**Granta EduPack Exercises**

Author

Ansys Academic Development Team

**Multiple Choice Questions – Introduction to Materials**

These questions are written in GIFT format, so that they may be easily uploaded into Moodle or other Virtual learning environments. More information: https://docs.moodle.org/33/en/GIFT\_format

Some of the questions are a little repetitive so that you can choose which ones best suit your course and swap them from year to year.

As with any teaching resource we provide, we have reviewed the answers to these questions, however, it is important that you check that you agree with our answers and that if you find any inaccuracies, you please let us know so that we can correct them.

If you have any multiple-choice questions, in GIFT format, that you would be willing to share with other educators using Granta EduPack, please contact us.

These questions are part of **the Materials Science and Engineering Package**, which includes:

* An Overview Paper
* An Overview Lecture Unit
* Explore for yourself Active Learning Exercises
* Other related papers

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# Functional Materials

:::: All pyroelectric materials are also piezoelectric.

{T}

:::: Piezoelectric crystals are centrosymmetric.

{F}

:::: The Curie temperature of samarium-cobalt in degrees celsius is:

{=760 ~670 ~343 ~433}

:::: The pyroelectric coefficient of lithium tantalate is {~0.00023 ~25.7 ~23.1 =230} microcoulombs per metre squared per kelvin.

:::: The recorded semiconductor with the largest band gap is:

{~GaN ~Diamond =ZnS ~Graphite}

:::: Which of these has the highest ferroelectric Curie temperature?

{=Lithium Niobiate ~Bismuth Titanate ~Lithium Tantalate ~PVDF}

::::Which of these has the lowest saturation induction?

{~hard ferrite ~AlNiCo ~amorphous iron alloy =soft ferrite}

::::Which of these has the lowest direct band gap?

{=indium antimonide ~gallium nitride ~zinc sulfide ~bismuth telluride}

::::Diamond is a fullerene.

{F}

:::: Manganese-Nickel-Gallium alloy has a variable transition temperature

{T}

:::: which material is often used in mechanical watches?

{ ~PVDF =quartz ~PZT ~Barium Titanate}

:::: Which of these best describes the coercive force of a magnet?

{=The external magnetic field required to reverse magnetisation.

~The external electric field required to reverse polarisation.

~The external magnetic field required to reverse polarisation.

~The external electric field required to reverse magnetisation.}

:::: Which of these best describes a band gap in a semiconductor?

{~The energy difference between the valence band and the fermi energy.

~the energy difference between the fermi energy and the conduction band. =The energy difference between the valence and conduction bands.}

:::: Which of these best describes pyroelectricity?

{~The voltage across a crystal changes with strain.

=The voltage across a crystal changes with temperature.

~The charge stored on a crystal changes with temperature.   
~The charge stored on a crystal changes with strain.}

:::: A positive Seebeck coefficient indicates that the charge carriers are:

{=holes ~electrons}

:::: Heat conduction in diamond mainly arises from:

{=electrons ~phonons ~both}

:::: A good thermoelectric material requires:

{~high electrical conductivity, high thermal conductivity and high Seebeck coefficient.

=high electrical conductivity, low thermal conductivity and high Seebeck coefficient.

~low electrical conductivity, low thermal conductivity and low Seebeck coefficient.}

:::: The main contribution to the thermal conductivity of thermoelectric materials arise from:

{~phonons =electrons }

:::: Metals have lower Seebeck coefficient than semiconductors

{T}

# Phase Diagrams

$CATEGORY: Phase Diagrams/Ansys Materials Division

## Reading phase diagrams

:::: What is the upper limit of solubility of tin in solid lead (Pb), at any temperature?

{ ~18.3 at% =18.3 wt.% ~2.2 wt.% ~2.2 at%}

:::: The solubility of tin in solid lead (Pb) has a maximum at a temperature of {#183} degrees Celsius.

:::: According to the Al-Cu phase diagram, the limit of copper solubility in solid aluminum is:

{~33 wt. % ~54 wt. % =6 wt. % ~0 wt. %}

:::: The maximum solubility of carbon in austenite is:

{ =2.14 wt.% ~0.76 wt.% ~0.02 wt.% ~4.30 wt.%}

:::: The silica-alumina phase diagram has a eutectic reaction at a composition of {#7..9} wt.% alumina.

:::: The Fe-C phase diagram has a eutectic reaction at which composition?

{~0.76 wt.% C ~2.14 wt.% C =4.30 wt.% C }

:::: The copper-nickel phase diagram forms a complete solid solution across all compositions.

{T}

## Identifying phases in given conditions

:::: Which phases are present in the alloy Al-10 wt.% Cu at 600 degrees Celsius?

{=%50%Aluminum solid solution, %50%Liquid ~%-100%Theta phase ~%-100%Copper solid solution}

:::: Which phases are present in equilibrium for a mixture of 80 wt.% silica, 20 wt.% alumina at 1500 degrees Celsius?

