Q1.

This question is about $CFCl_3$

$CFCl_3$ used to be the propellant in most aerosol cans.

(a) Use IUPAC rules to name $CFCl_3$

_____

(1)

(b) Give an equation for each of the **two** propagation steps in the conversion of $CHFCl_2$ into $CFCl_3$

Equation 1

_____

Equation 2

_____

(2)

(c) In the presence of ultraviolet radiation, $CFCl_3$ breaks down in the upper atmosphere to form chlorine free radicals.

Give an equation for this reaction.

_____

(1)

(d) Chlorine free radicals catalyse the decomposition of ozone.

Give **two** equations to show how chlorine free radicals decompose ozone.

Equation 1

_____

Equation 2

_____

(2)

(e) The production and use of CFCs have been banned in many countries because they decrease the amount of ozone in the upper atmosphere.

State why ozone in the upper atmosphere is important for life on Earth.

_____

_____

(1)

(Total 7 marks)

Q2.

This question is about hydrocarbons.

(a) Eicosane ($C_{20}H_{42}$) can be cracked by heating to 700 K in the presence of a catalyst.

The products are

- an aromatic hydrocarbon C_8H_{10}
- an alkane C_6H_{14}
- another alkane.

$$C_{20}H_{42} \longrightarrow C_8H_{10} + C_6H_{14} + \_\_\_\_\_$$

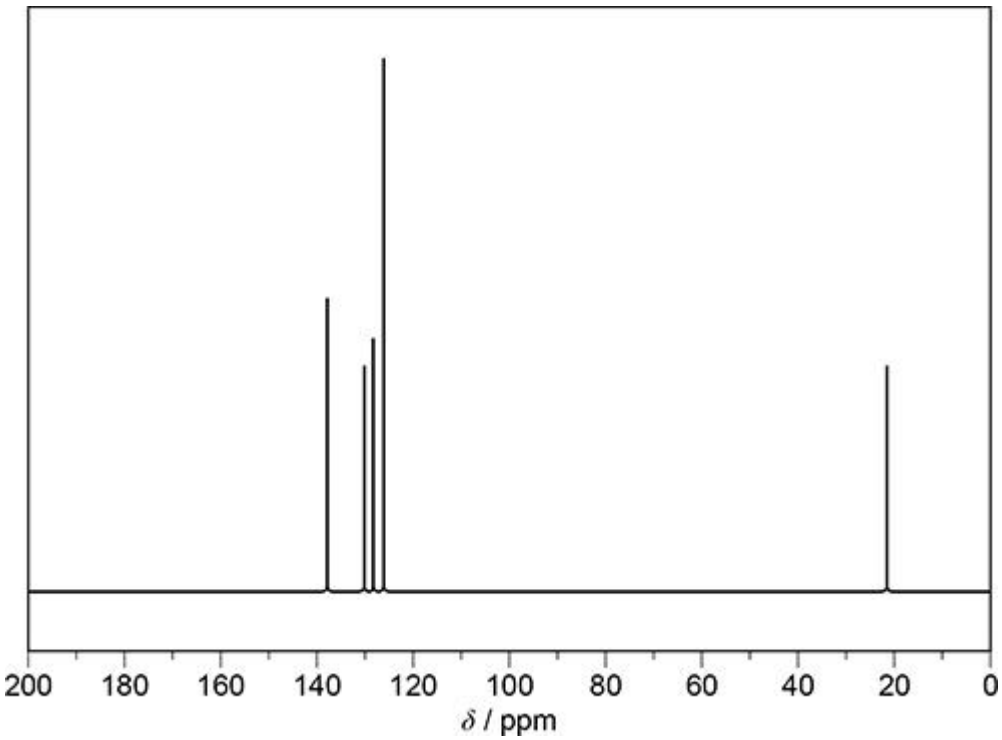
Complete the equation for this reaction.

Give a suitable catalyst for this reaction.

