YUSO 2017 MATERIALS SCIENCE ANSWER KEY

SECTION ONE: MATERIAL PERFORMANCE

1. 10 points

a) $\sigma_{sg} = \sigma_{sl} + \sigma_{lg}(\cos \theta)$ 7 points
b) hydrophobic (bad wetting) 3 points

2. 10 points

a) acceptor: A dopant atom that forms a p-type region when added to a semiconductor. (3 points)
b) examples of acceptors: silicon, boron, aluminum, indium, and gallium (there may be other acceptable answers. (2 points)
c) An acceptor causes unsatisfied bonding when doped into an intrinsic semiconductor, which contributes hole levels low in the band gap of the semiconductor. Due to this, electrons can be easily excited from the valence band into these low-level holes, which then leaves holes in the valence band. This shifts the effective Fermi level to about halfway between the acceptor level and the valence band. (5 points)

Lab practical: 30 points (10 points per step)

1) *Initiation*: The first step of the chain reaction that produces a radical species, usually through homolytic cleavage. Heat or light are two examples that cause radical species production.
2) *Propagation*: During propagation, the polymer grows as the radical species reacts with the monomer, which produces further radical species (including the growing polymer) that continue to react in a chain-like manner.
3) *Termination*: With time, two radical species will react with each other to form more stable, non-radical species. When all radical species are extinguished, the reaction stops.

SECTION TWO: INTERMOLECULAR FORCES OF MATERIALS

1. 10 points

In diamond, the electrons located in the covalent bonds are localized between two carbon atoms and cannot move freely throughout the crystal structure. With graphite, although three of its four available valence electrons are used for bonding with adjacent carbon atoms, the extra electron is delocalized among the planar structure throughout the crystal. This delocalization of electrons between the graphite sheets allow free movement and electrical conductance.

2. 10 points

The study supports hypothesis (B).
Hypothesis (A) relies on dipole-dipole interactions between polar molecules on the gecko's feet and polar water molecules. In a dipole-dipole force, the unbalanced distribution of electrons in the molecule creates a net dipole with a slightly positive and negative charge at opposite ends of the molecule, which tend to be weaker than the charges of ions.
Hypothesis (B) relies only on van der Waal forces, which are present in all molecules due to the random nature of electron distribution in a molecule (which can be represented as an electron cloud). Thus, it does not matter whether the interaction is between polar or nonpolar molecules. The fact that the gecko feet stuck to both nonpolar and polar surfaces indicate that van der Waals most likely are the predominant force of attraction. It does not support hypothesis (A) because if the interaction depended on dipole-dipole forces, the gecko would not have been able to stick to the nonpolar surface.