

CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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CHEMISTRY

9701/36

Paper 3 Advanced Practical Skills 2

October/November 2018

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 14 and 15.
A copy of the Periodic Table is printed on page 16.

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.

Session	
Laboratory	

For Examiner's Use	
1	
2	
Total	

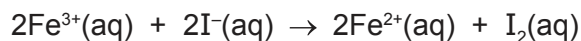
This document consists of **14** printed pages and **2** blank pages.

Quantitative Analysis

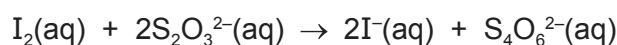
Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

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

1 Iron(III) ions oxidise iodide ions, I^- , to iodine, I_2 .



In this experiment you will investigate how the rate of this reaction is affected by the concentration of Fe^{3+} ions. To do this you will add thiosulfate ions, $S_2O_3^{2-}$, and starch indicator to a mixture of $Fe^{3+}(aq)$ and $I^-(aq)$. The iodine produced by the reaction reacts immediately with the thiosulfate ions and is reduced back to iodide.



When all the thiosulfate has reacted, the iodine remaining in solution turns the starch indicator blue-black. The rate of reaction can be determined by timing how long it takes for the reaction mixture to turn blue-black.

FB 1 is $0.0500 \text{ mol dm}^{-3}$ acidified iron(III) chloride, $FeCl_3$.

FB 2 is $0.0500 \text{ mol dm}^{-3}$ potassium iodide, KI.

FB 3 is $0.00500 \text{ mol dm}^{-3}$ sodium thiosulfate, $Na_2S_2O_3$.

FB 4 is starch indicator.

(a) Method*Experiment 1*

- Fill the burette labelled **FB 1** with **FB 1**.
- Run 20.00 cm³ of **FB 1** into a 100 cm³ beaker.
- Using the measuring cylinder add the following to the second 100 cm³ beaker:
 - 10 cm³ of **FB 2**
 - 20 cm³ of **FB 3**
 - 10 cm³ of **FB 4**
- Add the contents of the first beaker to the second beaker and start timing immediately.
- Stir the mixture once and place the beaker on a white tile.
- Stop timing as soon as the solution turns blue-black. Ignore any colour changes that occur before the intense blue-black colouration.
- Record this reaction time to the nearest second in the space provided on page 4.
- Rinse both beakers and shake dry. Rinse and dry the glass rod.

Experiment 2

- Fill a second burette with distilled water.
- Run 10.00 cm³ of **FB 1** into a 100 cm³ beaker.
- Run 10.00 cm³ of distilled water into the same beaker containing **FB 1**.
- Using the measuring cylinder add the following to the second 100 cm³ beaker:
 - 10 cm³ of **FB 2**
 - 20 cm³ of **FB 3**
 - 10 cm³ of **FB 4**
- Add the contents of the first beaker to the second beaker and start timing immediately.
- Stir the mixture once and place the beaker on a white tile.
- Stop timing as soon as the solution turns blue-black. Ignore any colour changes that occur before the intense blue-black colouration.
- Record this reaction time to the nearest second in the space provided on page 4.
- Rinse both beakers and shake dry. Rinse and dry the glass rod.

Experiments 3–5

- Carry out three further experiments to investigate how the reaction time changes with different volumes of **FB 1**.
Remember that the combined volume of **FB 1** and distilled water must always be 20.00 cm³.
Do **not** carry out an experiment using 15.00 cm³ of **FB 1**.
Do **not** use a volume of **FB 1** that is less than 5.00 cm³.

Keep all FB labelled solutions for use in (e) and in Question 2.

Record all your results in a single table. You should include the volume of **FB 1**, the volume of distilled water and the reaction time.

The relative rate for the reaction is given by the following expression.

