AS LEVEL CHEMISTRY

PAPER 2

PRACTICE PAPER 24

(structured questions only)

Answer all questions

Max 80 marks

Name ……..
Mark ……../80 ……....% Grade ……

Note – this paper only contains structured questions

This paper contains legacy 2016 questions

1. **(a)** Octane (C_8H_{18}) is an important compound in petrol.

(a) (i) Identify the homologous series to which octane belongs.

[1 mark]

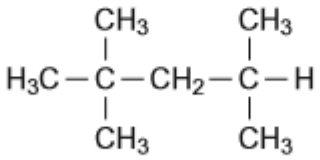
_____

(a) (ii) Write an equation to show the complete combustion of C_8H_{18}

[1 mark]

_____

(a) (iii) An isomer of octane used to improve the performance of car engines is shown.

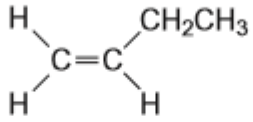


Give the IUPAC name of this isomer.

[1 mark]

_____

(b) Compound **X** is produced when an alkane is cracked.



X

(b) (i) Give the IUPAC name for compound **X**.

[1 mark]

_____

(b) (ii) One molecule of an alkane is cracked to produce one molecule of compound **X**, one molecule of octane and one molecule of ethene.

Deduce the molecular formula of this alkane.

[1 mark]

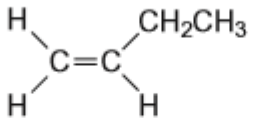
(b) (iii) Name the type of cracking that produces a high yield of compound **X**.
Give **two** conditions required for this process.

[2 marks]

Type of cracking _____

Conditions _____

(b) (iv) Compound **X** has several isomers. The structure of **X** is repeated here.



X

Draw the displayed formula of a chain isomer, a position isomer and a functional group isomer of compound **X**.

[3 marks]

Type of isomer	Displayed formula of isomer of compound X
Chain	
Position	
Functional group	

[Total 10 marks]

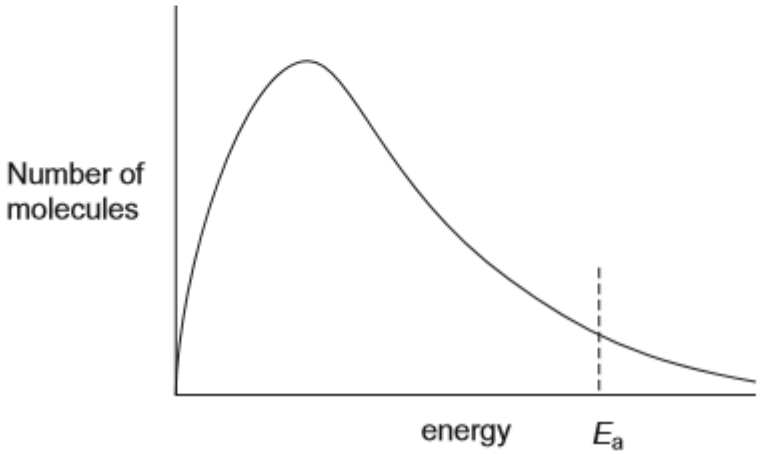
2. Methanol, for use as a fuel, can be produced by the reaction of carbon monoxide with hydrogen.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -90 \text{ kJ mol}^{-1}$$

The reaction is typically carried out at 300 °C and 3×10^7 Pa, in the presence of a catalyst.

(a) **Figure 2** shows the Maxwell–Boltzmann distribution for a mixture of carbon monoxide and hydrogen at 300 °C.

Figure 2



(a) (i) Sketch a second curve on **Figure 2** to show the distribution of molecular energies in this mixture at a higher temperature.

[1 mark]

(a) (ii) Explain with reference to both curves in **Figure 2** how a small change in temperature leads to a large change in the rate of reaction.

[2 marks]

(b) Both the rate of production and equilibrium yield of methanol are considered when choosing the most appropriate conditions for the operation of this process on an industrial scale.

(b) (i) State and explain the effect of a higher pressure on the equilibrium yield of methanol.

[3 marks]

(b) (ii) By considering both rate and yield, state why the reaction is carried out at a temperature of 300 ºC rather than at a higher temperature.

[2 marks]

[Total 8 marks]

3. Alite must be made at temperatures above 1250 ºC. This means that Portland cement manufacture is a very energy-intensive process.

In the 1950s, heavy fuel oil was used. A typical heavy fuel oil contains compounds with the molecular formula $C_{20}H_{42}$. This kind of fuel requires pre-heating before it can be burned. The equation for the complete combustion of $C_{20}H_{42}$ is

$$2C_{20}H_{42}(g) + 61O_2(g) \longrightarrow 40CO_2(g) + 42H_2O(g)$$

(a) Suggest why combustion of the fuel oil is likely to be incomplete.

[1 mark]

(b) The large volume of exhaust gases can cause dust to be blown out of the kiln. The amount of dust can be decreased by passing the exhaust gases through electrostatic precipitators. These can produce sparks because of the high voltage.

Identify a gas that may be present because of incomplete combustion. Suggest why the use of electrostatic precipitators could be a hazard if this gas were present.

[2 marks]

Identity of gas _____

Reason _____

(c) Cold air is blown over the alite at the end of the process so that it is cooled as quickly as possible.

Suggest how the resulting air can be used to improve the economy of the whole process.

[1 mark]

_____

_____

[Total 4 marks]

4. An engineer was trying to develop a new fuel for a motorboat by blending mixtures of different alcohols in order to find out which mixture released the most energy when used in the engine.

