Characteristic reactions of organic functional groups

Alkanes

Functional group: alkanes do not have a functional group in the usual sense of the term. The reactions of alkanes are characteristic of C−C and C−H bonds which are non-polar and inert to polar and ionic reagents.

Physical properties

C1 to C4 alkanes are gases. Common alkanes from C5 upwards are colourless liquids.

Solubility and acid–base character

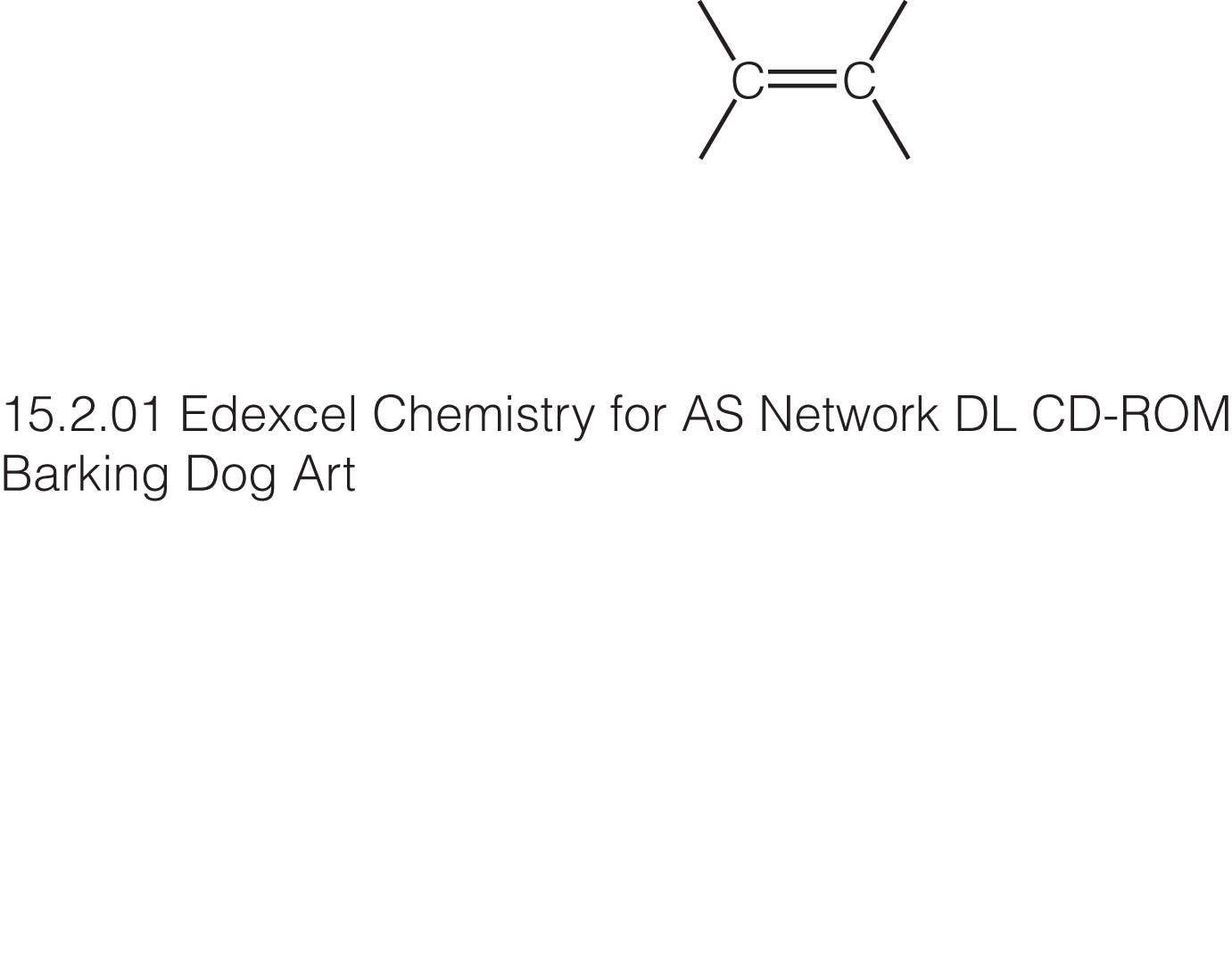
Alkanes do not mix with water. They are inert to all aqueous reagents. They have no acid–base properties.

