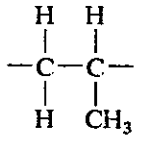
※ 注意：請於試卷上「非選擇題作答區」標明題號並依序作答。

I. Multiple choices (**There may be more than one correct answer.** Except for the last question, all others have **7** points each. **One** error costs you **4** points, until no more point is available with that particular problem)

1. Apple iPhone 15 Pro and iPhone 15 Pro Max use titanium as the material for their cases. About titanium, which of the following are correct?
(A) The primary crystal structure of commercially pure titanium at room temperature is body-centered cubic (BCC).
(B) Titanium is often alloyed with aluminum and vanadium to form Ti-6Al-4V, which has a dual-phase structure at equilibrium at room temperature.
(C) Titanium alloys are generally difficult to machine due to their low thermal conductivity and high chemical reactivity at elevated temperatures.
(D) The density of titanium is approximately 4.5 g/cm^3, making it heavier than stainless steel but lighter than aluminum.
(E) Pure titanium is used extensively in high-temperature applications because it retains its strength at temperatures above 1000°C.

2. Which of the following can be considered a method used to enhance the toughness of ceramic materials?
(A) Incorporation of whiskers or fibers
(B) Grain size refinement
(C) Doping with rare earth elements
(D) Increasing the brittleness of the ceramic
(E) Introduction of porosity

3. Which of the following statements about polymers is correct?
(A) Thermosetting polymers can be melted and reshaped multiple times.
(B) Polymers with high crystallinity generally have lower density and higher solubility in solvents.
(C) Cross-linking in polymers increases their flexibility and reduces their melting temperature.
(D) Glass transition temperature (T_g) is the temperature above which a polymer becomes brittle.
(E) This is a repeating unit of polypropylene. 

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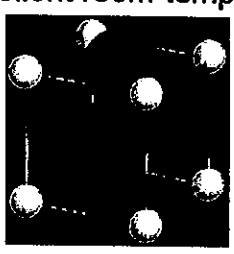
4. TSMC (Taiwan Semiconductor Manufacturing Company) is recently reported the 8th largest company in the world. In the context of the semiconductor industry, which of the following statements are true?
   (A) Moore's Law predicts that the number of transistors on a chip doubles approximately every 12 months.
   (B) The process of doping involves introducing impurities into a semiconductor to modify its electrical properties.
   (C) Photolithography is a key technique used in semiconductor manufacturing for patterning the intricate circuits on silicon wafers.
   (D) Silicon is the only material used for making semiconductor devices.
   (E) FinFET (Fin Field-Effect Transistor) technology is used to overcome short-channel effects in modern transistors.

5. About an intermetallic compound Ni_3Al...
   (A) It has a face-centered cubic (FCC) crystal structure.
   (B) It is known for its excellent high-temperature strength and oxidation resistance, making it suitable for high-temperature applications.
   (C) It is widely used for improvement of magnetic properties, such as permanent magnets.
   (D) It is most well-known for its excellent room-temperature ductility.
   (E) The unit cell may look like this: 

6. Which of the following statements about the thermal properties of materials are correct?
   (A) At 0 K, the entropy of all materials is 0.
   (B) The specific heat capacity of a material is independent of temperature.
   (C) Thermal expansion refers to the change in a material's volume with a change in temperature.
   (D) The coefficient of thermal expansion quantifies the fractional change in length per degree change in temperature.
   (E) Heat capacity is defined as the amount of heat required to raise the temperature of by one degree Celsius.

7. Which of the following statements about diffusion in solids are true?

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(A) Diffusion in metals primarily occurs through vacancy and interstitial mechanisms.
(B) The diffusion coefficient increases with decreasing temperature.
(C) In a substitutional alloy, atoms can only diffuse through the interstitial mechanism.
(D) Fick's first law of diffusion states that the flux of atoms is proportional to the concentration gradient.
(E) The activation energy for diffusion is typically lower in crystalline solids compared to amorphous solids.

8. Which of the following statements about electronic structures in materials are correct?
(A) The band gap of a semiconductor decreases with increasing temperature.
(B) In metals, the Fermi level lies within the conduction band at absolute zero temperature.
(C) Doping a semiconductor with donor impurities shifts the Fermi level closer to the conduction band.
(D) The density of states in a material describes the number of electronic states at each energy level that are available to be occupied.
(E) In an insulator, the valence band is completely empty at absolute zero temperature.

9. Which of the following phenomena related to light are primarily influenced by the material's electronic structure and band gap properties?
(A) Photoluminescence
(B) Total internal reflection
(C) Photoelectric effect
(D) Optical absorption
(E) Diffraction

10. Which of the following statements about the hardenability of steels are true?
(A) Hardenability can be influenced by the carbon content in steel.
(B) The Jominy end-quench test is a standard method used to measure the hardenability of a steel sample.
(C) Hardenability determines the maximum hardness that can be achieved in a steel alloy.
(D) Alloying elements such as chromium, molybdenum, and manganese

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increase the hardenability of steel.
(E) Hardenability is the ability of a steel to be hardened throughout its entire thickness.

11. In the context of pitting corrosion, which of the following factors are most likely to initiate and propagate pitting corrosion on a stainless steel surface?
(A) Presence of chloride ions in the environment.
(B) High pH (alkaline) environment.
(C) Surface passivation with a protective oxide layer.
(D) Localized breakdown of the protective oxide film.
(E) Uniform exposure to oxygenated water.

12. At the eutectic composition and eutectic temperature, which of the following statements are correct?
(A) The eutectic reaction is described by Liquid$\rightarrow\alpha+\beta$
(B) At the eutectic temperature, the liquid phase transforms into two solid phases simultaneously.
(C) Eutectic transformation is a type of congruent transformation.
(D) The eutectic point is a unique composition at which the eutectic reaction occurs.
(E) The eutectic structure typically consists of alternating layers or lamellae of the two solid phases.
(F) The eutectic reaction results in the formation of a single supersaturated solid phase from the liquid phase.

13. A high degree of substitutional solid solubility of one atom type in another is possible when the Hume-Rothery rules are obeyed. The rules describe:
(A) The crystal structures for metals of both atom types must be the same.
(B) Atomic sizes of two elements must not differ by more than 15%.
(C) Elements should form compounds with each other.
(D) High difference in electronegativity is a requirement.
(E) Elements should have the same valence electrons.

14. Which of the following statements are true regarding the optical properties of materials?
(A) The refractive index of a material is always greater than 0.95.
(B) Materials with a high refractive index always exhibit strong absorption of light.

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(C) Photoluminescence is the emission of light from a material after it absorbs photons.
(D) Transparent materials have a high absorption coefficient.
(E) The band gap of a semiconductor determines the wavelengths of light it can absorb.
(F) Metals typically exhibit high reflectivity due to free electrons on their surface.
(G) Metamaterials can be engineered to have unusual optical properties, excluding a negative refractive index.

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