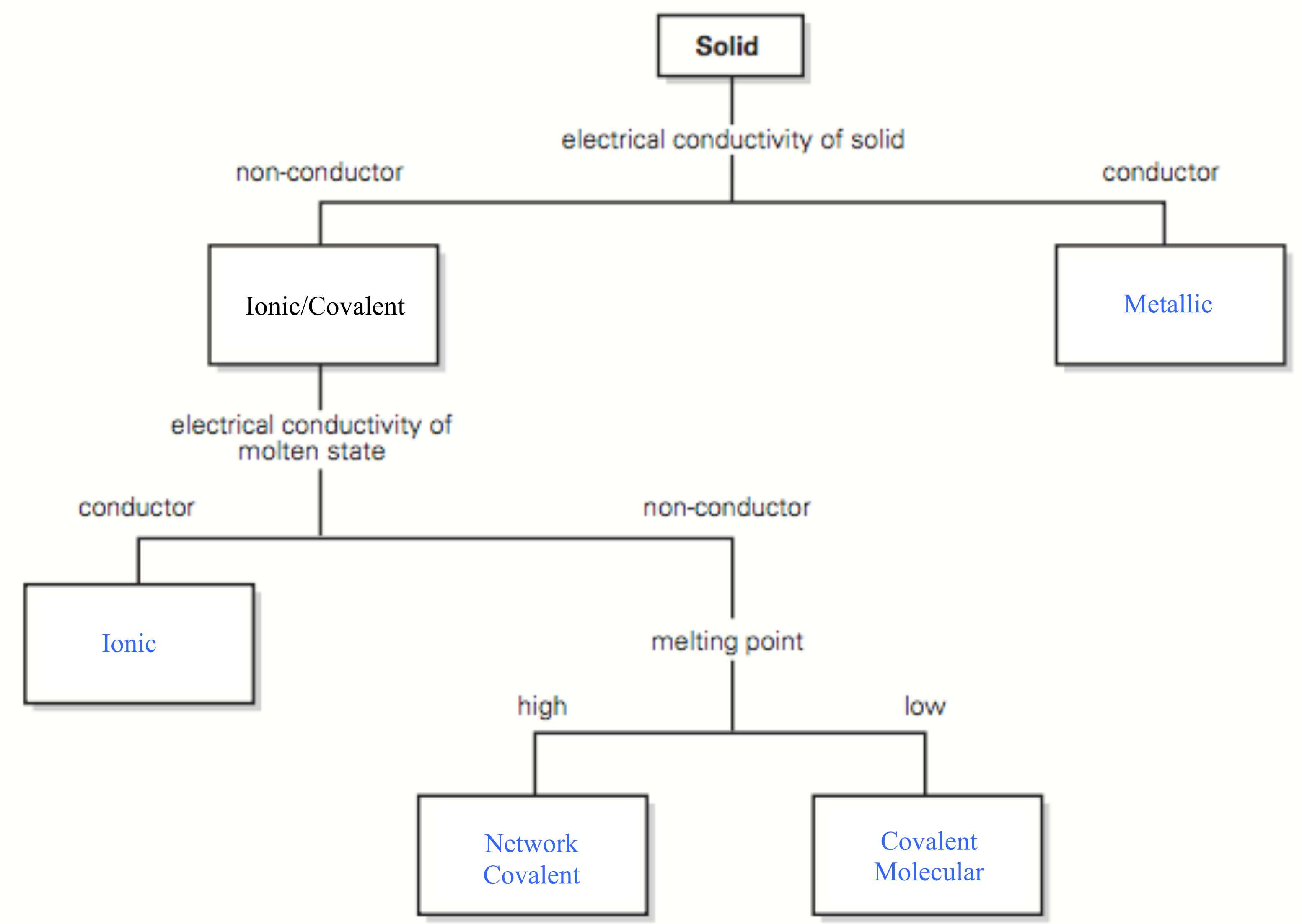
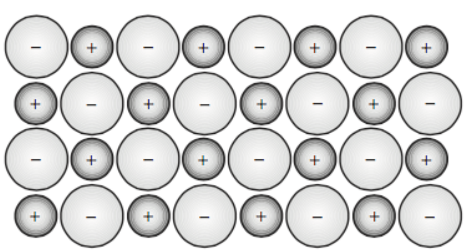
CHEMISTRY 11 AP – BONDING AND PROPERTIES OF SOLIDS WORKSHEET

