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ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2015

Centre Number

Candidate Number

Chemistry

Assessment Unit AS 2
assessing
Module 2: Organic, Physical and Inorganic Chemistry

MV18

[AC122]
MONDAY 15 JUNE, AFTERNOON

TIME

1 hour 30 minutes, plus your additional time allowance.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fifteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided.
Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all five** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **14(d)(i)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed at the end of each question indicate the marks awarded to each question or part question.
A Periodic Table of the Elements, containing some data, is included in this question paper.

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(Questions start overleaf)

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following is the general formula of an alkyl group?

A C_nH_{2n}

B C_nH_{2n-1}

C C_nH_{2n+1}

D C_nH_{2n+2}

2 1.4 g of a pure alkene forms 3.8 g of a dichloroalkane on reaction with chlorine. Which one of the following is the molecular formula for the alkene?

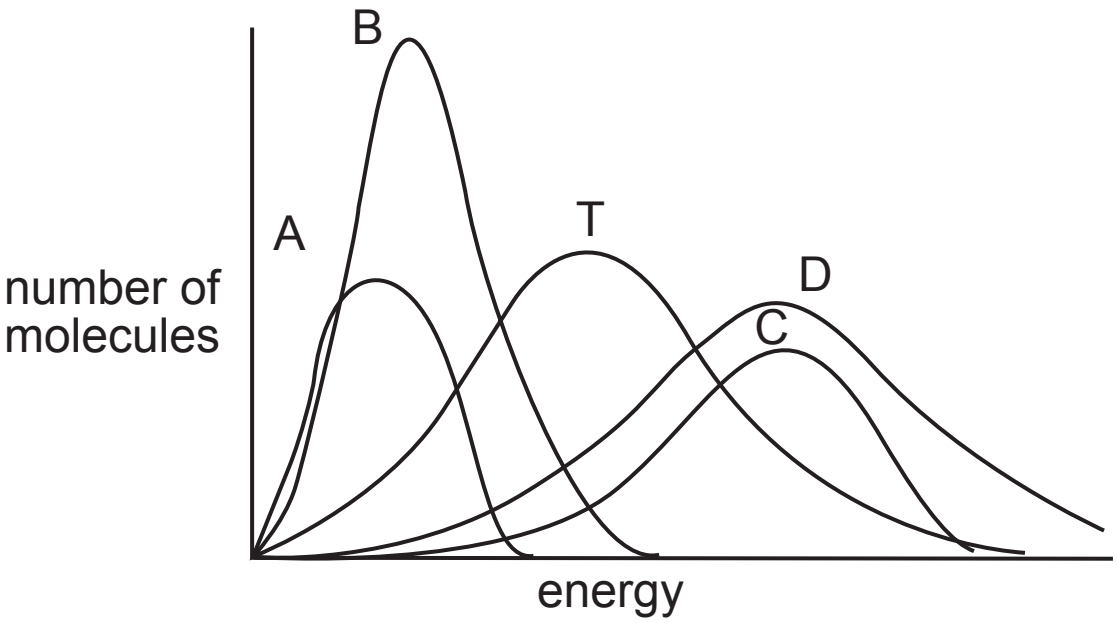
A C_2H_4

B C_3H_6

C C_4H_8

D C_6H_{12}

3 The diagram below represents the Maxwell–Boltzmann distribution curves for methane under various conditions. Curve T is that of methane at temperature T.



Which one of the curves is that of methane at a higher temperature than T?

4 The hydrolysis of a bromoalkane is shown below.

$C_3H_7Br(l) + NaOH(aq) \rightarrow C_3H_7OH(aq) + NaBr(aq)$

Which one of the following describes the mechanism of this reaction?

A Electrophilic addition

B Electrophilic substitution

C Nucleophilic addition

D Nucleophilic substitution

5 The dibromoalkene shown below exists in E and Z forms.

CHBr=CH−CH=CHBr

Which one of the following is the number of E–Z isomers that this molecule can form?

A 2

B 3

C 4

D 6

6 Which one of the following is **not** used in the laboratory preparation of a pure chloroalkane from the corresponding alcohol?