The engineer had a number of alcohols in unlabelled bottles. It was decided to identify the alcohols by determining their enthalpies of combustion and comparing these values with those from a data book.

Outline a simple practical experiment that the engineer could use, including the measurements to be taken, in order to determine the enthalpy of combustion for one of the unknown alcohols. You do **not** need to include details of any calculations.

[5 marks]

Other than heat loss to the surroundings, identify **two** major sources of error in the experiment. Do **not** refer to the precision of the equipment.

[2 marks]

The engineer found that the experimental values for the enthalpies of combustion of butan-1-ol and methylpropan-2-ol were very similar and so these values could not be used to distinguish between the two alcohols.

Identify a reagent that the engineer could use to distinguish between these two alcohols. Give the observation in each case.

[3 marks]

Reagent _____

_____

Butan-1-ol _____

_____

Methylpropan-2-ol _____

_____

The filter in the air intake for the engine in the motorboat may become partially blocked by dust and debris.

Explain with the aid of an equation why combustion of methylpropan-2-ol under these circumstances would be of economic and environmental concern to the engineer.

[3 marks]

_____

_____

_____

_____

_____

_____

[Total 13 marks]

5. Draw a fully labelled diagram of the apparatus to show how propan-1-ol can be converted into propanoic acid in the laboratory.

[4 marks]

[Total 4 marks]

6. A Grignard reagent is a compound in which magnesium is bonded to an alkyl group (R) and a halogen (X). It can be represented by the formula RMgX.

A Grignard reagent is formed by the reaction of magnesium metal with a haloalkane using dry ethoxyethane as a solvent. Ethoxyethane has a boiling point of 35 ºC, forms a dense vapour and is highly flammable.

(a) Give **one** reason why a hot water bath is used rather than direct heating with a Bunsen burner when preparing the Grignard reagent.

[1 mark]

_____

(b) Grignard reagents react with water.

Suggest **one** reason why the ethoxyethane protects the Grignard reagent from reacting with water vapour in the air.

[1 mark]

_____

(c) A Grignard reagent can be used to introduce an extra carbon atom into an organic molecule.
For example, propanone (CH_3COCH_3) reacts with CH_3MgBr in a two-stage process to form 2-methylpropan-2-ol, $(CH_3)_3COH$. The isomer 2-methylpropan-1-ol is not formed in this process.

Suggest a suitable reagent and the associated observations that could be used to distinguish between 2-methylpropan-2-ol and its isomer 2-methylpropan-1-ol.

[3 marks]

Reagent _____

Observation with 2-methylpropan-2-ol _____

_____

Observation with 2-methylpropan-1-ol _____

_____

[Topic 5 marks]

7. (a) Bromine molecules react with propene at room temperature. Outline a mechanism for this reaction.

(4)

(b) Bromine atoms are involved in the reaction between bromine and methane to form bromomethane. Write equations for the two propagation steps in this reaction.

.....

.....

(2)

(c) When heated, bromine molecules can be atomised as shown in the equation below.

$$Br_2(g) \rightleftharpoons 2Br^{\bullet}(g)$$

In an experiment, 6.30 g of bromine in a sealed container of volume 2.00 dm^3 were heated to a high temperature. Under these conditions, at equilibrium, 20% of the bromine is converted into atoms.

(c) (i) Write an expression for the equilibrium constant, K_c, for this reaction.

(1)

(c) (ii) Calculate a value for K_c under these conditions.

.....

.....

.....

.....

.....

(5)

(c) (iii) Suggest what happens to the value of K_c when the reaction is carried out at a higher temperature. Explain your answer.

.....

.....

.....

.....

(3)

(Total 15 marks)

8. Glucose, $C_6H_{12}O_6$, can be converted into ethanol. Ethanol can be used as a fuel or can be converted into ethene by acid-catalysed dehydration. Most of the ethene used by industry is formed by the thermal cracking of alkanes.

(a) State **four** essential conditions for the conversion of glucose into ethanol. Name the process and give an equation for the reaction which takes place. Write an equation for the complete combustion of ethanol.

.....

.....

.....

.....

.....

.....

.....

(7)

(b) Explain what is meant by the term *dehydration*. Identify a catalyst which could be used in the acid-catalysed dehydration of ethanol. Write an equation for the reaction which takes place.

.....

.....

.....

.....

(3)

(c)

State what is meant by the term *cracking*. Describe what happens during the thermal cracking of alkanes. Give an essential condition for this process.
Write an equation for the thermal cracking of butane to give ethene as one of the products.

.....

.....

.....

.....

.....

.....

(4)

(Total 14 marks)

9. Bromomethane (CH_3Br) reacts with bromine by a free-radical substitution mechanism to form dibromomethane, CH_2Br_2
The reaction mechanism is similar to that for the reaction of chlorine with methane.

(a) Write equations for the following steps in the mechanism for the reaction of bromine with CH_3Br to form CH_2Br_2

Initiation step

.....

First propagation step

.....

Second propagation step

.....

(3 marks)

(b) The bromination of bromomethane will produce a mixture of products including dibromomethane, tribromomethane and tetrabromomethane.

(i) Write an overall equation for the conversion of bromomethane into tetrabromomethane, CBr_4

.....

(1 mark)

(ii) State how the reaction conditions would have to be adjusted to produce the highest possible yield of tetrabromomethane.

.....

.....

(1 mark)

(c) Complete and balance the following equation for the reaction of ammonia with bromomethane. Give the name of the organic product of this reaction.

CH_3Br + ... ⟶ ..... + NH_4Br

Name of product .....

(2 marks)

(Total 7 marks)