1) Complete the following flowchart by filling in the boxes:



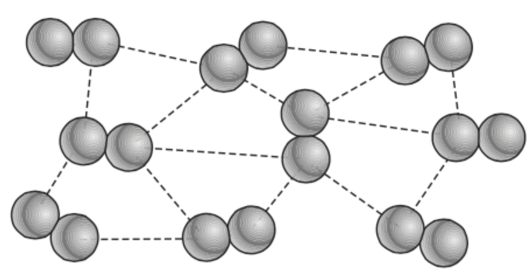
2) Identify the type of solid shown by each of the following diagrams. Explain the types of particles and bonding represented by the diagram.

(a)



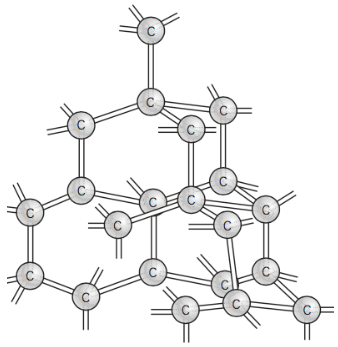
Ionic solid since the particles are positive and negative ions that are held together by electrostatic attraction between oppositely charged particles.

(c)



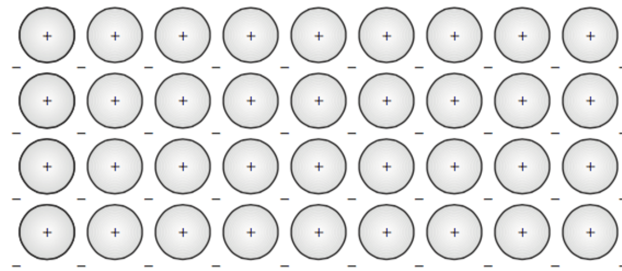
Covalent molecular solid since the particles are molecules that are held together by weak intermolecular forces.

(b)



Network covalent solid since the particles are atoms which are covalently bonded to each other forming an extremely large lattice structure.

(d)



Metallic solids since the particles are positive ions and delocalized electrons. The metal is held together by the attraction between the positive ions and the negative delocalized electrons.

3) Classify Ge, RbI, $C_6(CH_3)_6$ and Zn according to their type of solid and arrange them in order of increasing melting point. Explain.

Germanium is located on the periodic table just under silicon, along the diagonal line of metalloids, which suggests that elemental Ge is likely to have the same structure as Si (a tetrahedral diamond structure). Therefore Ge is probably a network covalent solid and would have an incredibly high melting point.

RbI is an ionic solid and would have a high melting point.

$C_6(CH_3)_6$ is a combination of non-metals forming a covalent molecular solid which will form isolated molecules with weak intermolecular forces between them. Therefore $C_6(CH_3)_6$ will have a low melting point due to the ease with which these weak IMFs can be broken.

Zn is a metal and will therefore form a metallic solid with a high melting point.

Arranging these substances in order of increasing melting point is relatively straightforward, with one exception. We would expect that the $C_6(CH_3)_6$ to have the lowest melting point and Ge to have the highest melting point with RbI somewhere in between. The melting points of metals, however, are difficult to predict based on the models presented so far. Since Zn has a filled valence shell and is therefore relatively stable at a lower energy state, it should not have a particularly high melting point, so a reasonable guess is:

$$C_6(CH_3)_6 < Zn \approx RbI < Ge$$

The actual melting points are $C_6(CH_3)_6$ (166°C), Zn (419°C), RbI (642°C) and Ge (938°C).

