

CANDIDATE  
NAME

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CENTRE  
NUMBER

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CANDIDATE  
NUMBER

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**CHEMISTRY**

**9701/35**

Paper 3 Advanced Practical Skills 1

**May/June 2019**

**2 hours**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

**READ THESE INSTRUCTIONS FIRST**

Write your centre number, candidate number and name on all the work you hand in.  
Give details of the practical session and laboratory where appropriate, in the boxes provided.  
Write in dark blue or black pen.  
You may use an HB pencil for any diagrams or graphs.  
Do not use staples, paper clips, glue or correction fluid.  
**DO NOT WRITE IN ANY BARCODES.**

Answer **all** questions.  
Electronic calculators may be used.  
You may lose marks if you do not show your working or if you do not use appropriate units.  
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.  
A copy of the Periodic Table is printed on page 12.

At the end of the examination, fasten all your work securely together.  
The number of marks is given in brackets [ ] at the end of each question or part question.

<b>Session</b>	
<b>Laboratory</b>	

<b>For Examiner's Use</b>	
<b>1</b>	
<b>2</b>	
<b>3</b>	
<b>Total</b>	

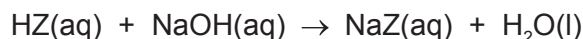
This document consists of **12** printed pages.

## Quantitative Analysis

Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

- 1 The reaction between acids and alkalis is exothermic. You will find the concentration of a monoprotic acid, HZ, by a thermometric method using a solution of sodium hydroxide of known concentration.



**FA 1** is a solution of acid HZ.

**FA 2** is  $2.00 \text{ mol dm}^{-3}$  sodium hydroxide, NaOH.

### (a) Method

- Place the thermometer into **FA 1**. Record the temperature of **FA 1** in the table. This is the temperature when the volume of **FA 2** is 0.0.
- Rinse and dry the thermometer.
- Place the thermometer into **FA 2**. Record the temperature of **FA 2** in the table. This is the temperature when the volume of **FA 1** is 0.0.
  
- Fill a burette with **FA 1**.
- Support the plastic cup in the  $250 \text{ cm}^3$  beaker.
- From the burette transfer  $35.0 \text{ cm}^3$  of **FA 1** into the plastic cup.
- Use the  $50 \text{ cm}^3$  measuring cylinder to measure  $5.0 \text{ cm}^3$  of **FA 2**.
- Transfer the  $5.0 \text{ cm}^3$  of **FA 2** into the plastic cup. Stir the mixture and record the highest temperature.
- Tip out the solution, rinse the plastic cup with water, shake it to remove excess water and replace the cup in the beaker.
- Rinse and dry the thermometer.
  
- Use the burette to transfer  $30.0 \text{ cm}^3$  of **FA 1** into the plastic cup.
- Use the measuring cylinder to transfer  $10.0 \text{ cm}^3$  of **FA 2** into the plastic cup.
- Stir the mixture and record the highest temperature.
- Tip out the solution, rinse the plastic cup with water, shake it to remove excess water and replace the cup in the beaker.
- Rinse and dry the thermometer.
  
- Continue the experiment using the volumes of **FA 1** and **FA 2** given in the table and record the maximum temperature of each mixture.

