Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Time 1 hour 20 minutes

Paper reference **WCH13/01**

Chemistry

International Advanced Subsidiary/Advanced Level
UNIT 3: Practical Skills in Chemistry I

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.*

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.
- Show all your working in calculations and include units where appropriate.
- Check your answers if you have time at the end.

Turn over ▶

Pearson

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

1 This question is about ammonium chloride, NH_4Cl, a soluble ionic compound.

(a) An aqueous solution of NH_4Cl contains both ammonium ions, NH_4^+, and chloride ions, Cl^-.

(i) State what would be **seen** on the addition of acidified silver nitrate solution to an aqueous solution of NH_4Cl.

(1)

....

....

(ii) Describe a test to confirm the presence of NH_4^+ ions in a solution of NH_4Cl. Include the result of the positive test.

(2)

....

....

....

....

....

....

(b) A student investigated the enthalpy change when dissolving NH_4Cl in excess water.

$$NH_4Cl(s) + aq \rightarrow NH_4^+(aq) + Cl^-(aq)$$

Procedure

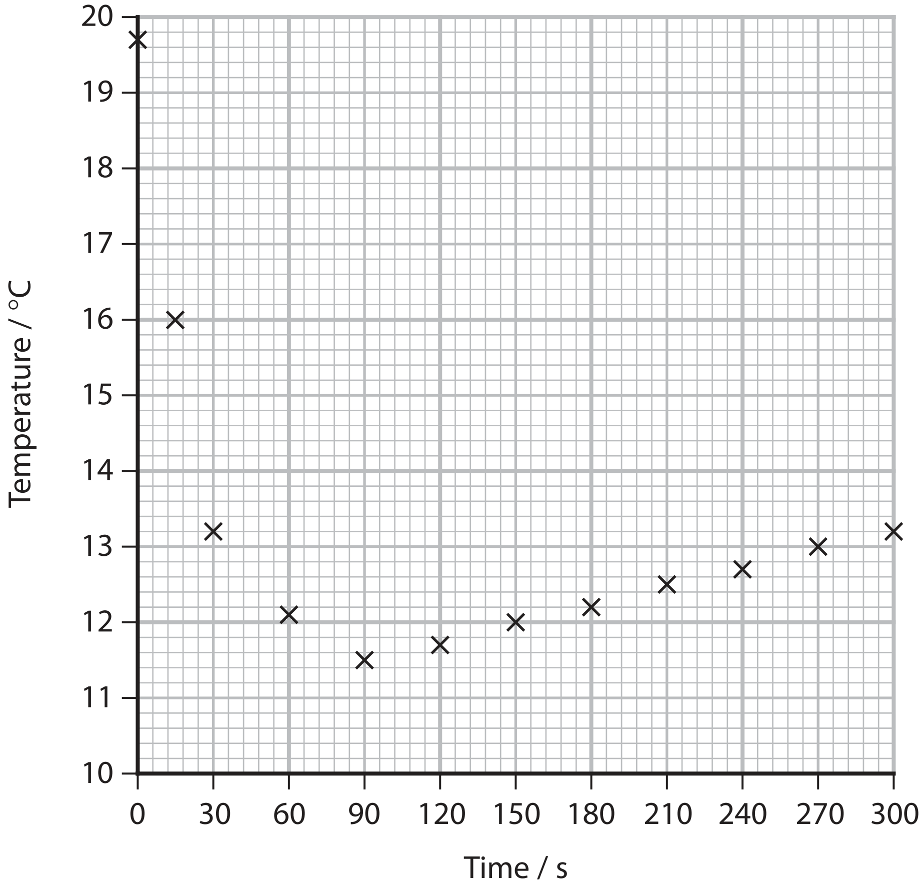
Step **1** Accurately weigh 7.17 g of NH_4Cl into a glass beaker.

Step **2** Fill a 50 cm^3 measuring cylinder with deionised water. Measure the temperature of the water using a thermometer.

Step **3** Pour the water from the measuring cylinder into the beaker and at the same time start a stopwatch. Stir the solution in the beaker, using the thermometer.

Step **4** Record the temperature at 15 s, 30 s and then at 30 s intervals while continuing to stir the solution.

The data from the experiment are shown on the graph.



(i) Give **two** reasons why the student stirred the solution in Steps **3** and **4**.

(2)

....

....

....

....

(ii) Use the graph to determine the maximum temperature change, ΔT, in this experiment. You **must** show your working on the graph.

