PRACTICE EXAMINATION QUESTIONS FOR 1.6 ALKANES

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

.....

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

.....

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

.....

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

.....

(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.

.....

(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.

Feature 1 .....

.....

Feature 2 .....

.....

(2)
(Total 8 marks)

2. The fractions obtained from petroleum contain saturated hydrocarbons that belong to the homologous series of alkanes.

(a) Any homologous series can be represented by a general formula.

(i) State **two** other characteristics of homologous series.

Characteristic 1 .....

.....

Characteristic 2 .....

.....

(ii) Name the process which is used to obtain the fractions from petroleum.

.....

(iii) State what is meant by the term *saturated*, as applied to hydrocarbons.

.....

.....

(4)

(b) Decane has the molecular formula $C_{10}H_{22}$

(i) State what is meant by the term *molecular formula*.

.....

.....

(ii) Give the molecular formula of the alkane which contains 14 carbon atoms.

.....

(iii) Write an equation for the incomplete combustion of decane, $C_{10}H_{22}$, to produce carbon and water only.

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(3)

(c) When petrol is burned in an internal combustion engine, some nitrogen monoxide, NO, is formed. This pollutant is removed from the exhaust gases by means of a reaction in a catalytic converter.

(i) Write an equation for the reaction between nitrogen and oxygen to form nitrogen monoxide.

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(ii) Identify a catalyst used in a catalytic converter.

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(iii) Write an equation to show how nitrogen monoxide is removed from the exhaust gases as they pass through a catalytic converter.

.....

(3)
(Total 10 marks)

3. (a) Compound **A** (M_r = 215.8) contains 22.24% carbon, 3.71% hydrogen and 74.05% bromine by mass. Show that the molecular formula of **A** is $C_4H_8Br_2$.

(3)

(b) There are nine structural isomers of molecular formula $C_4H_8Br_2$, three of which have branched carbon chains. Give the names and draw the graphical formulae for **any two** of the branched chain isomers of $C_4H_8Br_2$.

Name of isomer 1 .....

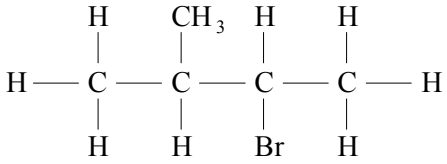
Graphical formula of isomer 1

Name of isomer 2 .....

Graphical formula of isomer 2

(4)
(Total 7 marks)

4. There are eight structural isomers with the molecular formula $C_5H_{11}Br$. Four of these are classed as primary, three as secondary and one as tertiary. The graphical formula of one of the secondary compounds, isomer **A**, is shown below.



isomer **A**

(a) Give the name of isomer **A**.

.....

(2)

(b) Explain what is meant by the term *structural isomers.*

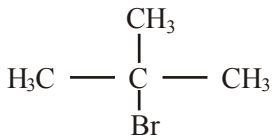
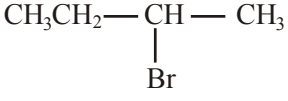
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(2)

(Total 4 marks)

5. The table below gives some of the names and structures of isomers having the molecular formula C_4H_9Br

Structure	Name
$CH_3CH_2CH_2CH_2Br$	
	2-bromo-2-methylpropane
	1-bromo-2-methylpropane
	2-bromobutane

Complete the table.

(Total 2 marks)

6. Petroleum is separated into fractions by fractional distillation.
The petrol fraction (C_4 to C_{12}) is burned in internal combustion engines and the naphtha fraction (C_7 to C_{14}) is cracked.

(a) Petroleum is separated into fractions when it is heated and the vapour mixture is passed into a fractionating column.

(i) Explain what is meant by the term *fraction* as applied to fractional distillation.

.....

.....

(ii) State a property of the molecules in petroleum which allows the mixture to be separated into fractions.

.....

.....

(iii) Describe the temperature gradient in the column.

.....

.....

(3)

(b) The fractions from petroleum contain alkane hydrocarbons.

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

.....

(ii) One isomer of C_8H_{18} is 2,2,3-trimethylpentane. Draw the structure of this isomer.

(2)

(c) State **one** economic reason for the cracking of petroleum fractions.

.....

(1)

(d) Identify a catalyst used in catalytic cracking.

.....

(1)

(e) Identify the different type of hydrocarbon produced in a high percentage by the thermal cracking of alkanes.

