New Specification

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ADVANCED
General Certificate of Education
2018

Centre Number

Candidate Number

Chemistry

Assessment Unit A2 1
assessing
Further Physical and
Organic Chemistry

MV18

[ACH12]

TUESDAY 5 JUNE, AFTERNOON

Time

2 hours, 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 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**.
You must answer the questions in the spaces provided.
Do not write on blank pages.
Complete in black ink only.

Information for Candidates

The total mark for this paper is 110.
Quality of written communication will be assessed in Questions **13(a)** and **14(b)(iii)**.
In Section A all questions carry equal marks, i.e. **one** mark 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 Elements, containing some data, is included with 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 K_w has the units

A $mol^{-2}\ dm^{-6}$.

B $mol^{-2}\ dm^{6}$.

C $mol^{2}\ dm^{-6}$.

D $mol^{2}\ dm^{6}$.

2 Which solution has the lowest pH?

A 3.65 g of hydrogen chloride dissolved in 500 cm^3 of water

B 0.1 mol dm^{-3} hydrochloric acid

C 4.9 g of sulfuric acid dissolved in 250 cm^3 of water

D 0.1 mol dm^{-3} sulfuric acid

3 The equation for the reaction between P and Q is

$$2P + Q \rightarrow R + S$$

The rate equation for the reaction is rate = k[P][Q].

Which of the following is the mechanism for the reaction?

A	$P + P \xrightarrow{\text{fast}} P_2$	$P_2 + Q \xrightarrow{\text{slow}} R + S$
B	$P + P \xrightarrow{\text{slow}} P_2$	$P_2 + Q \xrightarrow{\text{fast}} R + S$
C	$P + Q \xrightarrow{\text{fast}} PQ$	$PQ + P \xrightarrow{\text{slow}} R + S$
D	$P + Q \xrightarrow{\text{slow}} PQ$	$PQ + P \xrightarrow{\text{fast}} R + S$

4 How many isomers exist with the formula C_3H_6O?

A Fewer than 4

B 4

C 5

D At least 6

5 The alkaline hydrolysis of $(CH_3)_3CCl$

A does not involve the formation of a carbocation.

B has the rate equation, rate = k $[(CH_3)_3CCl][OH^-]$.

C is an S_N1 mechanism.

D proceeds in one step.

6 Which of the following is a conjugate acid-base pair for the reaction?

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

	conjugate acid	conjugate base
A	NH_3	H_2O
B	NH_3	NH_4^+
C	H_2O	NH_4^+
D	H_2O	OH^-

7 Which titration has no suitable indicator?

A $0.1\,mol\,dm^{-3}$ HCl with $0.1\,mol\,dm^{-3}$ NH_3

B $0.1\,mol\,dm^{-3}$ HCl with $0.1\,mol\,dm^{-3}$ NaOH

C $0.1\,mol\,dm^{-3}$ CH_3COOH with $0.1\,mol\,dm^{-3}$ NH_3

D $0.1\,mol\,dm^{-3}$ CH_3COOH with $0.1\,mol\,dm^{-3}$ NaOH

8 Which reaction can **not** be used to prepare carboxylic acids?

A Hydrolysis of nitriles

B Hydrolysis of acyl chlorides

C Oxidation of aldehydes

D Oxidation of ketones

9 Which reaction has an increase in entropy?

A $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

B $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

C $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

D $4NO_2(g) + O_2(g) + 2H_2O(g) \rightarrow 4HNO_3(l)$

10 Propanone reacts with iodine as follows:

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

Which statement is correct?

A The brown colour fades

B The pH increases

C The purple colour fades

D This is not a redox reaction

Section B

Answer **all six** questions in this section

11 Barium chloride is formed from its elements as follows:

$$Ba(s) + Cl_2(g) \rightarrow BaCl_2(s) \quad -855\,kJ\,mol^{-1}$$

The following enthalpy changes can be used to calculate the lattice enthalpy of barium chloride:

I $Ba(s) \rightarrow Ba(g)$ $+175\,kJ\,mol^{-1}$

II $Ba(g) \rightarrow Ba^{2+}(g) + 2e^{-}$ $+1500\,kJ\,mol^{-1}$

III $Cl_2(g) \rightarrow 2Cl(g)$ $+242\,kJ\,mol^{-1}$

IV $Cl(g) + e^{-} \rightarrow Cl^{-}(g)$ $-364\,kJ\,mol^{-1}$

(a) What name is given to each of the enthalpy changes **I–IV**? [4 marks]