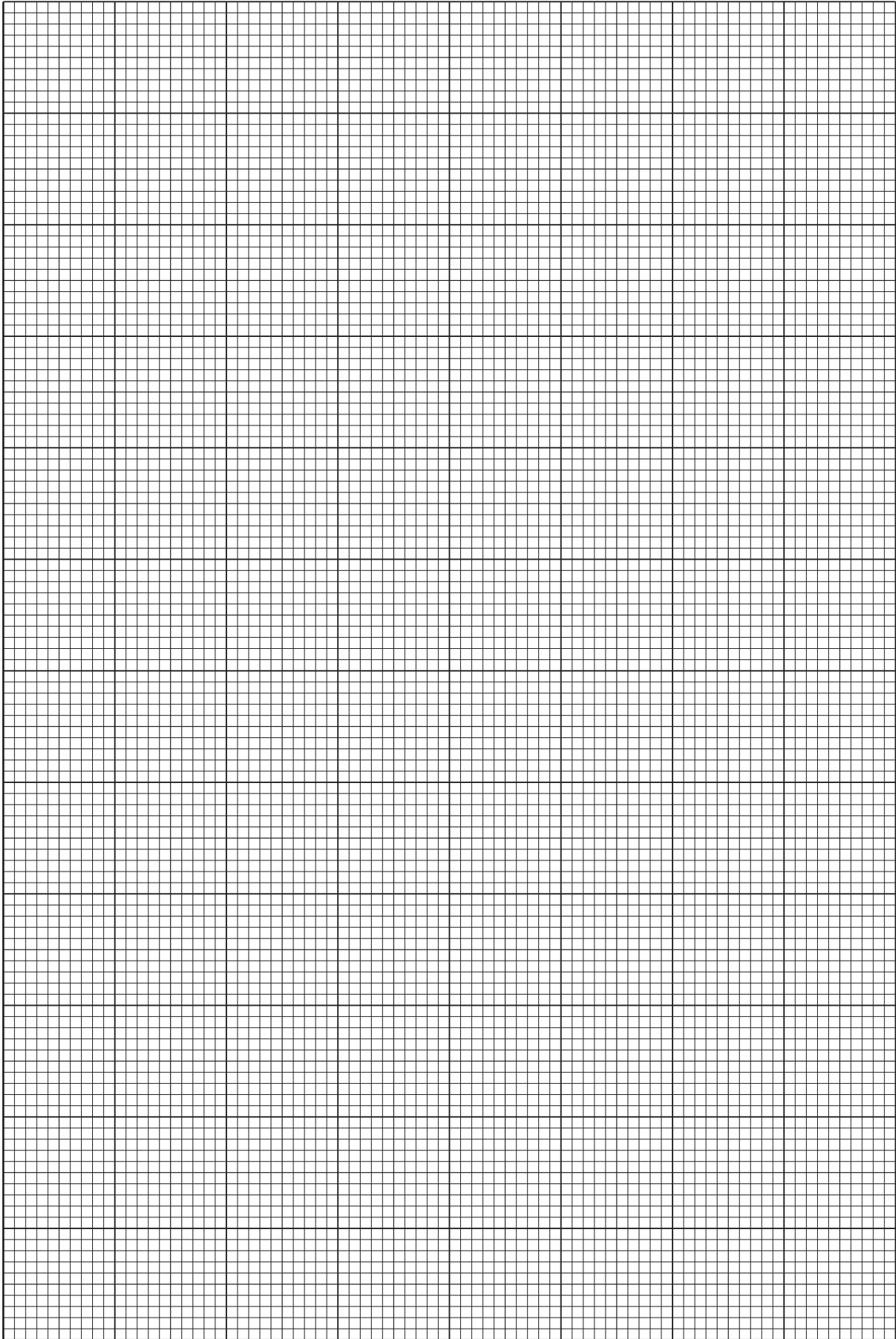
$$\text{relative rate} = \frac{1000}{\text{reaction time in seconds}}$$

Use this expression to calculate the relative rate for each of your experiments and record the values in your results table.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	
IX	
X	

[10]

- (b) On the grid opposite, plot the relative rate against the volume of **FB 1**. Include the origin in your plot. Label any points you consider anomalous. Draw a line of best fit.



I	
II	
III	
IV	

[4]

- (c) From your graph, what conclusion can you make about the relationship between the relative rate for the reaction and the volume of **FB 1** used? Explain your answer.

.....

.....

