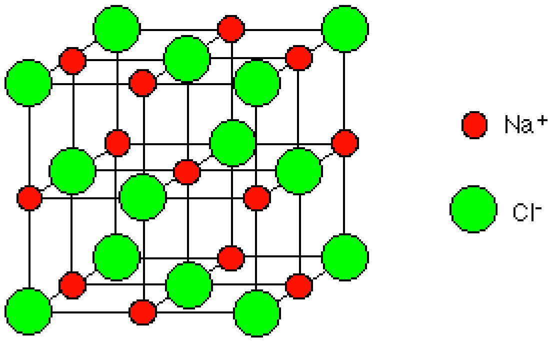
PERIOD 3: PROPERTIES OF THE CHLORIDES

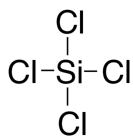
1. a)



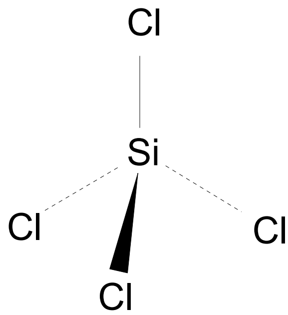
(A diagram is no use if you don't include a key showing the sodium and chloride ions.)

b) There are strong electrostatic forces between the ions which take a lot of heat energy to break to make the liquid.

c) A simple diagram showing $SiCl_4$ as a covalent molecule would do:



But it might be better to show its 3D shape:



Silicon(IV) chloride is a liquid at room temperature because the forces between one $SiCl_4$ molecule and its neighbours are only van der Waals dispersion forces. These don't take anything like as much energy to break as ionic bonds.

(You could possibly also add that it isn't a gas because the molecule is big enough with enough electrons to undergo temporary polarisation that the van der Waals forces are strong enough to hold it as a liquid.)

d) The difference is between the ionic sodium chloride and the covalent silicon(IV) chloride. Whether it is ionic or covalent depends on the electronegativity difference between the atoms in the bond.

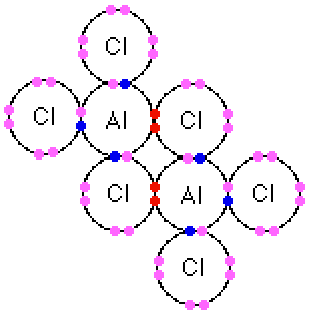
Electronegativity increases as you go across the period. There is a large enough electronegativity difference between sodium and chlorine for the bond to be ionic. There isn't enough difference between silicon and chlorine, and so the bond is covalent.

e) Sodium chloride doesn't conduct electricity as a solid because it has no mobile electrons and the ions aren't free to move. It undergoes electrolysis when it is molten. The covalent silicon(IV) chloride doesn't conduct electricity under any conditions.

f) $SiCl_4 + 2H_2O \longrightarrow SiO_2 + 4HCl$

g) Like sodium chloride: magnesium chloride. Like silicon(IV) chloride: any of the other covalent chlorides - for example, PCl_3, PCl_5, S_2Cl_2, or even $AlCl_3$ although because of its complex behaviour, it isn't quite the same as $SiCl_4$, so is perhaps better avoided.

2. a) Al_2Cl_6



b) Because this is a covalent molecule, it only has relatively weak van der Waals forces to hold it to its neighbours instead of ionic bonds. This causes it to sublime once it has taken up this structure.

c) $Al_2Cl_6 \rightleftharpoons 2AlCl_3$

d) The highly positive aluminium ion at the centre of the complex with the water molecules pulls electrons from the water strongly towards the aluminium. The net effect is to make the hydrogens in the water molecules fairly positive. These can react with water molecules in the solution to give hydroxonium ions, and therefore an acidic solution.

$$[Al(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Al(H_2O)_5(OH)]^{2+} + H_3O^+$$

or more simply:

$$[Al(H_2O)_6]^{3+}{}_{(aq)} \rightleftharpoons [Al(H_2O)_5(OH)]^{2+}{}_{(aq)} + H^+{}_{(aq)}$$

e) The reaction is strongly exothermic. The hydrogen ions (hydroxonium ions) produced as above and the chloride ions already present (from the reaction of the aluminium chloride with the water) will form a solution containing hydrochloric acid. If there is only a small amount of water present, the heat released will boil off steamy fumes of hydrogen chloride.

3. a) $[PCl_4]^+$ $[PCl_6]^-$

b) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

c) You get steamy fumes of hydrogen chloride.

d) $PCl_3 + 3H_2O \longrightarrow H_3PO_3 + 3HCl$