(2)

(iii) Another student carried out the experiment using a polystyrene cup in place of the glass beaker.

Explain how this student's graph would be different.
You may annotate the graph as part of your answer.

(3)

....

....

....

....

....

....

....

....

(c) The experimental results of another student were used in the equation shown to calculate the enthalpy change, ΔH, for dissolving one mole of NH_4Cl in excess water.

$$\Delta H = \frac{m \quad c \quad \Delta T}{n}$$

$$= +14\,500 \text{ J mol}^{-1}$$

In the equation

m = mass of solution = 50 g

c = specific heat capacity of water = 4.18 J g^{-1} °C^{-1}

ΔT = maximum temperature change of solution

n = moles of NH_4Cl

(i) State **two** assumptions made in this calculation.
You do **not** need to justify your answers.

(2)

....

....

....

....

(ii) The total percentage uncertainty in this experiment was 2.6%.

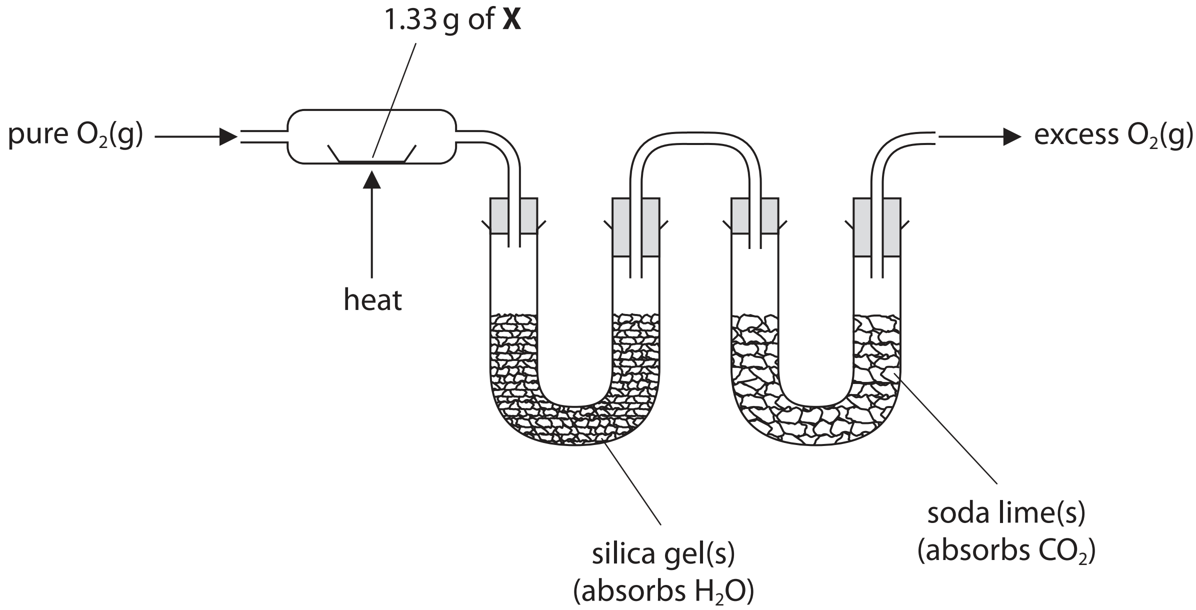
Show that the enthalpy change of 14.5 kJ mol^{-1} is consistent with a data book value of 14.8 kJ mol^{-1}.

(2)

(Total for Question 1 = 14 marks)

2 This question is about two organic compounds, **X** and **Y**. Both are liquids which contain carbon, hydrogen and oxygen only.

(a) The mass of hydrogen and of carbon present in 1.33 g of **X** were determined by passing its combustion products through the apparatus shown.



(i) State the **measurements** that should be made.

(2)

....

....

....

....

(ii) Give **two** reasons why pure O_2(g), and **not** air, should be used.

(2)

....

....

....

....

(iii) The experiment showed that 1.33 g of **X** contains 0.14 g of hydrogen and 0.63 g of carbon.

Calculate the empirical formula of **X**, using these data.
You **must** show your working.

(3)

(b) When phosphorus(V) chloride is added to **X**, steamy white fumes are seen.

State what can be deduced about compound **X** from this observation only.

(1)

....

....

