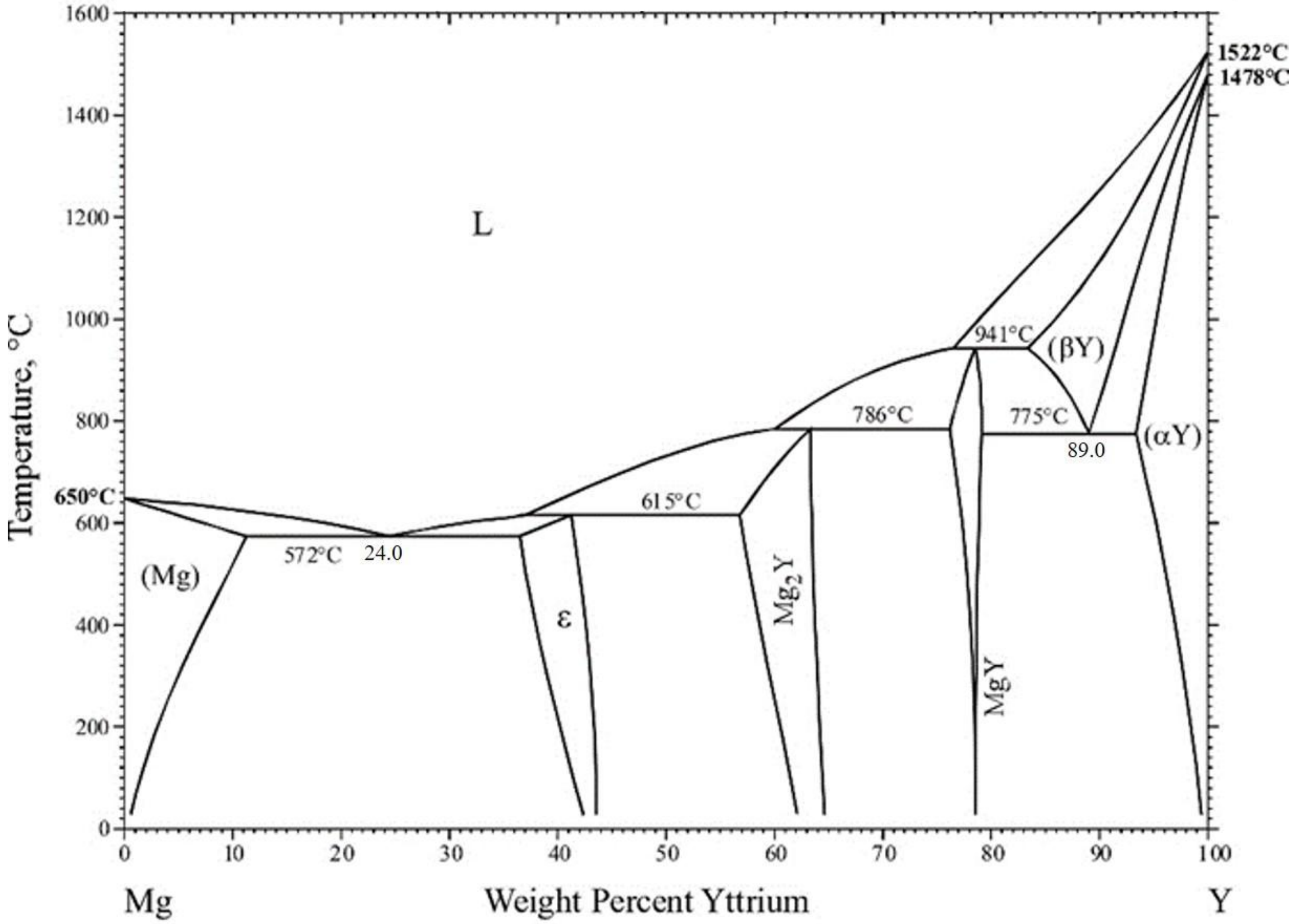
