very, very small. Only then can you afford to immerse the object in large quantities of solvent. There are obvious examples where an object's solubility is too high, such as alabaster in water, limestone and bronze in acids. There are many other examples of solvents that attack both dirt and object. Many stains and dyes are both affected by the washing of textiles. Published recommendations to use unusual solvents, such as N-methyl-2-pyrrolidone for dissolving starch away from cellulose, usually stress the problems of safeguarding the object rather than those of attacking the unwanted material. Starch and cellulose are very similar chemically and this solvent has been chosen because it is more selective than any other. It may not *be the worst solvent for cellulose nor the best for starch but it is one* of few compounds which distinguishes between them.

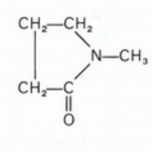

Figure 3.3 *The structure of N-methyl-2-pyrrolidone. The* pyrrolid *part of the name refers to the five-membered ring containing a nitrogen atom. The* 2 *and the* -one *say that the second atom counting round the ring from the nitrogen has a double bonded oxygen attached. The* N-methyl *tells you there is a CH_3 group joined to the nitrogen atom.*

For cleaning, therefore, you must find a solvent which:

- does not dissolve to a significant extent any part of the object.
- dissolves the dirt or whatever is holding the dirt in place.
- dries out, but not so quickly that it leaves dirt infiltrated into the object.

C The science of solutions

C1 Making a solution

When a solid is put into a liquid the significant events occur at the interface between the two substances. You can think of what goes on using Figure 3.4:

The kinetic energy of the molecules of both liquid and solid results in some of the liquid molecules worming their way into the solid (stage 2). As this effect increases the solid swells because the molecules of the solid move apart. As the solvent penetrates further, molecules of the solid lose contact with their neighbours and join in the random wriggling motion of the liquid. In going from stage 1 to stage 2 a molecule of the liquid, which happens to be moving fast enough in the right direction to penetrate the solid's surface, has broken the strong bond between two "solid" molecules and

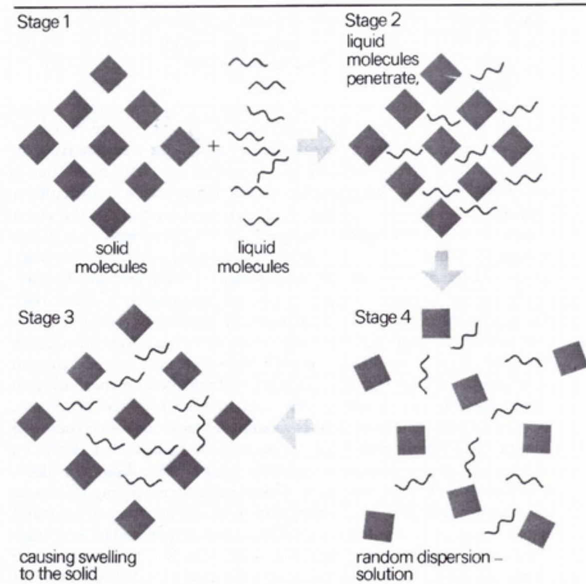

Figure 3.4

replaced it by bonds between "solid" molecules and "liquid" molecules.

There are, however, two factors which are likely to affect this process. The faster the "liquid" molecules move the more likely it is that bonds will be broken and that the form of energy involved will change from kinetic to potential. The new bonds formed between "solid" molecules and "liquid" molecules need to be as strong as the bonds which previously existed between the molecules of the solid (which they now replace) so that the penetrating "liquid" molecules do not have the tendency to separate out again. Bearing in mind these considerations, you will see that the solid is more likely to dissolve if:

- **The temperature is high** since this means more molecules are moving fast.
- **The forces between the molecules of the liquid and the molecules of the solid are of similar strength.** This then means that the solid will be more likely to accept "liquid" molecules into it and that the "liquid" molecules are not strongly pulled back themselves to remain as a separate liquid.