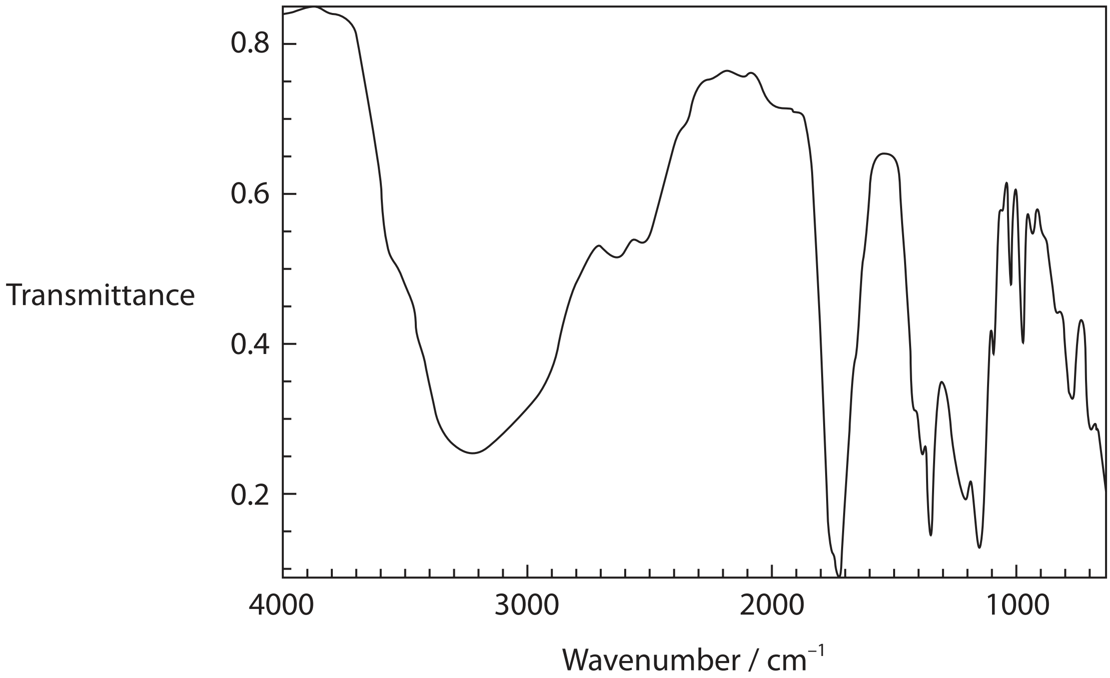
(c) Compound **X** is converted into compound **Y** when refluxed with **excess** sodium dichromate(VI) in sulfuric acid.

Compound **Y** is a liquid that is soluble in the reaction mixture.

Draw a **labelled** diagram of the apparatus that could be used to separate **Y** from the reaction mixture.

(3)

(d) The infrared spectrum of **Y** is shown.



The table shows some infrared absorption data.

Bond	Wavenumber range / cm^{-1}
C—H (alkane)	2962 – 2853
O—H (alcohols and phenols)	3750 – 3200
O—H (carboxylic acids)	3300 – 2500
C=C (alkene)	1669 – 1645
C=O (aldehydes, ketones, carboxylic acids)	1740 – 1680

Explain how this spectrum shows that **Y** contains a carboxylic acid functional group, quoting data from the table.

(2)

....

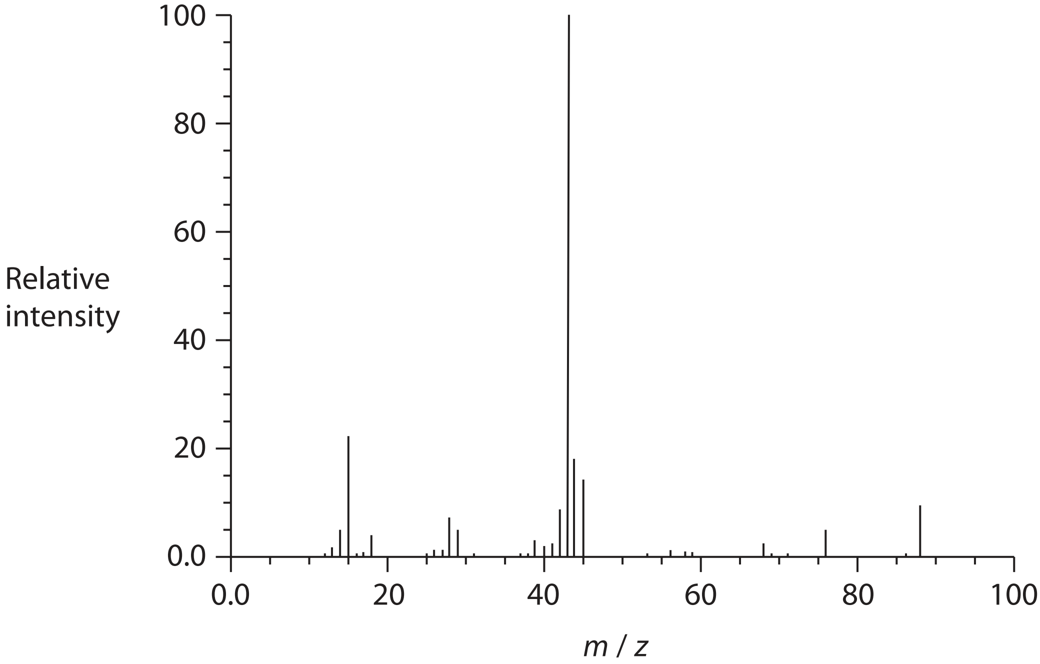
....

