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Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2013

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical
and Inorganic Chemistry

[AC122]

AC122

WEDNESDAY 16 JANUARY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces
provided at the top of this page.
Answer **all sixteen** 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 six** 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 **15(c)**.
In Section A all questions carry equal marks, i.e. **two** marks for
each question.
In Section B the figures in brackets printed down the right-hand
side of the pages indicate the marks awarded to each question or
part question.
A Periodic Table of Elements (including some data) is provided.

For Examiner's use only	
Question Number	Marks
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
Total Marks	

8245

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2

Section A

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

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

1 Which one of the following hydroxides is the most soluble in water?

   A Barium hydroxide

   B Calcium hydroxide

   C Magnesium hydroxide

   D Strontium hydroxide

2 How many structural isomers have the formula C_5H_{12}?

   A Two

   B Three

   C Four

   D Five

3 Which one of the following is a tertiary alcohol?

   A pentan-2-ol

   B pentan-3-ol

   C 2-methylpentan-1-ol

   D 2-methylpentan-2-ol

4 Propan-1-ol can be dehydrated to form propene:

$$CH_3CH_2CH_2OH \rightarrow CH_3CH{=}CH_2 + H_2O$$

30.0 g of propan-1-ol produces 16.8 g of propene. Which one of the following is the percentage yield?

   A 50.0

   B 60.0

   C 70.0

   D 80.0

5 Which one of the following metal chlorides gives a green colour in a flame

    A $BaCl_2$

    B $CaCl_2$

    C   KCl

    D   NaCl

6 Which one of the following is the mass of magnesium oxide required to neutralise $25.0\,cm^3$ of $0.1\,mol\,dm^{-3}$ hydrochloric acid?

    A $0.025\,g$

    B $0.050\,g$

    C $0.100\,g$

    D $0.250\,g$

7 Which one of the following is the number of π (pi) bonds present in propene?

    A   One

    B   Two

    C   Three

    D   Six

8 Which one of the following is formed by the complete oxidation of propan-2-ol?

    A   a carboxylic acid

    B   a ketone

    C   a secondary alcohol

    D   an aldehyde

9 Which one of the following pairs of enthalpy changes shows how a catalyst <s>in an</s> endothermic reaction?

Enthalpy

products

reactants

w x y z

Reaction Coordinate
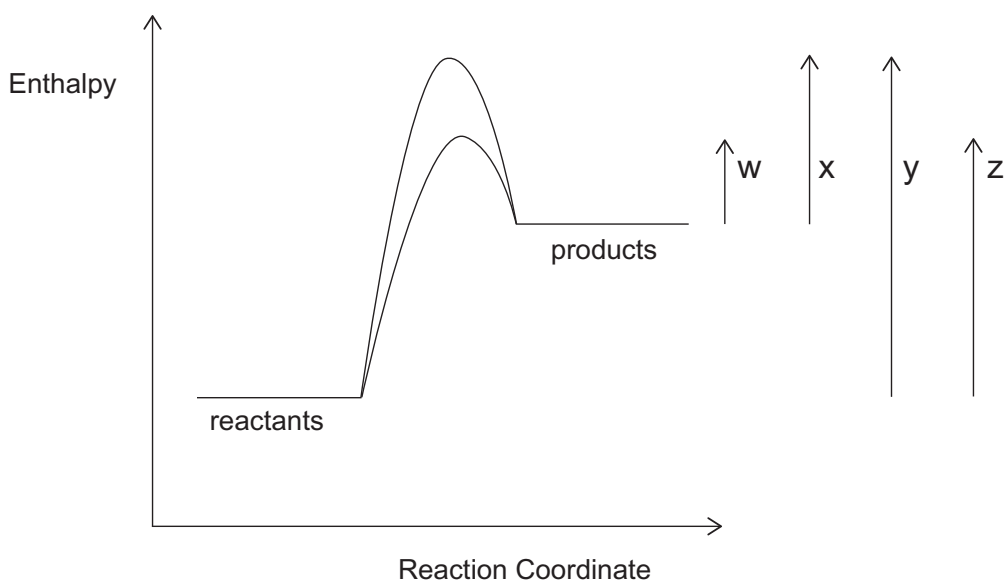
A w and x

B w and z

C x and y

D y and z

10 Which one of the following is the IUPAC name for the hydrocarbon shown below?

$$CH_3-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{C}}-H$$
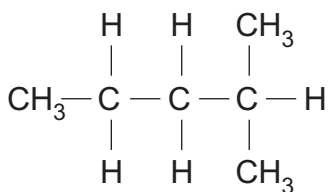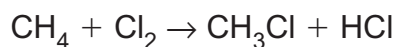
A 1,1-dimethylbutane

B 4,4-dimethylbutane

C 2-methylpentane

D 1,1,3-trimethylpropane

Section B

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

11 An excess of methane reacts with chlorine, in the presence of light, to form chloromethane as the main product.

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

(a) Name the type of mechanism for this reaction.

