

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
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Pearson Edexcel
International
Advanced Level

Centre Number

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Candidate Number

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Time 1 hour 20 minutes

Paper reference **WCH16/01**

Chemistry
International Advanced Level
UNIT 6: Practical Skills in Chemistry II

You must have:
Scientific calculator, ruler

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.*
- Show all your working in calculations and include units where appropriate.

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.
- Try to answer every question.
- Check your answers if you have time at the end.
- Good luck with your examination.

Turn over ►

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

1 This question is about compounds containing the ammonium ion, NH_4^+ .

(a) Ammonium vanadate(V), NH_4VO_3 , is a white solid.

- (i) When excess dilute sulfuric acid is added to an aqueous solution of NH_4VO_3 , the VO_3^- ion is converted into the VO_2^+ ion.

Write the **ionic** equation for the conversion of VO_3^- to VO_2^+ on the addition of dilute sulfuric acid. State symbols are not required.

(1)

- (ii) State the colour of an **acidified** solution of ammonium vanadate(V).

(1)

- (iii) A student added zinc metal to an acidified solution of ammonium vanadate(V). The zinc reduced the vanadium in a series of reactions.

The student suggested that the sequence of colours observed could be explained by the presence of the vanadium species shown in the table.

Sequence of colours observed	starting colour $\rightarrow$ green $\rightarrow$ blue $\rightarrow$ green $\rightarrow$ violet
Suggested vanadium species	$\text{VO}_2^+ \rightarrow \text{V}^{3+} \rightarrow \text{VO}^{2+} \rightarrow \text{V}^{3+} \rightarrow \text{V}^{2+}$

Explain whether or not the student is correct.

Refer to oxidation states of vanadium and account for each colour in the sequence.

(2)

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- (iv) When the mixture obtained at the end of the sequence in (a)(iii) is filtered, the filtrate changes colour from violet to green on standing. No further changes occur.

Suggest an explanation for these observations.

(2)

- (b) Ammonium tetrachlorocuprate(II) dihydrate, $(\text{NH}_4)_2\text{CuCl}_4 \cdot 2\text{H}_2\text{O}$, is a blue-green solid. When ammonium tetrachlorocuprate(II) dihydrate is dissolved in water, a blue-green solution **T** is formed.

- (i) Suggest the formulae of **two** complex ions present in solution **T**.

(2)

- (ii) State how the colour of solution **T** would change on the addition of excess concentrated hydrochloric acid.

(1)

- (iii) Describe what would be observed on the addition of aqueous sodium hydroxide to solution **T**.

(1)

- (iv) When the mixture from (b)(iii) is warmed, a gas is evolved. Give a test to identify the gas stating the positive result of the test.

(2)

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- (c) A white solid with a slight vinegar-like smell contains ammonium ions, NH_4^+ , and an anion represented by Y^- .

The smell of vinegar intensifies on the addition of a few drops of concentrated sulfuric acid to an aqueous solution of NH_4Y .

On subsequent addition of a few drops of ethanol and heating the mixture, the smell of vinegar is replaced by a sweet and fruity smell.

Explain how **all** this information can be used to identify the anion Y^- .

(3)

(Total for Question 1 = 15 marks)

- 2 This question concerns the laboratory preparation of tetraamminecopper(II) sulfate-1-water, $\text{Cu}(\text{NH}_3)_4\text{SO}_4 \cdot \text{H}_2\text{O}$.

Procedure

- Step 1 Weigh between 2.1 g and 2.3 g of hydrated copper(II) sulfate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, in a boiling tube. Add 8 cm^3 of distilled water and place the boiling tube in a hot water bath. Stir the mixture until the crystals have dissolved.
- Step 2 Working in a fume cupboard, slowly pour 5 cm^3 of concentrated aqueous ammonia into the boiling tube. Stir until a clear solution is obtained.
- Step 3 Measure 12 cm^3 of ethanol into a 100 cm^3 conical flask and add the contents of the boiling tube from Step 2. Stopper the flask and swirl the contents before placing the flask in an ice bath. Allow the mixture to stand until crystals of $\text{Cu}(\text{NH}_3)_4\text{SO}_4 \cdot \text{H}_2\text{O}$ have formed.
- Step 4 Filter the crystals obtained in Step 3 under reduced pressure, using a Buchner funnel and flask.
- Step 5 Pour 5 cm^3 of cold ethanol over the crystals in the funnel.
- Step 6 Using a spatula, transfer the crystals to a filter paper on a watch glass. Press a second piece of filter paper on the crystals, to dry them as much as possible.
- Step 7 Transfer the crystals to a dry, pre-weighed sample bottle and reweigh.
- (a) Give a reason why a measuring cylinder is more suitable than a graduated pipette for measuring the distilled water in Step 1.

