Rewarding Learning

Centre Number

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2016

Chemistry

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

MV18

[AC122]
WEDNESDAY 22 JUNE, MORNING

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**. **You must answer the questions in the spaces provided.**
Complete in blue or black ink only.

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 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.

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 Industrially, ammonia is converted to nitric acid according to the following equation:

$$NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$$

Which one of the following is the atom economy for the production of nitric acid?

A 20.1%

B 22.2%

C 77.8%

D 79.0%

2 The boiling points of the halogenoethanes are shown below.

halogenoethane	**boiling point/°C**
fluoroethane	−37
chloroethane	16
bromoethane	39
iodoethane	73

The change in boiling point is due to an increase in

A hydrogen bonding.

B hydrogen bonding and van der Waals' forces.

C polarity of the carbon halogen bond.

D van der Waals' forces.

3 Which one of the following molecules does **not** have E–Z isomers?

A $CH_3CH_2CHCH_2$

B $CH_3CHCHCH_3$

C $CH_3CClCHCH_3$

D $CH_3CClCClCH_3$

4 Which one of the following correctly describes the properties of barium hydroxide compared to calcium hydroxide?

	thermal stability	**solubility in water**	**pH of solution**
A	higher	higher	higher
B	higher	lower	lower
C	lower	higher	higher
D	lower	lower	lower

5 42 g of sodium hydrogencarbonate were heated to constant mass producing 0.5 mole of gas. Which one of the following is the equation for this decomposition?

A $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$

B $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

C $2NaHCO_3(s) \rightarrow NaOH(s) + NaO(s) + CO_2(g)$

D $2NaHCO_3(s) \rightarrow Na_2O(s) + H_2O(g) + 2CO_2(g)$

6 The thermal cracking of alkanes

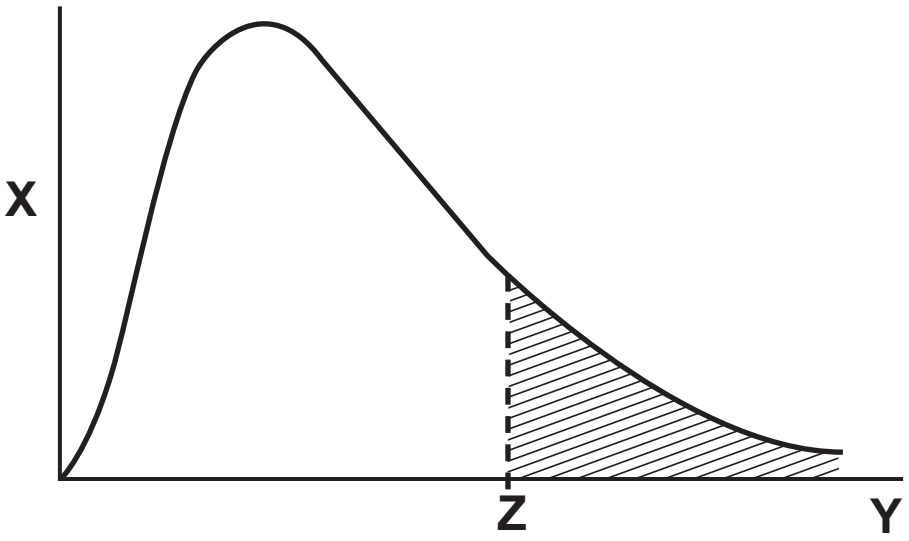
A involves decomposition.

B is an exothermic process.

C produces only small alkanes.

D requires hydrogen.

7 The diagram below shows the Maxwell–Boltzmann distribution of molecular energies for a gas.



Which one of the following is the correct labelling for the diagram?

	X	**Y**	**Z**
A	activation energy	kinetic energy	number of molecules
B	kinetic energy	number of molecules	activation energy
C	number of molecules	activation energy	kinetic energy
D	number of molecules	kinetic energy	activation energy

8 Which one of the following will **not** react with ethanol to form 1-chloroethane?

A Cl_2 in sunlight at 100°C

B NaCl and concentrated sulfuric acid

C PCl_5

D $SOCl_2$ at room temperature

9 A white crystalline solid produced a crimson colour in a flame test. A solution of the solid formed a white precipitate with silver nitrate solution. Which one of the following is the white solid?