I _____

II _____

III _____

IV _____

(b) Explain what is meant by the term **lattice enthalpy**. [2 marks]

(c) Calculate, to four significant figures, the lattice enthalpy of barium chloride. [2 marks]

(d) What name is given to the cycle used to calculate lattice enthalpy? [1 mark]

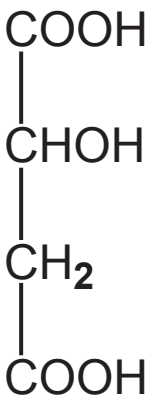
(e) Given

$Ba^{2+}(g) \rightarrow Ba^{2+}(aq) \quad -1309\,kJ\,mol^{-1}$

$Cl^{-}(g) \rightarrow Cl^{-}(aq) \quad -378\,kJ\,mol^{-1}$

calculate, to an appropriate number of significant figures, the enthalpy of solution of barium chloride and use it to explain why barium chloride is soluble in water. [3 marks]

12 Malic acid is found in some apples, giving them a sour taste.



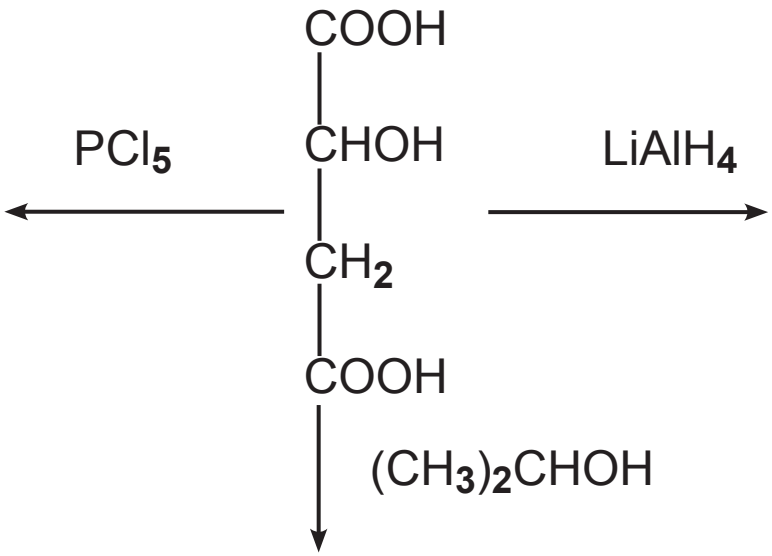
malic acid

(a) (i) Draw the structure of malic acid showing **all** the bonds present. [1 mark]

(ii) Suggest the IUPAC name for malic acid. [2 marks]

_____

(b) (i) Show the organic products for the reaction of malic acid with an excess of each of the following: PCl_5, $LiAlH_4$ and $CH_3CHOHCH_3$. [4 marks]



(ii) Name the organic product formed from the reaction with $LiAlH_4$. [1 mark]

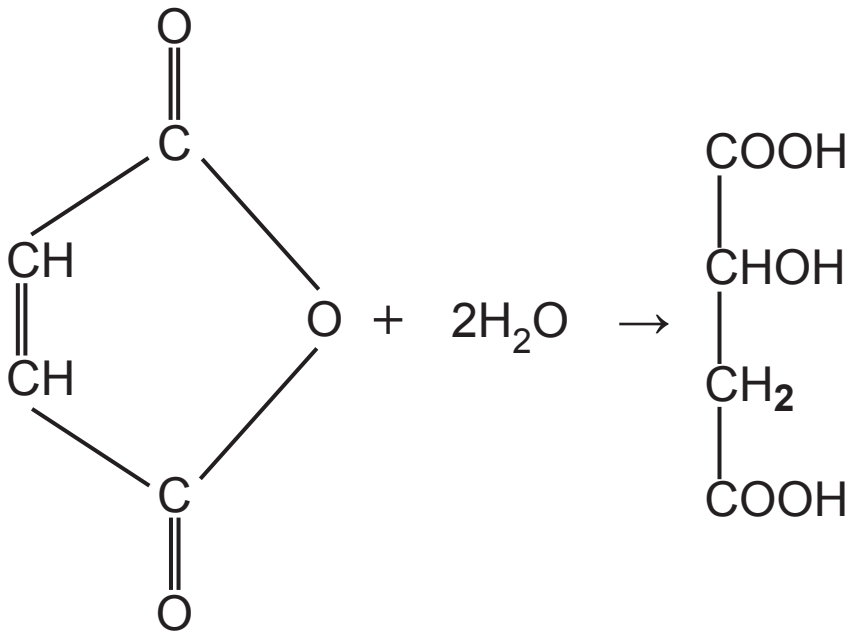
_____

(c) Malic acid melts at 130 °C and has a solubility of 0.558 kg dm^{-3} at 20 °C.