(1)

- (b) Give the colour of the solution at the end of Step 2.

(1)

- (c) Give the reason why Step 2 should be carried out in a fume cupboard.

(1)

- (d) Give the reason why the addition of ethanol in Step 3 results in the precipitation of crystals of $\text{Cu}(\text{NH}_3)_4\text{SO}_4 \cdot \text{H}_2\text{O}$.

(1)

- (e) Draw a **labelled** diagram of the apparatus used to filter the crystals under reduced pressure in Step 4.

(3)

- (f) (i) State the purpose of the ethanol in Step 5.

(1)

- (ii) Give a reason why the ethanol is cold.

(1)

(g) Starting with 2.17 g of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ and using excess ammonia, a student obtained 2.54 g of product.

(i) Calculate the **apparent** percentage yield of $\text{Cu}(\text{NH}_3)_4\text{SO}_4 \cdot \text{H}_2\text{O}$.

Give your answer to an appropriate number of significant figures.

(3)

(ii) Suggest a reason why the apparent percentage yield in this preparation is often greater than 100%.

(1)

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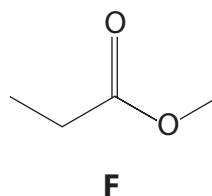
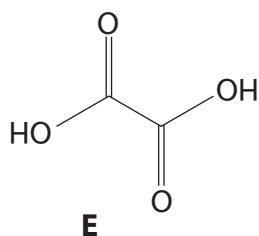
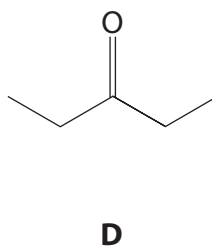
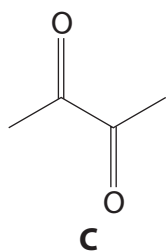
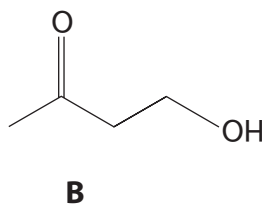
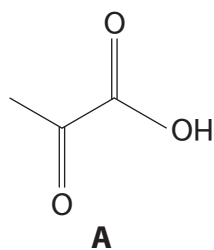
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(Total for Question 2 = 13 marks)

3 This question is about the identification of six organic compounds.



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(a) From **A, B, C, D, E** and **F**, identify the compound with

(i) the fewest peaks in its **carbon-13** NMR spectrum.

(1)

(ii) the most peaks in its **low** resolution **proton** NMR spectrum.

(1)

(iii) three peaks with relative peak area 3:2:3 in its **low** resolution proton NMR spectrum.

(1)

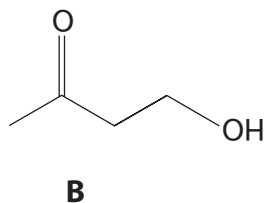
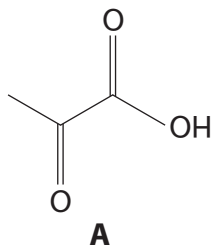
(iv) one triplet and one quartet as the only peaks in its **high** resolution proton NMR spectrum.

(1)

- (b) For each of the following pairs, give **one chemical** test, not including indicators, that could be used to distinguish the compounds.

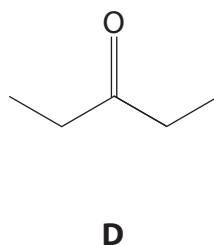
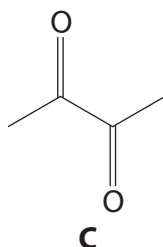
Identify the reagents and give the results of each test.