A Calcium bromide

B Calcium chloride

C Lithium bromide

D Lithium chloride

10 Aspirin can be produced from salicylic acid according to the following equation:

$$HOC_6H_4COOH + CH_3COOH \rightarrow CH_3COOC_6H_4COOH + H_2O$$

salicylic acid aspirin

Which one of the following is the mass of salicylic acid needed to produce 8.4 g of aspirin assuming a 40% yield?

A 2.8 g

B 7.0 g

C 6.4 g

D 16.1 g

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(Questions continue overleaf)

Section B

Answer all **five** questions in the spaces provided

11 Methane reacts with steam at 200 °C in a closed container to produce the following equilibrium:

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +210 \text{ kJ mol}^{-1}$

Suggest and explain how each of the following changes affects the position of the equilibrium and the rate of the reaction.

(a) The temperature is reduced to 120 °C.

The position of the equilibrium. [1 mark]

The rate of the reaction. [1 mark]

(b) The volume of the container is doubled.

The position of the equilibrium. [1 mark]

The rate of the reaction. [1 mark]

(c) The addition of a catalyst.

The position of the equilibrium. [1 mark]

The rate of the reaction. [1 mark]

12 Hess's Law can be used to calculate enthalpy changes that cannot be measured by experiment.

(a) State **Hess's Law**. [2 marks]

(b) Carbon dioxide and hydrogen can react to form methane according to the following equation:

$CO_2(g) + 4H_2(g) \rightarrow CH_4(g) + 2H_2O(l)$

Standard enthalpies of formation are given in the table below.

	standard enthalpy of formation/kJ mol^{-1}
carbon dioxide	–393.5
methane	–74.8
water	–241.8

(i) What is meant by the term **standard enthalpy of formation**? [2 marks]

(ii) Explain why no value is given for the standard enthalpy of formation of hydrogen. [1 mark]

(iii) Calculate the enthalpy change for the reaction between carbon dioxide and hydrogen. [3 marks]

(c) The average bond enthalpy of each of the bonds involved in the reaction are shown in the table below.

bond	**average bond enthalpy /kJ mol^{-1}**
C═O	803
H—H	436
C—H	413
O—H	463

(i) Calculate the enthalpy change for the reaction between carbon dioxide and hydrogen using the average bond enthalpies. [3 marks]

(ii) What is meant by the term **average bond enthalpy**? [2 marks]

(iii) Compare the enthalpy change obtained using average bond enthalpies to that using Hess's Law and explain the difference. [1 mark]

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(Questions continue overleaf)

13 In nature, magnesium occurs as magnesite, $MgCO_3$, and barium as witherite, $BaCO_3$.

(a) Explain why magnesium and barium are regarded as s-block elements. [1 mark]

(b) Explain the difference in thermal stability between magnesite and witherite. [3 marks]

(c) Barium can be extracted from witherite. The witherite is heated to form barium oxide which is then reacted with aluminium forming barium and barium aluminate, $Ba(AlO_2)_2$.

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

(ii) Write the equation for the reaction of barium oxide with aluminium. [1 mark]

(d) Magnesium can be extracted by electrolysis of magnesium chloride. The magnesium ions form magnesium atoms at the cathode. The chloride ions form chlorine molecules at the anode.

(i) Write the equation for the reaction at the cathode. [1 mark]

_____

(ii) Write the equation for the reaction at the anode. [1 mark]

_____

(iii) Describe a chemical test for chlorine. [2 marks]

_____

_____

(e) Magnesium is also found as hydrated magnesium sulfate in Epsom salts.
Explain how Epsom salts could be used to distinguish between sodium carbonate and sodium hydrogencarbonate solutions. [2 marks]

_____

_____

_____

_____

(f) The first ionisation energy of barium is 500 kJ mol^{-1} and that of magnesium is 740 kJ mol^{-1}.

(i) Write an equation, including state symbols, for the first ionisation energy of barium. [2 marks]

(ii) The second ionisation energy of barium is 1000 kJ mol^{-1}.
Explain why the second ionisation energy is greater than the first ionisation energy. [2 marks]

(iii) Explain why the first ionisation energy of barium is less than the first ionisation energy of magnesium. [2 marks]

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(Questions continue overleaf)

14 1,2-dichloroethane can be made either by the chlorination of ethane or the addition of chlorine to ethene.

(a) The photochlorination of ethane is carried out using electromagnetic radiation and produces 1,2-dichloroethane together with other chlorinated products.