_____ [2]

(b) Write an equation for the initiation step.

_____ [1]

(c) Write **two** equations for the propagation steps.

_____

_____ [2]

(d) Write an equation for the termination step which results in the formation of ethane.

_____ [1]

12 The empirical formula of a molecular covalent compound can be calculated using percentage composition by mass.

(a) Explain the term **empirical formula** as applied to a molecular covalent compound.

_____

_____ [1]

(b) Explain the term **molecular formula** as applied to a molecular covalent compound.

_____

_____ [1]

(c) An oxide of phosphorus contains 43.7% by mass of phosphorus. The relative molecular mass of the oxide is 284. This oxide reacts with sodium hydroxide to form sodium phosphate (Na_3PO_4) and water as the only products.

(i) Calculate the empirical and molecular formulae of the oxide.

_____

_____

_____

_____

_____

empirical formula: _____

molecular formula: _____ [4]

(ii) Write an equation for the reaction of the oxide with sodium hydroxide.

_____ [2]

13 3-methylpent-2-ene, $CH_3CH = C(CH_3)CH_2CH_3$, exists as stereoisomers.

(a) (i) Explain the meaning of the term **stereoisomers**.

_____

_____

_____ [2]

(ii) Give **two** reasons why 3-methylpent-2-ene exists as stereoisomers.

_____

_____

_____ [2]

(iii) Draw the E-isomer of 3-methylpent-2-ene.

[1]

(iv) Draw and name a structural isomer of 3-methylpent-2-ene which cannot form stereoisomers.

_____ [2]

(b) 3-methylpent-2-ene is an unsaturated hydrocarbon. It can be converted into a saturated hydrocarbon by catalytic hydrogenation.

   (i) Name the catalyst used in the hydrogenation reaction and describe its state.

   _____ [2]

   (ii) Write an equation for the reaction and use it to calculate the percentage atom economy for the equation.

   _____

   _____

   _____ [2]

(c) 3-methylpent-2-ene can undergo addition polymerisation. Draw a section of the resulting polymer chain showing **two** repeating units.

[1]

14 Recently chemists have developed alternatives to fossil fuels. Ethanol obtained from a biological source may have a significant role to play, e.g. some of the petrol sold in the UK and Ireland contains up to 10% ethanol. In Brazil the percentage is even higher.

(a) The standard enthalpy of combustion of ethanol can be calculated using Hess's Law.
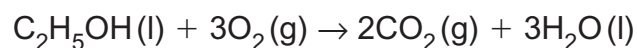
(i) State Hess's Law.

_____

_____ [2]

(ii) Define the term **standard enthalpy of combustion**.
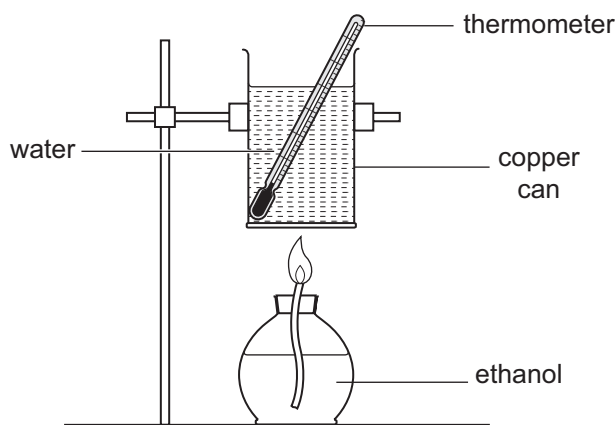
_____

_____

_____ [2]

(iii) Use the standard enthalpies of formation given in the table below to calculate the standard enthalpy of combustion of ethanol.