- (i) **A** and **B**



(2)

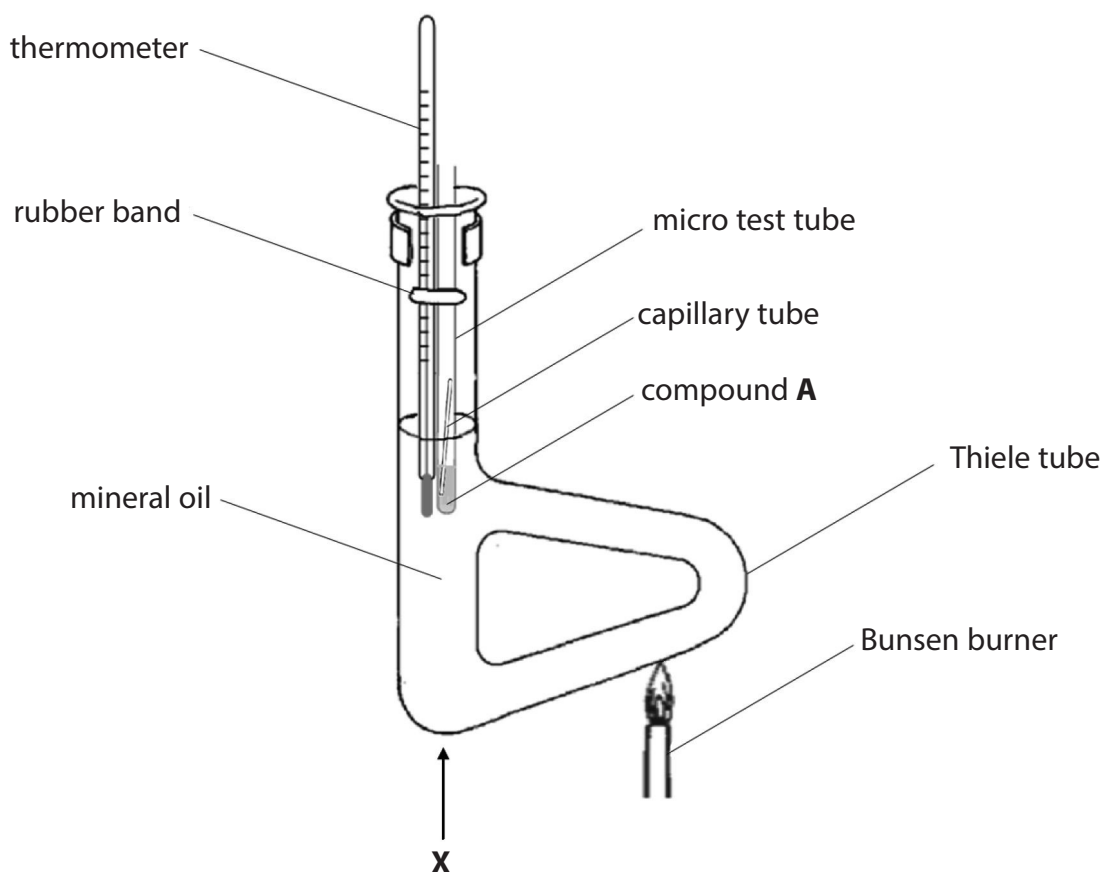
- (ii) **C** and **D**



(2)

- (c) Liquids boil at the temperature at which their vapour pressure is equal to atmospheric pressure.

The apparatus shown below was used to determine the boiling temperature of compound **A**, which is a liquid at room temperature and pressure and has a boiling temperature in the range 120°C to 180°C.



Procedure

- Step 1** Place a capillary tube, sealed at one end and with the open end facing down, into 0.5 cm³ of compound **A** in a micro test tube. Attach the micro test tube to a thermometer with a rubber band.
- Step 2** Clamp the micro test tube and thermometer in the mineral oil, making sure neither test tube nor thermometer bulb is in contact with the glass walls of the Thiele tube.
- Step 3** Move a small Bunsen flame back and forth along the lower part of the side-arm of the Thiele tube. An initial stream of bubbles will come from the open end of the capillary tube.
- Step 4** Continue heating until a rapid and continuous stream of bubbles comes from the capillary tube. Stop heating and record the temperature as soon as compound **A** is drawn up into the capillary tube.

- (i) State what causes the initial stream of bubbles from the capillary tube in Step 3.

(1)

- (ii) Suggest why the side-arm of the Thiele tube is heated, rather than point **X** on the diagram.

(1)

- (iii) Suggest why mineral oil, and not water, is used in the Thiele tube when determining the boiling temperature of compound **A**.