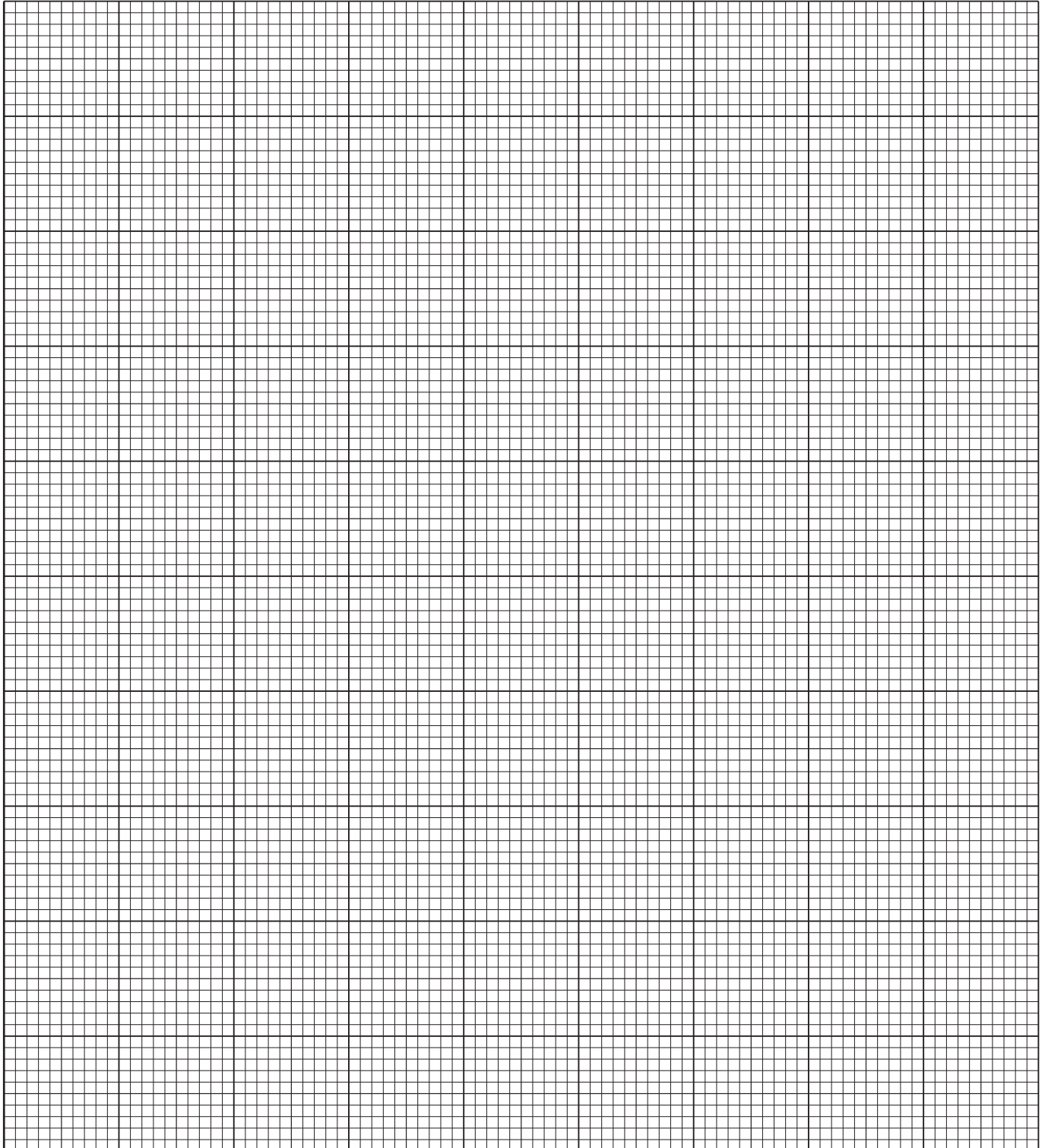
volume <b>FA 1</b> / $\text{cm}^3$	40.0	35.0	30.0	25.0	20.0	15.0	10.0	5.0	0.0
volume <b>FA 2</b> / $\text{cm}^3$	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0
temperature / $^{\circ}\text{C}$									

[3]

**Keep FA 1 for use in Question 2.**

- (b) (i) Plot a graph of temperature of solution ( $y$ -axis) against volume of **FA 2** added ( $x$ -axis) on the grid. Select a scale on the  $y$ -axis to include a temperature of  $2^{\circ}\text{C}$  above your maximum thermometer reading. Label any points you consider anomalous.

Draw two lines of best fit through the points on your graph, the first for the increase in temperature and the second for the decrease in temperature of the mixtures. Extrapolate the two lines so they intersect. [3]



I	
II	
III	

- (ii) The intersection on your graph occurs at the volume of **FA 2** that reacted to form a neutral solution.

Determine the volumes of **FA 1** and **FA 2** required to form a neutral solution.