....

....

....

(e) The mass spectrum of **Y** is shown.



(i) Show that the mass spectrum is consistent with **Y** having the molecular formula $C_3H_4O_3$.

(1)

(ii) Suggest the structure of the ion causing the peak at $m / z = 43$ in the mass spectrum of **Y**.

(1)

(f) Compound **X** contains one type of functional group.

Compound **Y** contains two different functional groups.

Use the information in the question to deduce the structures of **X** and **Y**.

(2)

Compound **X**

Compound **Y**

(Total for Question 2 = 17 marks)

3 A student used a precipitation titration to determine the value of **x** in the formula of a sample of hydrated barium chloride, $BaCl_2 \cdot \mathbf{x} H_2O$.

Procedure

Step **1** Prepare a solution by dissolving 1.57 g of $BaCl_2 \cdot \mathbf{x} H_2O$ in deionised water, making the solution up to the mark in a 250.0 cm^3 volumetric flask and then mixing thoroughly.

Step **2** Use a pipette to transfer 10.0 cm^3 of the barium chloride solution into a conical flask.
Add excess sodium sulfate solution and swirl the mixture.

Step **3** Fill a burette with 0.0324 mol dm^{-3} silver nitrate solution.

Step **4** Add three drops of potassium chromate(VI) solution to the conical flask and titrate the contents, while swirling, with the silver nitrate solution.
The end-point is shown by the appearance of a permanent pale red precipitate.

Step **5** Repeat Steps **2** to **4** until concordant results are obtained.

During the titration, two precipitation reactions occur.

Reaction **1** Silver ions react with chloride ions forming silver chloride.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

Reaction **2** Once all chloride ions have reacted, silver ions react with chromate(VI) ions to form a red precipitate of silver chromate(VI).

$$2Ag^+(aq) + CrO_4^{2-}(aq) \rightarrow Ag_2CrO_4(s)$$

(a) (i) Give the **ionic** equation for the reaction that occurs when sodium sulfate solution is added to the conical flask in Step **2**.
Include state symbols.

(1)

(ii) Give a possible reason why it is necessary to add sodium sulfate solution.
Justify your answer.

(1)

....

....

....

(b) Suggest why the red precipitate of silver chromate(VI) only forms after all the chloride ions have reacted.

(1)

....

....

(c) Some data obtained in the experiment are shown.

Titration number	1	2	3	4
Burette reading (final) / cm^3	16.15	32.05	48.30	47.40
Burette reading (initial) / cm^3	0.00	16.15	32.50	31.55
Titre / cm^3	16.15			

(i) Complete the table and use the concordant results to calculate the mean titre.

(2)

(ii) Determine the value of **x** in the formula of the hydrated salt, $BaCl_2 \cdot \mathbf{x} H_2O$.
Use information from the procedure and your mean titre from (c)(i).
You **must** show your working.

