Q1.   Petrol contains saturated hydrocarbons. Some of the molecules in petrol have the molecular formula C_8H_{18} and are referred to as octanes. These octanes can be obtained from crude oil by fractional distillation and by cracking suitable heavier fractions.

Petrol burns completely in a plentiful supply of air but can undergo incomplete combustion in a car engine.

(a)   State the meaning of both the words *saturated* and *hydrocarbon* as applied to the term *saturated hydrocarbon*.

Name the homologous series to which C_8H_{18} belongs.

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(3)

(b)   Outline the essential features of the fractional distillation of crude oil that enable the crude oil to be separated into fractions.

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(4)

(c) C_8H_{18} is obtained by the catalytic cracking of suitable heavy fractions.
State what is meant by the term *cracking* and name the catalyst used in catalytic cracking.

Write an equation to show how one molecule of $C_{14}H_{30}$ is cracked to form one molecule of C_8H_{18} and one molecule of another hydrocarbon.

Explain why oil companies need to crack 'suitable heavy fractions'.

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(4)

(d)   Write an equation for the incomplete combustion of C_8H_{18} to form carbon monoxide and water only.

A catalytic converter is used to remove carbon monoxide from the exhaust gases in a car. Identify a catalyst used in the catalytic converter.

Write an equation to show how carbon monoxide is removed in a catalytic converter.

State why the water produced in the exhaust gases may contribute to global warming.

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(4)

(e)   When some petrol was accidentally contaminated in 2007, the sensors in the

affected cars caused a decrease in the supply of petrol to the engine.

Suggest the effect that the contaminated fuel would have on the performance of the cars.

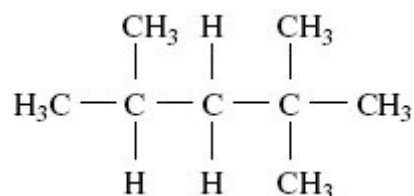State how the oil company might have recognised the problem before the petrol was sold.

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(2)

(f)   The molecular formula C_8H_{18} represents several structural isomers.

State what is meant by the term *structural isomers.*

Name the following structural isomer of C_8H_{18}

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(3)
(Total 20 marks)

Q2.   (a)   (i)   Name the process used to separate petroleum into fractions.

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(ii) Give the molecular formula for an alkane with nine carbon atoms.

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(iii) Write an equation for the complete combustion of the alkane $C_{11}H_{24}$

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(iv) Write an equation for the incomplete combustion of $C_{11}H_{24}$ to produce carbon and water only.

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(4)

(b) Alkenes can be produced by cracking the naphtha fraction obtained from petroleum.

(i) Write an equation for the thermal cracking of one molecule of $C_{10}H_{22}$ to give one molecule of propene and one molecule of an alkane only.

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(ii) Draw the structure of the chain isomer of but-1-ene.

(2)

(c) The alkanes and the alkenes are examples of homologous series of compounds. One feature of an homologous series is the gradual change in physical properties as the relative molecular mass increases. State **two** other general features of an homologous series of compounds.

Page 5

Feature 1 ....

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Feature 2 ....

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(2)
(Total 8 marks)

Q3. Many hydrocarbon compounds burn readily in air.

(i) Write an equation to show the complete combustion of $C_{15}H_{32}$

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(ii) One of the gaseous products of the incomplete combustion of methane in gas fires is known to be poisonous. Identify this product and write an equation for the reaction in which it is formed from methane.

Identity of product ....

Equation ....

(Total 4 marks)

Q4. (a) State what is meant by the term *homogeneous* as applied to a catalyst.

....

(1)

(b)   (i)   State what is meant by the term *autocatalysis*.

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(ii)   Identify the species which acts as an autocatalyst in the reaction between ethanedioate ions and manganate(VII) ions in acidic solution.

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(2)

(c)   When petrol is burned in a car engine, carbon monoxide, carbon dioxide, oxides of nitrogen and water are produced. Catalytic converters are used as part of car exhaust systems so that the emission of toxic gases is greatly reduced.

(i)   Write an equation for a reaction which occurs in a catalytic converter between two of the toxic gases. Identify the reducing agent in this reaction.

Equation ....

....

Reducing agent ....

(ii)   Identify a transition metal used in catalytic converters and state how the converter is constructed to maximise the effect of the catalyst.

Transition metal ....

How effect is maximised ....

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(5)

(d)   The strength of the adsorption of reactants and products onto the surface of a transition metal helps to determine its activity as a heterogeneous catalyst.

(i)   Explain why transition metals which adsorb strongly are not usually good catalysts.

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(ii) Explain why transition metals which adsorb weakly are not usually good catalysts.

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(2)
(Total 10 marks)

Q5. (a) Hexane (C_6H_{14}) is a hydrocarbon which is a component of LPG (liquid petroleum gas), used as a fuel for heating. When burning fuels in boilers it is important to ensure complete combustion.

(i) Give two reasons why boilers are designed to ensure complete combustion.

Reason 1 ....

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Reason 2 ....

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(ii) Write an equation for the incomplete combustion of hexane.

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(iii) Suggest how an engineer or a chemist could demonstrate that the combustion of hexane in a faulty boiler was incomplete.

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(5)

(b) Branched chain alkanes are often preferred as fuels. Draw the structure of two branched chain isomers of hexane and name the first isomer.

Page 8

Isomer 1   Isomer 2

Name of isomer 1 ....

(3)

(c)   Hexane can be cracked in the presence of a catalyst to produce another hydrocarbon, Z, and methane.

    (i)   Draw a possible structure for Z.

    (ii)   Give a suitable catalyst for this reaction.
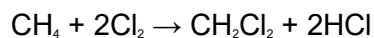
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    (iii)   Suggest why the product Z has more commercial value than hexane.

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(3)

(d)   The overall equation for the production of dichloromethane from methane and chlorine is shown below.

$$CH_4 + 2Cl_2 \rightarrow CH_2Cl_2 + 2HCl$$

    (i)   Calculate the % atom economy for the formation of CH_2Cl_2 in this reaction.

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(ii)   Give one reason why this atom economy of less than 100% is an important
consideration for the commercial success of this process and predict how a
chemical company would maximise profits from this process.

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(3)
(Total 14 marks)