(1)

- (iv) Suggest why the results obtained when using this apparatus on different days may **not** be the same, even when no mistakes are made in carrying out the experiment.

(1)

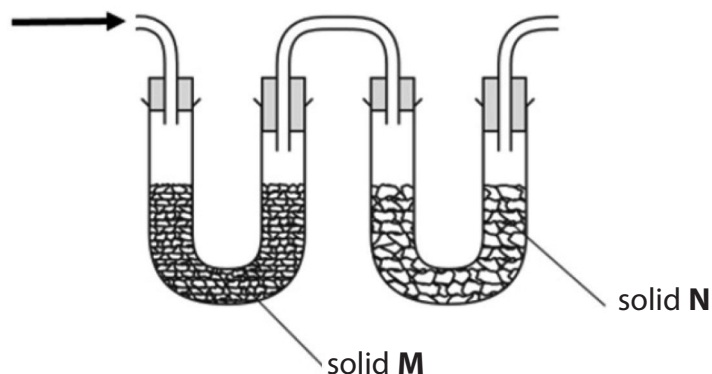
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(d) **One** of the compounds **A**, **B**, **C**, **D**, **E** or **F** was analysed.

To determine its empirical formula, 1.57 g of the compound was burned completely and the combustion products passed through the apparatus shown.



Solid **M** absorbed water and increased in mass by 1.28 g.

Solid **N** absorbed carbon dioxide and increased in mass by 3.14 g.

(i) Identify, by name or formula, suitable substances for solids **M** and **N**.

(2)

Solid **M**

Solid **N**

(ii) Calculate the **empirical** formula of the compound, using the data given.

You **must** show your working.

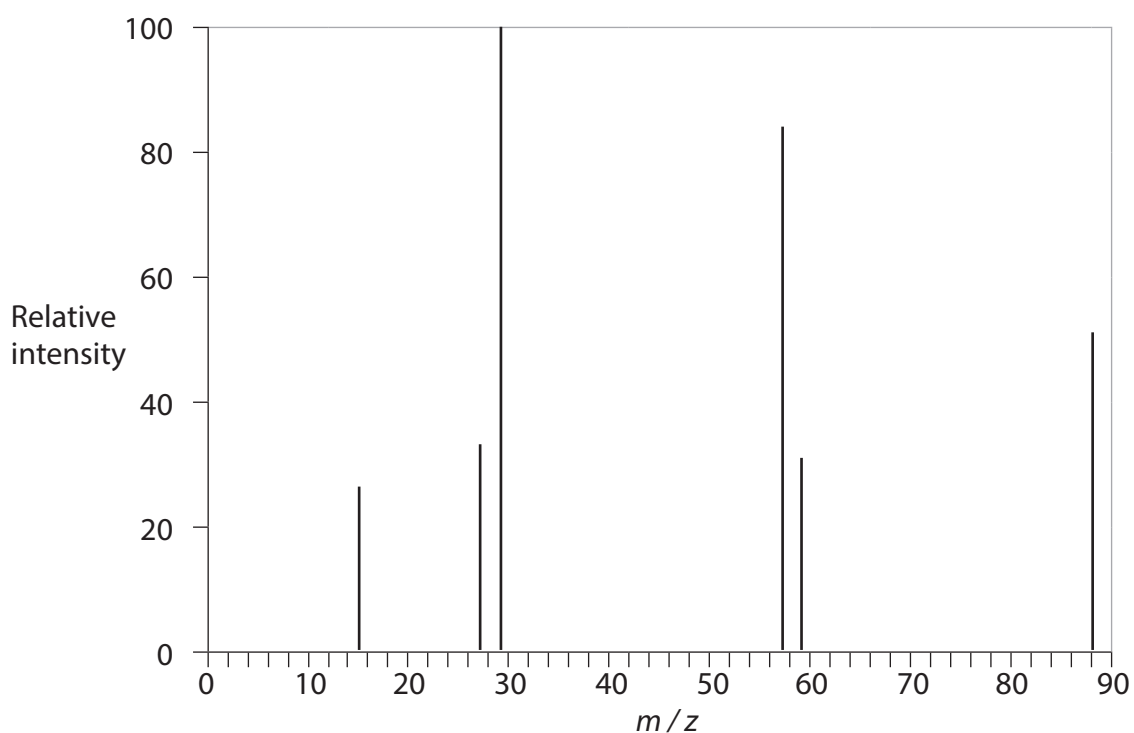
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(iii) The mass spectrum of the compound is shown.