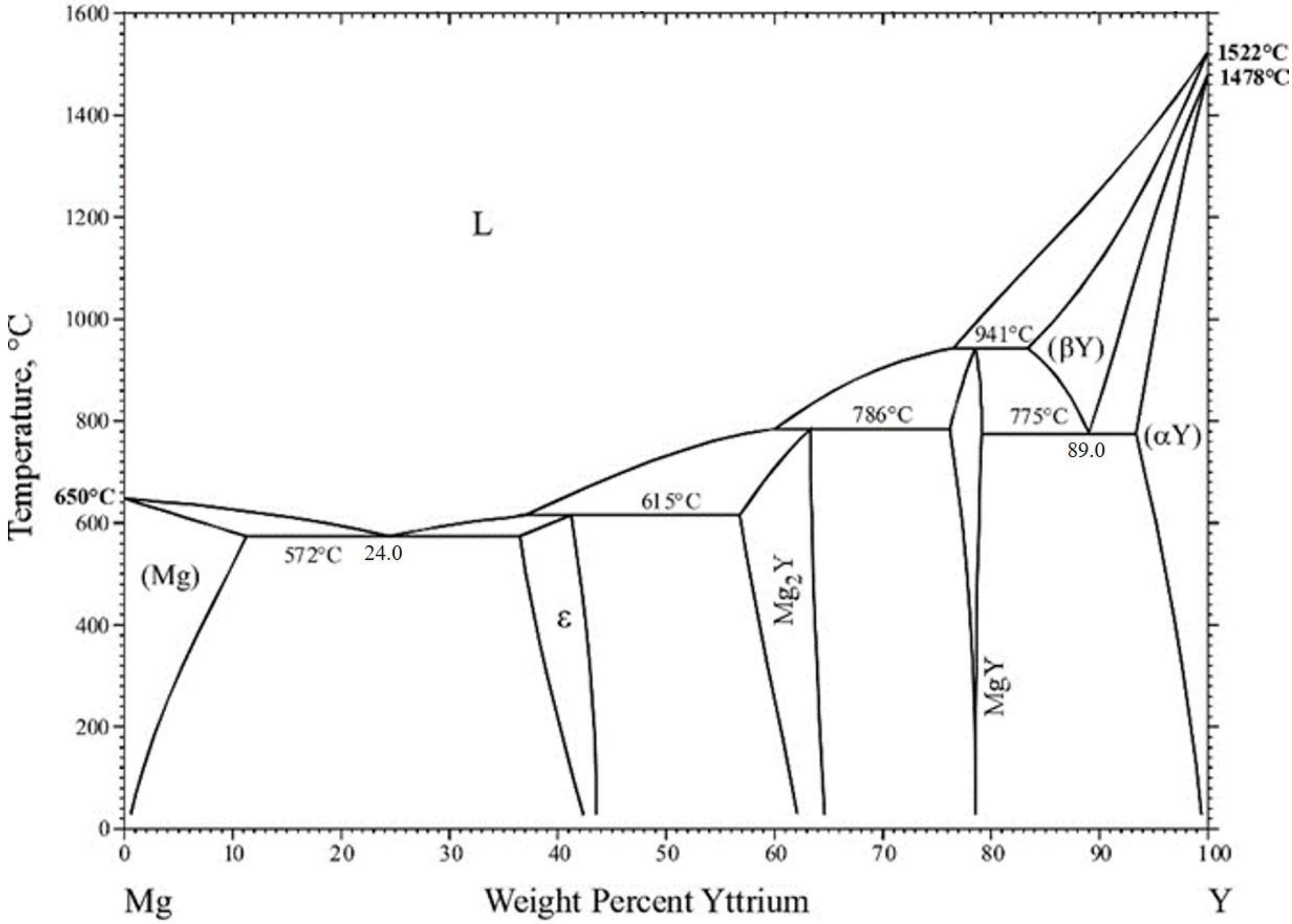


