Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Wednesday 16 January 2019

Morning (Time: 1 hour 30 minutes) | Paper Reference **WCH02/01**

Chemistry
Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Candidates must have: Scientific calculator

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Check your answers if you have time at the end.

Turn over ▶

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P 5 4 3 4 2 A 0 1 2 4

Pearson

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of these molecules is planar?

☒ **A** Ethane, CH_3CH_3

☒ **B** Ethanoic acid, CH_3COOH

☒ **C** Methanal, HCHO

☒ **D** Methanol, CH_3OH

(Total for Question 1 = 1 mark)

2 Which molecule contains bond angles of both 90° and 120°?

☒ **A** SF_6

☒ **B** PCl_5

☒ **C** BCl_3

☒ **D** $BeCl_2$

(Total for Question 2 = 1 mark)

3 Which molecule has the most polar **bond**?

☒ **A** $CH_3CH_2NH_2$

☒ **B** CH_3CH_2OH

☒ **C** CH_3CH_2Cl

☒ **D** CH_3CH_2I

(Total for Question 3 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

4 Which is correct for tetrabromomethane, CBr_4?

	Polarity of C-Br bond	Polarity of CBr_4 molecule
☒ **A**	polar	polar
☒ **B**	non-polar	non-polar
☒ **C**	non-polar	polar
☒ **D**	polar	non-polar

(Total for Question 4 = 1 mark)

5 In alkanes, increasing the length and branching of the carbon chain both affect the boiling temperature.

Which of the following combination of effects is correct?

	Effect on boiling temperature	
	Increasing chain length	Increasing branching
☒ **A**	increases	decreases
☒ **B**	decreases	increases
☒ **C**	decreases	decreases
☒ **D**	increases	increases

(Total for Question 5 = 1 mark)

6 What is the correct order of boiling temperatures for the hydrogen halides, from the lowest to highest?

☒ **A** HCl, HBr, HI, HF

☒ **B** HF, HCl, HBr, HI

☒ **C** HBr, HCl, HF, HI

☒ **D** HI, HBr, HCl, HF

(Total for Question 6 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

7 What is **always** formed when s-block nitrates thermally decompose?

- ☒ **A** A metal nitrite
- ☒ **B** A metal oxide
- ☒ **C** Nitrogen dioxide
- ☒ **D** Oxygen

(Total for Question 7 = 1 mark)

8 When solid potassium bromide reacts with concentrated sulfuric acid, which substance does **not** form?

- ☒ **A** HBr
- ☒ **B** Br_2
- ☒ **C** SO_2
- ☒ **D** H_2S

(Total for Question 8 = 1 mark)

9 Which equation does **not** represent a disproportionation reaction?

- ☒ **A** $Cl_2 + H_2O \rightarrow HClO + HCl$
- ☒ **B** $3Cl_2 + 6KOH \rightarrow KClO_3 + 5KCl + 3H_2O$
- ☒ **C** $2KClO_3 \rightarrow 2KCl + 3O_2$
- ☒ **D** $4KClO_3 \rightarrow 3KClO_4 + KCl$

(Total for Question 9 = 1 mark)

10 How does the addition of a catalyst to a reaction affect the shape of the Maxwell-Boltzmann distribution curve?

- ☒ **A** There is no change.
- ☒ **B** The peak moves to the left and is higher.
- ☒ **C** The peak moves to the right and is lower.
- ☒ **D** The total area under the curve increases.

(Total for Question 10 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

11 This question is about the equilibrium between sulfur dioxide, oxygen and sulfur trioxide in the gas phase.

$$SO_2(g) + \tfrac{1}{2}O_2(g) \rightleftharpoons SO_3(g) \quad \Delta H^{\ominus} = -98\,kJ\,mol^{-1}$$

(a) What are the effects of **decreasing** the temperature?

(1)

	Effect on rate	Effect on equilibrium yield of SO_3
☒ **A**	increases	decreases
☒ **B**	decreases	increases
☒ **C**	decreases	decreases
☒ **D**	increases	increases

(b) What are the effects of **increasing** the pressure?

(1)

	Effect on rate	Effect on equilibrium yield of SO_3
☒ **A**	increases	decreases
☒ **B**	decreases	increases
☒ **C**	decreases	decreases
☒ **D**	increases	increases

(c) The equation for the reaction can also be written as

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The enthalpy change for this equation is

(1)

☒ **A** $-49\,kJ\,mol^{-1}$

☒ **B** $-98\,kJ\,mol^{-1}$

☒ **C** $-196\,kJ\,mol^{-1}$

☒ **D** $-9604\,kJ\,mol^{-1}$

(Total for Question 11 = 3 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

12 A sample of 50 cm^3 of ethanol gas is burned completely in 200 cm^3 of oxygen.

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

All volumes are measured at a temperature of 400 K and 1 atm pressure.