(i) Explain why malic acid has a relatively high melting point. [2 marks]

(ii) Calculate, to three significant figures, the molarity of a saturated solution of malic acid at 20 °C.
[2 marks]

(d) Malic acid is produced industrially by the double hydration of maleic anhydride. Although malic acid contains an asymmetric centre, the product of this reaction is not optically active.



maleic anhydride

(i) Explain what is meant by the term **optically active**. [2 marks]

_____

_____

(ii) On the above diagram circle the asymmetric centre on the malic acid. [1 mark]

(iii) What name is given to this type of optically inactive product? [1 mark]

_____

(iv) Explain why the product in this reaction is not optically active. [1 mark]

_____

_____

13 Ethyl ethanoate is hydrolysed in alkaline conditions as follows:

$$CH_3COOC_2H_5 + OH^- \rightarrow CH_3COO^- + C_2H_5OH$$

(a) Explain, giving experimental details, how you would follow the rate of this reaction with respect to hydroxide ions using pH and how you would use your results to find the order of the reaction with respect to hydroxide ions. [6 marks]

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.

(b) The following results were obtained for the reaction.

$[CH_3COOC_2H_5]$ /mol dm^{-3}	$[OH^-]$ /mol dm^{-3}	initial rate of the reaction /mol dm^{-3} s^{-1}
0.152	0.038	1.13×10^{-2}
0.038	0.076	5.65×10^{-3}
0.019	0.152	5.65×10^{-3}

(i) Deduce the rate equation for the reaction.
[2 marks]

(ii) Calculate, to three significant figures, the value of the rate constant and state its units. [2 marks]

(iii) State and explain the effect of increasing the temperature on the value of the rate constant.
[2 marks]

(c) Ethanoic acid reacts with butan-1-ol to form the ester butyl ethanoate as follows:

$$CH_3COOH(l) + C_4H_9OH(l) \rightleftharpoons CH_3COOC_4H_9(l) + H_2O(l)$$

$-39.8\,kJ\ mol^{-1}$

(i) What mass of butan-1-ol is required to produce 58 g of butyl ethanoate when reacted with 45 g of ethanoic acid in 50 cm^3 of water? Give your answer to two significant figures. [4 marks]

(K_C = 3.0 at 20 °C; the density of water is 1 g cm^{-3})

(ii) Suggest and explain the effect of increasing the temperature to 40 °C on the position of the equilibrium. [2 marks]

(iii) Explain why the equilibrium constant has no units. [1 mark]

(d) The ester tallow is an animal fat which is formed from two molecules of stearic acid, $CH_3(CH_2)_{16}COOH$, and one molecule of oleic acid, $CH_3(CH_2)_7CHCH(CH_2)_7COOH$.

(i) Tallow exists as two isomers. Draw the structure of **one** isomer of tallow. [2 marks]

(ii) Tallow can undergo transesterification. Explain what is meant by the term **transesterification**.
[2 marks]

_____

_____

(iii) State **two** uses of transesterification reactions.
[2 marks]

_____

_____

14 The buttery flavour of butterscotch is due to the presence of diacetyl, $CH_3COCOCH_3$.

(a) Suggest the IUPAC name for diacetyl. [1 mark]

(b) Diacetyl can be made from the corresponding alcohol.

(i) Write an equation for the reaction, using [O] to represent the oxidising agent. [2 marks]

(ii) State the reagent and the condition required for this reaction. [2 marks]

(iii) Diacetyl is a liquid at room temperature with a melting point of −3 °C and a boiling point of 88 °C. The diacetyl obtained in this reaction contains water. Explain how you would use fractional distillation to purify the diacetyl. Describe how you would dry the diacetyl. State how you would use infrared spectroscopy to confirm the diacetyl is pure.
[6 marks]

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.

(c) Diacetyl may react with one or two molecules of 2,4-dinitrophenylhydrazine.

(i) Write the equation for the reaction of diacetyl with one molecule of 2,4-dinitrophenylhydrazine.
[2 marks]

(ii) Describe the appearance of the product.
[1 mark]

(iii) Explain why the melting point of the product formed with one molecule of 2,4-dinitrophenylhydrazine would differ from that formed from the reaction with two molecules of 2,4-dinitrophenylhydrazine.
[2 marks]

15 Phenylethanone, $C_6H_5COCH_3$, used in making resins and pharmaceuticals can be made by reacting benzene with ethanoyl chloride.