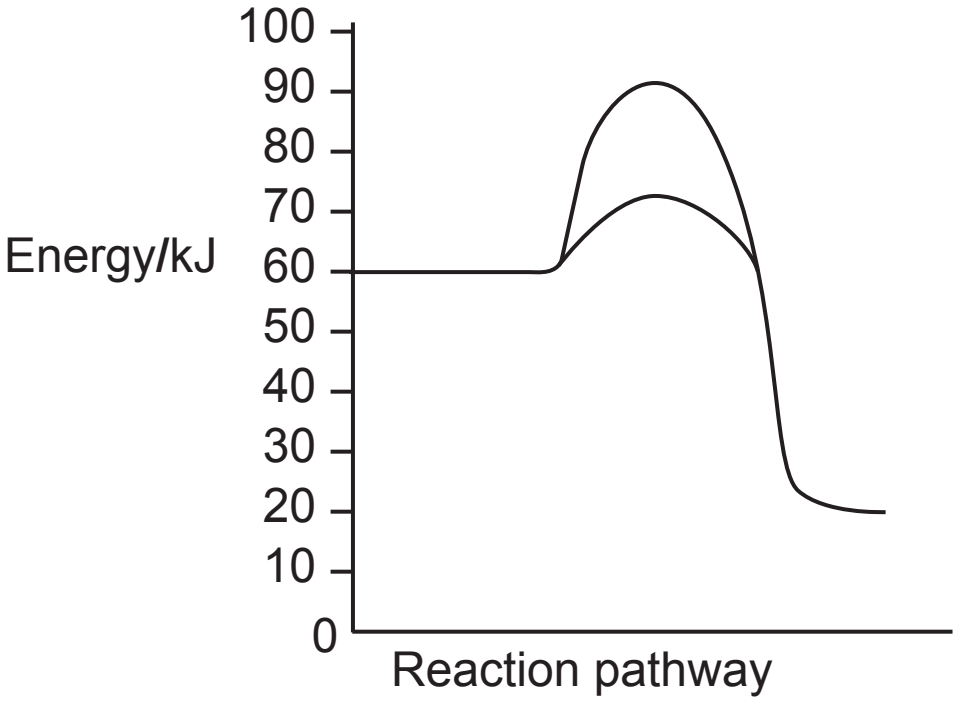
A Aqueous sodium chloride

B Aqueous hydrogencarbonate ions

C Distillation

D Refluxing

7 The enthalpy level diagram below is for a catalysed and uncatalysed reversible reaction.



Which one of the following is the activation enthalpy for the reverse reaction without a catalyst?

A 10 kJ

B 30 kJ

C 40 kJ

D 70 kJ

8 When crude oil undergoes fractional distillation which one of the following fractions is **not** distilled?

A Bitumen

B Low mass alkanes

C Lubricating oil

D Waxes

9 The bond between atoms I and Br consists of two electrons, I:Br. Which one of the following equations represents homolytic fission?

A $IBr \rightarrow I^+ + Br^-$

B $IBr \rightarrow I^- + Br^+$

C $IBr \rightarrow I\cdot + Br\cdot$

D $IBr \rightarrow I: + Br$

10 Which one of the following is a correct statement for the homologous series of hydrocarbons called alkenes?

A Each member of the series has a different empirical formula and different molecular formula

B Each member of the series has the same empirical formula and same molecular formula

C Each member of the series has a different empirical formula and different structural formula

D Each member of the series has the same empirical formula and the same general formula

Section B

Answer **all five** questions in this section in the spaces provided.

11 The reaction between methane and chlorine involves free radicals created by the action of light. Free radicals can also be created by the use of high temperatures which is known as pyrolysis. The following reactions occur when ethane is pyrolysed at 700 °C.