(i) What type of electromagnetic radiation is used? [1 mark]

_____

(ii) What is the name of the mechanism for photochlorination? [1 mark]

_____

(iii) Draw and name the structure of the other dichloroethane. [2 marks]

_____

(iv) Suggest why photochlorination is not used to produce 1,2-dichloroethane commercially. [2 marks]

_____

_____

(b) 1,2-dichloroethane is manufactured in high yield by the addition of chlorine to ethene in the presence of iron(III) chloride.

$$CH_2{=}CH_2 + Cl_2 \rightarrow CH_2ClCH_2Cl$$

(i) Suggest the purpose of the iron(III) chloride. [1 mark]

_____

(ii) Suggest how you would obtain the 1,2-dichloroethane from the reaction mixture. [2 marks]

_____

_____

(c) Vinyl chloride, $CH_2{=}CHCl$, is used to manufacture PVC (polyvinyl chloride). It is obtained from 1,2-dichloroethane.

(i) Vinyl chloride was discovered in 1835 by Justus von Liebig. He heated 1,2-dichloroethane with potassium hydroxide in ethanol. Write the equation for the reaction. [2 marks]

_____

(ii) Explain why it is important not to use an excess of potassium hydroxide when heating it with 1,2-dichloroethane. [1 mark]

_____

_____

(iii) Today, vinyl chloride is manufactured by the thermal cracking of 1,2-dichloroethane. Explain what is meant by the term **thermal cracking**. [1 mark]

_____

_____

(d) Vinyl chloride reacts with hydrogen bromide in a similar way to ethene forming two isomers.

(i) Draw the structures of the two isomers. [2 marks]

(ii) Name the two isomers. [2 marks]

_____

_____

(iii) Draw the two intermediates in the mechanisms for the formation of the two isomers. [2 marks]

(e) Vinyl chloride may be polymerised to form PVC. Draw three repeating units of PVC. [2 marks]

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(Questions continue overleaf)

15 Butanol, C_4H_9OH, can be produced by the fermentation of sugars using the bacterium **Clostridium acetobutylicum**. It is mixed with petrol and used as a fuel for cars.

(a) Butanol produced by fermentation is described as a biofuel. Suggest what is meant by the term **biofuel**. [1 mark]

(b) State the conditions required for fermentation. [2 marks]

(c) Butanol produces fewer harmful environmental emissions from cars than petrol.
Explain, without using equations, the role of catalytic converters in reducing the harmful environmental emissions from petrol engines. [4 marks]

Quality of written communication [2 marks]

(d) There are four alcohols which have the formula C_4H_9OH.

(i) Draw the structures for each of these alcohols and name them. [4 marks]

(ii) Some of these alcohols can be oxidised.
State the reagent necessary for the oxidation and name the organic products formed in each complete oxidation. [4 marks]

Reagent:

_____

Names of products:

_____

_____

(e) The enthalpy of combustion of a butanol is $-2675\,kJ\ mol^{-1}$.

(i) Write the equation for the complete combustion of butanol, C_4H_9OH. [1 mark]

(ii) Calculate the mass of butanol required to raise the temperature of 250 g of water by 80°C, assuming complete combustion. [3 marks]
(The specific heat capacity of water is 4.2 J g^{-1} $°C^{-1}$)

Energy required:

Moles of butanol required:

Mass of butanol:

THIS IS THE END OF THE QUESTION PAPER

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

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Periodic Table of the Elements

For the use of candidates taking

Advanced Subsidiary and Advanced Level
Chemistry Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations.

gce A/AS examinations

chemistry (advanced)

COUNCIL FOR THE **CURRICULUM EXAMINATIONS** AND **ASSESSMENT** 29 Clarendon Road, Clarendon Dock, Belfast BT1 3BG
✆ +44 (0)28 9026 1200 🖷 +44 (0)28 9026 1234 ☎ +44 (0)28 9024 2063 ✉ info@ccea.org.uk 🌐 www.ccea.org.uk

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THE PERIODIC TABLE OF ELEMENTS

I	II										III	IV	V	VI	VII	0
1 H Hydrogen 1																4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4										11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12										27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La* Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac† Actinium 89														

One mole of any gas at 20 °C and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3.

Planck Constant = 6.63×10^{-34} Js

Gas Constant = 8.31 J mol^{-1} K^{-1}

Avogadro Constant = 6.02×10^{23} mol^{-1}

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103

* 58–71 Lanthanum series

† 90–103 Actinium series

a / b x

a = relative atomic mass (approx.)

x = atomic symbol

b = atomic number