Answer key (for the teacher)

Key Answer key for the teacherworksheet boxes 2–9 and all eight test questions

- **Box 2:** jars 1 and 2 smell; jars 3 and 4 smell exactly alike (of nothing); jar 3 holds the caffeine dissolved in water.
- **Box 3:** for the example label, 32 × 250 ÷ 100 = 80 mg; a coffee cup usually gives no number.
- **Box 4:** C 8, H 10, N 4, O 2; $C_8H_{10}N_4O_2$; 24 atoms.
- **Box 5:** any score; about 18 of the 24 letters can be read from the front, the other 6 need turning.
- **Box 6:** the five-membered ring contains two nitrogens, the six-membered ring contains two nitrogens; the two rings share two carbon atoms.
- **Box 7:** the two C=O groups; three methyl groups of three equivalent hydrogens plus one ring hydrogen give four signals; the molecular-ion peak, $M^{+\cdot}$ at *m/z* 194.
- **Box 8:** (a) $C_8H_{10}N_4O_2$; (b) pure caffeine is odourless, and the aroma of coffee comes from many other compounds in the mixture; (c) EU law requires the warning and the amount on drinks other than coffee and tea with more than 150 mg per litre; (d) a mixture.
- **Box 9:** for example: “Coffee is a mixture of many compounds because caffeine itself has no smell, yet coffee smells strongly. One limitation: we smelled only one concentration of caffeine.”
- **Test:** 1 $C_8H_{10}N_4O_2$; 2 has no smell; 3 a mixture; 4 four; 5 an energy drink.
- **Question 6:** their surroundings differ. Three nitrogens each carry a methyl group (N1, N3, N7); the fourth (N9) has no methyl and forms a double bond to carbon in the five-membered ring. Different neighbours and bonds give different chemical environments, which is also why they appear differently in spectra.
- **Question 7:** a band belongs to a vibration of the whole molecule in which several atoms move at once; the two C=O groups sit in one ring system, so the carbonyl region shows where the C=O groups contribute most, not one band per bond.
- **Question 8:** in a crystal very many molecules are packed in a regular, ordered pattern. Crystals that are not cubic split light into two parts travelling at different speeds (birefringence); this comes from the ordered packing, a property no single molecule has.