4) Explain why covalent molecular substances are mostly soft while the other three types of substances are usually hard.

Covalent molecular substances are soft because there are only weak intermolecular forces between the molecules therefore they are easily separated. The other three types of substances have strong forces so it is more difficult to separate the particles.

5) Explain why metallic and molten ionic substances conduct electricity while covalent substances do not.

Metallic and ionic substances can conduct electricity because they have charged particles that are free to move. Covalent substances do not have charged particles therefore they cannot conduct electricity.

6) Four vials labeled A – D contain sucrose, zinc, quartz (SiO_2) and sodium chloride, although not necessarily in that order. The following table summarizes the results of the series of analyses you have performed on the contents:

	A	B	C	D
Melting Point	High	High	High	Low
Thermal Conductivity	Poor	Poor	Good	Poor
Electrical Conductivity in solid state	Moderate	Poor	High	Poor
Electrical Conductivity in liquid state	High	Poor	High	Poor
Hardness	Hard	Hard	Soft	Soft
Luster	None	None	High	None

Match each vial with its contents and classify the type of solid.

A: NaCl since it is an ionic solid
B: Quartz since it is a network covalent solid.
C: Zinc since it is a metal.
D: Sucrose since it is a covalent molecular solid.

7) Do ionic solids generally have higher or lower melting points than molecular solids? Explain.

Ionic solids generally have higher melting points than molecular solids since they have strong electrostatic attractions between their cations and anions while covalent molecular solids are only held together by relatively weak intermolecular forces.

8) Do ionic solids generally have higher or lower melting points than network covalent solids? Explain.

Ionic solids generally have lower melting points than network covalent solids since network covalent solids are held together by extremely strong covalent bonds between all of their atoms therefore in order to melt a network covalent solid, enough energy must be provided as to break every one of these bonds.

9) The strength of London (dispersion) forces in molecular solids tends to increase with molecular mass, causing a smooth increase in melting points. Some molecular solids, however, have significantly lower melting points than predicted by their molecular masses. Why?

Some molecular solids have lower melting points than would be predicted since their molecules are being held together by strong covalent bonds, but neighbouring molecules may be held together by weaker intermolecular forces. When these weak IMFs break, the molecular solids will melt.

10) Explain the differences between an interstitial alloy and a substitutional alloy. Given an alloy in which the identity of one metallic element is known, how could you determine whether it is a substitutional alloy or an interstitial alloy?

In a substitutional alloy, the impurity atoms are similar in size and chemical properties to the atoms of the host lattice; consequently, they simply replace some of the metal atoms in the normal lattice and ***do not greatly change the structure and physical properties***. In an interstitial alloy, the impurity atoms are generally much smaller, have very different chemical properties, and occupy holes between the larger metal atoms. Interstitial impurities tend to ***have a large effect on the mechanical properties of the metal, making it harder, denser, less ductile, and less malleable***. Comparing the mechanical properties of an alloy with those of the parent metal could be used to decide whether the alloy were a substitutional or interstitial alloy.

11) Which has the higher melting point? Explain your reasoning in each case.

(a) Os or Hf

Both are metallic solids. Osmium would have a higher melting point, due to the fact that it has more valence electrons available for metallic bonding. The greater the number of valence electrons, the stronger the metallic bond and the higher the energy required to separate the atoms.

(b) SnO_2 or ZrO_2

Both are ionic solids. ZrO_2 would have the higher melting point since it would have a greater ionic character. Since there is a larger difference between the electronegativities of Zr (1.4) and O (3.5) compared to Sn (1.8) and O (3.5), the electrostatic force attraction between Zr^{4+} and O^{2-} would be stronger than the electrostatic force attraction between Sn^{4+} and O^{2-}. The stronger the force, the greater the energy required to break that bond.