P $C_2H_6 \rightarrow 2CH_3\cdot$

Q $CH_3\cdot + C_2H_6 \rightarrow C_2H_5\cdot + CH_4$

R $C_2H_5\cdot \rightarrow C_2H_4 + H\cdot$

S $H\cdot + C_2H_6 \rightarrow H_2 + C_2H_5\cdot$

T $2C_2H_5\cdot \rightarrow C_2H_6 + C_2H_4$

U $2C_2H_5\cdot \rightarrow C_4H_{10}$

(a) Write the formulae of the species, in these equations, which are free radicals. [2 marks]

(b) Classify these reactions, using the letters P–U, under the headings initiation, propagation and termination. [3 marks]

Initiation

Propagation

Termination

12 Hex-1-ene reacts rapidly with bromine in a solvent such as 1,1,1-trichloroethane (TCE). The reaction is carried out in a glass beaker and is exothermic. Using experimental data it is possible to determine the enthalpy of bromination of hex-1-ene and to determine the C–Br bond enthalpy.

(a) (i) Draw the structure of hex-1-ene. [1 mark]

(ii) Draw the structure of TCE. [1 mark]

(iii) Write the equation for the reaction of hex-1-ene with bromine. [2 marks]

(iv) The reaction of hex-1-ene with bromine is not an equilibrium reaction. Describe a simple experiment to show this fact. [2 marks]

(b) 100 cm^3 of a solution of bromine in TCE is placed in an insulated glass beaker and its temperature is measured. 2 cm^3 of hex-1-ene is added to the beaker. The mixture is stirred and the temperature is measured again.

(i) Calculate the quantity of heat energy produced, per mole of hex-1-ene, according to the following headings: [5 marks]

the mass of 2.0 cm^3 of hex-1-ene if the density of hex-1-ene is 0.68 g cm^{-3}

_____

the rise in temperature if the initial temperature of the TCE is 24.9 °C and the final temperature is 32.1 °C

_____

the mass of 100 cm^3 of TCE if the density of TCE is 1.33 g cm^{-3}

_____

the heat energy received by the 100 cm^3 of TCE if the specific heat capacity of TCE is 1.30 J $°C^{-1}$ g^{-1}.

_____

the molar mass of hex-1-ene

_____

the number of moles of hex-1-ene in 2.0 cm^3

_____

the molar enthalpy of bromination of hex-1-ene

_____

(ii) In the reaction of hex-1-ene with bromine a carbon-carbon double bond is broken requiring 612 kJ mol^{-1} and a bromine-bromine bond requiring 193 kJ mol^{-1}. At the same time a carbon-carbon single bond is formed releasing 348 kJ mol^{-1} and two C–Br bonds are formed. Using the molar enthalpy of bromination calculated in part **(i)** determine the molar C–Br bond enthalpy. [3 marks]

(c) The product from the bromination of hex-1-ene is a dibromoalkane with the following structure.

$CH_3CH_2CH_2CH_2CHBrCH_2Br$

(i) Draw the structure of the product when the dibromoalkane is reacted with an **excess** of aqueous alkali. [1 mark]

(ii) Draw the structure of the product when the dibromoalkane is reacted with an **excess** of ammonia. [1 mark]

(iii) Draw the structure of the product when the dibromoalkane is reacted with an **excess** of cyanide ions. [1 mark]

(d) When the dibromohexane produced from the reaction of hex-1-ene with bromine is reacted with **excess** ethanolic potassium hydroxide an organic product is formed. Suggest the structure of the product. [1 mark]

13 Magnesium is the eighth most abundant metal in the earth's crust but if its presence in seawater is taken into account it is the most abundant metal. Manufacture of magnesium is usually from calcined (heated) dolomite.

(a) Dolomite, a mixture of calcium and magnesium carbonates, has the formula $CaCO_3.MgCO_3$. When calcined dolomite decomposes it forms the metal oxides.

(i) Write the equation for the decomposition of dolomite. [1 mark]

_____

(ii) State the order of thermal stability of the Group II metal carbonates starting with the least stable. [1 mark]

_____

(iii) Explain the thermal stability of the Group II carbonates in terms of the cations. [3 marks]

_____

_____

_____

(b) The calcined dolomite is slaked (reacted with water) to form the hydroxides. Seawater, which contains magnesium chloride, can be treated with an excess of slaked calcined dolomite.