..... [2]

- (d) A student carried out the same experiment but used 15.00 cm^3 of **FB 1**. The student recorded a value for the reaction time of 28 s.

- (i) Use your graph to calculate the time you would have expected to record if you had carried out an experiment using 15.00 cm^3 of **FB 1**.
Show the construction lines on your graph and show your working in the calculation.

reaction time = s [2]

- (ii) Calculate the percentage difference between your value and that of the student.
Show your working.

percentage difference = % [1]

- (e) You are to carry out a sixth experiment. The concentrations of iron(III) chloride, sodium thiosulfate and starch indicator should all be the same as in *Experiment 2* but the concentration of **iodide ions** should be **twice** the value that it is in *Experiment 2*.

State the volume of each solution used and record the reaction time to the nearest second.

[2]

- (f) (i) 20.00 cm³ of 0.0500 mol dm⁻³ FeCl₃, **FB 1**, were reacted with excess KI, **FB 2**.

Using the information on page 2, calculate the number of moles of I₂ produced.

moles I₂ = mol [2]

- (ii) The iodine produced in (i) required 35.00 cm³ of a different solution of sodium thiosulfate for complete reaction.

Calculate the concentration of the solution of sodium thiosulfate used.

concentration of Na₂S₂O₃ = mol dm⁻³ [1]

[Total: 24]

Qualitative Analysis

Where reagents are selected for use in a test, the **full 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.

- 2 (a) **FB 1** is aqueous acidified iron(III) chloride, FeCl_3 .
FB 5 is $0.150 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

- (i) Carry out the following tests and record your observations.

<i>test</i>	<i>observations</i>
To a 1 cm depth of FB 1 in a test-tube add a 1 cm depth of FB 5 . Leave to stand until there is no further change, then	
add aqueous sodium hydroxide.	
To a 1 cm depth of FB 5 in a test-tube add a few drops of dilute hydrochloric acid. Leave to stand. Rinse the tube thoroughly.	

[3]

- (ii) In (i) you should have observed a reaction between $\text{Fe}^{3+}(\text{aq})$ and $\text{S}_2\text{O}_3^{2-}(\text{aq})$.

Do you think that this reaction affected your results in **Question 1**? Refer to the equations on page 2. Explain your answer.

.....
 [1]

- (b) **FB 6** is a solution containing a halide ion.

- (i) Carry out the following tests and record your observations.

<i>test</i>	<i>observations</i>
To a 1 cm depth of FB 6 in a test-tube add aqueous silver nitrate, then	
add aqueous ammonia.	
To a 1 cm depth of FB 6 in a test-tube add aqueous silver nitrate, then	
add FB 5 .	

[2]

- (ii) The halide in **FB 6** is

[1]

(c) **FB 7** is a solution of copper(II) sulfate, CuSO_4 .

(i) Carry out the following tests and record your observations.

<i>test</i>	<i>observations</i>
To a 1 cm depth of FB 7 in a test-tube add a 1 cm depth of FB 2 , KI, then	
add FB 4 , starch indicator.	
To a 1 cm depth of FB 7 in a test-tube add a 1 cm depth of FB 5 , then	
add a 1 cm depth of FB 2 followed by FB 4 , starch indicator.	

[3]

(ii) Give the formula of one of the products formed in the reaction of **FB 7** with **FB 2** in the first test.

.....

[1]

(d) **FB 8** is a solution of a salt containing one cation and one anion from those listed in the Qualitative Analysis Notes.

The cation in **FB 8** is one of Mg^{2+} , Zn^{2+} or Al^{3+} .

The anion in **FB 8** is either SO_3^{2-} or SO_4^{2-} .

(i) Select reagents and carry out tests to identify which ions are present in **FB 8**.
Give details of your tests and observations.

[4]

(ii) The formula of **FB 8** is

[1]

[Total: 16]

Qualitative Analysis Notes

1 Reactions of aqueous cations

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

2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	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, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and 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, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	'pops' with a lighted splint
oxygen, 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>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <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>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <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>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <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>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <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>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <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>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <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

actinoids

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 europium 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 mendelevium —	102 No nobelium —	103 Lr lawrencium —