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ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2009

Chemistry

Assessment Unit AS 2

assessing

Module 2: Further Physical and Inorganic Chemistry and Introduction to Organic Chemistry

[AC121]

AC121

THURSDAY 11 JUNE, AFTERNOON

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(d)(iii)**.
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 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	

4994

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   A free radical is a particle with

    A   an unpaired electron.
    B   a negative charge.
    C   a positive charge.
    D   a lone pair of electrons.

2   Which one of the following hydrocarbons contains a double bond?

    A CH_4
    B C_2H_2
    C C_2H_4
    D C_2H_6

3   Which one of the following describes the reaction between hydroxide ions and 1-bromopentane?

    A   Electrophilic addition
    B   Electrophilic substitution
    C   Nucleophilic addition
    D   Nucleophilic substitution

4   Which one of the following equations corresponds to a standard enthalpy of formation?

    A $2NO(g) \rightarrow N_2(g) + O_2(g)$
    B $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
    C $Na(s) + Cl(g) \rightarrow NaCl(s)$
    D $Mg(s) + Br_2(l) \rightarrow MgBr_2(s)$

5   Which one of the following reagents could detect the presence of ethanol in Gasohol which can be regarded as a mixture of alkanes, alkenes and ethanol?

    A   bromine
    B   hydrogen chloride
    C   sodium
    D   universal indicator

6   How many structural isomers exist with the formula, C_4H_{10}?

    A   1
    B   2
    C   3
    D   4

7   A tube is filled with $50\,cm^3$ of methane and $150\,cm^3$ of oxygen at room temperature over a beaker containing NaOH(aq) as shown.
The following reaction took place when a spark was applied to the mixture:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$
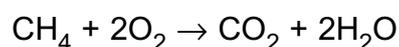
When the tube is cooled to room temperature, what level will the liquid have reached?
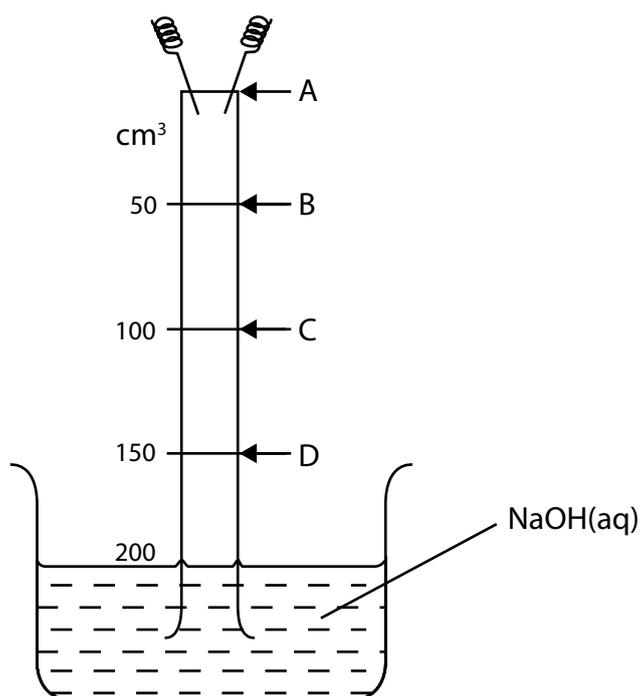
8 In which one of the following pairs will **neither** of the hydroxides dissolve in an excess of aqueous sodium hydroxide?

A $Al(OH)_3$ and $Fe(OH)_2$
B $Al(OH)_3$ and $Zn(OH)_2$
C $Fe(OH)_2$ and $Mg(OH)_2$
D $Mg(OH)_2$ and $Zn(OH)_2$

9 Which one of the following substances has the highest boiling point?

A CH_3CH_2Cl
B $CH_3CH_2CH_2OH$
C $CH_3CH_2CH_2CH_3$
D $CH_3CH_2CH_2CH_2CH_3$

10 In the laboratory preparation of a halogenoalkane, any acidic impurities present are removed using

A sodium chloride
B sodium hydrogencarbonate
C sodium hydroxide
D sodium sulphate

Section B

Answer all **six** questions in this section

11 The table below shows the results of analysing four aqueous solutions.

compound	colour of aqueous solution	addition of aqueous barium chloride	other information
A	blue	white precipitate	blue-green flame test
B	colourless	white precipitate	pH = 1
C	yellow	yellow precipitate	yellow/orange flame test
D	colourless	white precipitate	lilac flame test

Name the four compounds.

