

Solutions

Original guidance; do not award a conductivity explanation based on moving protons.

2.1 $\text{N}^{3-} > \text{F}^- > \text{Al}^{3+}$. Each has ten electrons, but proton number increases $7 \rightarrow 9 \rightarrow 13$, increasing nuclear attraction and drawing the electron cloud closer.

2.2 Al^{3+} is smaller and more highly charged than Na^+ , giving greater polarising power. I^- is larger than F^- and its cloud is more readily distorted, giving greater polarisability. This increases covalent character; it does not mean all bonding becomes purely covalent.

2.3 Copper has mobile delocalised electrons. In solid NaCl the ions are fixed in the lattice. On melting, ions can move and carry charge; electrons are not released as the charge carriers.

3.1 Four electron regions arrange approximately tetrahedrally, with a lone pair occupying one region; molecular shape is pyramidal. Lone-pair/bond-pair repulsion affects angles, but actual values also depend on atom, orbital and bonding details, so no fixed subtraction applies to every molecule. An exact angle is not requested.

3.2 Diamond: each carbon bonds to four others in a rigid giant covalent network; no freely mobile electrons, so insulating; cutting tools use its hardness. Graphite: each carbon bonds to three others in layers, with delocalised electrons that conduct along layers; lubricant uses layers sliding over one another. Graphene: one covalently bonded carbon layer with delocalised electrons; conducting, strong films can use its conductivity and strength. Accept other scientifically justified uses.

3.3 Silicon has a giant covalent structure requiring many strong bonds to be broken on melting. P_4 and S_8 are molecules and argon is monatomic; melting overcomes much weaker attractions between their particles. S_8 has more electrons than P_4 , so stronger London attractions require more energy to overcome. Melting does not break every P–P or S–S bond in these molecules.

3.4 Mg^{2+} and O^{2-} have higher charge magnitudes than Na^+ and Cl^- , giving stronger attraction at similar separation. Actual ion sizes and lattice structure also affect the energy and melting behaviour, so the charge comparison is a model-based trend rather than a universal numerical prediction.