

## Question Source:

### NMTA (New Mexico) General Science Sample Test

A researcher wants to experimentally evaluate the effectiveness of three different types of insulation. The researcher completely wraps three identical glass containers in 1-cm-thick pieces of each type of insulation. The researcher fills the containers with water at 100°C and then quickly seals them. After 15 minutes, the containers are opened and the temperature of the water in each container is measured. The same experiment is then repeated two more times with the same apparatus. The results of the three separate trials are then averaged. Which of the following changes to the experimental design would make this a better experiment?

- A. carrying out an additional trial that uses ice cubes to measure how long it takes the ice cubes to fully melt in the three different types of insulated containers
- B. measuring the temperature of the water in the three containers at several different time intervals to create a heat-loss curve for each material
- C. setting up a control in each trial to measure the change in temperature in a matching glass container without any added insulation
- D. increasing the thickness of the insulation used in order to more clearly distinguish the insulating properties of each of the materials

**C.** This question requires the examinee to demonstrate knowledge of the principles and procedures for designing and carrying out scientific investigations. To improve the experimental design the researcher should test the insulating capacity of a matching glass container that has no insulation as part of each trial. The use of a control establishes a baseline against which the various insulating materials can be compared when analyzing the results.

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Lynn Margulis is a U.S. biologist whose contribution to the understanding of the evolution of the eukaryotic cell was groundbreaking. Although originally rejected repeatedly by mainstream biologists, her theory on the evolution of the eukaryotic cell is now widely accepted. Margulis's work has helped establish that chloroplasts and mitochondria in eukaryotic cells originally developed as a result of:

- A. the incorporation of free-living prokaryotes into other prokaryotic cells.
- B. the merging of two varieties of eukaryotic cell into a single-celled organism.
- C. the incorporation of nonpathogenic viral DNA into a primitive eukaryotic cell.
- D. the mutation of RNA in ancient prokaryotes that led to more efficient energy use.

**A.** This question requires the examinee to demonstrate knowledge of the historical development of major scientific ideas, including contributions by men and women of diverse backgrounds. Lynn Margulis's original paper on the evolution of the eukaryotic cell and her work on endosymbiotic theory established that certain cell organelles (e.g., mitochondria, chloroplast) originated as free-living bacteria that moved into other prokaryotic cells, eventually evolving into eukaryotic cells over millions of years. Her persistence in arguing in support of the theory of endosymbiosis, even though it was strongly criticized by the mainstream biological community, demonstrates the importance of tenacity in putting forward new scientific ideas.

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In a number of well-publicized cases, some of the most important and reputable scientific journals have had to retract published research papers because the research proved to be fraudulent. Which of the following strategies would most improve the system used by these journals for identifying fraudulent research papers before they are published?

- A. verifying that the data and methodologies described in research papers are legitimate
- B. giving priority to scientists who have previously submitted legitimate research papers
- C. releasing data and findings presented in research papers directly to the general public
- D. having scientists from outside the field review research papers when they are submitted

**A.** This question requires the examinee to analyze social, economic, and ethical issues associated with technological and scientific developments. Prior to publication in a professional scientific journal, research papers are typically reviewed by scientists with similar professional backgrounds and knowledge of the research subject. Although the system usually works well, the complexity of some research makes peer review of submitted papers a costly and time-consuming process. Since appropriate methodology and accurate data are underpinnings of legitimate scientific research, further scrutiny of these two areas provides the best method for reducing the publication of fraudulent research papers.

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**Dissolving table salt in water elevates the boiling point of the salt solution. This colligative property of the salt solution is most directly affected by which of the following factors?**

- A. the reactivity of sodium and chloride ions
- B. the concentration of the solute dissolved in the solution
- C. the specific heat capacity of the solution
- D. the reduced hydrogen bonding between water molecules

**B.** This question requires the examinee to analyze the colligative properties of solutions (e.g., freezing point, boiling point, osmotic pressure, vapor pressure). Colligative properties, such as the boiling point and freezing point of a substance, have been shown experimentally to be influenced by the number of particles present in the system, but not the properties of the particles themselves. Therefore, the concentration of salt in the solution is the factor that most directly affects the solution's boiling point.



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Calcium chloride ( $\text{CaCl}_2$ ) is a strong electrolyte. If 1.00 mol of  $\text{CaCl}_2$  is dissolved in water to make 1.00 L of solution, what is the concentration of chloride ( $\text{Cl}^-$ ) ions in the solution?

- A. 0.500 *M*
- B. 1.00 *M*
- C. 1.50 *M*
- D. 2.00 *M*

**D.** This question requires the examinee to apply knowledge of stoichiometry and the mole concept in balancing chemical equations and solving problems involving the mass relationships of reactants and products. Molarity ( $M$ ) is the concentration of a solution expressed as moles of solute per liter of solution. The calcium chloride solution has a concentration of 1.00 mol. Each molecule of calcium chloride ( $\text{CaCl}_2$ ) contains two chloride ions. So for every mole of calcium chloride dissolved to make the solution, 2 moles of chloride ions disassociate from each calcium chloride molecule. Therefore, the concentration of chloride ions in solution is  $2.00\text{ }M\left(\frac{2.00\text{ mol Cl}^-}{1.00\text{ L solution}}\right)$ .

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### Calorimetry experiment:

- Place 25 mL of 0.1 *M* solution of reactant A at 25°C and 25 mL of 0.1 *M* solution of reactant B at 25°C into a coffee-cup calorimeter.
- Allow the reaction to proceed and record the final temperature of the reaction mixture.
- Using the specific heats for reactant A and reactant B, calculate the enthalpy change for this reaction.

A student performing the calorimetry experiment described above determines that the temperature of the final reaction mixture is 18°C. Which of the following conclusions is supported by the data generated in this experiment?

- A. The specific heat of reactant A is greater than that of reactant B.
- B. The reaction between reactant A and reactant B is endothermic.
- C. The calorimeter has too low of a heat capacity.
- D. The reaction between reactant A and reactant B is exothermic.

**B.** This question requires the examinee to demonstrate knowledge of the laws of thermodynamics and the principles of calorimetry, including solving basic calorimetry problems. The change in the temperature of the reaction mixture from 25°C to 18°C indicates that the reaction has absorbed energy from its surroundings. A reaction that absorbs energy from its surroundings is defined as an endothermic process.