

Material Science

Exam Information	Description
Exam number 6625 Items 33 National Career Cluster Advanced Manufacturing Certification available Yes	The Material Science industry certification exam assesses learners' knowledge of the basic skills necessary for transitioning to either college-level study or the workplace. It covers the development and use of materials, emphasizing job opportunities in today's marketplace. Basic principles of physics, chemistry, and biology are used to enhance the learning experience and provide the scientific basis for the study of materials.

Exam Blueprint and Performance Skills

Standard	Percentage of exam score
1. Safety Practices	4%
2. Material Properties	17%
3. Metal Properties	17%
4. Polymers Properties	22%
5. Ceramic & Glass Properties	17%
6. Composite Properties	19%

*Includes performance skill evaluation

Standard 1 - Safety Practices (8% of exam score)

3D modeling with dimensional and geometric size constraints

Objective 1 A student's notebook/portfolio records:

1. Assess workplace conditions regarding safety and health.
2. Identify potential safety issues and align with relevant safety standards to ensure a safe workplace/jobsite.
3. Locate and understand the use of shop safety equipment.
4. Select appropriate personal protective equipment.
5. Learn about and obtain useful information from Safety Data Sheets.

Objective 2 Use safe work practices.

1. Use personal protective equipment according to manufacturer rules and regulations.
2. Follow correct procedures when using any hand or power tools.

Objective 3 Complete a basic safety test without errors (100%) before using any tools or shop equipment

Standard 2 - Material Properties (17%)

Candidates will understand the basic nature and properties of materials

Objective 1 Demonstrate a basic understanding of Chemistry.

1. Know the principal parts of an atom.
2. Demonstrate the use of the periodic table as a meaningful tool.
3. List the different types of chemical bonds.
4. Give examples of allotropes.
5. Explain how heat and energy are related to different states of matter.

Objective 2 Identify different types of materials in both household and industrial products through examination.

1. Separate them into four groups: metals, ceramics and glasses, polymers, and
2. composites.
3. Describe the basic differences between the groups and show evidence of
4. similarities.
5. Describe the thermal properties of materials.
6. Describe the electrical properties of materials.
7. Describe the strength of materials.
8. Identify and once again separate materials into two categories: crystalline and amorphous.

Objective 3 Know three kinds of crystalline structures for metals and that solids may have more than one crystalline structure.

1. Body Centered Cubic (BCC)

2. Face Centered Cubic (FCC)
3. Hexagonal Close Packed (HCP)
4. Identify the effects of heat on crystalline structure (heat treating)

Objective 4 List and identify several types of stress to which materials are exposed.

1. Tension
2. Compression
3. Torsion
4. Shear

Objective 5 Identify tests as destructive or nondestructive.

1. Make predictions based on data from a destructive test.

Objective 6 Describe the significant developments in the history of materials

1. Investigate and report how the use of materials has changed throughout history.
2. Provide an example of how each group of materials is used in today's society.
3. Describe and report on the development of technology and the use of materials.

Objective 7 State ways in which materials have been closely related to the advancement of civilizations throughout history.

1. Provide an example from each category of material used in today's society.
2. Explain how science and technology complement one another.
3. Explain that the most easily obtained elements are generally the most used ones.

Standard 3 - Metal Properties (17%)

Candidates will understand the basic nature of metals.

Objective 1 Examine the characteristics of metals.

1. State several properties of metals.
2. Identify where the metallic elements are found on the periodic table.
3. Define what a ferrous metal is.

Objective 2 Describe the changes in metals and their structures through mechanical treatments.

1. Explain that the ductility of a metal is related to its crystalline structure.
2. Examine the changes in a metal through work hardening and cold hardening of metals. (e.g., rolling, drawing wire, bending, etc).
3. Conduct an experiment on the treatment of metals. (e.g., annealing, quenching, tempering, and solutionizing and aging in aluminum).

Objective 3 Investigate the properties of alloys.

1. Explain that the term "metals" includes elements and alloys.
2. State at least two reasons for forming alloys.
3. Create a simple binary alloy. Conduct an experiment on the effects of temperature and construct a phase diagram of the binary alloy. Explain the areas of interest on the phase diagram (e.g., solid regions, liquid regions, slush regions, eutectic point).

4. Conduct an experiment for molding metals. (e.g., plaster casting, sand casting, silicon casting.)
5. Relate mechanical properties to manufacturing properties, weldability, machinability, formability, and castability.

Objective 4 Demonstrate an understanding of the effects of corrosion on metals.

Objective 5 List characteristics of both oxidation and reduction.

Objective 6 Reference a reactivity chart to determine which of two elements is more reactive.

Objective 7 Test a variety of metal samples.

1. Describe and perform a tensile test.
2. Describe the elastic limit.
3. Describe what is shown by a stress-strain graph.
4. Impact test
5. Hardness test

Standard 4 - Polymers Properties (22%)

Candidates will understand the basics of polymers.

Objective 1 Analyze polymer structures.

1. Explain that polymers are molecular compounds made of nonmetals.
2. Define a hydrocarbon.
3. Describe the process of creating a polymer by addition and condensation.
4. Differentiate between natural polymers and man-made polymers.
5. Understand glass transition and melting temperature.

Objective 2 Characterize polymers.

