Solutions

Each answer shows the steps, then the **result**.

2.1

- hydrogen (H_2) with a Pt or Ni catalyst; and heat

2.2

- carbon monoxide (and/or carbon/soot); water

3.1 B

- Free-radical substitution needs ultraviolet light

3.2 B

- Strong, non-polar C–H and C–C bonds offer no site for a polar reagent

3.3

(a)

- initiation: $Cl_2 \rightarrow 2Cl\cdot$; propagation: $Cl \cdot + C_2H_6 \rightarrow C_2H_5 \cdot + HCl$ and $C_2H_5 \cdot + Cl_2 \rightarrow C_2H_5Cl + Cl\cdot$

(b)

- $C_2H_5 \cdot + Cl\cdot \rightarrow C_2H_5Cl$

3.4

- it produces carbon monoxide, a toxic gas that binds to haemoglobin and prevents oxygen transport

3.5

(a)

- Initiation: $Cl_2 \xrightarrow{uv} 2Cl\bullet$. Propagation: $Cl\bullet + CH_4 \rightarrow \bullet CH_3 + HCl$ and $\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + Cl\bullet$. Termination: any two radicals combining, e.g. $\bullet CH_3 + Cl\bullet \rightarrow CH_3Cl$. Each step correctly labelled

(b)

- Ultraviolet light supplies the energy to break the Cl–Cl bond **homolytically**; without it no radicals are produced, so the chain can never start

(c)

- Chloromethane still contains C–H bonds, so a chlorine radical can attack it in turn and substitution continues; dichloromethane, CH_2Cl_2, and trichloromethane, $CHCl_3$. (Ethane, from two methyl radicals combining, is also acceptable.)

(d)

- C–C and C–H bonds are strong, so a large energy input is needed to break them; carbon and hydrogen have very similar electronegativities, so the bonds are essentially non-polar; there is therefore no $\delta+$ carbon for a nucleophile to attack