.....

(1)

(Total 8 marks)

7. Many hydrocarbon compounds burn readily in air.

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

.....

.....

(b) 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)

8. (a) Crude oil is separated into fractions by fractional distillation. Outline how different fractions are obtained by this process.

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.....

.....

.....

(3)

(b) The table below gives details of the supply of, and demand for, some crude oil fractions.

Fractions	Approximate %	
	Typical supply from crude oil	**Global demand**
Gases	2	4
Petrol and naphtha	16	27
Kerosine	13	8
Gas oil	19	23
Fuel oil and bitumen	50	38

(i) Use the data given above to explain why catalytic cracking of crude oil fractions is commercially important.

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.....

.....

(ii) Give the two main types of product obtained by catalytic cracking.

Type 1 .....

Type 2 .....

(4)

(c) Name a catalyst used in catalytic cracking and outline the industrial conditions used in the process.

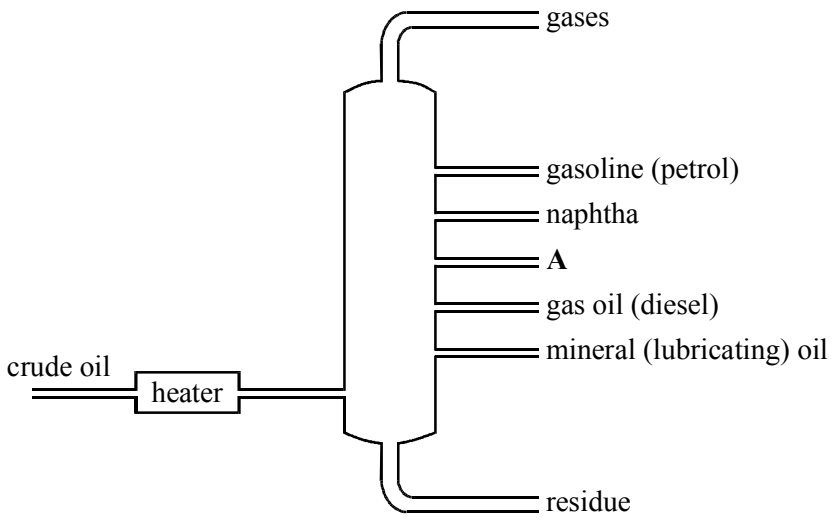
Catalyst .....

Conditions .....

.....

(3)
(Total 10 marks)

9. (a) The diagram below represents the industrial fractional distillation of crude oil.



(i) Identify fraction **A**.

.....

(ii) What property of the fractions allows them to be separated in the column?

.....

(2)

(b) A gas oil fraction from the distillation of crude oil contains hydrocarbons in the C_{15} to C_{19} range. These hydrocarbons can be cracked by strong heating.

(i) Write the molecular formula for the alkane with 19 carbon atoms.

.....

(ii) Write an equation for one possible cracking reaction of the alkane $C_{16}H_{34}$ when the products include ethene and propene in the molar ratio 2:1 and only one other compound.

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(3)
(Total 5 marks)

10. Name the alkene $CH_3CH_2CH{=}CH_2$

.....

(Total 1 mark)

11. The table below shows the fractions obtained from crude oil:

Name of fraction	**Number of carbon atoms**	**Use**
Gases	1-4	bottled fuels for camping
Petrol (gasoline)	4-12	fuel for cars
Naphtha	7-14	
	11-15	jet fuel
Gas oil (diesel)	15-19	central heating fuel
Mineral oil	20-30	lubrication
Fuel oil	30-40	
Wax	41-50	Candles
Bitumen	over 50	road surfacing

(a) Complete the table above by writing in the empty boxes

(3)

(b) Give **one** structural formula in each case for the following components of crude oil:

(i) the isomer of C_5H_{12} with the lowest boiling point

(ii) a saturated compound with molecular formula C_5H_{10}

(2)

(c) Give a molecular formula for each of the following components of crude oil:

(i) the alkane which, on cracking, forms, as the only products, two moles of ethene and one mole of butane per mole of alkane.

.....

(ii) the straight chain alkane found in the petrol fraction which contains the lowest percentage by mass of hydrogen. Refer to the table at the start of the question to deduce your answer.

