11.3 Alkenes

Set A **Answer key**

A From the lesson

10 MARKS

1. Only **(b)**. In (a), C1 has two H. In (c), C2 has two CH_3. [1]

2. **2-bromobutane**, $CH_3CHBrCH_2CH_3$ [1]
   H adds to C1 (more H atoms), giving a 2° carbocation [1]
   stabilised by two electron-donating alkyl groups which disperse the positive charge more than in the 1° carbocation. [1]

3. Propanone comes from the $=C(CH_3)_2$ end of the alkene, and ethanoic acid comes from the $=CHCH_3$ end. [1]
   $(CH_3)_2C=CHCH_3$, 2-methylbut-2-ene [1]

4. Restricted rotation about C=C, and each C of C=C has two different groups. [1]

5. Steam, H_3PO_4 catalyst, 300 °C, 60 atm. [1]

6. Electrophilic addition. [1]

7. CO_2 and H_2O. [1]

B Practice

19 MARKS

8. **C** It is an electrophile. [1]
   It is an electrophile, as the carbon carrying the positive charge is electron deficient.
   - **A** Only the carbon carrying the positive charge in the intermediate is trigonal planar. The other carbon has a tetrahedral geometry.
   - **B** The carbocation intermediate has a positive charge.
   - **D** The intermediate does not have any unpaired electrons.

9 **B** Neither reacts with bromine to give 1,4-dibromobutane. [1]

The electrophilic addition of bromine to an alkene occurs across adjacent carbon atoms. $CH_3CH_2CH=CH_2$ gives $CH_3CH_2CHBrCH_2Br$ (1,2-dibromobutane), while $CH_3CH=CHCH_3$ gives $CH_3CHBrCHBrCH_3$ (2,3-dibromobutane).

A $CH_3CH=CHCH_3$, but not $CH_3CH_2CH=CH_2$, can exhibit cis-trans isomerism.

C Both react with hydrogen to form butane.

D Both may be oxidised by alkaline potassium manganate(VII) to form a diol, due to the presence of C=C.

10 A C=C double bond consists of a sigma (σ) bond and a pi (π) bond. The π bond is a region of high electron density and is susceptible to attack by electrophiles (electron deficient species). [1]

Many reactions involve breaking the weak π bond while the σ bond remains intact. Alkanes are less reactive, as they contain the stronger σ bonds only. [1]

11 **(a)** Reagent: Br_2 in CCl_4. Condition: dark, room temperature. Bubble a sample of each gas through Br_2 dissolved in CCl_4. [1]

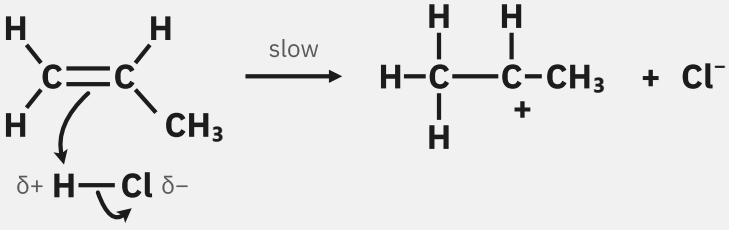
When ethene is bubbled through, orange Br_2 is decolourised: $CH_2=CH_2 + Br_2 \rightarrow CH_2BrCH_2Br$. Orange Br_2 does not decolourise when ethane is bubbled through it. [1]

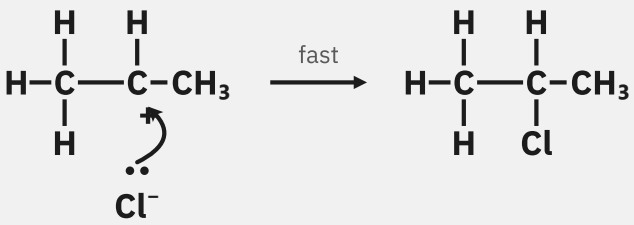
(b) Reagent: $KMnO_4(aq)$, $H_2SO_4(aq)$. Condition: heat. Bubble a sample of each gas into a mixture of several drops of $KMnO_4(aq)$ in excess sulfuric acid, and heat. [1]

With but-1-ene, the purple $KMnO_4$ is decolourised and a colourless gas (CO_2), which forms a white precipitate when bubbled through $Ca(OH)_2(aq)$, is evolved. $CH_3CH_2CH=CH_2 + 5[O] \rightarrow CH_3CH_2COOH + CO_2 + H_2O$, $CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$ [1]

With but-2-ene, the purple $KMnO_4$ is decolourised, but no gas is evolved. $CH_3CH=CHCH_3 + 4[O] \rightarrow 2CH_3COOH$ [1]

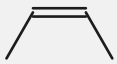
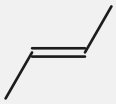
12 Mechanism: electrophilic addition



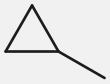


[3]

13 **(a)**

A: cis-but-2-ene  B: trans-but-2-ene  [1]

C: but-1-ene, $CH_2=CHCH_2CH_3$ D: 2-methylpropene, $(CH_3)_2C=CH_2$ [1]

E: cyclobutane  F: methylcyclopropane  [1]

(b)

A is polar (non-zero net dipole moment), while B is non-polar (zero net dipole moment). [1]

The intermolecular forces between molecules of cis-but-2-ene (permanent dipole–permanent dipole and instantaneous dipole–induced dipole interactions) are stronger than those between molecules of trans-but-2-ene (only instantaneous dipole–induced dipole interactions). Since boiling involves overcoming the intermolecular forces, cis-but-2-ene has a higher boiling point than trans-but-2-ene. [1]

(c)

A: $CH_3COO^-Na^+$ B: $CH_3COO^-Na^+$ [1]

C: $CH_3CH_2COO^-Na^+ + Na_2CO_3$ D: $CH_3COCH_3 + Na_2CO_3$ [1]