..... cm<sup>3</sup> of **FA 1** neutralises ..... cm<sup>3</sup> of **FA 2**.  
[1]

- (c) (i) Calculate the number of moles of sodium hydroxide, **FA 2**, required to obtain a neutral solution in this experiment.

moles of NaOH = ..... mol [1]

- (ii) Hence calculate the concentration of HZ in **FA 1**.

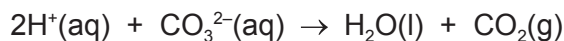
concentration of HZ = ..... mol dm<sup>-3</sup> [1]

- (d) Explain how you would use the data obtained to calculate the enthalpy change of neutralisation of HZ. You do not need to carry out the calculation.

.....  
.....  
.....  
.....  
.....  
.....  
..... [3]

[Total: 12]

- 2 You will now determine the concentration of HZ in **FA 1** by titration using aqueous sodium carbonate of known concentration.



**FA 3** is  $0.0353 \text{ mol dm}^{-3}$  aqueous sodium carbonate,  $\text{Na}_2\text{CO}_3$ .  
methyl orange indicator

**(a) Dilution of FA 1**

- Use the  $10.0 \text{ cm}^3$  pipette to transfer  $10.0 \text{ cm}^3$  of **FA 1** into the  $250 \text{ cm}^3$  volumetric flask.
- Add distilled water to the mark.
- Shake the flask to mix the solution thoroughly and label it **FA 4**.

**Titration**

- Fill the second burette with **FA 4**.
- Pipette  $25.0 \text{ cm}^3$  of **FA 3** into a conical flask.
- Add approximately 10 drops of methyl orange.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is .....  $\text{cm}^3$ .

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make certain that any recorded results show the precision of your practical work.
- Record all of your burette readings and the volume of **FA 4** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b)** From your accurate titration results, obtain a suitable value for the volume of **FA 4** to be used in your calculations. Show clearly how you obtained this value.

$25.0 \text{ cm}^3$  of **FA 3** required .....  $\text{cm}^3$  of **FA 4**. [1]

- (c) (i) Give your answers to (ii), (iii) and (iv) to an appropriate number of significant figures. [1]
- (ii) Calculate the number of moles of sodium carbonate in the **FA 3** pipetted into the conical flask.

moles of  $\text{Na}_2\text{CO}_3 = \dots\dots\dots$  mol [1]

- (iii) Deduce the number of moles of HZ present in the volume of **FA 4** recorded in (b).

moles of HZ =  $\dots\dots\dots$  mol [1]

- (iv) Calculate the concentration of HZ present in **FA 1**.

concentration of HZ in **FA 1** =  $\dots\dots\dots$   $\text{mol dm}^{-3}$  [1]

- (d) In **Question 1** you determined the concentration of HZ in **FA 1** by a thermometric method. In **Question 2** you determined the concentration of HZ in **FA 1** by titration. Tick which one of the following statements you believe to be true.

The method in <b>Question 1</b> is more accurate than the method in <b>Question 2</b> .	<input type="checkbox"/>
The method in <b>Question 2</b> is more accurate than the method in <b>Question 1</b> .	<input type="checkbox"/>
The two methods are of equal accuracy.	<input type="checkbox"/>

Explain your answer.

.....

.....

.....

[1]

- (e) A teacher informed a class that 112.3g of pure HZ had been dissolved in distilled water to make 1 dm<sup>3</sup> of **FA 1**. A student in the class suggested that HZ could be ethanoic acid.

Using your answer to (c)(iv) show, by calculation, whether the student was correct.  
(If you were unable to complete the calculation in (c)(iv) you may assume the concentration was 2.08 mol dm<sup>-3</sup>. This is not the correct value.)

The student was correct/incorrect because .....

.....  
[1]

[Total: 14]

## Qualitative Analysis

Where reagents are selected for use in a test, the **name** or **correct formula** of the element or compound must be given.

At each stage of any test you are to record details of the following:

- colour changes seen;
- the formation of any precipitate and its solubility in an excess of the reagent added;
- the formation of any gas and its identification by a suitable test.

