Organic Chemistry [S]

1. Crude oil is the source of many of the substances studied in organic chemistry.

    a. Fill in the gaps: **[7]**

    Crude oil is a _____ of _____ (compounds of

    _____ and _____ only).

    It is formed by the action of high pressure and temperature on dead sea-life.

    Different _____ in crude oil can be separated by

    _____ _____.

    b. Explain how the fractions of crude oil are separated industrially: **[3]**

    c. Name three fractions of crude oil and provide two uses for each: **[9]**

    Fraction:

    Uses:

    Fraction:

    Uses:

    Fraction:

    Uses:

d. A student has collected two liquid fractions, each at a different temperature, from a sample of crude oil using distillation in a laboratory and he can't remember which is which. Describe how he could identify the fraction collected at the higher temperature using its boiling point and viscosity. **[4]**

2. Alkanes are the main constituents of crude oil. They form a homologous series of hydrocarbons.

   a. Define the term *homologous series*: **[2]**

   b. The general formula for alkanes is C_nH_{2n+2}.

      i. Write the formula of an alkane with 13 carbon atoms: **[1]**

      ii. Write the formula of an alkane with 18 hydrogen atoms: **[1]**

   c. Draw two branched-chain (not straight-chain) isomers of hexane: **[2]**

d. Alkanes make good fuels because their combustion is very exothermic.

   i. Write a balanced equation for the complete combustion of propane: **[2]**

   ii. Explain why carbon monoxide, a product of incomplete combustion, is toxic to humans: **[2]**

e. Alkanes can react with chlorine or bromine under certain conditions.

   i. State the condition required for such a reaction to occur: **[1]**

   ii. Represent the reaction of methane with bromine using displayed formulae: **[3]**

3. Alkane molecules can be shortened by an industrial process known as *catalytic cracking*.

   a. State the conditions required for this process: **[2]**

   b. Write a balanced equation for the catalytic cracking of dodecane ($C_{12}H_{26}$): **[3]**

c. Explain why catalytic cracking is important to industry and the economy: **[3]**

4. The alkenes are a useful homologous series of unsaturated hydrocarbons that are produced when alkanes are catalytically cracked.

   a. Define the term *unsaturated*: **[1]**

   b. Draw a molecule of propene: **[1]**

   c. State:

      i. The general formula of alkenes: **[1]**

      ii. The name and formula of an alkene with 4 carbon atoms: **[2]**

   d. Describe, using a suitable diagram, how ethene reacts with bromine water and state the colour change observed: **[3]**

5. Ethanol is an important crude oil derivative used in a wide range of industries globally.

    a. Draw a molecule of ethanol: **[1]**

    b. Under certain conditions, ethanol can be converted into ethene.

        i. State the catalyst required for this reaction: **[1]**

        ii. State the term used to describe this type of reaction: **[1]**

    c. Ethanol can be manufactured by the hydration of ethene or the fermentation of glucose.

        i. State the conditions required for the hydration of ethene: **[3]**

        ii. Describe *two* advantages and *two* disadvantages of mass-producing ethanol industrially by the fermentation of sugars: **[4]**

6. Polymers can be made from a wide variety of molecules and are used in almost every aspect of human activity.

    a. Addition polymerisation of an alkene involves only one type of monomer.

        i. Draw the monomer required to produce poly(ethene): **[1]**

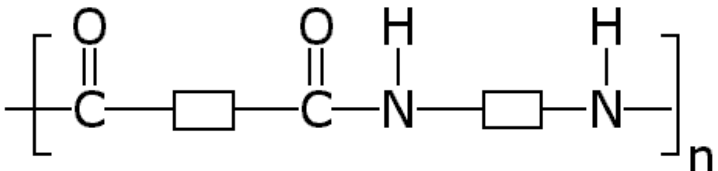
        ii. Draw a repeating unit of poly(propene): **[2]**

        iii. State one function of poly(chloroethene): **[1]**

    b. Nylon is a commonly used *condensation polymer*.

        i. Define *condensation polymerisation*: **[2]**

        ii. Draw the monomers used to make nylon (repeating unit shown): **[2]**



nylon

Organic Chemistry [S]

1. Crude oil is the source of many of the substances studied in organic chemistry.

    a. Fill in the gaps: **[7]**

    Crude oil is a **mixture** of **hydrocarbons** (compounds of **hydrogen** and **oxygen** only).

    It is formed by the action of high pressure and temperature on dead sea-life.

    Different **compounds** in crude oil can be separated by **fractional distillation.**

    b. Explain how the fractions of crude oil are separated industrially: **[3]**

    fractions have different boiling points [1]

    each fraction rises up the column a different amount before… [1]

    … condensing and being tapped off [1]

    c. Name three fractions of crude oil and provide two uses for each: **[9]**

    Fraction: **bitumen [1]**

    Uses: **roofing [1] and road surfacing [1]**

    Fraction: **fuel oil [1]**

    Uses: **fuel for ships [1] and power stations [1]**

    Fraction: **naphtha [1]**

    Uses: **solvents [1] and vehicle fuel [1]**

d. A student has collected two liquid fractions, each at a different temperature, from a sample of crude oil using distillation in a laboratory and he can't remember which is which. Describe how he could identify the fraction collected at the higher temperature using its boiling point and viscosity. **[4]**

pour both fractions [1]

the less runny fraction was collected at the higher temperature [1]

measure the boiling point of both fractions [1]

the higher boiling point fraction was collected at the higher temperature [1]

