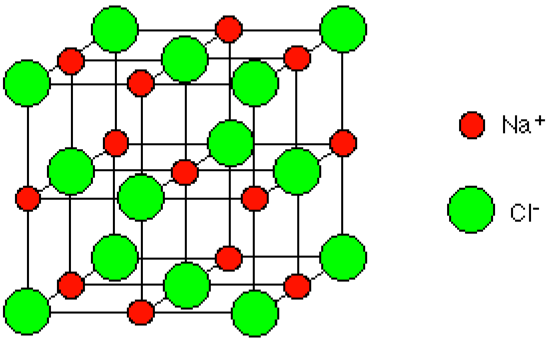
Chemguide – answers

GIANT IONIC STRUCTURES

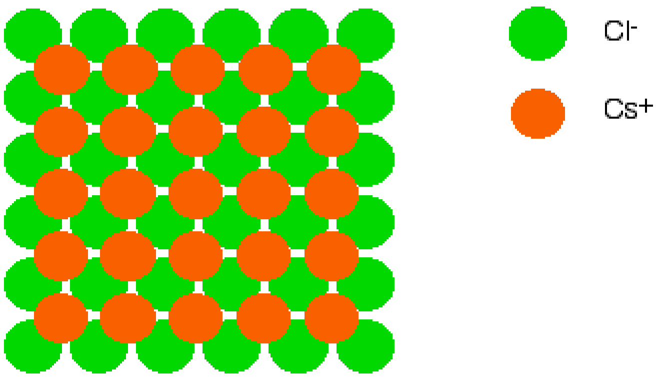
1. a)



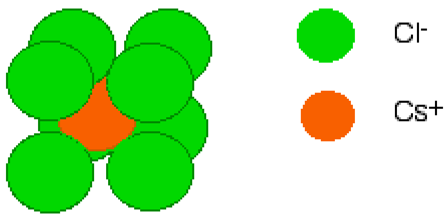
It doesn't matter which ion ends up in the centre of the structure (it could just as well be a chloride ion), but your ions must alternate in each of the three dimensions. You must include a key, and it helps if you remember, and show, that chloride ions are bigger than sodium ions.

b) Each sodium ion is touching 6 chloride ions, and each chloride ion is touching 6 sodium ions.The lines in the sketch show which ions are touching each other. The sodium ion in the centre is being touched by 6 chloride ions. The diagram shows that a chloride ion in the centre of each face is being touched by 5 sodium ions in this bit of structure, plus another one as the structure continues making 6 in all. (Or words to that effect. It certainly wouldn't be worth spending time in an exam drawing a second diagram with a different ion in the centre just to make this point.)

2. a) Each caesium ion is touching 8 chloride ions, and each chloride ion is touching 8 caesium ions. Diagrams you could use include:



and



If you used the left-hand version, you need only draw perhaps 9 (or even just 4) ions in the base layer, and don't forget to point out that the next layer would look exactly the same as the bottom layer with a repeat of the caesium layer on top of that. If you use the right-hand one, don't forget to say that the pattern would be exactly the same if the ions were swapped so that you had a chloride ion in the middle with caesium ions around it.

b) Caesium ions are bigger than sodium ions, and you can fit eight chloride ions around a caesium ion without the chloride ions touching. If you try to fit eight chloride ions around a sodium ion, they would touch, and therefore repel. Repulsion reduces the stability of the structure.

3. Melting and boiling points depend on the attractions between the ions. In MgO, 2+ magnesium ions are attracting 2- oxide ions. These attractions will be much stronger than those between 1+ sodium and 1- chloride ions.

4. A small shock to the crystal brings ions of the same charge alongside each other. The repulsions will shatter the crystal. (You could do this perfectly well with simple diagrams.)

5. a) Positive sodium ions are attracted to the negatively charged cathode. When they get there, they are neutralised when electrons from the electrode jump on to the ion. Neutral sodium atoms are formed, which come together as a drop of molten sodium metal.

$$Na^+ + e^- \longrightarrow Na$$

b) Negative chloride ions are attracted to the positively charged anode. When they get there, they release electrons to the electrode, and form chlorine atoms. These immediately pair up to give chlorine gas, Cl_2.

$$2Cl^- \longrightarrow Cl_2 + 2e^-$$

c) Electrons are being removed from the cathode, leaving a space on the cathode. Electrons are being added to the anode. The power source can move electrons through the external circuit from the anode to the cathode to replace those being removed. Movement of electrons is an electric current.

c) This only works if ions are free to move in the sodium chloride. In solid sodium chloride, they are locked into a rigid lattice and aren't free to move.

6. The minimum you would need to say would be the following. It doesn't matter if you haven't phrased it exactly like this, as long as the sense is the same.

For a solid to dissolve in a solvent, you have to break up the solid lattice. This needs energy. This can only happen if that energy can be recovered when new forces are set up between the particles in the solid and the solvent molecules.

There are strong forces set up between the very polar water molecules and both sodium ions and chloride ions. But there aren't any strong forces set up between the ions and a non-polar solvent like hexane. That means that there is nothing to help to break up the strong ionic lattice.

You could also add:

It is the lone pairs on the oxygen atoms in the water molecules which are strongly attracted to the sodium ions.

Water molecules attach to chloride ions via hydrogen bonds.