$MgCl_2 + Ca(OH)_2.Mg(OH)_2 \rightarrow 2Mg(OH)_2 + CaCl_2$

The magnesium hydroxide is filtered off and calcined.

(i) Write the equation for the reaction of calcined dolomite with water. [1 mark]

_____

(ii) Magnesium hydroxide is precipitated. What is the solubility trend of the Group II hydroxides? [1 mark]

_____

_____

(iii) Calculate the atom economy of $Mg(OH)_2$ from the reaction of magnesium chloride with slaked calcined dolomite. [2 marks]

_____

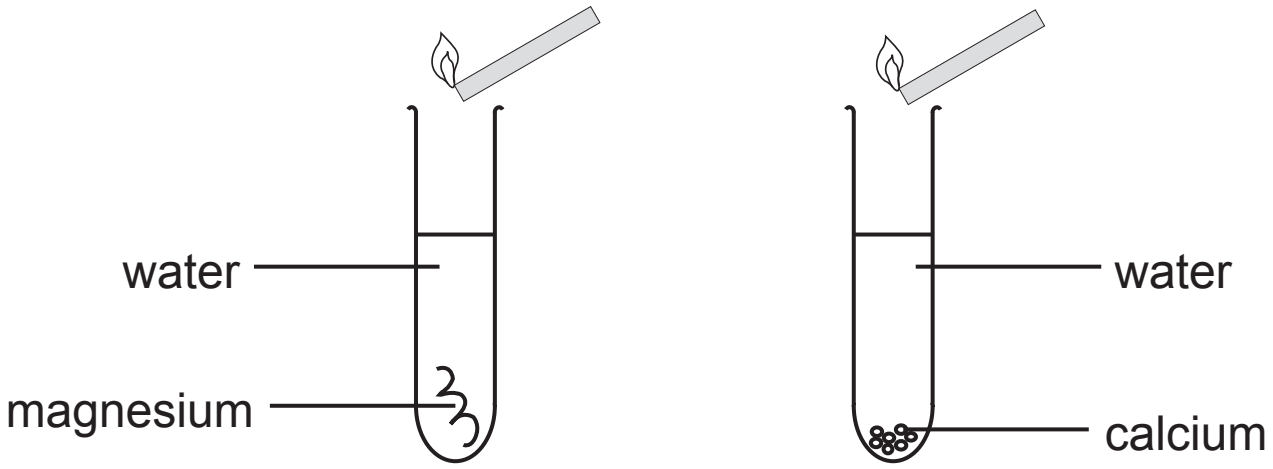
_____

_____

(iv) Write the equation for the calcination of magnesium hydroxide. [1 mark]

_____

(c) Magnesium ribbon and calcium turnings were added to water in separate boiling tubes as shown in the diagram below. A lit splint was held above each boiling tube.



(i) Describe what is observed in each boiling tube.

Magnesium [2 marks]

_____

_____

Calcium [2 marks]

_____

_____

(ii) Describe what happens around the lit splint for each boiling tube.

Magnesium [1 mark]

Calcium [1 mark]

(iii) Describe and explain what happens when Universal Indicator is added to the boiling tubes after thirty minutes.

Magnesium [2 marks]

Calcium [2 marks]

14 In a car engine, petrol vapour, a mixture of C_5 to C_{10} alkanes, and air are ignited by an electric spark. It is important that the mixture explodes smoothly. This is achieved by using branched chain alkanes.

(a) (i) What is the molecular formula for a C_8 alkane? [1 mark]

_____

(ii) Write an equation for the complete combustion of octane. [2 marks]

_____

(iii) Draw the structure of a branched chain isomer of octane. [1 mark]

(b) One-fifth of air by volume is oxygen. What volume of air is required for the complete combustion of 28.5 g of octane vapour at 20 °C? [3 marks]

_____

_____

_____

(c) A typical composition of the gases in petrol engine exhaust fumes is:

Substance	**%**
Water vapour	9
Carbon dioxide	8
Carbon monoxide	4–6
Oxygen	4
Hydrogen	2
Hydrocarbons	0.2
Oxides of nitrogen	0.3

(i) Which gas in the exhaust fumes is a consequence of incomplete combustion? [1 mark]

_____

(ii) The percentage of gases does not add up to 100**%**. Suggest the names of the **two** missing gases. [1 mark]

_____

(iii) One of the oxides of nitrogen formed is nitrogen(II) oxide which is produced at a high temperature from nitrogen and oxygen. Write an equation for its formation. [1 mark]

_____

(d) Catalytic converters are used in reducing the environmental damage due to vehicle emissions.