Catalyst _____

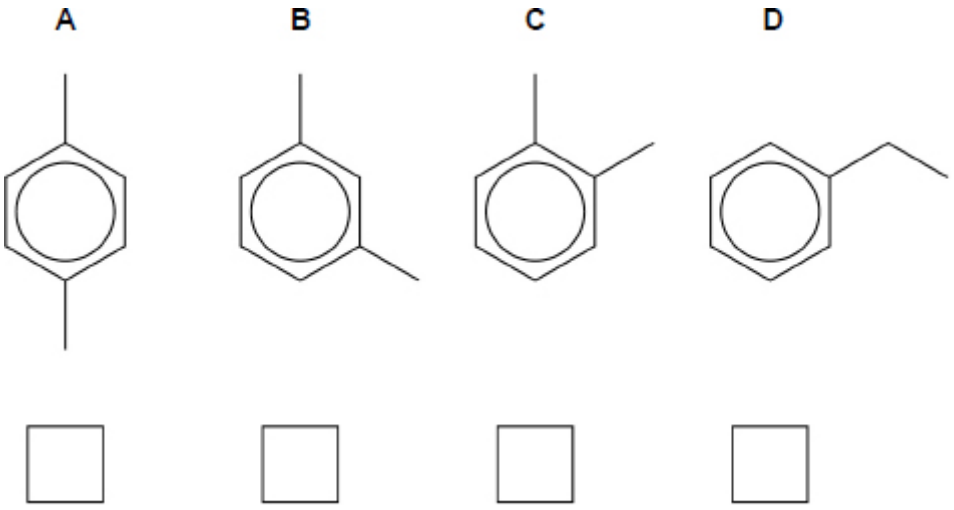
(2)

(b) The figure below shows the ^{13}C NMR spectrum for the aromatic hydrocarbon C_8H_{10}



Which of these is the structure of C_8H_{10}?

Tick (✓) **one** box.



(1)

(c) Cracking can also be done without a catalyst, using a temperature of 1200 K and a pressure of 7000 kPa

State the type of product that is formed in high percentage in this type of cracking.

_____

(1)

(d) A sample of butane has a volume of 20 cm^3 at room temperature and pressure.

The sample is burned completely in 1350 cm^3 of air.

The final mixture is cooled to room temperature and pressure.

$$C_4H_{10} + 6\tfrac{1}{2}\ O_2 \longrightarrow 4\ CO_2 + 5\ H_2O$$

Calculate the total volume of gas in the final mixture.
Assume that air contains 21% by volume of oxygen.

Total volume of gas remaining _____ cm^3

(4)

(e) Natural gas is used in power stations to produce electricity.

Natural gas contains sulfur impurities. Sulfur dioxide forms when these impurities are burned.

State an environmental problem caused by sulfur dioxide.

Give the formula of a compound that is used to help remove sulfur dioxide from the combustion products.

Environmental problem _____

Formula of compound _____

_____

(2)

(Total 10 marks)

Q3.

This question is about fuels.

(a) Crude oil is separated into fractions by fractional distillation.

State the meaning of the term 'fraction' in this context.

_____

_____

_____

(1)

(b) Petrol for cars contains branched and cyclic alkanes produced by catalytic cracking.

Identify the catalyst used in this process.

_____

(1)

(c) 3-Ethyl-4-methylhexane is a branched alkane in petrol.

Draw the skeletal formula of this alkane.

(1)

(d) Give the equation for the complete combustion of 3-ethyl-4-methylhexane. Use the molecular formula for 3-ethyl-4-methylhexane in your equation.

_____

(2)

(e) Carbon dioxide is a product from the combustion of petrol in cars. Carbon dioxide acts as a greenhouse gas when it absorbs infrared radiation.

Give **one** reason why carbon dioxide absorbs infrared radiation.

_____

_____

_____

(1)

(f) Nitrogen monoxide (NO) is formed when petrol is burned in cars.

State **one** environmental problem that NO causes.

State what is used to remove NO from the exhaust gases formed in petrol-fuelled cars.

Environmental problem _____

_____

Removal of NO _____

_____

(2)

(g) Petrol sold in the UK contains 10% bioethanol. Bioethanol is ethanol made from crops by fermentation and is considered to be carbon-neutral.

State what is meant by the term ‘carbon-neutral’.

_____

_____

_____

(1)

(Total 9 marks)

Q4.

Trichlorofluoromethane (CCl_3F) was developed as a refrigerant. The production and use of CCl_3F is now restricted.

(a) The equation for a process used to manufacture CCl3F is

$$SbF_3Br_2 + CCl_4 \rightarrow CCl_3F + SbF_2Br_2Cl$$

Calculate the percentage atom economy for the production of CCl_3F in this reaction. Give your answer to 3 significant figures.

Percentage atom economy _____

(2)

An alternative synthesis of CCl_3F is the free-radical substitution reaction between fluoromethane (CH_3F) and chlorine.

(b) An intermediate in this alternative synthesis is dichlorofluoromethane ($CHCl_2F$)

Give equations to represent the two propagation steps in the conversion of $CHCl_2F$ into CCl_3F

Propagation step 1

_____

Propagation step 2

_____

(2)

(c) Analysis of the products of this reaction shows the formation of a compound with the empirical formula CCl_2F

Give an equation to represent a termination step forming this compound. Show the structural formula of the product in the equation.

_____

(1)

(Total 5 marks)