Questions 22-31 are based on the following passage and supplementary material.

This passage is adapted from Rachel Ehrenberg, "Salt Stretches in Nanoworld." ©2009 by Society for Science & the Public. The "nanoworld" is the world observed on a scale one billionth that of ordinary human experience.

Inflexible old salt becomes a softy in the nanoworld, stretching like taffy to more than twice its length, researchers report. The findings may lead to new approaches for making nanowires that could end up in solar cells or electronic circuits. The work also suggests that these ultra-tiny salt wires may already exist in sea spray and large underground salt deposits.

"We think nanowires are special and go to great lengths to make them," says study coauthor Nathan Moore of Sandia National Laboratories in Albuquerque. "Maybe they are more common than we think."

Metals such as gold or lead, in which bonding angles are loosey-goosey, can stretch out at temperatures well below their melting points. But scientists don't expect this superplasticity in a rigid, crystalline material like salt, Moore says.

This unusual behavior highlights that different forces rule the nanoworld, says theoretical physicist Krzysztof Kempa of Boston College. "Forget about gravity. It plays no role," he says. Surface tension and electrostatic forces are much more important at this scale.

Moore and his colleagues discovered salt's stretchiness accidently. They were investigating how water sticks to a surface such as salt and created a super-dry salt sample for testing. After cleaving a chunk of salt about the size of a sugar cube with a razor, the scientists guided a microscope that detects forces toward the surface. When the tip was far away there was no measured force, but within about seven nanometers a very strong attraction rapidly developed between the diamond tip of the microscope and the salt. The salt actually stretched out to glom on to the microscope tip. Using an electron microscope to see what was happening, the researchers observed the nanowires.

The initial attraction between the tip and salt might be due to electrostatic forces, perhaps good old van der Waals interactions,[1] the researchers speculate. Several mechanisms might lead to the elasticity, including the excessive surface tension found in the nanoworld (the same tension that allows a water strider to skim the surface of a pond).

The surface tension is so strong that as the microscope pulls away from the salt, the salt stretches, Kempa says. "The inside has no choice but to rearrange the atoms, rather than break," he says.

This bizarre behavior is actually mirrored in the macroworld, the researchers say. Huge underground deposits of salt can bend like plastic, but water is believed to play a role at these scales. Perhaps salty nanowires are present in these deposits as well.

"Sodium chloride[2] is everywhere—in the air, in our bodies," Moore says. "This may change our view of things, of what's happening at the nanoscale."

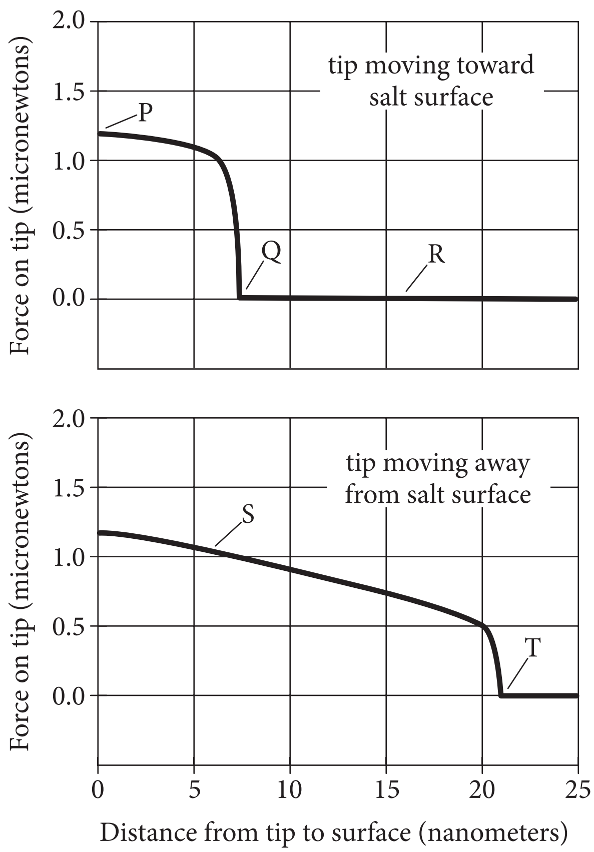
The work also suggests new techniques for making nanowires, which are often created through nano-imprinting techniques, Kempa says. "We invoke the intuition of the macroworld," he says. "Maybe instead of stamping [nanowires] we should be nano-pulling them."

[1] Attractive forces between nearby atoms

[2] Common salt

CONTINUE

Interaction of Microscope Tip with Salt Surface



Adapted from Moore et al., "Superplastic Nanowires Pulled from the Surface of Common Salt." ©2009 by American Chemical Society.

22

One central idea of the passage is that

A) sometimes materials behave contrary to expectations.

B) systems can be described in terms of inputs and outputs.

C) models of materials have both strengths and weaknesses.

D) properties of systems differ from the properties of their parts.

23

Which choice best describes the overall structure of the passage?

A) A list of several ways in which salt's properties differ from researchers' expectations

B) A presentation of a hypothesis regarding salt behavior, description of an associated experiment, and explanation of why the results weaken the hypothesis

C) A description of two salt crystal experiments, the apparent disagreement in their results, and the resolution by more sensitive equipment

D) An introduction to an interesting salt property, description of its discovery, and speculation regarding its application

24

Which choice provides the best evidence for the claim that Moore's group was surprised to observe salt stretching?

A) Lines 17-18 ("But . . . says")

B) Lines 26-28 ("They were . . . testing")

C) Lines 36-38 ("Using . . . nanowires")

D) Lines 55-56 ("Sodium . . . says")

25

As used in line 20, "rule" most nearly means

A) mark.

B) control.

C) declare.

D) restrain.

26

According to the passage, researchers have identified which mechanism as potentially responsible for the initial attraction between the microscope tip and the salt?

A) Gravity
B) Nano-imprinting
C) Surface tension
D) Van der Waals interactions

27

As used in line 42, "lead to" most nearly means

A) guide to.
B) result in.
C) point toward.
D) start with.

28

Based on the passage, which choice best describes the relationship between salt behavior in the nanoworld and in the macroworld?

A) In both the nanoworld and the macroworld, salt can be flexible.
B) Salt flexibility is expected in the nanoworld but is surprising in the macroworld.
C) Salt nanowires were initially observed in the nanoworld and later observed in the macroworld.
D) In the nanoworld, salt's interactions with water lead to very different properties than they do in the macroworld.

29

Which choice provides the best evidence for the answer to the previous question?

A) Lines 12-13 ("Maybe . . . think")
B) Lines 22-24 ("Surface . . . scale")
C) Lines 39-42 ("The initial . . . speculate")
D) Lines 51-53 ("Huge . . . scales")

30

According to the information in the graph, when the microscope tip is moving away from the salt surface and is 15 nanometers from the surface, what is the approximate force on the microscope tip, in micronewtons?

A) 0
B) 0.25
C) 0.75
D) 1.25

31

Based on the passage and the graph, which label on the graph indicates the point at which a salt nanowire breaks?

A) P
B) Q
C) R
D) T