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(2)
(Total 7 marks)

12. (a) Central heating fuel is obtained by distillation of crude oil. An alkane present in central heating fuel contains 16 carbon atoms per molecule. When a molecule of this alkane is cracked, propene is formed.

(i) Name the crude oil fraction used as central heating fuel.

.....

(ii) Write an equation for the cracking of the 16-carbon alkane to form octane, propene and ethene as the only products.

.....

(iii) Give one important commercial use of propene.

.....

(4)

(b) A catalytic converter in the exhaust system of a car contains a ceramic honeycomb covered with a thin coating of the catalyst. When hot gases containing nitrogen monoxide and unburnt octane are passed over the catalyst, they react to form nitrogen, carbon dioxide and water.

(i) Explain why the catalyst is coated on a honeycomb.

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.....

(ii) Write an equation for the reaction of octane with nitrogen monoxide to form nitrogen, carbon dioxide and water.

.....

(4)
(Total 8 marks)

13. (a) Gas oil (diesel), kerosine (paraffin), mineral oil (lubricating oil) and petrol (gasoline) are four of the five fractions obtained by the fractional distillation of crude oil within the temperature range 40–400 °C.

Identify the missing fraction and state the order in which the five fractions are removed as the fractionating column is ascended. Give **two** reasons why the fractions collect at different levels in the fractionating column.

(4)

(b) Thermal cracking of large hydrocarbon molecules is used to produce alkenes. State the type of mechanism involved in this process. Write an equation for the thermal cracking of $C_{21}H_{44}$ in which ethene and propene are produced in a 3:2 molar ratio together with one other product.

(3)

(c) Write equations, where appropriate, to illustrate your answers to the questions below.

(i) Explain why it is desirable that none of the sulphur-containing impurities naturally found in crude oil are present in petroleum fractions.

(ii) The pollutant gas NO is found in the exhaust gases from petrol engines. Explain why NO is formed in petrol engines but is not readily formed when petrol burns in the open air.

(iii) The pollutant gas CO is also found in the exhaust gases from petrol engines. Explain how CO and NO are removed from the exhaust gases and why the removal of each of them is desirable.

(10)
(Total 17 marks)

14. (a) Petrol engines in cars produce a number of pollutants which can be removed by catalytic converters.

Discuss this statement, indicating what the pollutants are, how they arise and how they are removed as efficiently as possible in a catalytic converter. Write equations for any reactions you discuss.

(11)

(b) Petrol is obtained, not only by fractional distillation of crude oil, but also by cracking of hydrocarbons from heavy fractions.

State why hydrocarbons from heavy fractions are cracked and explain why these hydrocarbons are less easy to ignite than those in petrol.

(4)
(Total 15 marks)

15. Ethene and other important hydrocarbons can be produced industrially from decane, $C_{10}H_{22}$. Name the process involved. Write **two** equations for reactions in which ethene is formed from decane by this process. Explain the economic importance of the process.

(Total 7 marks)

16. The petroleum and petrochemicals industries use a small number of processes to produce a large number of final products. Three of these processes are fractional distillation, vacuum distillation and cracking.

(a) Describe briefly how fractional distillation can be used to convert crude oil into a small number of fractions.

(4)

(b) The residue from the fractional distillation process is usually vacuum distilled. This process allows the compounds in the residue to boil at temperatures much lower than their normal boiling points. State whether the sizes of the molecules of the compounds in the residue are smaller or larger than those in the other fractions and suggest why the process of vacuum distillation is used.

(2)

(c) Cracking is carried out by heating long-chain hydrocarbons, often in the presence of steam and a catalyst. Steam cracking is used to produce a mixture of alkanes and alkenes in reactions such as the following:

$$C_9H_{20} \rightarrow C_6H_{14} + C_3H_6$$

(i) Give a name for each compound produced in this reaction.

(2)

(ii) Nonane, C_9H_{20}, can be cracked to give other products. One molecule of nonane can give two molecules of ethene, one molecule of ethane and one molecule of another substance. What is the molecular formula of the other substance?

(1)

(d) Halogenoalkanes have been used for a long time as anaesthetics, for example trichloromethane and 2-bromo-2-chloro-1,1,1-trifluoroethane(halothane). Give the formulae of both trichloromethane and 2-bromo-2-chloro-1,1,1-trifluoroethane.

(2)

(Total 11 marks)