Compound	$\Delta H_f^{\ominus}$/kJ mol^{-1}
$C_2H_5OH\,(l)$	-277
$CO_2\,(g)$	-394
$H_2O\,(l)$	-286

$$C_2H_5OH\,(l) + 3O_2\,(g) \rightarrow 2CO_2\,(g) + 3H_2O\,(l)$$

_____

_____

_____ [3]

(b) The enthalpy of combustion for ethanol can also be obtained experimentally by using the apparatus shown below:

The results of the experiment are summarised in the table below:

Mass of water in the copper can	200.0 g
Mass of spirit burner + ethanol (before burning)	150.0 g
Mass of spirit burner + ethanol (after burning)	148.6 g
Initial temperature of water	18.0 °C
Final temperature of water	42.0 °C

(i) Calculate the heat energy released by the combustion of the ethanol using the equation:

heat energy released (J) = mass of water × 4.18 × temperature rise

_____

_____ [1]

(ii) Calculate the enthalpy of combustion of ethanol in kJ mol^{-1}.

heat energy released (in kJ) _____

moles of ethanol _____

enthalpy of combustion _____ [3]

(iii) State **two** reasons to explain the difference between this experimental value and the theoretical value obtained in **(a)(iii)**.

_____

_____

_____ [2]

15 Group II carbonates and nitrates decompose when heated. Magnesium carbonate decomposes to form magnesium oxide and carbon dioxide. Magnesium nitrate forms magnesium oxide, nitrogen(IV) oxide and oxygen.

(a) (i) Write an equation for the decomposition of magnesium nitrate.

_____ [2]

(ii) Suggest whether or not strontium nitrate would be more or less stable than magnesium nitrate when heated. Explain your reasoning.

_____

_____

_____ [2]

(b) Nitrogen(IV) oxide is a brown gas which can form the colourless gas, dinitrogen tetroxide, N_2O_4, in a dynamic equilibrium.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -58\ kJ\,mol^{-1}$$

(i) Explain the term **dynamic equilibrium**.

_____

_____ [2]

(ii) What is observed when the pressure on the equilibrium mixture is increased? Explain your answer.

_____

_____

_____ [3]

(iii) What is observed when the equilibrium mixture is cooled? Explain your answer.

_____

_____

_____ [3]

(c) Describe how a solution of magnesium nitrate can be used to distinguish between solid samples of potassium carbonate and potassium hydrogencarbonate. Give experimental details, observations and include an ionic equation, with state symbols, for any reaction which occurs.
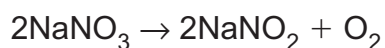
_____

_____

_____

_____

_____

_____

_____

_____ [4]

Ionic equation

_____ [2]

Quality of written communication   [2]

(d) Sodium nitrate decomposes when heated to produce sodium nitrite and oxygen:

$$2NaNO_3 \rightarrow 2NaNO_2 + O_2$$

Calculate the volume of oxygen produced, at 20 °C and a pressure of 1 atmosphere, when 4.25 g of sodium nitrate decomposes.
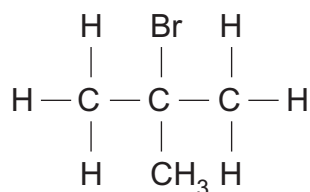
Moles of sodium nitrate

_____ [1]

Moles of oxygen produced

_____ [1]

Volume of oxygen, cm^3

_____ [1]

16 2-bromo-2-methylpropane is a tertiary halogenoalkane.

$$
\begin{array}{ccccc}
 & H & Br & H & \\
 & | & | & | & \\
H- & C- & C- & C & -H \\
 & | & | & | & \\
 & H & CH_3 & H & \\
\end{array}
$$

(a) What is the general formula for a bromoalkane?

_____ [1]

(b) Why is 2-bromo-2-methylpropane classified as a tertiary halogenoalkane?

_____

_____

_____ [2]

(c) 2-bromo-2-methylpropane reacts with aqueous potassium hydroxide to produce a tertiary alcohol.

(i) Name the type of mechanism for this reaction.

_____ [1]

(ii) Write an equation for the first step in the mechanism.

_____ [1]

(iii) Draw the structure of the organic product in the first step.

_____ [1]

(iv) Write an equation for the second step in the mechanism.

_____ [1]

(d) How could infrared spectroscopy be used to distinguish between 2-bromo-2-methylpropane and the tertiary alcohol produced in this reaction?

_____

_____

_____ [2]

(e) 2-bromo-2-methylpropane reacts with ethanolic potassium hydroxide to produce a different product.

    (i) Write an equation for this reaction.

_____ [2]

    (ii) Name the organic product.

_____ [1]

    (iii) Name the type of reaction.

_____ [1]

(f) 1-bromobutane is a structural isomer of 2-bromo-2-methylpropane.

    (i) Define the term **structural isomer**.

_____

_____ [2]

    (ii) State, giving reasons for your choice, which of these two compounds would be expected to have the higher boiling point.

_____

_____

_____

_____ [3]

113598