A melt of a magnesium-yttrium alloy with 70 wt.% Y is cooled slowly from 1500 °C to room temperature. Which is the first solid phase formed?

Vælg en svarmulighed

- MgY
- MgY + L
- Mg_2Y
- Mg_2Y + L
- (ß-Y)
- (ß-Y)+L

The figure shows the phase diagram of the binary alloy system magnesium-yttrium (Mg-Y). The lines end at room temperature.



A melt of a magnesium-yttrium alloy with 89.0 wt.% Y is cooled slowly from 1500 °C to room temperature. Which microstructure is present at room temperature?

Vælg en svarmulighed

- ○ Solely a eutectoid structure with alternating lamellae of MgY and (α-Y)
- ○ A eutectoid with alternating lamellae of MgY and (α-Y) and additionally pro-eutectoid (ß-Y).
- ○ A eutectoid with alternating lamellae of MgY and (α-Y) and additionally pro-eutectoid (α-Y).
- ○ A eutectoid with alternating lamellae of MgY and (α-Y) and additionally pro-eutectoid (MgY).

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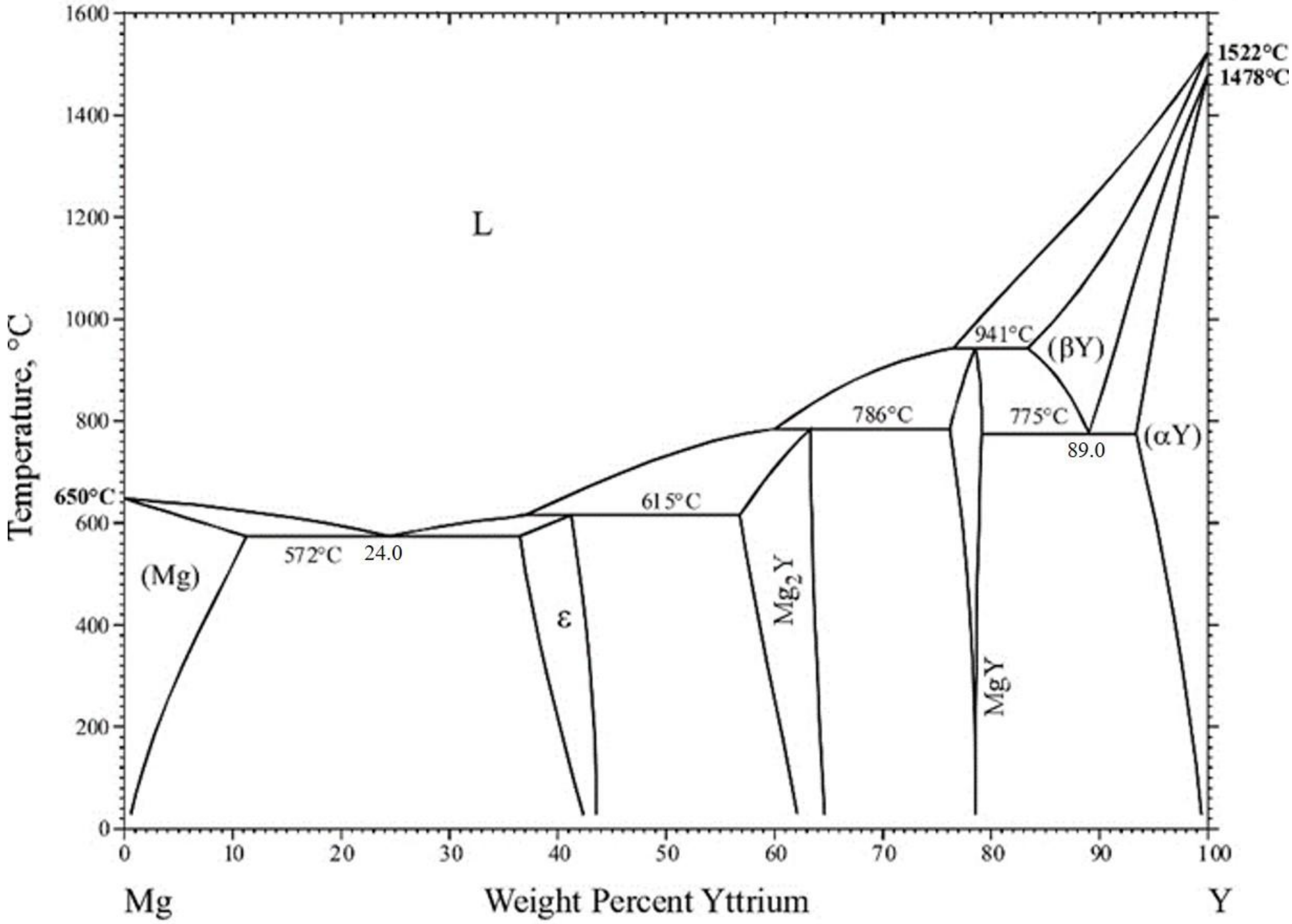
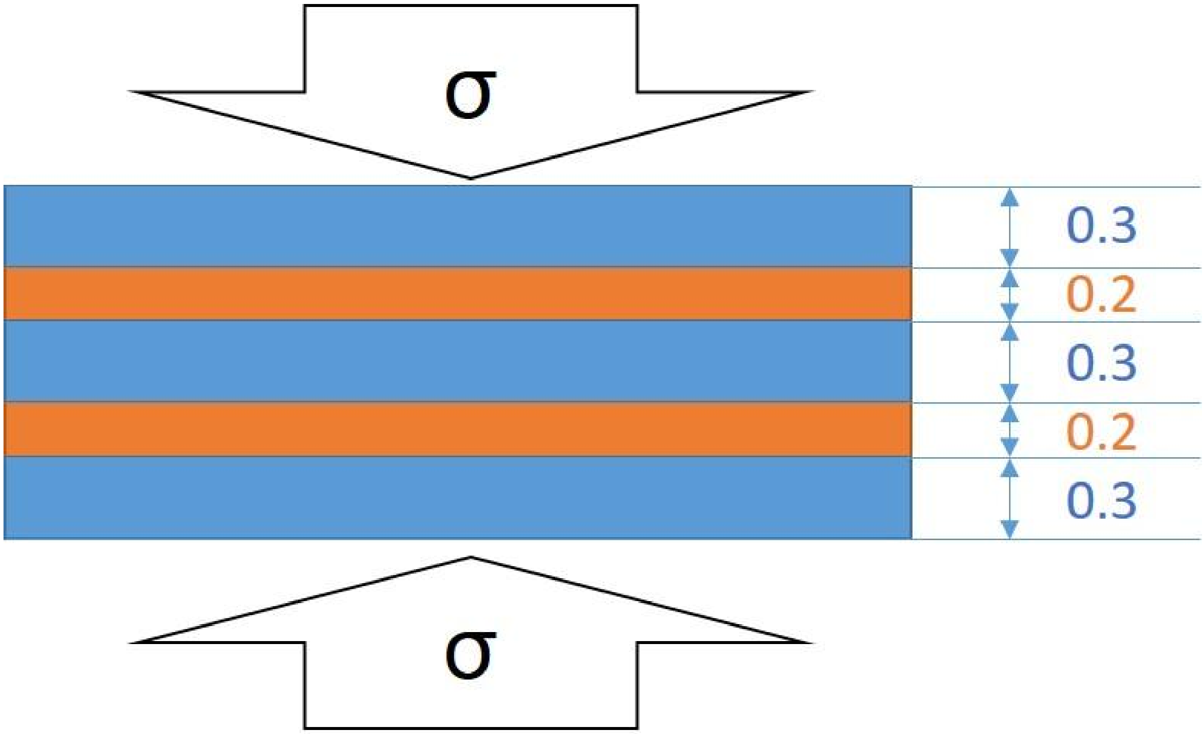


