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Advanced Level

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Chemistry

Advanced Subsidiary
Unit 3: Chemistry Laboratory Skills I

Tuesday 8 May 2018 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
WCH03/01

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 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

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

Turn over ▶

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

1 The inorganic compounds **A** and **B** contain the same Group 2 cation but different anions.

(a) Two tests were carried out on **A**. The observations made for each test are recorded in the table.

(i) Complete the statements in the inference column in the table by writing the names or formulae of the ions.

(3)

Test	Observation	Inference
Dilute sulfuric acid was added to an aqueous solution of **A**	A white precipitate formed	Two possible **cations** in **A** are ....
A sample of **A** was heated in a test tube A glowing splint was held in the mouth of the test tube	A brown gas was evolved The splint relit	The **anion** in **A** is .....

(ii) There were two gases evolved when **A** was heated; a brown gas **C**, and a gas **D** which relit the glowing splint.
Identify the gases **C** and **D** by giving their name or formula.

(2)

Gas **C** .....

Gas **D** .....

(iii) Name a test that could be used to distinguish between the two cations identified in (a)(i).
Include the expected result of the test for **both** cations.

(3)

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(b) A test was carried out on **B**. The observations made for the test are recorded in the table.

(i) Complete the statement in the inference column in the table by writing the **formula** of the anion.

(1)

Test	Observation	Inference
Concentrated sulfuric acid was added to a sample of solid **B** in a test tube	An orange-brown gas **E** was evolved	The **formula** of the anion in **B** is .....

(ii) Identify the orange-brown gas **E** by giving its name or formula.

(1)

Gas **E** is .....

(iii) Two colourless acidic gases were also evolved in the test in (b)(i).

These gases were dissolved in water.
Aqueous silver nitrate and dilute nitric acid were added to the solution and a cream precipitate formed.

Give the name or formula of the gas identified by this method.

(1)

.....

(iv) Suggest the identity of the other acidic gas by giving its name or formula.

(1)

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(Total for Question 1 = 12 marks)

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2 This question is about an organic compound **X**.

Information about compound X

Molecular formula: $C_4H_{10}O$

Test 1

Phosphorus(V) chloride was added to **X**.
Steamy fumes were formed.

(a) (i) Use all the information about **X** to identify the type of functional group present in **X**.

(1)

.....

(ii) Draw the four possible structural isomers of **X**.
Use your answer to (a)(i) and the molecular formula of **X**.

(4)

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(b) Another test was carried out on **X**.

Test 2

A few drops of acidified potassium dichromate(VI) solution were added to **X** and the mixture was heated.
The mixture stayed orange.

Use the result of **Test 2** to further classify the functional group present in **X**.

(1)

(c) Use your answer to (b) to identify which of the four isomers of $C_4H_{10}O$ you have drawn in (a)(ii) is **X**.

(1)

(d) (i) Write the equation for the reaction between **X** and phosphorus(V) chloride. State symbols are not required.

(1)