(5)

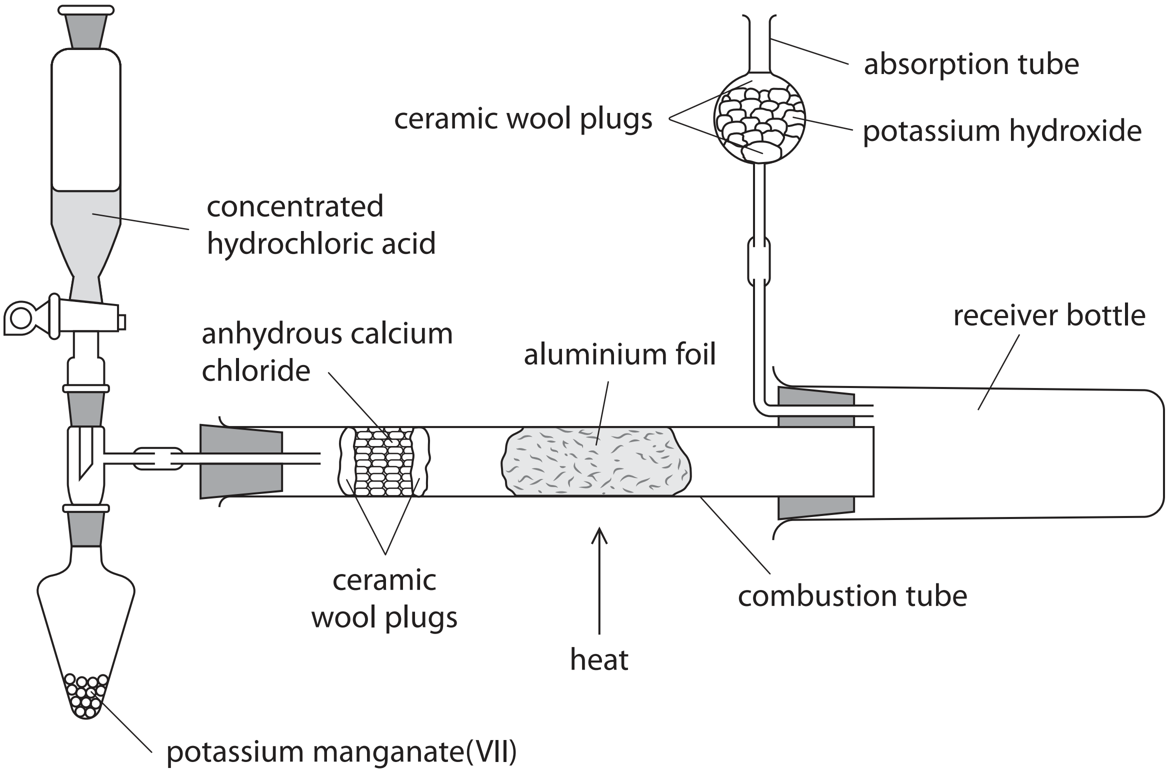
(Total for Question 3 = 10 marks)

BLANK PAGE

4 This question is about the preparation of anhydrous aluminium chloride, $AlCl_3$, which reacts vigorously with water and must be stored in tightly sealed containers.

A sample of anhydrous $AlCl_3$ was prepared by passing chlorine gas over hot aluminium foil using the apparatus shown.

$$2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$$



Procedure

Step **1** Assemble the apparatus with about 5 g of potassium manganate(VII) in the pear-shaped flask, 10 cm^3 of concentrated hydrochloric acid in the tap funnel and a known mass of aluminium foil in the combustion tube.

Step **2** Carefully open the tap of the funnel, allowing the acid to enter the pear-shaped flask drop by drop. Wait for twenty seconds.

Step **3** Heat the aluminium foil until it glows brightly. Continue heating until the reaction is complete. Allow the apparatus to cool before closing the tap of the funnel.

Step **4** Remove the receiver bottle, quickly scrape the product into a sample tube and seal with a lid.

(a) Granules of anhydrous calcium chloride are held between two ceramic wool plugs in the combustion tube.

(i) Explain the purpose of the anhydrous calcium chloride.

(2)

....

....

....

(ii) Give the reason why granules of anhydrous calcium chloride are used rather than powder.

(1)

....

....

....

(b) The reaction occurring in Step **2** produces chlorine gas.

(i) Identify the main hazard related to chlorine gas, giving the **best** way of minimising the risk when using this gas.

(2)

....

....

....

....

(ii) Give a reason why the concentrated hydrochloric acid is added 'drop by drop' to the pear-shaped flask.

(1)

....

....

(c) Suggest why the heating of the aluminium in Step **3** is delayed by 20 s after the initial production of chlorine gas.

(1)

....

....

....

(d) State how you would know the reaction is complete in Step **3**.

(1)

....

....

....

(e) Suggest the purpose of the potassium hydroxide in the absorption tube.

(1)

....

....

(Total for Question 4 = 9 marks)

TOTAL FOR PAPER = 50 MARKS

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

BLANK PAGE

The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
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											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