You should indicate clearly at what stage in a test a change occurs.

If any solution is warmed, a **boiling tube** must be used.

Rinse and reuse test-tubes and boiling tubes where possible.

**No additional tests for ions present should be attempted.**

- 3 (a) **FA 5, FA 6** and **FA 7** are solutions each containing one cation and one anion. One of the cations and all of the anions are listed in the Qualitative Analysis Notes. You will carry out a series of tests on **FA 5, FA 6** and **FA 7** and draw conclusions from your observations. Use a separate 1 cm depth of each solution in a test-tube for the following tests.

<i>test</i>	<i>observations</i>		
	<b>FA 5</b>	<b>FA 6</b>	<b>FA 7</b>
Add a 1 cm depth of aqueous sodium carbonate.	X		
Add a 1 cm length of magnesium ribbon.	X		
Add 2 or 3 drops of aqueous silver nitrate, then			
add aqueous ammonia.			
Add a 1 cm depth of aqueous barium nitrate, then			
add a 1 cm depth of dilute hydrochloric acid.			



<i>test</i>	<i>observations</i>		
	<b>FA 5</b>	<b>FA 6</b>	<b>FA 7</b>
Add aqueous sodium hydroxide.			
Add a 1 cm depth of <b>FA 7</b> .			X

[10]

- (b) Use your observations from (a) to identify as many ions as possible. Give the formula of each ion present. Write 'unknown' if you were unable to make a positive identification of an ion.

	<b>FA 5</b>	<b>FA 6</b>	<b>FA 7</b>
cation			
anion			

[3]

- (c) Give the ionic equation for any precipitation reaction involving **FA 5** that you observed in (a). Include state symbols.

..... [1]

[Total: 14]

## Qualitative Analysis Notes

## 1 Reactions of aqueous cations

ion	reaction with	
	NaOH(aq)	NH <sub>3</sub> (aq)
aluminium, Al <sup>3+</sup> (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH <sub>4</sub> <sup>+</sup> (aq)	no ppt. ammonia produced on heating	–
barium, Ba <sup>2+</sup> (aq)	faint white ppt. is nearly always observed unless reagents are pure	no ppt.
calcium, Ca <sup>2+</sup> (aq)	white ppt. with high [Ca <sup>2+</sup> (aq)]	no ppt.
chromium(III), Cr <sup>3+</sup> (aq)	grey-green ppt. soluble in excess	grey-green ppt. insoluble in excess
copper(II), Cu <sup>2+</sup> (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe <sup>2+</sup> (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe <sup>3+</sup> (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg <sup>2+</sup> (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn <sup>2+</sup> (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn <sup>2+</sup> (aq)	white ppt. soluble in excess	white ppt. soluble in excess

## 2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, $\text{CO}_3^{2-}$	$\text{CO}_2$ liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$ )
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$ )
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$ )
nitrate, $\text{NO}_3^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil
nitrite, $\text{NO}_2^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acids)

## 3 Tests for gases

<i>gas</i>	<i>test and test result</i>
ammonia, $\text{NH}_3$	turns damp red litmus paper blue
carbon dioxide, $\text{CO}_2$	gives a white ppt. with limewater (ppt. dissolves with excess $\text{CO}_2$ )
chlorine, $\text{Cl}_2$	bleaches damp litmus paper
hydrogen, $\text{H}_2$	'pops' with a lighted splint
oxygen, $\text{O}_2$	relights a glowing splint