Functional group test

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| Test | Observations | Inferences |
| Ignite the alkane. | Burns with a yellowish and slightly smoky flame. | Not a definitive test but helps distinguish alkanes from unsaturated compounds which often burn with much smokier flames. |

Alkenes

Functional group:



Physical properties

Ethene, propene and the butenes are colourless gases. Common alkenes with more than four carbon atoms are liquids.

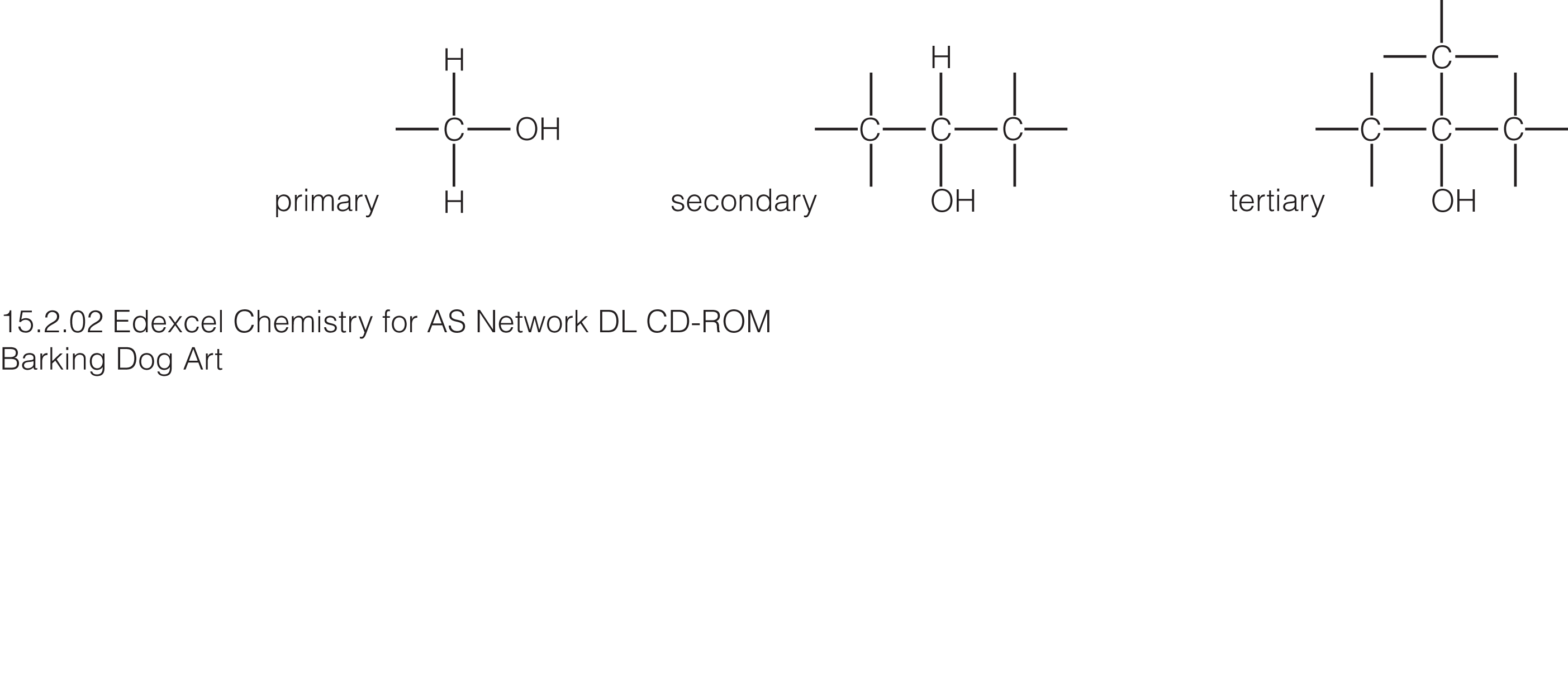
Solubility and acid–base character

Alkenes, like other hydrocarbons, do not mix with or dissolve in water. They have no acid–base properties.