What is the **total** volume of gas when the reaction is complete?

☒ **A** 150 cm^3

☒ **B** 200 cm^3

☒ **C** 250 cm^3

☒ **D** 300 cm^3

(Total for Question 12 = 1 mark)

13 Which is a tertiary alcohol?

☒ **A** 2-methylbutan-2-ol

☒ **B** 2-methylbutan-1-ol

☒ **C** pentan-2-ol

☒ **D** pentan-3-ol

(Total for Question 13 = 1 mark)

14 Excess ammonia in ethanol reacts with 1-bromobutane at high pressure.

Which products could be formed in this reaction?

☒ **A** $C_4H_9NH_2$ and NH_4Br

☒ **B** $C_4H_9NH_2$ and C_4H_{10}

☒ **C** C_4H_{10} and HBr

☒ **D** C_4H_8, NH_4Br and HBr

(Total for Question 14 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

15 This question is about mechanisms and reaction types.

(a) The reaction between an alkane and a halogen to form a halogenoalkane is

(1)

☒ **A** electrophilic addition.

☒ **B** nucleophilic addition.

☒ **C** free radical substitution.

☒ **D** nucleophilic substitution.

(b) The reaction between ammonia and a halogenoalkane is

(1)

☒ **A** electrophilic addition.

☒ **B** nucleophilic addition.

☒ **C** free radical substitution.

☒ **D** nucleophilic substitution.

(Total for Question 15 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

16 Which of these substances causes the greatest amount of anthropogenic global warming?

- ☒ **A** Carbon dioxide
- ☒ **B** Methane
- ☒ **C** Dinitrogen monoxide
- ☒ **D** Dichlorodifluoromethane

(Total for Question 16 = 1 mark)

17 In which pair do **both** substances deplete the ozone layer?

- ☒ **A** Water vapour and carbon dioxide
- ☒ **B** Dichlorodifluoromethane and nitrogen monoxide
- ☒ **C** Dichlorodifluoromethane and carbon dioxide
- ☒ **D** Water vapour and nitrogen monoxide

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

18 This question is about diamond, graphite and other carbon structures.

(a) (i) In diamond, each carbon atom is covalently bonded to four others, in a three-dimensional structure.

Draw a diagram showing this arrangement.

(1)

(ii) Explain the shape and bond angle of this arrangement of carbon atoms in diamond.

(3)

Shape .....

Bond angle .....

Explanation .....

.....

.....

.....

(b) Graphite consists of a layer lattice, with strong covalent bonds within the layers and a weaker force between the layers.

(i) Draw a diagram to show part of **one** layer of graphite with between 13 and 19 carbon atoms, and give the bond angle.

(2)

Diagram

Bond angle .....

(ii) Name the force between the layers.

(1)

.....

(iii) Give a reason why graphite conducts electricity whereas diamond does not.

(1)

.....

.....

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(iv) A graphite shield was used on the front of early spacecraft to prevent them getting too hot when re-entering the atmosphere.

Use your knowledge of the structure of graphite and its physical properties to suggest **two** reasons for this use.

(2)

(c) Name **one** other form of pure carbon.

(1)

(Total for Question 18 = 11 marks)

19 This question is about the structure, properties and reactions of the alcohols, ethanol and butan-2-ol.

(a) Ethanol mixes with water in all proportions, but butan-2-ol has limited solubility in water.

(i) Name **all** the intermolecular forces present in these alcohols.

(2)

*(ii) Explain why butan-2-ol has limited solubility in water.

(2)

(b) Both alcohols react with sodium.

(i) Describe what you **see** when ethanol reacts with sodium.

(2)

(ii) Write the equation for the reaction of ethanol with sodium.
State symbols are not required.

(2)

(c) Both alcohols are separately heated under reflux with acidified potassium dichromate(VI).

After refluxing, the organic product is distilled from each mixture.

(i) Name the organic product formed from ethanol and give a chemical test, with the result, to show the functional group present in the product.

(2)

Name .....

Test and result .....

.....

.....

.....

.....

(ii) Give the structure of the organic product formed from butan-2-ol.

(1)

(iii) State the ways in which the infrared spectra of butan-2-ol and its oxidation product would differ.
Specific wave numbers are not required.

(2)

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.....

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(Total for Question 19 = 13 marks)

20 This question is about iodine and some of its compounds.

(a) Iodine can be obtained from iodine compounds, such as potassium iodide, by reaction with chlorine.

(i) Write the **ionic** equation for the formation of iodine, by the addition of chlorine to aqueous potassium iodide.
State symbols are not required.

(1)

(ii) The colour of the iodine solution formed is red-brown.