## The Periodic Table of Elements

		Group															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">1 H hydrogen 1.0</div> <div style="border: 1px solid black; padding: 2px;">2 He helium 4.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">3 Li lithium 6.9</div> <div style="border: 1px solid black; padding: 2px;">4 Be beryllium 9.0</div> <div style="border: 1px solid black; padding: 2px;">5 B boron 10.8</div> <div style="border: 1px solid black; padding: 2px;">6 C carbon 12.0</div> <div style="border: 1px solid black; padding: 2px;">7 N nitrogen 14.0</div> <div style="border: 1px solid black; padding: 2px;">8 O oxygen 16.0</div> <div style="border: 1px solid black; padding: 2px;">9 F fluorine 19.0</div> <div style="border: 1px solid black; padding: 2px;">10 Ne neon 20.2</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">11 Na sodium 23.0</div> <div style="border: 1px solid black; padding: 2px;">12 Mg magnesium 24.3</div> <div style="border: 1px solid black; padding: 2px;">13 Al aluminium 27.0</div> <div style="border: 1px solid black; padding: 2px;">14 Si silicon 28.1</div> <div style="border: 1px solid black; padding: 2px;">15 P phosphorus 31.0</div> <div style="border: 1px solid black; padding: 2px;">16 S sulfur 32.1</div> <div style="border: 1px solid black; padding: 2px;">17 Cl chlorine 35.5</div> <div style="border: 1px solid black; padding: 2px;">18 Ar argon 39.9</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">19 K potassium 39.1</div> <div style="border: 1px solid black; padding: 2px;">20 Ca calcium 40.1</div> <div style="border: 1px solid black; padding: 2px;">21 Sc scandium 45.0</div> <div style="border: 1px solid black; padding: 2px;">22 Ti titanium 47.9</div> <div style="border: 1px solid black; padding: 2px;">23 V vanadium 50.9</div> <div style="border: 1px solid black; padding: 2px;">24 Cr chromium 52.0</div> <div style="border: 1px solid black; padding: 2px;">25 Mn manganese 54.9</div> <div style="border: 1px solid black; padding: 2px;">26 Fe iron 55.8</div> <div style="border: 1px solid black; padding: 2px;">27 Co cobalt 58.9</div> <div style="border: 1px solid black; padding: 2px;">28 Ni nickel 58.7</div> <div style="border: 1px solid black; padding: 2px;">29 Cu copper 63.5</div> <div style="border: 1px solid black; padding: 2px;">30 Zn zinc 65.4</div> <div style="border: 1px solid black; padding: 2px;">31 Ga gallium 69.7</div> <div style="border: 1px solid black; padding: 2px;">32 Ge germanium 72.6</div> <div style="border: 1px solid black; padding: 2px;">33 As arsenic 74.9</div> <div style="border: 1px solid black; padding: 2px;">34 Se selenium 79.0</div> <div style="border: 1px solid black; padding: 2px;">35 Br bromine 79.9</div> <div style="border: 1px solid black; padding: 2px;">36 Kr krypton 83.8</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">37 Rb rubidium 85.5</div> <div style="border: 1px solid black; padding: 2px;">38 Sr strontium 87.6</div> <div style="border: 1px solid black; padding: 2px;">39 Y yttrium 88.9</div> <div style="border: 1px solid black; padding: 2px;">40 Zr zirconium 91.2</div> <div style="border: 1px solid black; padding: 2px;">41 Nb niobium 92.9</div> <div style="border: 1px solid black; padding: 2px;">42 Mo molybdenum 95.9</div> <div style="border: 1px solid black; padding: 2px;">43 Tc technetium —</div> <div style="border: 1px solid black; padding: 2px;">44 Ru ruthenium 101.1</div> <div style="border: 1px solid black; padding: 2px;">45 Rh rhodium 102.9</div> <div style="border: 1px solid black; padding: 2px;">46 Pd palladium 106.4</div> <div style="border: 1px solid black; padding: 2px;">47 Ag silver 107.9</div> <div style="border: 1px solid black; padding: 2px;">48 Cd cadmium 112.4</div> <div style="border: 1px solid black; padding: 2px;">49 In indium 