Functional group test

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| Test | Observations | Inferences |
| Shake with dilute, aqueous bromine. | Bromine rapidly decolorised. (Note that a hydrocarbon that is not an alkene will simply extract the bromine colour from the aqueous layer.) | This test detects the presence of alkene double bonds but other compounds can decolorise bromine. |
| Shake with a few drops of dilute, acidified potassium managanate(vii). | Purple colour quickly disappears. | A compound that can reduce manganate(vii). Other organic compounds gives this result. |

Alcohols

Functional group:

Physical properties

All common alcohols are colourless liquids.

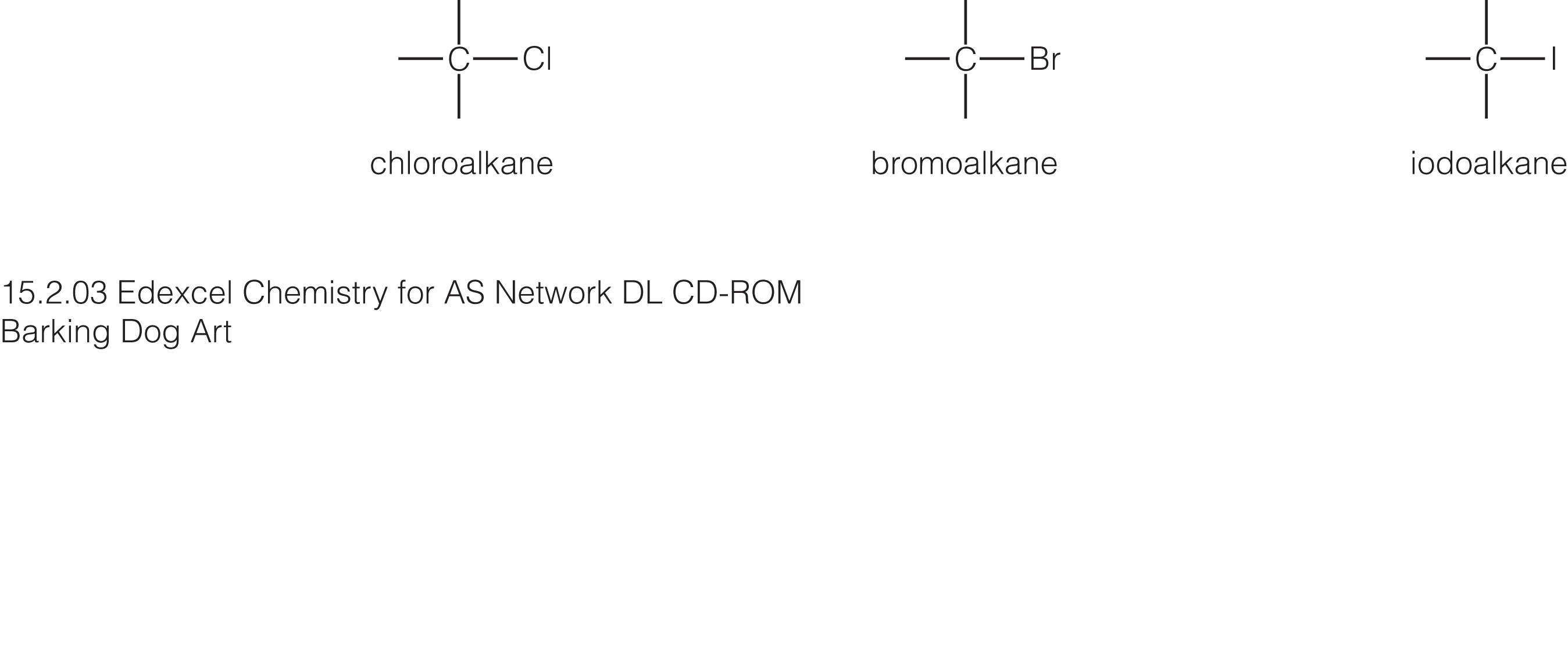
Solubility and acid–base character

Alcohols with relatively short hydrocarbon chains are soluble in water.   
Alcohols are not acidic in aqueous solution.

Functional group tests

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| Test | Observations | Inferences |
| Add solid PCl5 to the anhydrous compound. | Mixture fizzes. A colourless, fuming, acidic gas forms. | The gas is hydrogen chloride from the reaction of PCl5 with an −OH group. |
| Warm with an acidic solution of potassium dichromate(vi). | Orange solution turns green and the vapour given off has a stronger smell than the alcohol. | Primary and secondary (but not tertiary) alcohols are oxidised to more volatile aldehydes or ketones. |

Halogenoalkanes

Functional group:

Physical properties

Most common halogenoalkanes are colourless liquids at room temperature.