Compare the properties of four specimens with different compositions: specimen A is pure Mg, specimen B is a magnesium-yttrium alloy with 5 wt.% Y, specimen C is a magnesium-yttrium alloy with 20 wt.% Y and specimen D is a magnesium-yttrium alloy with 40 wt.% Y. Which statement is correct at 500 °C?

Vælg en svarmulighed

- Specimen A is the strongest.
- Specimen B is the softest.
- Specimen C is the most ductile.
- Specimen D is the most brittle.

In the aircraft industry, aluminium-polymer composites are used to reduce the effect of cracks. Consider the five-layer laminate composite illustrated in the figure made of three 0.3 mm thick layers of an aluminium alloy and two 0.2 mm thick layers of a polymer. The table summarizes the properties of the materials.



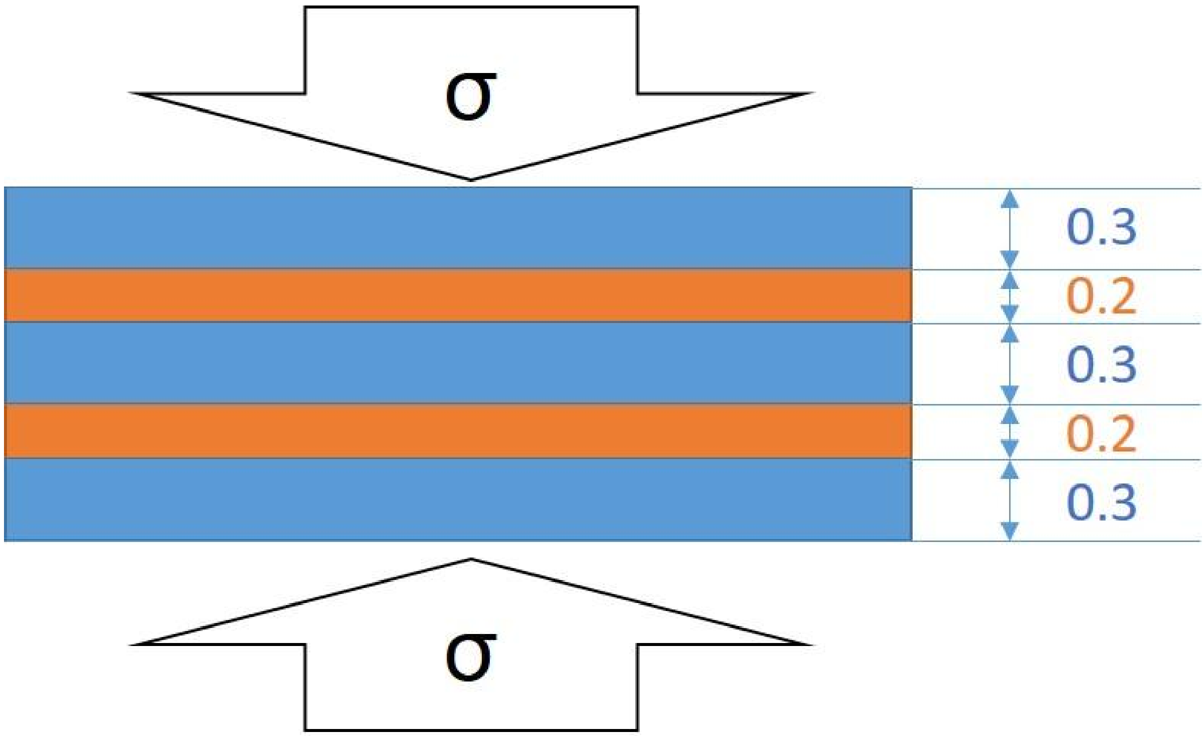
Material	Young's modulus	Shear modulus	Poisson ratio	Density	Yield strength
Al alloy	72.4 GPa	27.0 GPa	0.33	2.80 g/cm³	494 MPa
Polymer	27.0 GPa	10.1 GPa	0.34	1.38 g/cm³	373 MPa

What is the elastic strain of the laminate along the loading direction when a compressive stress of 200 MPa is applied perpendicular to the layers?

Vælg en svarmulighed

- ○ Less than 0.31%.
- ○ At least 0.31 %, but less than 0.36%.
- ○ At least 0.36 %, but less than 0.41%.
- ○ At least 0.41 %, but less than 0.46%.
- ○ At least 0.46 %, but less than 0.51%.
- ○ At least 0.51%.

Consider the five-layer laminate composite illustrated in the figure made of three 0.3 mm thick layers of an aluminium alloy and two 0.2 mm thick layers of a polymer. The table summarizes the properties of the materials.



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The aluminium-polymer lamellar composite shall replace an aluminium alloy plate of same height (1.3 mm). During service, the aluminium alloy plate is loaded in compression along its height to the maximum load it can endure without deforming plastically. Does the lamellar composite or, alternatively, a pure polymer plate of same height constitute a lightweight alternative to the aluminium alloy plate?

Vælg en svarmulighed

- ○ Yes, both, the lamellar composite and a polymer plate can substitute the aluminium alloy plate with less weight.
- ○ Yes, the lamellar composite can substitute the aluminium alloy plate with less weight, but the polymer plate cannot.
- ○ Yes, the polymer plate can substitute the aluminium alloy plate with less weight, but the lamellar composite cannot.