114.8</div> <div style="border: 1px solid black; padding: 2px;">50 Sn tin 118.7</div> <div style="border: 1px solid black; padding: 2px;">51 Sb antimony 121.8</div> <div style="border: 1px solid black; padding: 2px;">52 Te tellurium 127.6</div> <div style="border: 1px solid black; padding: 2px;">53 I iodine 126.9</div> <div style="border: 1px solid black; padding: 2px;">54 Xe xenon 131.3</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">55 Cs caesium 132.9</div> <div style="border: 1px solid black; padding: 2px;">56 Ba barium 137.3</div> <div style="border: 1px solid black; padding: 2px;">57–71 lanthanoids —</div> <div style="border: 1px solid black; padding: 2px;">72 Hf hafnium 178.5</div> <div style="border: 1px solid black; padding: 2px;">73 Ta tantalum 180.9</div> <div style="border: 1px solid black; padding: 2px;">74 W tungsten 183.8</div> <div style="border: 1px solid black; padding: 2px;">75 Re rhenium 186.2</div> <div style="border: 1px solid black; padding: 2px;">76 Os osmium 190.2</div> <div style="border: 1px solid black; padding: 2px;">77 Ir iridium 192.2</div> <div style="border: 1px solid black; padding: 2px;">78 Pt platinum 195.1</div> <div style="border: 1px solid black; padding: 2px;">79 Au gold 197.0</div> <div style="border: 1px solid black; padding: 2px;">80 Hg mercury 200.6</div> <div style="border: 1px solid black; padding: 2px;">81 Tl thallium 204.4</div> <div style="border: 1px solid black; padding: 2px;">82 Pb lead 207.2</div> <div style="border: 1px solid black; padding: 2px;">83 Bi bismuth 209.0</div> <div style="border: 1px solid black; padding: 2px;">84 Po polonium —</div> <div style="border: 1px solid black; padding: 2px;">85 At astatine —</div> <div style="border: 1px solid black; padding: 2px;">86 Rn radon —</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">87 Fr francium —</div> <div style="border: 1px solid black; padding: 2px;">88 Ra radium —</div> <div style="border: 1px solid black; padding: 2px;">89–103 actinoids —</div> <div style="border: 1px solid black; padding: 2px;">104 Rf rutherfordium —</div> <div style="border: 1px solid black; padding: 2px;">105 Db dubnium —</div> <div style="border: 1px solid black; padding: 2px;">106 Sg seaborgium —</div> <div style="border: 1px solid black; padding: 2px;">107 Bh bohrium —</div> <div style="border: 1px solid black; padding: 2px;">108 Hs hassium —</div> <div style="border: 1px solid black; padding: 2px;">109 Mt meitnerium —</div> <div style="border: 1px solid black; padding: 2px;">110 Ds darmstadtium —</div> <div style="border: 1px solid black; padding: 2px;">111 Rg roentgenium —</div> <div style="border: 1px solid black; padding: 2px;">112 Cn copernicium —</div> <div style="border: 1px solid black; padding: 2px;">113 Nh nihonium —</div> <div style="border: 1px solid black; padding: 2px;">114 Fl flerovium —</div> <div style="border: 1px solid black; padding: 2px;">115 Mc moscovium —</div> <div style="border: 1px solid black; padding: 2px;">116 Lv livermorium —</div> <div style="border: 1px solid black; padding: 2px;">117 Ts tennessine —</div> <div style="border: 1px solid black; padding: 2px;">118 Og oganeson —</div> </div>															

lanthanoids

57	La	lanthanum	138.9	58	Ce	cerium	140.1	59	Pr	praseodymium	140.9	60	Nd	neodymium	144.4	61	Pm	promethium	—	62	Sm	samarium	150.4	63	Eu	europtium	152.0	64	Gd	gadolinium	157.3	65	Tb	terbium	158.9	66	Dy	dysprosium	162.5	67	Ho	holmium	164.9	68	Er	erbium	167.3	69	Tm	thulium	168.9	70	Yb	ytterbium	173.1	71	Lu	lutetium	175.0
89	Ac	actinium	—	90	Th	thorium	232.0	91	Pa	protactinium	231.0	92	U	uranium	238.0	93	Np	neptunium	—	94	Pu	plutonium	—	95	Am	americium	—	96	Cm	curium	—	97	Bk	berkelium	—	98	Cf	californium	—	99	Es	einsteinium	—	100	Fm	fermium	—	101	Md	meitnerium	—	102	No	nobelium	—	103	Lr	lawrencium	—

actinoids