Name an organic solvent that can be added to extract iodine from its aqueous solution, and give the colour of the organic layer.

(2)

Name .....

Colour .....

(iii) Iodine reacts with sodium thiosulfate solution.

$$I_2(aq) + 2Na_2S_2O_3(aq) \rightarrow 2NaI(aq) + Na_2S_4O_6(aq)$$

State which element is oxidised and which is reduced, giving the relevant changes in oxidation number.

(2)

.....

.....

.....

.....

(b) The two isomers of C_3H_7I are 1-iodopropane and 2-iodopropane.

(i) Draw the **skeletal** formulae of these two isomers.

(1)

(ii) Iodoalkanes are easily distinguished from chloroalkanes and bromoalkanes using mass spectrometry because they only give a single molecular ion peak.

Suggest why 1-iodopropane only has one molecular ion peak whereas 1-chloropropane and 1-bromopropane both have two molecular ion peaks.

(1)

.....

.....

(iii) The mass spectrum of 1-iodopropane has a peak at $m/e = 43$.

Give the structure of the ion responsible for this peak and state how it is formed.

(2)

.....

.....

(c) 1-iodopropane and 2-iodopropane are separately dissolved in ethanol and hot silver nitrate solution is added. A precipitate forms in each reaction.

(i) State the colour and name of the precipitate.

(2)

Colour ..... Name .....

(ii) Write the ionic equation, with state symbols, for the formation of this precipitate.

(1)

(d) Aqueous sodium hydroxide reacts with 1-iodopropane to form propan-1-ol.

Draw the mechanism for this reaction. Include curly arrows and relevant lone pairs.

(2)

(e) Hot concentrated potassium hydroxide in ethanol reacts with 1-iodopropane and 2-iodopropane.
The same organic compound is formed in each case.

(i) State the type of reaction occurring.

(1)

.....

(ii) **Name** the organic product formed in both reactions.

(1)

.....

(Total for Question 20 = 16 marks)

TOTAL FOR SECTION B = 40 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

21 'Hard' water is water that contains significant concentrations of calcium ions or magnesium ions.

Hard water may be produced when rainwater, containing dissolved carbon dioxide, passes through rocks containing calcium carbonate. Calcium hydrogencarbonate is formed in solution.

Hard water may also be formed when rain water passes through minerals containing calcium sulfate or magnesium sulfate.

Hard water causes two problems.

The first is that it forms a precipitate (scum) when mixed with soap.

The second is that, on heating, it will form a deposit of calcium or magnesium carbonate which reduces the efficiency of heating elements and may lead to blockages in boiler pipes.

(a) A flame test can be used to detect the metal ion present in the precipitate formed by heating hard water.

*(i) Explain how metal ions produce a colour in a flame test.

(3)

(ii) Give the colour of the flame you would expect to see when calcium ions are present.

(1)

(iii) Give the reason why magnesium ions do not produce a flame colour.

(1)

(b) Write an equation to show how calcium hydrogencarbonate is formed when rainwater, containing dissolved carbon dioxide, reacts with calcium carbonate. State symbols are not required.

(1)

(c) Suggest why calcium sulfate and magnesium sulfate can form hard water but barium sulfate cannot.

(1)

(d) Group 2 metal carbonates decompose on heating.

$$MCO_3 \rightarrow MO + CO_2$$

*(i) Explain why calcium carbonate requires stronger heating to decompose than magnesium carbonate.

(3)

(ii) When 10.00 g of a Group 2 metal carbonate is completely decomposed by heating, 1.626 dm^3 of carbon dioxide forms, at room temperature and pressure (r.t.p.).

Deduce by calculation the metal ion present.

[Molar volume of a gas at r.t.p. = 24.0 $dm^3 mol^{-1}$]

(3)

(iii) Calcium oxide dissolves in water to form calcium hydroxide (limewater), $Ca(OH)_2(aq)$.

Write the equation for the reaction of carbon dioxide with limewater. Include state symbols.

(1)

(e) The solubility of calcium hydroxide in water is determined by titration of a saturated solution.

An excess of calcium hydroxide is added to about 100 cm^3 of distilled water in a conical flask.

The flask is stoppered, shaken and allowed to stand overnight.

10.0 cm^3 portions of this saturated solution are titrated with 0.0500 mol dm^{-3} hydrochloric acid.

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + H_2O$$

(i) Suggest a suitable indicator for this titration and give the colour change you would expect to see at the end-point.

(2)

Indicator .....

Colour change from ..... to .....

(ii) The mean titre is 8.90 cm^3.

Calculate the concentration of the saturated calcium hydroxide solution, in g dm^{-3}.

(4)

(Total for Question 21 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] 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							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	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	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	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