- ○ No, neither the lamellar composite, nor the polymer plate constitute a lightweight alternative to the aluminium alloy plate.

Consider silver with an electrical conductivity of $60 \cdot 10^6$ $(\Omega m)^{-1}$. A silver wire that is 20 cm long is subject to the requirement that the voltage drop should be 3 V when a current of 1 mA passes through it. What shall the diameter of the wire be?

Vælg en svarmulighed

- ○ 75 nm
- ○ 450 nm
- ○ 1.2 µm
- ○ 52 µm

Lead is a face-centered cubic material with a unit cell length of 0.495 nm. Assume there is one conduction electron per unit cell and an electrical conductivity of $4.8 \cdot 10^6$ $(\Omega m)^{-1}$. What is the drift velocity of the electrons in a field of 1 V/m?

Vælg en svarmulighed

- 3.6 mm/s
- 2.2 cm/s
- 8.4 m/s
- 59 m/s

The electrical conductivity of a certain ZnTe device is measured to be $1.0 \cdot 10^{-6}$ $(\Omega m)^{-1}$. The electron and hole mobilities of ZnTe are 0.053 m^2/Vs and 0.010 m^2/Vs, respectively. What is the intrinsic carrier concentration for ZnTe at room temperature?

Vælg en svarmulighed

- ○ $3.4 \cdot 10^{12}$ m^{-3}
- ○ 1.510^{13} m^{-3}
- ○ $9.9 \cdot 10^{13}$ m^{-3}
- ○ $1.5 \cdot 10^{14}$ m^{-3}

Polyethylene foam is a good thermal insulator. Which of the following statements does **not** provide a valid explanation for this property?

Vælg en svarmulighed

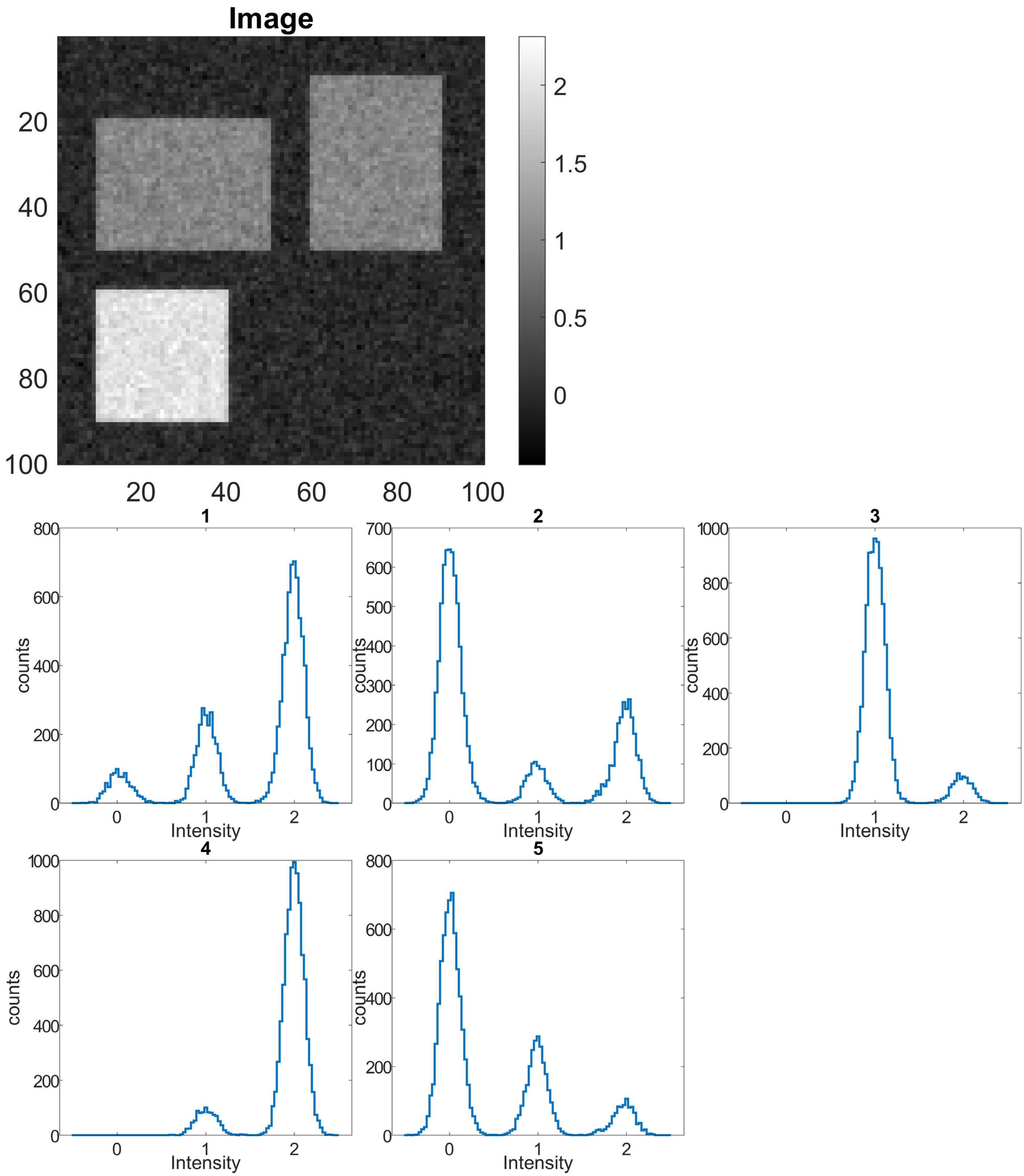
- Polyethylene foam is porous.
- Polyethylene foam is not crystalline and phonons cannot easily propagate.
- Polyethylene foam is not metallic and electrons cannot easily propagate.
- Polyethylene foam has a low heat capacity and cannot store heat.

