X-Ray Diffraction & Scanning Probe Microscopy Assessment

Name_____

Date_____Period____

Matching

Match the word with the best definition.

_____	1. diffraction	a. an instrument that can image atoms and operates by sensing the force between the surface atoms of a sample and a probe tip
_____	2. atom	b. an instrument that can image atoms by the quantum mechanical tunneling of tunneling effect electrons between an electrically conducting atomic tip and a substrate
_____	3. rastering	c. energy of the most weakly bound electrons in a metal
_____	4. tunneling effect	d. the scattering of light from a regular array, producing constructive and destructive interference
_____	5. X-ray	e. opposition to the flow of electric current
_____	6. piezoelectric material	f. visible light-based method of investigating atomic arrangements at a macroscopic level
_____	7. AFM	g. the movement of an electron due to its wave nature through a classical barrier
_____	8. STM	h. the smallest unit of a chemical element
_____	9. electrical resistance	i. radiant energy that exhibits wavelike behavior and travels through space at the speed of light in a vacuum
_____	10. electromagnetic radiation	j. material that distorts when a voltage is applied to it
_____	11. optical transform experiment	k. scanning back and forth across the surface of a material
_____	12. Fermi Energy	l. electromagnetic radiation with a wavelength of about the size of an atom

Multiple Choice

Choose the best answer.

____ 13. _____ forces act between the electrons and the nuclei of atoms to hold the atoms of a metal together.

a. Magnetic
b. Covalent
c. Intermolecular
d. Electrostatic

____ 14. The STM uses differences in height or ____ to "map out" the atomic surface.

a. spatial orientation
b. electrical current
c. resolution
d. light

____ 15. Challenges that must be overcome in order to have scanning probe microscopy work effectively include all of the following **EXCEPT**

a. vibrations
b. probe sharpness
c. position control
d. substance is nonconductor of electricity

Problems

16. The radius of a tungsten atom is estimated to be 137 pm. What is the <u>diameter</u> in meters, centimeters, and angstrom units of a perfect STM tip that terminates in a single atom of tungsten? **SHOW WORK!**

17. How far (in meters) does an STM tip traverse in scanning a row of 400 nickel atoms? The radius of a nickel atom is 1.24 angstroms. **SHOW WORK!**

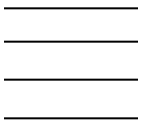
18. a.) What is the frequency of an X-ray with a wavelength of 1.54 angstroms, the wavelength produced by an X-ray tube with a copper target? (The speed of light is 2.998×10^8 m/s.)

b.) What is the frequency of an X-ray with a wavelength of 0.7107 angstroms, the wavelength produced by an X-ray tube with a molybdenum target?

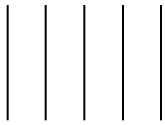
19. What is the frequency of a 670 nm red laser?

20. Sketch a qualitative representation of the diffraction pattern produced by the following two-dimensional arrays.

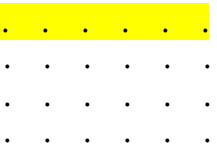
a



b



c

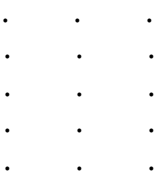


21. Sketch a qualitative representation that shows the difference in the diffraction pattern produced by the following pairs of two-dimensional arrays.

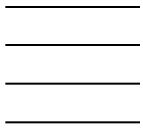
a.

b.

c.



d.



22. Why must X-rays be used in crystal-structure determinations rather than visible light?

23. Why does X-ray diffraction give more information about the three-dimensional structure of a crystalline solid than does scanning tunneling microscopy?

24. Use the Bragg equation to explain the observation that as the spacing between the atoms decreases, the spacings in the resulting diffraction pattern increase.

25. Briefly explain how the STM works.