A _____

B _____

C _____

D _____ [4]

12 Hydrogen is produced on an industrial scale by the reaction between methane and steam. The reaction is endothermic.

$$CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g)$$
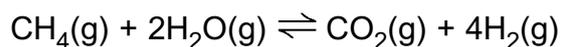
The reaction is carried out at 1023 K and a pressure of 40 atmospheres in the presence of a nickel catalyst.

(a) Explain the use of a temperature of 1023 K.

_____

_____

_____ [3]

(b) Calculate the atom economy for the reaction assuming that the carbon dioxide is a waste product and comment on the value obtained.

_____

_____

_____

_____ [4]

(c) Use the following bond energies to calculate ΔH for the reaction.

	kJ mol^{-1}
C–H	413
O–H	464
C=O	805
H–H	436

_____

_____

_____ [3]

(d) Although the raw materials are cheap, the running costs of this reaction are significant. Suggest **two** reasons for this.

_____

_____ [2]

(e) Another reaction which can occur is

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$$
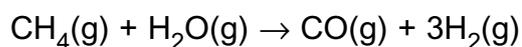
(i) Explain why this reaction is environmentally undesirable.

_____ [1]

(ii) Suggest how the occurrence of this reaction could be prevented.

_____

_____ [1]

(iii) Calculate the volume of hydrogen produced at 20 °C and 1 atmosphere pressure from the reaction of 4 tonnes of methane with steam.

_____

_____

_____ [3]

13 Chloromethane, CH_3Cl, is the largest natural source of ozone-depleting chlorine compounds in the atmosphere. Some common tropical plants emit considerable quantities of chloromethane.

(a) Chloromethane may be prepared in the laboratory by the reaction of methanol with a mixture of sodium chloride and concentrated sulphuric acid which generates hydrogen chloride.

(i) Describe the chemical test to show that hydrogen chloride is produced.

_____ [2]

(ii) Write the equation for the reaction of methanol with hydrogen chloride.

_____ [1]

(iii) The preparation of chloromethane is difficult because it is a gas at room temperature and pressure.
Suggest how this would cause problems during the preparation.

_____ [1]

(b) Another method of preparing chloromethane is by the reaction of methane with chlorine in the presence of ultra violet light. The reaction proceeds by a free radical mechanism.

**(i)** Write the equation for the reaction of methane with chlorine to form chloromethane.

_____ [1]

(ii) Give the electronic structure of a chlorine radical.

_____ [1]

(iii) What is the role of the ultra violet light?

_____

_____ [2]

**(iv)** Ethane is formed as an impurity during the reaction. Explain how it is formed.

_____

_____ [1]

(c) Complete the scheme below writing the formulae of the organic products.

$$\xleftarrow{\quad NH_3 \quad} CH_3Cl \xrightarrow{\quad NaOH(aq) \quad}$$

9
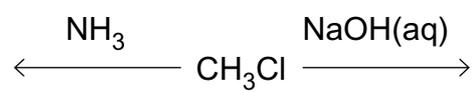
14 The diagram shows the distribution curve for the energies of the molecules of a gas in a given system. E_a is the activation energy for a particular reaction.

energy E_a
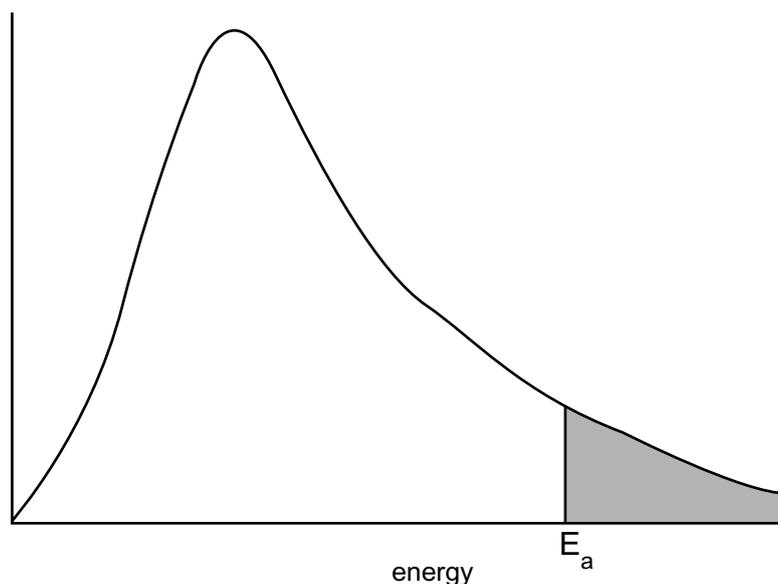
(a) (i) Label the vertical axis on the diagram. [1]

(ii) Explain why the curve starts at the origin.