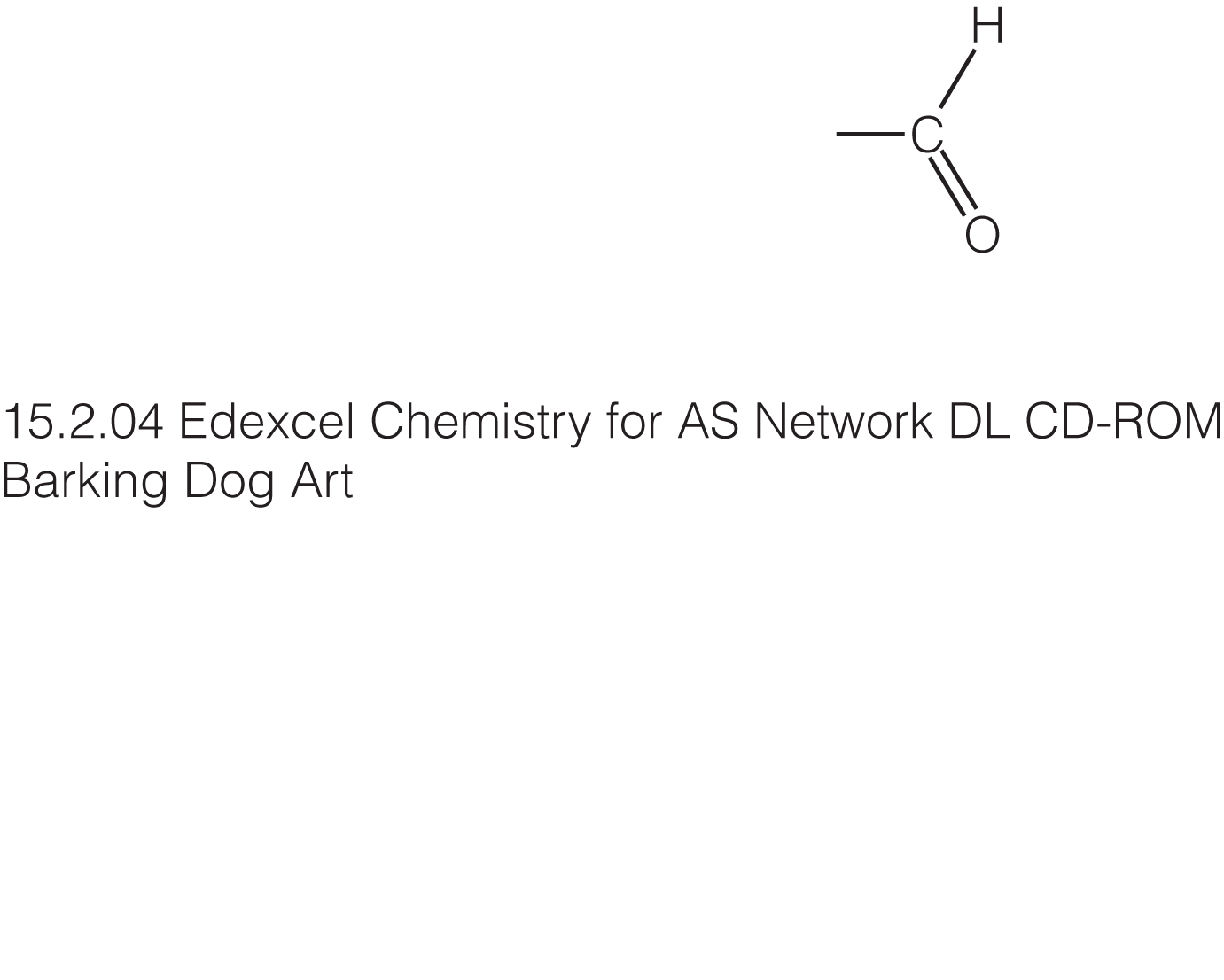
Solubility and acid–base character

Halogenoalkanes do not mix with water. They have no acid–base properties.

Functional group tests

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| Test | Observations | Inferences |
| Add a drop of the halogenoalkane to a little ethanol. Mix with silver nitrate solution. Stand in a warm water bath. | Heavy yellow precipitate forms in seconds.  Cream precipite forms after  2–5 minutes.  Faint white precipitate after about 10 minutes. | Hydrolysis with water slowly produces halide ions from covalent molecules. The silver ions form precipitates: white AgCl forms very slowly from a chloroalkane; creamy AgBr forms a little faster from a bromoalkane and yellow AgI forms rapidly from an iodoalkane. |
| Warm with a solution of sodium hydroxide, acidify with nitric acid and then add silver nitrate. | A white, creamy-yellow or yellow precipitate on adding silver nitrate.  Hydrolysis is fastest with iodoalkanes and slowest with chloroalkanes. | Hydrolysis with alkali produces halide ions from covalent molecules. In acid solution the silver ions form precipitates: white AgCl from a chloroalkane; creamy AgBr from a bromoalkane and yellow AgI from an iodoalkane. |

Aldehydes

Functional group:

Physical properties

Methanal is a gas at room temperature. Ethanal boils at 21 °C. All other common aldehydes are colourless liquids.