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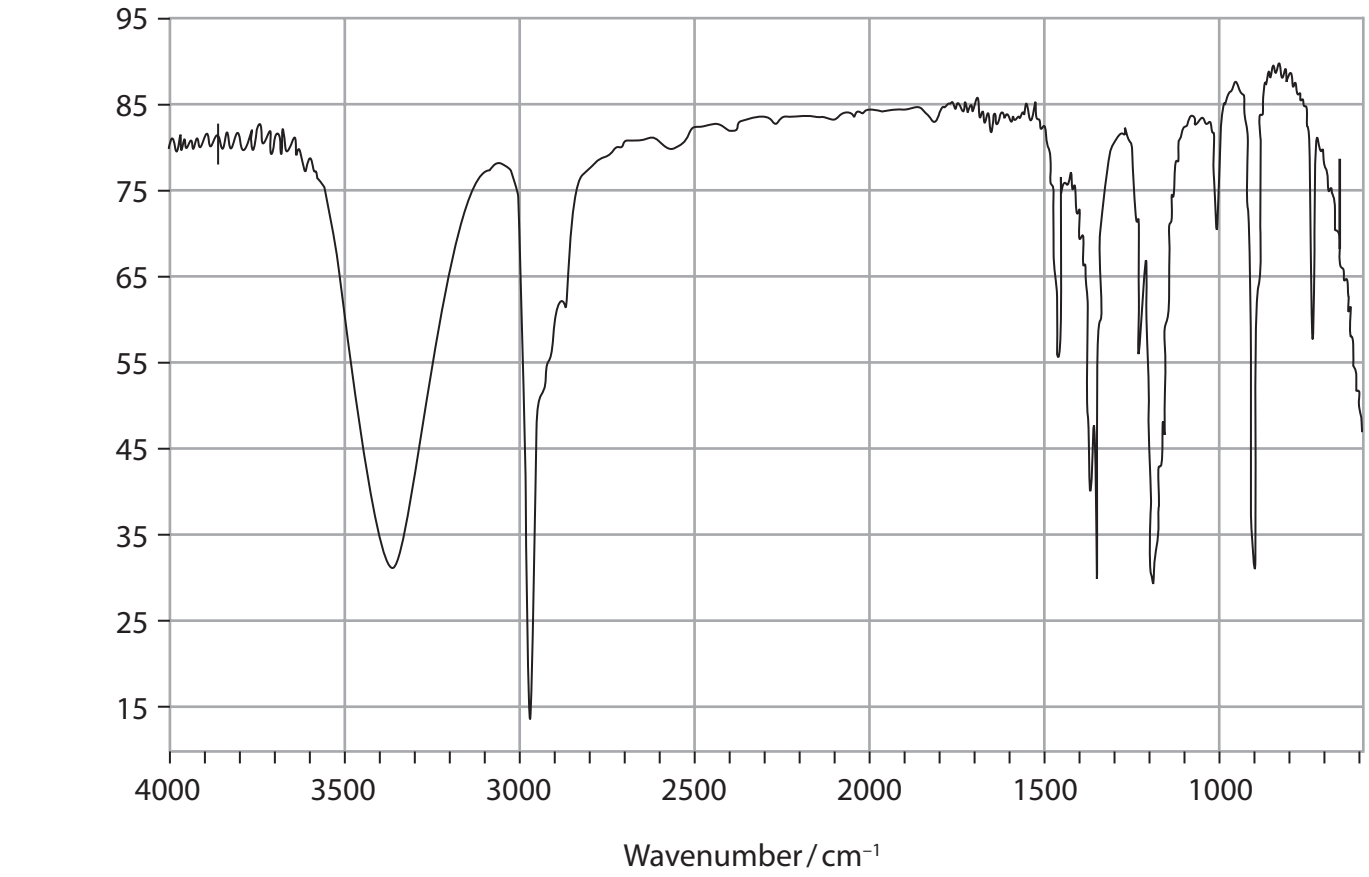
(ii) The infrared spectrum of **X** is shown.



Some data about infrared spectra are given in the table.

Group	Bond	Wavenumber / cm^{-1}
alkane	C–H stretch	2962–2853
alkane	C–H bend	1485–1365
alcohol	O–H stretch	3750–3200

Circle the peak on the spectrum that will **not** be present in the infrared spectrum of the **organic product** of the reaction between **X** and phosphorus(V) chloride.

(1)

(Total for Question 2 = 9 marks)

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3 This question is about the preparation of crystals of hydrated sodium sulfate.

(a) You are provided with the following apparatus and materials to prepare a solution of sodium sulfate from sulfuric acid and aqueous sodium hydroxide:

- a burette, ready to use, filled with dilute sulfuric acid to the 0.00 cm^3 line
- an aqueous solution of sodium hydroxide
- methyl orange indicator
- access to other laboratory volumetric apparatus.

The equation for the reaction is

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(i) A preliminary (rough) titration shows that about 18 cm^3 of sulfuric acid is required to react with 25.0 cm^3 of the aqueous sodium hydroxide.

Describe how you would carry out a second titration to find the accurate volume of sulfuric acid that reacts with 25.0 cm^3 of the aqueous sodium hydroxide.

In your answer, you should include the colour change of the indicator at the end-point.

(5)

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(ii) The results of three further titrations are shown in the table.

Titration number	Rough	1	2	3
Final burette reading / cm^3	18.2	17.90	35.55	17.65
Initial burette reading / cm^3	0.00	0.00	18.00	0.00
Titre / cm^3	18.2	17.90	17.55	17.65
Used in mean (✓)				

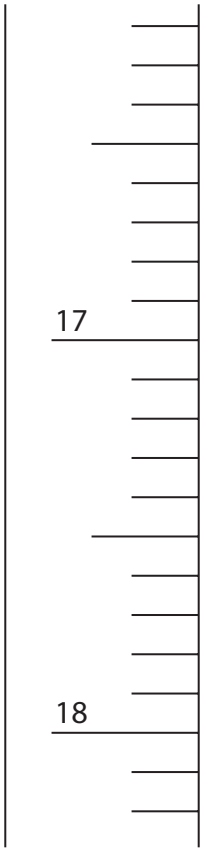
Calculate the mean titre.
Show which titres you have used in your calculation by putting a tick (✓) in the appropriate boxes in the table.

(1)

mean titre ..... cm^3

(iii) On the diagram of part of a burette, show the level of dilute sulfuric acid when the final burette reading is recorded in **Titration 3**.

(2)



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(b) Using results from the table, briefly describe how to obtain a sample of pure crystals of hydrated sodium sulfate.