2. Alkanes are the main constituents of crude oil. They form a homologous series of hydrocarbons.

a. Define the term *homologous series*: **[2]**

a series of compounds with similar chemical properties [1] and trends in physical properties [1]

b. The general formula for alkanes is C_nH_{2n+2}.

i. Write the formula of an alkane with 13 carbon atoms: **[1]**

$C_{13}H_{28}$

ii. Write the formula of an alkane with 18 hydrogen atoms: **[1]**

C_8H_{18}

c. Draw two branched-chain (not straight-chain) isomers of hexane: **[2]**

Any two branched alkanes with the formula C_6H_{14} with ALL bonds and atoms shown [2]

d. Alkanes make good fuels because their combustion is very exothermic.

   i. Write a balanced equation for the complete combustion of propane: **[2]**

   $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

   ii. Explain why carbon monoxide, a product of incomplete combustion, is toxic to humans: **[2]**

   it binds to haemoglobin in red blood cells [1]

   reducing the oxygen carrying capacity of blood [1]

e. Alkanes can react with chlorine or bromine under certain conditions.

   i. State the condition required for such a reaction to occur: **[1]**

   ultra-violet light

   ii. Represent the reaction of methane with bromine using displayed formulae: **[3]**

   CH_4 and Br_2 reactants drawn with ALL bonds and atoms shown [1]

   CH_3Br product drawn with ALL bonds and atoms shown [1]

   HBr product drawn (formula alone is fine) [1]

3. Alkane molecules can be shortened by an industrial process known as *catalytic cracking*.

   a. State the conditions required for this process: **[2]**

   temp between 550 and 700°C [1] and Al_2O_3 or SiO_2 catalyst [1]

   b. Write a balanced equation for the catalytic cracking of dodecane ($C_{12}H_{26}$): **[3]**

   $C_{12}H_{26}$ reactant [1]
   alkane $C_{10}H_{22}$ or shorter product [1]
   corresponding alkene product [1]

c. Explain why catalytic cracking is important to industry and the economy: **[3]**

fractional distillation of crude oil produces more long chains than short [1]

we require more short chains than long [1]

cracking converts long chains into short chains [1]

4. The alkenes are a useful homologous series of unsaturated hydrocarbons that are produced when alkanes are catalytically cracked.

a. Define the term *unsaturated*: **[1]**

has a C=C double bond [1]

b. Draw a molecule of propene: **[1]**

propene drawn with ALL bonds and atoms [1]

c. State:

i. The general formula of alkenes: **[1]**

C_nH_{2n}

ii. The name and formula of an alkene with 4 carbon atoms: **[2]**

butene [1], C_4H_8 [1]

d. Describe, using a suitable diagram, how ethene reacts with bromine water and state the colour change observed: **[3]**

Br atoms add into molecule, one each side of the C=C double bond [1]
suitable diagram showing this [1]
colour change: orange → colourless [1]

5. Ethanol is an important crude oil derivative used in a wide range of industries globally.

    a. Draw a molecule of ethanol: **[1]**

    Ethanol molecule drawn with ALL bonds and atoms drawn [1]

    b. Under certain conditions, ethanol can be converted into ethene.

        i. State the catalyst required for this reaction: **[1]**

        aluminium oxide [1]

        ii. State the term used to describe this type of reaction: **[1]**

        dehydration [1]

    c. Ethanol can be manufactured by the hydration of ethene or the fermentation of glucose.

        i. State the conditions required for the hydration of ethene: **[3]**

        high temperature [1], high pressure [1], phosphoric acid catalyst [1]

        ii. Describe *two* advantages and *two* disadvantages of mass-producing ethanol industrially by the fermentation of sugars: **[4]**

        Advantages:
        renewable sources [1]
        cheap to maintain the low temperature required [1]

        Disadvantages (any 2):
        batch process is slow [1]
        slow reaction [1]
        produces impure product, needs separating [1]

6. Polymers can be made from a wide variety of molecules and are used in almost every aspect of human activity.

    a. Addition polymerisation of an alkene involves only one type of monomer.

        i. Draw the monomer required to produce poly(ethene): **[1]**

        ethene molecule drawn with ALL bonds and atoms [1]

        ii. Draw a repeating unit of poly(propene): **[2]**

        repeat unit drawn with bonds extending outwards [1]

        brackets and 'n' [1]

        iii. State one function of poly(chloroethene): **[1]**

        making ropes [1]

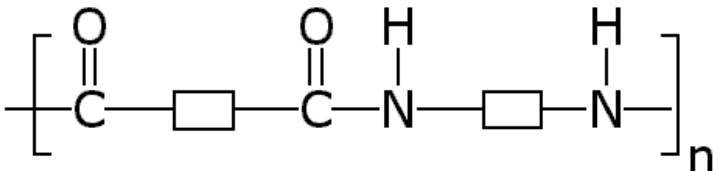
    b. Nylon is a commonly used *condensation polymer*.

        i. Define *condensation polymerisation*: **[2]**

        small molecules joining together [1]

        with the loss of a small molecule between [1]

        ii. Draw the monomers used to make nylon (repeating unit shown): **[2]**



nylon

Dicarboxylic acid drawn with ALL bonds and atoms shown [1]

Diamine drawn with ALL bonds and atoms shown [1]