(i) Discuss the environmental problems associated with the combustion of hydrocarbons. [3 marks]

Quality of written communication [2 marks]

(ii) Write equations for the conversion of carbon monoxide and nitrogen monoxide to less polluting products in the catalytic converter. [2 marks]

(iii) Explain the effect of leaded petrol on the catalytic converter. [1 mark]

15 The haloform reaction is one of the oldest known organic reactions. Serultas made iodoform in 1822 by the reaction of potassium with a mixture of iodine and aqueous ethanol. All of the trihalogenomethanes have been prepared.

name	**formula**	**state at 25 °C**	**boiling point/°C**
fluoroform	CHF_3	gas	–82
chloroform	$CHCl_3$	liquid	61
bromoform	$CHBr_3$	liquid	149
iodoform	CHI_3	solid	218

(a) (i) Suggest the role of potassium in the formation of iodoform. [1 mark]

_____

(ii) What structure is present in ethanol which leads to the formation of iodoform? [1 mark]

_____

(iii) State the colour of iodoform. [1 mark]

_____

(iv) Describe the smell of iodoform. [1 mark]

_____

(b) Explain why chloroform is a liquid and iodoform is a solid. [2 marks]

(c) There are four butanols which are shown below together with their boiling points.

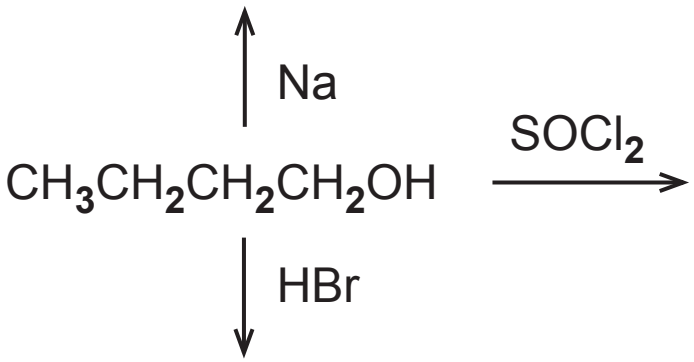
compound	formula	boiling point/°C
butan-1-ol	$CH_3CH_2CH_2CH_2OH$	118°
butan-2-ol	$CH_3CH_2CHOHCH_3$	99°
2-methylpropan-1-ol	$(CH_3)_2CHCH_2OH$	108°
2-methylpropan-2-ol	$(CH_3)_3COH$	83°

(i) Classify the butanols as primary, secondary or tertiary alcohols. [2 marks]

(ii) Explain which one of these butanols will give a positive iodoform test. [1 mark]

(iii) Explain why butan-1-ol has the highest boiling point. [2 marks]

(iv) Complete the diagram below for the reactions of butan-1-ol with the following reagents showing the organic products formed. [3 marks]



(d) Today, the identification of compounds is carried out using spectroscopic methods rather than test tube reactions.

(i) Explain why molecules absorb infrared radiation. [1 mark]

_____

_____

(ii) Which group of atoms in the butanol molecule is used to identify alcohols in infrared spectroscopy? [1 mark]

_____

(iii) If you had infrared spectra of the four butanols how would you use them to identify an unknown butanol? [1 mark]

_____

_____

(e) Butan-2-ol reacts with carboxylic acids to form volatile esters which are used as perfumes or flavourings. Write the equation for the reaction of butan-2-ol with ethanoic acid showing the structures of the reactants and products. [2 marks]

_____

THIS IS THE END OF THE QUESTION PAPER

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
Total Marks	