A cubic lunch box with six sides of equal area ($10 \times 10\ cm^2$ each) contains ice to keep the temperature at 0 °C. The box is placed in a room with a constant temperature of 20 °C. The thermal conductivity of the lunch box material is 0.12 W/(m·K) and the container is everywhere 1 mm thick. Assuming steady state heat flow, what is the heat loss rate (that leads to melting of the ice)?

Vælg en svarmulighed

- 8.6 kJ/min
- 92 kJ/min
- 144 kJ/min
- 242 kJ/min

Consider the image and the histograms.

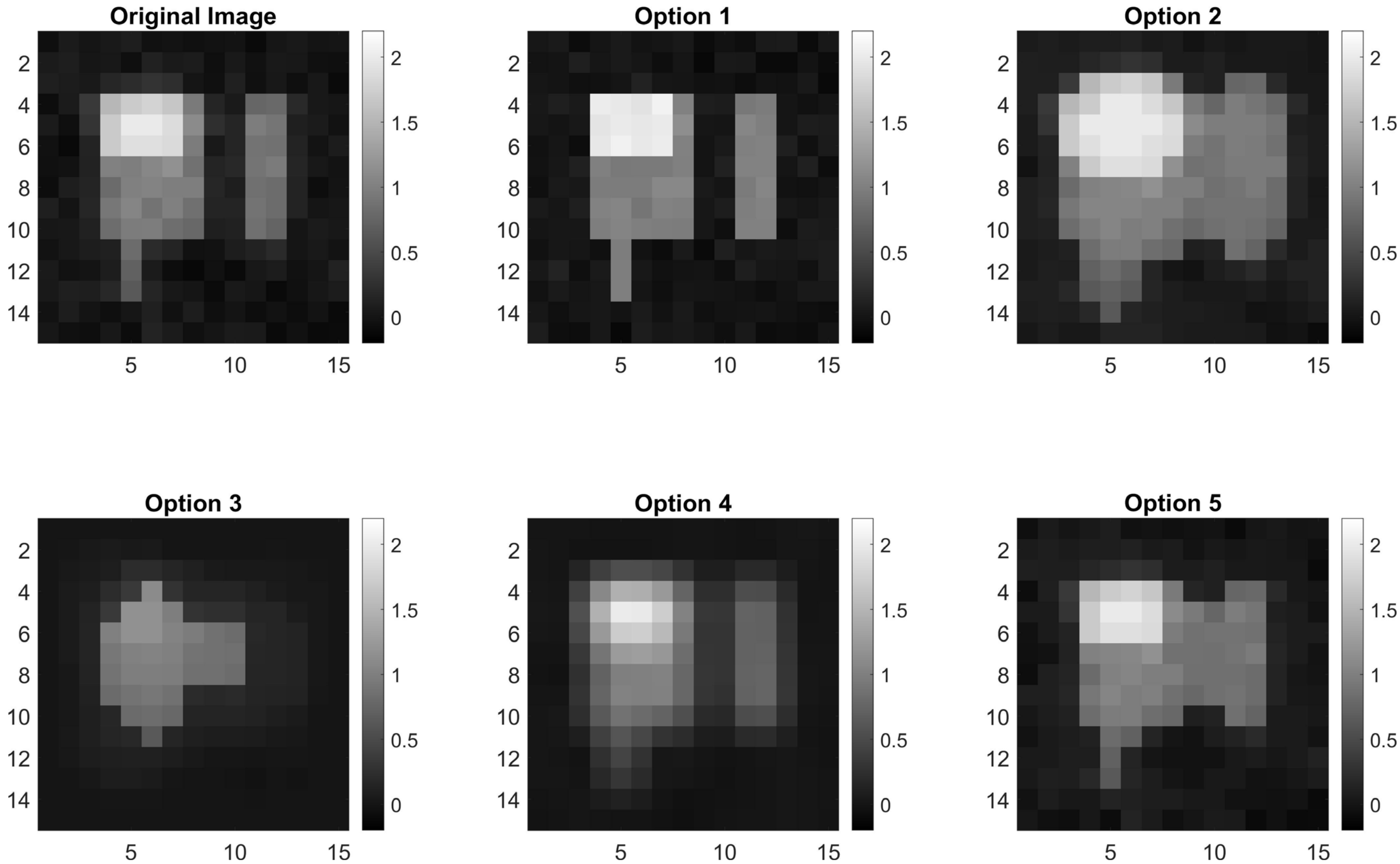


Which of the histograms shown corresponds to the image?

Vælg en svarmulighed

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5

Consider the small original image below with a size of 15 × 15 pixels.



Which of the five options given is the result of median filtering the original image with a median filter of size 5 × 5 pixels?

Vælg en svarmulighed

- 1
- 2
- 3
- 4
- 5

Consider a 3D image of a material consisting of two phases with a distinct interface between them. The image has 400 x 400 x 400 voxels and a voxel size of 3 µm x 3 µm x 3 µm. In the same image, the interface area between the two phases present is measured to be 3456 mm^2. What is the volume specific interface area between the two phases?

Vælg en svarmulighed

- 0.5 mm^2/mm^3
- 1.0 mm^2/mm^3
- 2.0 mm^2/mm^3
- 0.5 $\mu m^2/\mu m^3$