Deduce the relative molecular mass of the compound, using the mass spectrum.

(1)

(iv) Deduce the molecular formula of the compound, using your answers to (d)(ii) and (d)(iii).

(1)

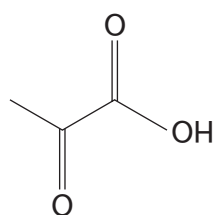
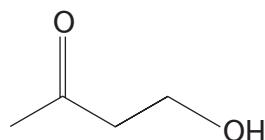
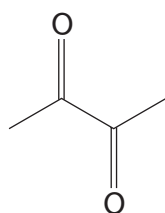
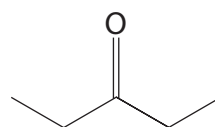
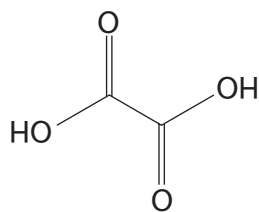
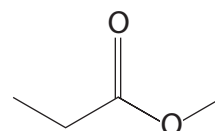
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- (v) Determine the identity of the compound, using your answer to (d)(iv) and the fragmentation pattern of the mass spectrum.
Justify your answer.

(2)

**A****B****C****D****E****F**

(Total for Question 3 = 22 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2	3	4	5	6	7	0 (8)
							(18)
		1.0 H hydrogen 1					
Key							
		relative atomic mass atomic symbol name atomic (proton) number					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
6.9 Li lithium 3	9.0 Be beryllium 4	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
23.0 Na sodium 11	24.3 Mg magnesium 12	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
39.1 K potassium 19	40.1 Ca calcium 20	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	101.1 Ru ruthenium 44
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
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
[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
Elements with atomic numbers 112-116 have been reported but not fully authenticated							
112 Cn copernicium 112	113 Nh nihonium 113	114 Fl flerovium 114	115 Mc moscovium 115	116 Lv livermorium 116	117 Ts tennessine 117	118 Og oganesson 118	119 Uue unbinilium 119
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428 Uuo unbinilium 428	429 Uuh unbinilium 429	430 Uub unbinilium 430	431 Uut unbinilium 431	432 Uuq unbinilium 432	433 Uup unbinilium 433	434 Uuq unbinilium 434	435 Uuh unbinilium 435
436 Uuo unbinilium 436	437 Uuh unbinilium 437	438 Uub unbinilium 438	439 Uut unbinilium 439	440 Uuq unbinilium 440	441 Uup unbinilium 441	442 Uuq unbinilium 442	443 Uuh unbinilium 443
444 Uuo unbinilium 444	445 Uuh unbinilium 445	446 Uub unbinilium 446	447 Uut unbinilium 447	448 Uuq unbinilium 448	449 Uup unbinilium 449	450 Uuq unbinilium 450	451 Uuh unbinilium 451
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460 Uuo unbinilium 460	461 Uuh unbinilium 461	462 Uub unbinilium 462	463 Uut unbinilium 463	464 Uuq unbinilium 464	465 Uup unbinilium 465	466 Uuq unbinilium 466	467 Uuh unbinilium 467
468 Uuo unbinilium 468	469 Uuh unbinilium 469	470 Uub unbinilium 470	471 Uut unbinilium 471	472 Uuq unbinilium 472	473 Uup unbinilium 473	474 Uuq unbinilium 474	475 Uuh unbinilium 475
476 Uuo unbinilium 476	477 Uuh unbinilium 477	478 Uub unbinilium 478	479 Uut unbinilium 479	480 Uuq unbinilium 480	481 Uup unbinilium 481	482 Uuq unbinilium 482	483 Uuh unbinilium 483
484 Uuo unbinilium 484	485 Uuh unbinilium 485	486 Uub unbinilium 486	487 Uut unbinilium 487	488 Uuq unbinilium 488	489 Uup unbinilium 489	490 Uuq unbinilium 490	491 Uuh unbinilium 491
492 Uuo unbinilium 492	493 Uuh unbinilium 493	494 Uub unbinilium 494	495 Uut unbinilium 495	496 Uuq unbinilium 496	497 Uup unbinilium 497	498 Uuq unbinilium 498	499 Uuh unbinilium 499
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