(2)

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(Total for Question 3 = 10 marks)

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4 An experiment is carried out to determine the value of n in the formula of hydrated zinc sulfate, $ZnSO_4.nH_2O$.

The following procedure is used.

Step **1** Weigh an empty crucible.

Step **2** Add two spatula measures of hydrated zinc sulfate to the crucible. Reweigh the crucible with the hydrated zinc sulfate.

Step **3** Heat the crucible and hydrated zinc sulfate to remove the water of crystallisation.

Step **4** Allow the crucible to cool. Reweigh the crucible and the anhydrous zinc sulfate.

The equation for the reaction is

$$ZnSO_4.nH_2O(s) \rightarrow ZnSO_4(s) + nH_2O(g)$$

Results

Measurement	Value / g
Mass of empty crucible	13.26
Mass of crucible + contents before heating	16.71
Mass of crucible + contents after heating	15.30
Mass of contents before heating	3.45
Mass of contents after heating	
Mass of water lost	

(a) Draw a labelled diagram of the apparatus set up for heating in Step **3**.

(2)

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(b) Complete the table of results.

(1)

(c) (i) Calculate the amount, in moles, of anhydrous zinc sulfate, $ZnSO_4$, left after heating.

(1)

amount of anhydrous zinc sulfate left = ... mol

(ii) Calculate the amount, in moles, of water lost during heating.

(1)

amount of water lost = ... mol

(iii) Calculate the value of n, using your answers to (c)(i) and (ii).

(1)

n = ...

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(d) A data book gives the formula of hydrated zinc sulfate as $ZnSO_4.7H_2O$.

Two possible errors that might occur during the experiment are:

Error 1

Some of the hydrated zinc sulfate was lost from the crucible during heating in Step **3**.

Error 2

The crucible was not heated for long enough for all of the water of crystallisation to be lost.

(i) Predict the effect, if any, each error will have on the measured mass of water lost and hence the calculated value of n.

(2)

Error 1

Effect on measured mass of water lost .....

Effect on calculated value of n .....

.....

Error 2

Effect on measured mass of water lost .....

Effect on calculated value of n .....

.....

(ii) Suggest how you could improve the experiment to stop the hydrated zinc sulfate from 'jumping out' of the crucible during heating.

(1)

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(iii) Suggest how you could make sure that all the water of crystallisation is lost during heating.

(1)

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(Total for Question 4 = 10 marks)

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5 Ethyl ethanoate is a colourless liquid with a boiling temperature of 77 °C.
It can be prepared by reacting ethanol with ethanoic acid.

$$C_2H_5OH(l) + CH_3COOH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$$

An outline procedure is given.

Step **1** Mix 20 cm^3 of ethanol and 20 cm^3 of ethanoic acid in a pear-shaped flask and add anti-bumping granules.

Step **2** Add 8 cm^3 of concentrated sulfuric acid slowly, and with cooling.

Step **3** Set up the apparatus for reflux, with the flask partially immersed in a water bath. Heat under reflux for 15 minutes.

Step **4** Allow the apparatus to cool, and then rearrange the apparatus for distillation. Collect all the distillate up to 80 °C.

(a) Give a reason why anti-bumping granules are used in Step **1**.

(1)

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.....

(b) Suggest a reason why the mixture is cooled as the concentrated sulfuric acid is added in Step **2**.

(1)

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(c) Give a reason why the flask is heated in a water bath, rather than directly with a Bunsen flame, in Step **3**.

(1)

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(d) Give a reason why the mixture is heated under reflux in Step **3**.

(1)

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The ethyl ethanoate is purified as follows:

Step **5** Place the distillate from Step **4** in a separating funnel and add 10 cm^3 of sodium carbonate solution. Shake the separating funnel carefully, releasing the pressure at regular intervals. Allow the layers to separate and then remove the lower, aqueous layer.

Step **6** Transfer the ethyl ethanoate to a dry flask. Add anhydrous calcium chloride, stopper the flask and leave to stand for 30 minutes.

Step **7** Pour the ethyl ethanoate into a clean pear-shaped flask. Distil and collect the pure ethyl ethanoate.

(e) (i) Identify the gas released when sodium carbonate solution is added to the distillate in the separating funnel in Step **5**.

(1)

.....

(ii) Describe how to release the pressure in the separating funnel in Step **5**.

(1)

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(f) (i) Give a reason why anhydrous calcium chloride is added to the ethyl ethanoate in Step **6**.

(1)

.....

.....

(ii) Suggest a reagent that could be used as an alternative to anhydrous calcium chloride in Step **6**.

(1)

.....

(g) Give a suitable temperature **range** over which to collect the pure ethyl ethanoate during the final distillation in Step **7**.

(1)

.....

(Total for Question 5 = 9 marks)

TOTAL FOR PAPER = 50 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									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									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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