- 1.0 $\mu m^2/\mu m^3$
- 2.0 $\mu m^2/\mu m^3$

Consider modeling the temperature distribution in a metal rod as a 1D heat transfer problem using the heat equation. At one end of the metal rod the boundary condition $\partial u/\partial n = 0$ is used. What is the type and the physical interpretation of this boundary condition?

Vælg en svarmulighed

- A Neumann boundary condition describing an insulating boundary.
- A Neumann boundary condition describing a boundary with a set temperature of 0° C.
- A Dirichlet boundary condition describing an insulating boundary.
- A Dirichlet boundary condition describing a boundary with a set temperature of 0° C.
- A Laplacian boundary condition describing an insulating boundary
- A Laplacian boundary condition describing a boundary with a set temperature of 0° C.

Consider modeling the temperature distribution in a rod of metal as a 1D heat transfer problem using the heat equation. The rod is 1 m long. The two ends of the rod are defined at x = 0 m (point A) and x = 1 m (point B).
The initial temperature in the rod is u = 0 °C with the following boundary conditions:
Point A: u = 100 °C
Point B: u = 0 °C
In the steady state solution, what is the temperature at x = 0.4 m?

Vælg en svarmulighed

- u = 0 °C
- u = 40 °C
- u = 50 °C
- u = 60 °C
- u = 100 °C
- A steady state solution does not exist.