_____

_____ [1]

(iii) Why does the curve not intersect the horizontal axis at higher energies?

_____

_____ [1]

(iv) What does the shaded area represent?

_____

_____ [2]

(b) (i) Draw a curve on the graph representing the distribution of energies for the same molecules at a higher temperature. [2]

(ii) By reference to the curve you have drawn in part **(i)**, explain the effect of the higher temperature on the rate of a chemical reaction.

_____

_____

_____ [1]

(c) By reference to the distribution curve, explain the effect of a catalyst on the rate of a chemical reaction.

_____

_____

_____ [2]

15 Magnesium sulphate occurs as the mineral Epsom salts, $MgSO_4.7H_2O$. Calcium sulphate occurs as gypsum, $CaSO_4.2H_2O$. Barium sulphate contains no water of crystallisation.

(a) Magnesium, calcium and barium are regarded as **s-block** elements. Explain this term.

_____ [1]

(b) Hydration of the sulphate is related to the trend in solubility of the Group II sulphates. State this trend.

_____ [1]

(c) When heated, the hydrated salts lose water to form the anhydrous sulphate. Further heating causes the sulphate to decompose to form the oxide and sulphur trioxide.

(i) Calculate the percentage yield of $CaSO_4$ when 34.4 g gypsum is heated to form 26.0 g of anhydrous calcium sulphate.

_____

_____

_____ [3]

(ii) Write the equation for the decomposition of anhydrous calcium sulphate.

_____ [1]

(iii) The thermal stability of the Group II sulphates may be explained in a similar way to that of the carbonates. Explain the relative stability of the sulphates with reference to the cations involved.

_____

_____

_____ [3]

(d) The enthalpy change for the hydration of magnesium sulphate may be determined using Hess's law.

$$MgSO_4(s) + 7H_2O(l) \rightarrow MgSO_4.7H_2O(s)$$
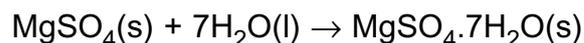
(i) State Hess's law.

_____

_____ [2]

(ii) Use the following data to calculate the molar enthalpy of hydration of magnesium sulphate. You may wish to construct an enthalpy cycle.

When 0.10 mol of anhydrous $MgSO_4$ was dissolved in 100 g of water, the temperature rose by 9 °C. When 0.10 mol of $MgSO_4.7H_2O$ was dissolved in 100 g of water, the temperature dropped 3 °C. (The specific heat capacity for water is $4.2\,J\,°C^{-1}g^{-1}$.)

[4]

(iii) Suggest how you would carry out this experiment in the laboratory, stating the equipment used, the measurements made and the possible sources of error. Explain how these errors can be minimised.

_____

_____

_____

_____

_____

_____ [5]

Quality of written communication [2]

16 Propenonitrile, CH_2=CHCN, can be polymerised to form a fibre known as Orlon, used for making clothes.

(a) Propenonitrile is manufactured from propene, ammonia and oxygen in the presence of molybdenum. Water is produced together with propenonitrile.

(i) Write an equation for the reaction.

_____ [2]

(ii) Suggest the role of the molybdenum.

_____ [1]

(iii) Suggest how you could use infra-red spectroscopy to show that no propene was present in the product from the reaction.

_____

_____

_____ [2]

(b) Propenonitrile may be prepared in the laboratory using chloroethene and sodium cyanide. Write the equation for the reaction.

_____ [2]

(c) (i) What is the molecular formula for propenonitrile?

_____ [1]

(ii) What is the empirical formula for propenonitrile?

_____ [1]

(iii) Draw the structure of a propenonitrile molecule, showing **all** the bonds present.

[2]

(iv) Explain whether propenonitrile is able to exist in *cis* and *trans* (E–Z) forms.

_____

_____ [2]

(d) Propenonitrile polymerises to form poly(propenonitrile) known as Orlon.

(i) Draw a diagram to represent the structure of Orlon, showing two of the repeating units.

[2]

(ii) State the type of polymerisation taking place.

_____ [1]

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