1. Differentiate between thermoplastics, thermosets, and elastomers.
2. Construct experiments on various types of polymers and demonstrate how cross-linking affects polymers. (e.g., thermal plastics, epoxy resin, flexible and rigid foams, latex balls, Gak®, and Slime®).
3. Differentiate between the various types of polymers, their properties and report on their uses. (e.g., PETE, HDPE, PVC, LDPE, PP, PS).

Objective 3 Research the issues with plastics and polymer recycling.

1. Research and report on the recycling of plastics and polymers. (e.g., PETE, HDPE, PVC, LDPE, PP, PS).
2. Differentiate between the various recycling codes and how they affect our local communities.
3. Analyze the effects of recycling on our global community.
4. Explain that a large number of monomers can be used to make polymers.
5. Describe how individual polymers can be formed from two or more different types of monomers.
6. State that changing one part of a monomer changes the polymer made from that monomer.
7. Classify and separate polymers based upon some physical properties.

Objective 4 List a variety of manufacturing processes for producing plastic parts and the associated cost trade-offs.

1. Understand traditional manufacturing and 3-D printing properties on the materials.

Standard 5 - Ceramic & Glass Properties (17%)

Candidates will understand the basics of ceramics and glasses.

Objective 1 Characterize the properties of ceramics and glasses.

1. Conduct experiments on the thermal properties of ceramics and glasses and compare them to the thermal properties of metals.
2. Examine and differentiate between the physical properties of ceramics and glasses.
3. Explain that glass is a ceramic that is amorphous.
4. Compare and contrast thermal shock in various ceramic and glass materials.
5. Explain why ceramics and glasses are not good conductors of electricity.

Objective 2 Demonstrate the creation of ceramics.

1. State the types of chemical bonds associated with ceramics.
2. List three categories of ceramics (i.e. oxides, nonoxides, and composite materials).
3. Clarify that ceramics are composed of compounds of metals or semimetals combined with nonmetals.
4. Characterize the processes of oxidation and reduction and why they are important to the creation of ceramic art.

Objective 3 List at least three ways that ceramic items are formed or shaped.

Objective 4 Characterize the unique properties of glasses.

1. Analyze the structure of glass and explain its components and their purposes. (e.g., glass former, modifier, intermediate).
2. List three categories of glass (i.e. soda-lime silica, borosilicate, and phosphate).
3. List at least four properties of glass.
4. Analyze the amorphous properties of glass. Explain why glass is an amorphous substance.
5. Demonstrate how a modifier lowers the melting temperature of glass.
6. State that glass is stronger when placed in compression and weaker when placed under tension.
7. State that annealing reduces stress in glass.
8. Explain that tempering places the surface of glass under compression.

Objective 5 Demonstrate the creation of glass.

1. Conduct an experiment to batch glass from its components.
2. Conduct an experiment to create glass beads from a simple substance. (i.e., borax beads).

Objective 6 List at least two ways that glass objects are formed.

Standard 6 - Composite Properties (19%)

Candidates will understand the basics of composites.

Objective 1 Characterize the properties of composite materials.

1. Define a composite.
2. Explain why composites are useful.
3. List three major classifications of composites (i.e., polymer matrix, ceramic matrix, and metal matrix).
4. Define specific strength.
5. Define specific stiffness.
6. Explain what Young's Modulus represents.

Objective 2 Describe wood as a natural composite

1. Explain that wood is made up of tubular cells held together by lignin.
2. List some differences between softwoods and hardwoods.
3. Explain that shrinkage in wood is due to a loss of moisture and that the amount of shrinkage is dependent upon the grain orientation.
4. List at least four human-fabricated wood composites.

Objective 3 Describe concrete as a particular reinforced composite.

1. List the main components of concrete and describe a good mix ratio.
2. Clarify the difference between concrete and cement.
3. State that too much water weakens concrete when it is mixed and that concrete cures rather than dries.

Objective 4 Evaluate composite materials and compare them to non-composite materials.

1. Conduct investigations on the strength of a composite vs a non-composite material. (e.g., cement vs concrete, foam board vs laminated foam board).
2. Create various objects from composite materials and evaluate them for strength. (e.g., paper, airfoils, balsa wood bridges, etc.).

Objective 5 Describe a fiber reinforced composite.

1. Explain that there are many types of fibers that may occur in many different physical
2. configurations.
3. Explain that fiber supports most of the load in the typical fiber reinforced composite.
4. Explain how the amount of fiber and its orientation affect a composite's strength.
5. List at least three commonly used types of fibers for fiber reinforced polymers (i.e., glass fibers, carbon fibers, aramid fibers).
6. Demonstrate that delamination and foreign object debris (FOD) weakens a laminar composite.

Objective 6 Describe at least 5 composite fabrication processes and their uses..

1. hand lay-up
2. vacuum bagging
3. open molding
4. filament winding
5. pultrusion

Performance Skills Evaluation

Exam name: Material Science

Candidate Name: _____

Performance assessments may be completed and evaluated any time before the certification is issued. The following performance skills can be used in connection with the associated standards and exam. The evaluator will function as the subject matter expert to determine if the candidate meets the skills requirements with a Yes/No for passing.

Performance Skills

- Participate in a significant activity that provides each candidate with an opportunity to render service to others, employ leadership skills, or demonstrate skills they have learned through this course, preferably through participation in a Career & Technical Student Organization (CTSO) such as the Technology Student Association (TSA).

Pass:

Evaluator Name:

Date:
