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Pearson Edexcel
International
Advanced Level

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Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Wednesday 17 January 2018 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH02/01

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.
- Try to answer every question.
- Check your answers if you have time at the end.
- Show all your working in calculations and units where appropriate.

Turn over ▶

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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 is a polar molecule?

☒ **A** $BeCl_2$

☒ **B** BCl_3

☒ **C** CCl_4

☒ **D** NCl_3

(Total for Question 1 = 1 mark)

2 Which bond angles are present in a molecule of methanol?

☒ **A** 90° and 104.5°

☒ **B** 104.5° and 109.5°

☒ **C** 109.5° and 180°

☒ **D** 90° and 180°

(Total for Question 2 = 1 mark)

3 This question is about the hydrides of carbon, nitrogen, oxygen and fluorine.

(a) The hydride with the highest boiling temperature is

(1)

☒ **A** CH_4

☒ **B** NH_3

☒ **C** H_2O

☒ **D** HF

(b) The hydride which has the strongest hydrogen bond in the pure liquid is

(1)

☒ **A** CH_4

☒ **B** NH_3

☒ **C** H_2O

☒ **D** HF

(Total for Question 3 = 2 marks)

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4 On descending Group 2, from magnesium to barium, what are the trends in the first ionisation energy of the elements, and in the solubility of the sulfates?

	First ionisation energy	Solubility of sulfate
☒ **A**	increases	increases
☒ **B**	increases	decreases
☒ **C**	decreases	increases
☒ **D**	decreases	decreases

(Total for Question 4 = 1 mark)

5 Flame tests are carried out on the chlorides of four Group 2 metals.

Select the metal chlorides that give these flame colours.

	Flame colour			
	Colourless	Crimson	Pale green	Yellow-red
☒ **A**	magnesium	calcium	strontium	barium
☒ **B**	barium	calcium	magnesium	strontium
☒ **C**	barium	strontium	magnesium	calcium
☒ **D**	magnesium	strontium	barium	calcium

(Total for Question 5 = 1 mark)

6 The s-block metal nitrate that decomposes on heating to form a nitrite is

☒ **A** lithium nitrate.

☒ **B** sodium nitrate.

☒ **C** magnesium nitrate.

☒ **D** calcium nitrate.

(Total for Question 6 = 1 mark)

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

7 Which statement is correct?

- ☒ **A** Chlorine is a pale green gas that dissolves in hexane to form a brown solution.
- ☒ **B** Chlorine is a pale green gas that dissolves in hexane to form a pale green solution.
- ☒ **C** Iodine is a brown liquid that dissolves in hexane to form a pink solution.
- ☒ **D** Iodine is a grey solid that dissolves in hexane to form a brown solution.

(Total for Question 7 = 1 mark)

8 The best way to prepare hydrogen iodide from potassium iodide is to add concentrated

- ☒ **A** hydrochloric acid.
- ☒ **B** nitric acid.
- ☒ **C** phosphoric(V) acid.
- ☒ **D** sulfuric acid.

(Total for Question 8 = 1 mark)

9 When concentrated sulfuric acid reacts with solid potassium bromide, sulfuric acid is reduced to

- ☒ **A** hydrogen sulfide.
- ☒ **B** sulfur.
- ☒ **C** sulfur dioxide.
- ☒ **D** sulfur trioxide.

(Total for Question 9 = 1 mark)

10 The greenhouse gas with the highest mean concentration in the atmosphere is

- ☒ **A** CO
- ☒ **B** CO_2
- ☒ **C** NO_2
- ☒ **D** H_2O

(Total for Question 10 = 1 mark)

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11 When potassium chloride dissolves in water, the main interaction between the ions and water molecules is

☒ **A** ion-dipole.

☒ **B** ion-ion.

☒ **C** dipole-dipole.

☒ **D** hydrogen bonding.

(Total for Question 11 = 1 mark)

12 What are the properties of the liquid 2-chlorobutane?

	Solubility in water	Effect of a charged rod on a stream of the liquid
☒ **A**	insoluble	stream diverted
☒ **B**	insoluble	stream unaffected
☒ **C**	soluble	stream diverted
☒ **D**	soluble	stream unaffected

(Total for Question 12 = 1 mark)

13 How many organic elimination products form when 2-bromobutane is heated with a concentrated solution of potassium hydroxide in ethanol?

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(Total for Question 13 = 1 mark)

14 Which two isomeric alcohols, with the formula C_4H_9OH, would you expect to give a peak due to CH_2OH^+ in their mass spectra?

☒ **A** butan-1-ol and 2-methylpropan-1-ol.

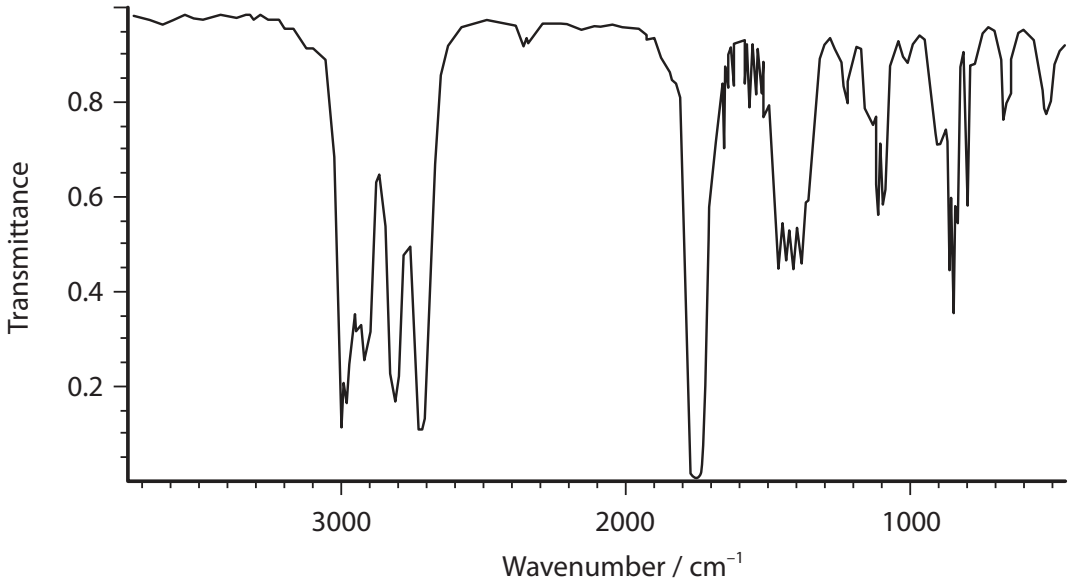
☒ **B** butan-1-ol and 2-methylpropan-2-ol.

☒ **C** 2-methylpropan-1-ol and 2-methylpropan-2-ol.

☒ **D** butan-1-ol and butan-2-ol.

(Total for Question 14 = 1 mark)

15 Part of the infrared (IR) spectrum of a compound is shown.



Bond	Wavenumber range / cm^{-1}
O—H (alcohol)	3750–3200
O—H (carboxylic acid)	3300–2500
C—H (alkane)	2962–2853
C—H (aldehyde)	2900–2820 and 2775– 2700
C=O (aldehyde or ketone)	1740–1680

The compound could be

☒ **A** propan-1-ol.

☒ **B** propanoic acid.

☒ **C** propanal.

☒ **D** propanone.

(Total for Question 15 = 1 mark)

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16 Two alcohols are oxidised under mild conditions.

These alcohols each form a compound that gives a red precipitate on heating with either Benedict's solution or Fehling's solution.

These alcohols could be

- ☒ **A** propan-1-ol and propan-2-ol.
- ☒ **B** propan-1-ol and butan-1-ol.
- ☒ **C** propan-2-ol and butan-2-ol.
- ☒ **D** butan-1-ol and butan-2-ol.

(Total for Question 16 = 1 mark)

17 Organic compounds which react with sodium but are **not** oxidised by acidified potassium dichromate(VI) are

- ☒ **A** primary alcohols.
- ☒ **B** secondary alcohols.
- ☒ **C** tertiary alcohols.
- ☒ **D** ketones.

(Total for Question 17 = 1 mark)

18 Which statement about the carbon footprint of fuels is true?

- ☒ **A** Hydrogen has a zero carbon footprint as it does not produce carbon dioxide.
- ☒ **B** Methane has a zero carbon footprint as it occurs naturally.
- ☒ **C** Biodiesel has a zero carbon footprint as it absorbs as much carbon dioxide in production as it produces in combustion.
- ☒ **D** No fuel has been discovered with a zero carbon footprint.

(Total for Question 18 = 1 mark)

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

19 Dinitrogen tetroxide and nitrogen dioxide form an equilibrium mixture in a gas syringe.

$$\underset{\text{Pale brown}}{N_2O_4(g)} \rightleftharpoons \underset{\text{Dark brown}}{2NO_2(g)}$$

The pressure is rapidly doubled and then the mixture allowed to stand.

The colour would

- ☒ **A** go darker then go paler.
- ☒ **B** go darker and remain darker.
- ☒ **C** go paler and remain paler.
- ☒ **D** go paler then go darker.

(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

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

20 This question is about the preparation and properties of 1-iodobutane.

(a) 1-iodobutane is prepared by warming a mixture of damp red phosphorus with iodine to produce phosphorus(III) iodide, PI_3. This reacts with butan-1-ol to form 1-iodobutane, C_4H_9I.

*(i) Draw a diagram to show the shape of phosphorus(III) iodide.
Predict the I—P—I bond angle.

Explain why the molecule has this shape and bond angle.

(4)

Diagram

Bond angle .....

Explanation .....

.....

.....

.....

.....

.....

(ii) Complete the balanced equation for the formation of 1-iodobutane.
State symbols are not required.

(1)

.....$C_4H_9OH + PI_3 \rightarrow$

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(iii) Draw **skeletal** formulae of the four structural isomers of C_4H_9I.

(2)

(b) 1-iodobutane, dissolved in ethanol, reacts with hot aqueous silver nitrate to form a yellow precipitate. The reaction involves two steps.

(i) In the first step, 1-iodobutane forms butan-1-ol.
Identify the attacking reagent, and state the type and mechanism of this reaction.

(2)

Attacking reagent .....

Type and mechanism of this reaction .....

(ii) Write the **ionic** equation for the formation of the yellow precipitate.
Include state symbols.

(1)

(c) Identify, by name or formula, both products of the reaction between 1-iodobutane and **excess** ammonia.

(2)

.....

.....

(Total for Question 20 = 12 marks)

21 This question is about nitrogen monoxide, NO.

(a) Nitrogen monoxide is formed in internal combustion engines.

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g) \qquad \Delta H^{\ominus}_{298} = +180\,kJ\,mol^{-1}$$

Explain how, if at all, an increase in temperature and an increase in pressure affect this equilibrium. Justify your answers.

(3)

(b) In industry, nitrogen monoxide is produced by the oxidation of ammonia at high temperature, with a platinum catalyst.

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

(i) Identify the two elements which change their oxidation number in this reaction. State the relevant oxidation numbers.

(2)

First element ..... from ..... to .....

Second element ..... from ..... to .....

(ii) Use the Maxwell-Boltzmann distribution to explain why increasing the temperature will result in a higher rate for this reaction.
A diagram is not required.

(1)

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(iii) Use the Maxwell-Boltzmann distribution to explain why the platinum catalyst produces a higher rate for this reaction.
A diagram is not required.

(1)

(c) Nitrogen monoxide is a major pollutant. High in the atmosphere, it is a greenhouse gas and it depletes the ozone layer.

(i) Explain why nitrogen monoxide is a greenhouse gas and how the presence of nitrogen monoxide in the atmosphere leads to global warming.

(3)

(ii) Write **two** equations to show how the free radical, nitrogen monoxide, depletes the ozone layer. Indicate free radicals in the usual way.
Hence write the equation which shows the overall change taking place.
State symbols are not required.

(3)

(Total for Question 21 = 13 marks)

22 Potassium iodate(V), KIO_3, is made by adding iodine to boiling concentrated potassium hydroxide solution.

(a) (i) Balance the equation for the reaction.

(2)

.....I_2 + ...KOH → KIO_3 + ...KI + ...H_2O

(ii) State the type of redox reaction between iodine and concentrated potassium hydroxide.