(a) The reaction is described as electrophilic substitution.

(i) Explain what is meant by the term **electrophile**. [2 marks]

(ii) Explain why the reaction is described as a substitution. [1 mark]

(b) (i) Write the equation for the formation of ethanoyl chloride from ethanoic acid. [1 mark]

(ii) Why is this reaction carried out under anhydrous conditions? [1 mark]

(c) (i) Write an equation for the formation of the electrophile when benzene reacts with ethanoyl chloride using a catalyst. [1 mark]

(ii) Draw the mechanism for the catalysed reaction using curly arrows. [4 marks]

16 Ammonium perchlorate, NH_4ClO_4, is used in solid rocket fuels. It can be formed by reacting ammonia with the strong acid perchloric acid as follows:

$$NH_3 + HClO_4 \rightarrow NH_4ClO_4$$

(a) (i) What is the oxidation number of chlorine in ammonium perchlorate? [1 mark]

(ii) Explain whether a solution of ammonium perchlorate is acidic, alkaline or neutral. [2 marks]

(b) Ammonium perchlorate decomposes, when heated, to produce a mixture of hydrogen chloride, nitrogen, oxygen and water.

(i) Write the equation for the thermal decomposition of ammonium perchlorate. [2 marks]

(ii) Calculate, to two significant figures, the volume of gas produced by the complete decomposition of 11.75 g of ammonium perchlorate at 250 °C and one atmosphere pressure. [3 marks]

(1 mole of a gas occupies 42 dm^3 at 250 °C and one atmosphere pressure)

(c) Ammonia solution can be used to make buffers by adding ammonium chloride.

(i) Explain what is meant by the term **buffer solution**. [2 marks]

(ii) Explain, including equations, how a mixture of ammonia and ammonium chloride solutions acts as a buffer. [4 marks]

(d) Ammonia is produced by the Haber process as follows:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The table below gives the $\Delta_f H$ and S values for the reactants and products.

	$\Delta_f H$ /kJ mol^{-1}	S /J mol^{-1} K^{-1}
N_2	0	192
H_2	0	131
NH_3	−46.2	193

(i) Calculate, to three significant figures, ΔS for the reaction. [1 mark]

(ii) Calculate, to three significant figures, ΔG for the reaction at 298 K. [2 marks]

(iii) At what temperature does the reaction become feasible? Give your answer to three significant figures. [2 marks]

(iv) State **one** factor which may prevent the reaction from occurring at the temperature calculated in part **(iii)**. [1 mark]

THIS IS THE END OF THE QUESTION PAPER

SYMBOLS OF SELECTED IONS

Positive ions

Name	Symbol
Ammonium	NH_4^+
Chromium(III)	Cr^{3+}
Copper(II)	Cu^{2+}
Iron(II)	Fe^{2+}
Iron(III)	Fe^{3+}
Lead(II)	Pb^{2+}
Silver	Ag^+
Zinc	Zn^{2+}

Negative ions

Name	Symbol
Butanoate	$C_3H_7COO^-$
Carbonate	CO_3^{2-}
Dichromate	$Cr_2O_7^{2-}$
Ethanoate	CH_3COO^-
Hydrogencarbonate	HCO_3^-
Hydroxide	OH^-
Methanoate	$HCOO^-$
Nitrate	NO_3^-
Propanoate	$C_2H_5COO^-$
Sulfate	SO_4^{2-}
Sulfite	SO_3^{2-}

SOLUBILITY IN COLD WATER OF COMMON SALTS, HYDROXIDES AND OXIDES

Soluble
All sodium, potassium and ammonium salts
All nitrates
Most chlorides, bromides and iodides EXCEPT silver and lead chlorides, bromides and iodides
Most sulfates EXCEPT lead and barium sulfates Calcium sulfate is slightly soluble

Insoluble
Most carbonates EXCEPT sodium, potassium and ammonium carbonates
Most hydroxides EXCEPT sodium, potassium and ammonium hydroxides
Most oxides EXCEPT sodium, potassium and calcium oxides which react with water

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Rewarding Learning

New Specification

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Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Science: Chemistry,
Science: Double Award
or Science: Single Award

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

gcse examinations

chemistry

For first teaching from September 2017

THE PERIODIC TABLE OF ELEMENTS

Group

1	2											3	4	5	6	7	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	98 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	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 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
X
b

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number