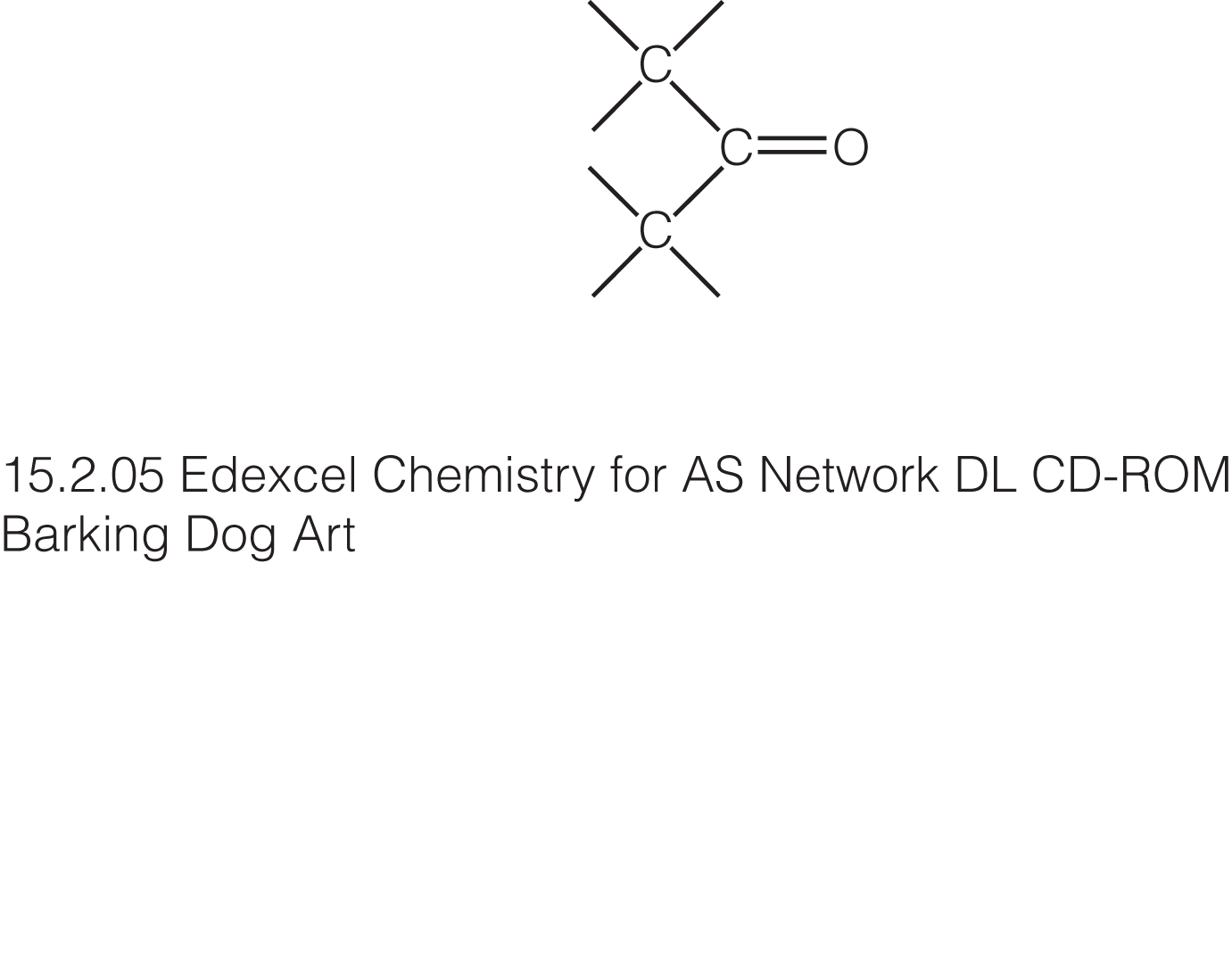
Solubility and acid–base character

The simpler aldehyes such as methanal and ethanal are freely soluble in water. They have no acid or base properties in aqueous solution.

**Functional group tests**

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| Test | Observations | Inferences |
| Warm with freshly prepared Fehling’s solution or Benedict’s reagent. | Mixture turns green, then the blue colour goes and an orange-red precipitate forms. | Aldehydes reduce copper(ii) ions in the reagent to copper(i) oxide. |

Ketones

Functional group:

Physical properties

All common ketones are colourless liquids at room temperature.

