11.2 Alkanes

Set B **Answer key**

A Multiple choice

4 MARKS

1

A 3 only [1]

1 Incorrect. For hydrogen gas to be produced, 2 hydrogen radicals need to collide in a termination step. However, the formation of hydrogen radicals is unlikely due to the strong C–H bond.

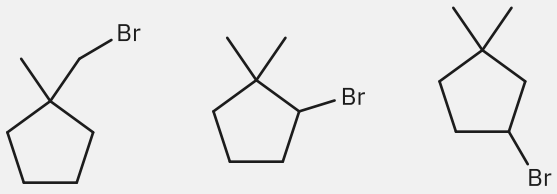
2 Incorrect. Bond breaking occurs at every step of the mechanism: initiation breaks the X–X bond to form halogen radicals, propagation breaks a C–H bond to form a C–X bond, and termination breaks another X–X bond to form halogen radicals.

3 Correct. CH_3Cl can form in the propagation step, $\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + Cl\bullet$, or in the termination step, $Cl\bullet + \bullet CH_3 \rightarrow CH_3Cl$.

2

B 3 [1]

There are a total of 6 primary hydrogens and 8 secondary hydrogens. Substitution of any of them gives a mono-brominated product. However, due to an internal plane of symmetry, mono-substitution of hydrogen on carbon-2 or carbon-5 gives the same product. The case is similar for carbon-3 or carbon-4, and for the 2 primary methyl groups on carbon-1. Hence there will be a total of 3 different mono-substituted products.



3

A $\bullet CHFCF_2Cl$ [1]

Homolytic fission of the C–Cl bond occurs, as the C–Cl bond is the weakest, compared with the C–F and C–H bonds.

4

A $CH_4 + CH_3\dot{C}HCl$ [1]

In this free radical substitution reaction, there is a higher probability of the methyl radical abstracting an H atom from chloroethane to form methane, than of it colliding with the C atom, which is sterically hindered by H atoms. Hence, option A is preferred to options C and D.

In addition, for option D, the formation of a hydrogen radical is highly unlikely and unfavourable. Option B will not happen, as there are too many bonds broken and formed simultaneously.

B Structured questions

17 MARKS

5 (a)

Due to the non-polar nature of alkanes, they are generally unreactive towards polar or ionic reagents like acids, alkalis or aqueous oxidising agents. The C–C and C–H bonds are very strong and require a large amount of energy to be broken. [1]

(b)(i)

Free radical substitution.

Initiation: $Br_2 \xrightarrow{\text{UV light}} 2Br\bullet$ [1]

Propagation:

$Br\bullet + H{-}CH(CH_3)CH_2CH_3 \longrightarrow H{-}Br + \bullet CH(CH_3)CH_2CH_3$

$CH_3CH_2(CH_3)CH\bullet + Br{-}Br \longrightarrow CH_3CH_2(CH_3)CH{-}Br + Br\bullet$ [1]

Termination (any one): $Br\bullet + \bullet Br \longrightarrow Br{-}Br$

$CH_3CH_2(CH_3)CH\bullet + \bullet Br \longrightarrow CH_3CH_2(CH_3)CH{-}Br$

$CH_3CH_2(CH_3)CH\bullet + \bullet CH(CH_3)CH_2CH_3 \longrightarrow CH_3CH_2(CH_3)CH{-}CH(CH_3)CH_2CH_3$ [1]

(ii)

Ratio of 1-bromobutane : 2-bromobutane = **3 : 2** [1]

(iii)

Both compounds have simple molecular structures. 2-bromobutane has a straight chain, but 2-bromo-2-methylpropane has a branched chain. [1]

Extent of surface area of contact, extent of distortion of the electron cloud, and so extent of the (weak) intermolecular instantaneous dipole–induced dipole attractions are greater for 2-bromobutane than for 2-bromo-2-methylpropane. [1]

More energy is required to overcome the instantaneous dipole–induced dipole attractions in 2-bromobutane than in 2-bromo-2-methylpropane. Hence, the boiling point of 2-bromobutane is higher than that of 2-bromo-2-methylpropane. [1]

6 (a)

$(CH_3)_3CC(CH_3)_3$, 2,2,3,3-tetramethylbutane [1]

(b)

$(CH_3)_2CHCH_2CH_2CH(CH_3)_2$, 2,5-dimethylhexane [1]

7

The catalyst in the catalytic converter is a heterogeneous catalyst. The reactant molecules adsorb onto the surface of the metal catalyst by forming weak, temporary bonds. **[1]**

This weakens the bonds in the reactant molecules and so provides an alternative reaction pathway of lower activation energy. The surface concentration of the reactants also increases. The product molecules then desorb from the catalyst surface, making the surface available for the adsorption of new reactant molecules. **[1]**

8

A: $CH_3CCl_2CH_3$ (gives only $CH_3CCl_2CH_2Cl$) **[1]**

B: $ClCH_2CH_2CH_2Cl$ (gives $ClCH_2CHClCH_2Cl$ and $Cl_2CHCH_2CH_2Cl$) **[1]**

C: $CH_3C^*HClCH_2Cl$ (gives $CH_3CHClCHCl_2$, $CH_3CCl_2CH_2Cl$ and $ClCH_2CHClCH_2Cl$) **[1]**

D: $CH_3CH_2CHCl_2$ (gives $CH_3CH_2CCl_3$, $CH_3CHClCHCl_2$ and $ClCH_2CH_2CHCl_2$) **[1]**

E: $CH_3C^*HClCHCl_2$ (optically active) **[1]**