(1)

.....

(b) What would you **see** when a slight excess of iodine has been added?

(1)

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(c) Potassium iodate(V) crystallises as the solution cools.

Suggest why potassium iodate(V), rather than potassium iodide, crystallises out.

(1)

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(d) The purity of the potassium iodate(V) formed is determined using the method outlined below.

0.100 g of the potassium iodate(V) sample is dissolved in distilled water and the volume made up to 100 cm^3.

A 10.0 cm^3 portion is taken and added to an excess of a mixture of potassium iodide in dilute sulfuric acid.

The iodine formed is titrated with 0.0100 mol dm^{-3} sodium thiosulfate solution.

The titration is repeated and the mean titre is 27.45 cm^3.

(i) Name the indicator that should be used for the titration and state when it should be added to the reaction mixture.

(2)

.....

.....

(ii) Give the colour change for the indicator at the end-point.

(1)

From ..... to .....

(iii) Calculate the number of moles of thiosulfate ions used in the titration.

(1)

(iv) Calculate the number of moles of potassium iodate(V) in the 10.0 cm^3 portion, given that 6 mol of thiosulfate ions is equivalent to 1 mol of iodate(V) ions.

(1)

(v) Calculate the mass of potassium iodate(V) in the original sample.

(3)

(vi) Calculate the percentage purity by mass of potassium iodate(V) in the original sample. Give your answer to **two** significant figures.

(2)

(vii) Suggest why the potassium iodate(V) obtained is not 100% pure.

(1)

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(Total for Question 22 = 16 marks)

TOTAL FOR SECTION B = 41 MARKS

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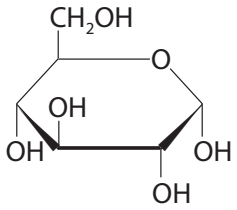
SECTION C

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

23 Glucose occurs naturally in many fruits. It is a white powder at room temperature and is extremely soluble in water. Glucose may be represented by the structure below.



Glucose

The fermentation of glucose is fundamental to brewing and baking. Glucose breaks down to form carbon dioxide and ethanol.

Drinks with a high alcohol content are obtained by distillation from a fermentation mixture.

For many years, the alcohol content of such drinks was measured as degrees proof. Originally this was defined by the gunpowder test. A pellet of gunpowder was soaked in the drink. If the gunpowder would still ignite, the alcohol drink was at least 100° proof. The reason for introducing this measure was that, from the sixteenth century, the tax on alcoholic drinks was related to their alcohol content.

Nowadays, most countries have adopted alcohol percentage by volume (ABV), which is the volume of ethanol, in cm^3, present in 100 cm^3 of the drink.

Today, most ethanol for chemical use is produced by an addition reaction of ethene.

*(a) (i) Name all the intermolecular forces between glucose molecules. For each type of force, indicate the atoms in the molecule involved.

A detailed explanation of how these forces arise is **not** required.

(6)

(ii) Explain why glucose is very soluble in water.

(2)

(b) Complete the equation for the fermentation of glucose. State symbols are not required.

(1)

$C_6H_{12}O_6 \rightarrow$

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(c) Suggest **two** advantages for the taxation of alcoholic drinks.

(2)

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(d) The ABV in a 100° proof drink is found to be 57.15%.

(i) Calculate the degrees proof of pure ethanol.

(1)

(ii) Calculate the concentration of ethanol, in mol dm^{-3}, in a solution when the ABV is 57.15%.
[Density of ethanol = 0.789 g cm^{-3}]

(3)

(e) Potassium nitrate is the main ingredient of gunpowder. Suggest how the gunpowder test for measuring the degrees proof of alcohol drinks works.

(1)

.....

.....

.....

.....

(f) Balance this simplified equation for the decomposition of gunpowder.

(1)

.....$KNO_3(s)$ + $S(s)$ + ...$C(s)$ → $K_2S(s)$ + $N_2(g)$ + ...$CO_2(g)$

(g) Write the equation, including state symbols, for the formation of ethanol from ethene and suggest conditions for the industrial preparation.

(2)

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(Total for Question 23 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										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

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