{ ~Liquid, Mullite =Cristobalite, Mullite ~Alumina, Mullite ~Mullite}

:::: Which phases are present in equilibrium for Cu-65 wt.% Zn at 600 degrees Celsius?

{=gamma ~alpha ~alpha, beta ~beta, gamma}

:::: The eutectic temperature of the silica-alumina system is 1587 degrees Celsius.

{T}

:::: The melting point of pure aluminum is {#660} degrees Celsius.

:::: The eutectic temperature of the Fe-C system is 727 degrees Celsius.

{F}

:::: On cooling, at what temperature does 50 wt.% Cu-50 wt.% Ni begin to solidify?

{#1310..1340} degrees Celsius

:::: At what temperature does iron with 3 wt.% carbon begin to melt?

{#1147} degrees Celsius

:::: What is the lowest melting temperature of any binary Pb-Sn alloy?

{#183} degrees Celsius

## The Lever Rule, calculating weight fractions and compositions

:::: In equilibrium, what weight percentage of the theta phase is present in Al-10 wt.% Cu at 200 degrees Celsius?

{#19:1}

:::: In steel, when pearlite forms from austenite at the eutectoid temperature, what weight percentage of cementite is present?

{#10..12}

:::: A sample of silica-alumina contains 75 wt.% mullite and 25 wt.% alumina. What is its overall composition?

{#79..82} wt. % alumina

:::: A hypoeutectoid steel is held at the eutectoid temperature. In total, it contains 90 wt.% ferrite and 10 wt.% cementite. If it was cooled slowly from liquid in equilibrium, what weight percentage of the steel is pearlite?

{#89..91} wt. % pearlite

## Reactions

:::: Which of these best describes a peritectic reaction, where L is a liquid and A, B, C are solids?

{ =A + L -> B ~L -> A + B ~A -> B + C ~A + B -> C}

:::: Which of these best describes a eutectic reaction, where L is a liquid and A, B, C are solids?

{ ~A + L -> B =L -> A + B ~A -> B + C ~A + B -> C}

:::: Which of these best describes a eutectoid reaction, where L is a liquid and A, B, C are solids?

{ ~A + L -> B ~L -> A + B =A -> B + C ~A + B -> C}

// The following questions are based on exam questions kindly shared by Andy Horsewell of DTU Denmark.

//

:::: How many single phase regions are shown in the Pb-Sn phase diagram?

{#3:0}

:::: From the Al-Mg phase diagram: What is the composition of maximum solid solubility of Mg in Al?

{=17 wt.% Mg ~36 wt.% Mg ~66 wt.% Mg ~100 wt.% Mg}

:::: From the Al-Mg phase diagram: What is the composition of the precipitates that can be formed by precipitation hardening (i.e. solution treating, quenching and hardening) of an alloy containing 6 wt.% Mg in Al?

{~6 wt.% Mg ~17 wt.% Mg =36 wt.% Mg ~100 wt.% Mg}

:::: How many two-phase regions are there on the Pb-Sn (lead-tin) diagram?

{~1 ~2 =3 ~6}

:::: Which of these compositions of Pb-Sn (lead-tin) alloy is best suited to soldering electronic components?

{~4 wt.% Pb =40 wt.% Pb ~60 wt.% Pb ~95 wt.% Pb}

:::: The Al-Cu system is used for precipitation hardening alloys. What is the composition of maximum solid solubility of Cu in Al?

{=6 wt.% Cu ~33 wt.% Cu ~54 wt.% Cu ~100 wt.% Cu}

:::: What is the composition of the precipitates that can be formed by precipitation hardening (i.e. solution treating, quenching and hardening) of an alloy containing 10 wt.% Cu in Al?

{~6 wt.% Cu ~10 wt.% Cu =54 wt.% Cu ~100 wt.% Cu}

:::: The Cu-Zn system is commonly known as brass. Which brass alloy is used to make musical instruments like trumpets and trombones, and gun cartridges? These components require a large amount of deformation during manufacture, such rolling and deep-drawing, to make them.

{=\~30 wt.% Zn ~\~40 wt.% Zn ~\~65 wt.% Zn ~Any of the above}

:::: Very slow cooling of mixtures of lead (Pb) and tin (Sn) produces an equilibrium phase diagram of the type known as a binary eutectic phase diagram. How many regions on the phase diagram show 2 phases in equilibrium?

{~1 ~2 =3 ~4}

:::: Consider a molten alloy of Pb-Sn containing 80 wt.% Sn at a temperature of 300 degrees Celsius. We assume that Pb and Sn are homogeneously mixed in the liquid phase. Next, consider what happens as the melt is slowly cooled to room temperature. What is the composition of the last liquid just before solidification is complete?

{~18.3 wt.% Sn =61.9 wt.% Sn ~80 wt.% Sn ~100 wt.% Sn}

:::: The annealing at constant temperature of super-saturated alloy solid solutions of Al-Cu results in the following sequence of precipitation: GP zones -- theta'' precipitates -- theta' precipitates -- theta precipitates. What is the equilibrium phase?