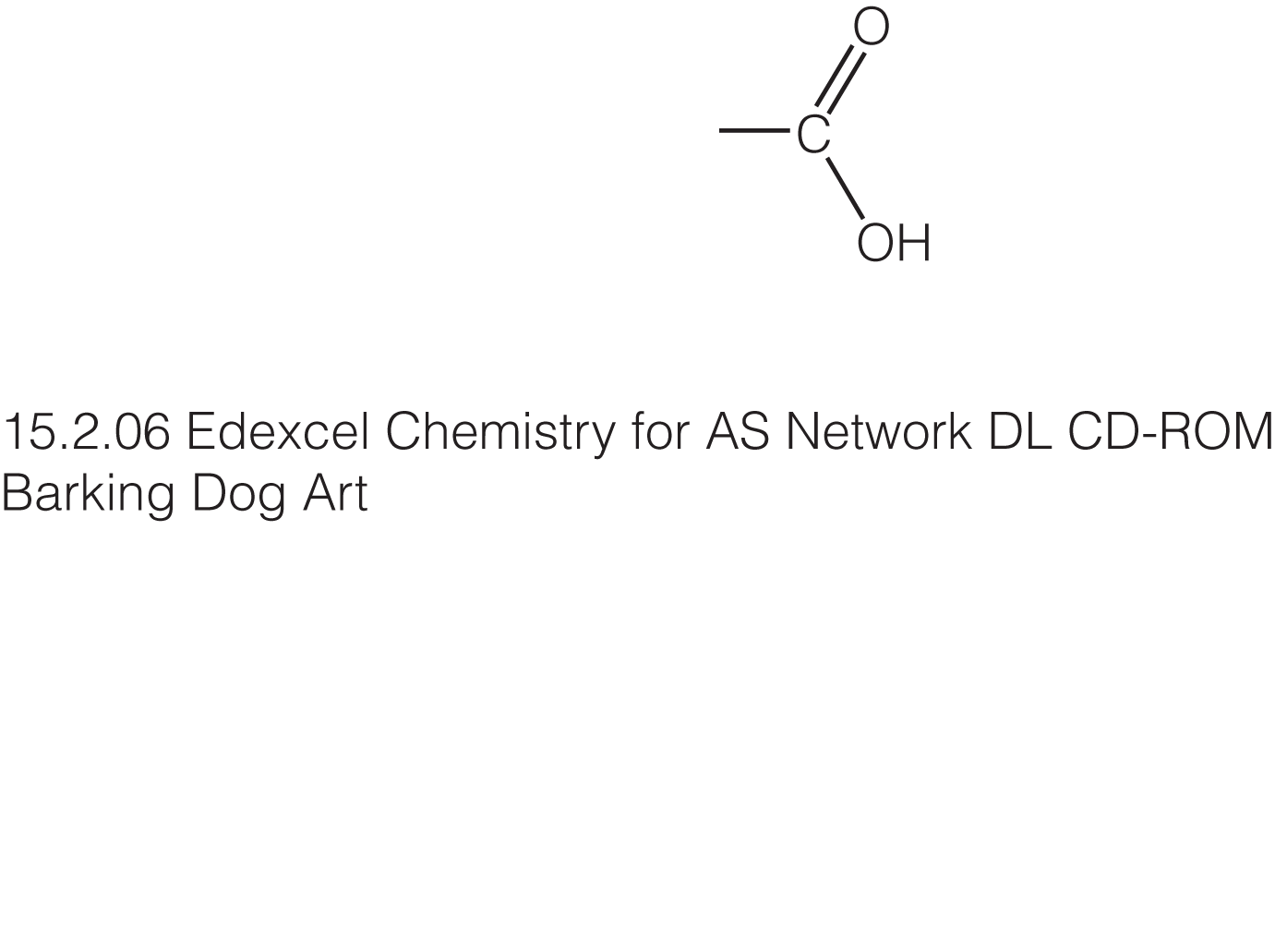
Solubility and acid–base character

The simpler ketones such as propanone mix freely with water but have no acid or base properties in aqueous solution.

Functional group tests

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| Test | Observations | Inferences |
| Warm with freshly prepared Fehling’s solution or Benedict’s reagent. | No reaction. | Ketones do not reduce Fehling’s solution. |

Carboxylic acids

Functional group:

Physical properties

The simplest carboxylic acids, such as methanoic and ethanoic acid, are colourless liquids.

Solubility and acid–base character

The simpler acids dissolve in water. They are weak acids. They give a solution with a pH below 7.

Functional group tests

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| Test | Observations | Inferences |
| Warm a little solid with dilute hydrochloric acid. | Smell of vapour. | Ethanoates give a strong smell of vinegar. |
| Add a solution of sodium carbonate. | The mixture fizzes and gives off a colourless gas that turns limewater cloudy white. | Carbon dioxide given off by an acid. |