{~GP zones ~theta'' precipitates ~theta' precipitates =theta precipitates}

:::: How many peritectic points are there in the Cu-Zn phase diagram?

{#5}

:::: What is the initial composition of the austenite that forms when 3 wt. % carbon-steel is slow-cooled from the liquid phase?

{#1.2..1.5} wt. % carbon

# Crystal structures

:::: The crystal structure of alpha brass is:

{ =face-centred cubic ~body-centred cubic ~hexagonal close packed ~tetragonal}

:::: The crystal structure of beta brass is:

{ =body-centered cubic ~face-centered cubic ~hexagonal close packed ~body-centered tetragonal}

:::: The crystal structure of alpha ferrite is:

{ ~face-centered cubic ~hexagonal close packed ~body-centered tetragonal =body-centered cubic }

:::: The crystal structure of pure tin is:

{ ~body-centered cubic ~ face-centered cubic ~hexagonal close packed  
=body-centered tetragonal}

# Property-Process Profiles

## 1. Alloying and Working: Copper alloys

:::: Cold working increases the ductility of a metal.

{F}

:::: Work Hardening does not affect the Young's Modulus of a metal.

{T}

:::: Which metal has the lowest fracture toughness?

{=precipitate hardened copper-beryllium ~fully cold-worked copper ~70% wt copper-nickel alloy ~work-hardened copper-beryllium alloy}

## 2. Heat Treatment: carbon and alloy steels

:::: A high temperature heat treatment of martensite will:

{=soften and toughen it ~harden and embrittle it ~harden and toughen it ~not affect it's mechanical properties}

:::: Normalization requires {=more rapid ~less rapid ~equally rapid} cooling from the austenite phase than annealing.

:::: Annealing gives a tougher, more ductile steel than normalization.

{T}

:::: How does the addition of a small amount of manganese affect the electrical conductivity of a steel?

{=it increases ~it decreases ~it is unchanged}

:::: Which of these materials has the lowest mechanical loss coefficient?

{=martensite ~pure iron ~annealed AISI 4340 steel ~normalized AISI 1137 steel}

## 3. Alloying and heat treatment: stainless steel

:::: Which of these classes of stainless steel has the highest ductility (greatest elongation percentage)?

{=austenitic ~martensitic ~precipitate-hardened martensite}

:::: What is the maximum service temperature of austenitic stainless steels?

{#750..980} Celsius

:::: Tougher stainless steels tend to be more expensive.   
{T}

## 4. Alloying and heat treatment: aluminum alloys

:::: Age-hardened aluminum alloys have an excellent combination of toughness and hardness.

{T}

:::: 5000 series wrought aluminum has {=lower ~higher} thermal conductivity than 1000 series.

:::: Which of these has the lowest melting point?

{=Al 520.0, T4 casting alloy ~Al 1050, H0 wrought alloy ~Al 6061, T6 wrought alloy}

:::: Harder aluminum alloys are also more ductile.

{F}

## 5. Filling and reinforcement: polymers

:::: Which filler gives higher strength and stiffness to polypropylene given the same degree of filling?

{=long glass-fiber ~chopped glass-fiber ~talc ~calcium carbonate}

:::: In metals, increased hardness often comes at the cost of reduced toughness. Is this true in filled polypropylene?

{=no ~yes}

:::: The failure elongation percentage of polypropylene decreases with increased degree of filling.

{T}

:::: A greater stiffness of filled polymer leads to a greater mechanical loss coefficient.

{F}

:::: Which filler gives the greatest increase in thermal conductivity for polypropylene?

{=long glass-fiber ~chopped glass-fiber ~talc ~calcium carbonate}

## 6. Powder processing: alumina

:::: Alumina can be used as a dielectric. The AC power loss is determined by the product of dielectric constant and dissipation factor. As the porosity increases, the AC loss:

{=decreases ~increases ~remains constant}

:::: Yield strength increases with decreasing porosity in alumina.

{T}

:::: Thermal conductivity increases with increasing porosity.

{F}

:::: Yield strength increases with decreasing porosity in alumina.

{T}

:::: Thermal conductivity increases with increasing porosity.

{F}

:::: As porosity increases the young's modulus of alumina:

{=decreases ~increases ~remains constant}

## 7. Foaming

:::: Foams are often used as thermal insulators. Trapped air pockets within them greatly reduce their thermal conductivity.

{T}

:::: Foams are favored as fillers for sandwich panels for their comparatively low weight.

{T}

:::: Foaming a material increases its young's modulus.

{F}

:::: Which of recorded foam is best suited to being used in an energy absorbing crumple zone? the energy absorbed by a crushed foam is equal to yield strength squared divided by young's modulus.

{=36% aluminum/silicon carbide ~12% polyethylene ~24% zirconia}

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