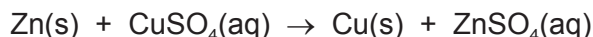


WORKSHEET NO. 2

- 1 Zinc metal is extracted from ores that, in addition to compounds of zinc, can also contain copper and silver. This means zinc metal is often impure.

You will investigate the percentage purity of a sample of zinc by reacting it with excess aqueous copper(II) sulfate and comparing the enthalpy change of the displacement reaction with the accepted value.



FB 1 is 1.00 mol dm⁻³ copper(II) sulfate, CuSO₄.

FB 2 is powdered impure zinc, Zn.

(a) Method

Read the whole method before starting any practical work.

- Weigh the container with **FB 2** and record the mass in the space below.
- Support the plastic cup in the 250 cm³ beaker.
- Use the measuring cylinder to transfer 25 cm³ of **FB 1** into the plastic cup.
- Place the thermometer in the solution and record the initial temperature in a suitable table of results. Tilt the cup if necessary so that the bulb of the thermometer is fully covered. This is the temperature at time zero ($t = 0$).
- Start timing and do not stop the clock until the whole experiment has been completed at $t = 8$ minutes.
- Measure and record the temperature of the **FB 1** in the cup every half minute up to and including $t = 2$ minutes.
- At $t = 2\frac{1}{2}$ minutes add all the **FB 2** into the cup and stir the contents until t is nearly 3 minutes.
- Measure and record the temperature of the mixture in the cup every half minute from $t = 3$ minutes until $t = 8$ minutes. Stir occasionally throughout this time.
- Weigh the container and any residual **FB 2**. Record this mass and calculate the mass of **FB 2** added.

Results

Mass

mass of FB2 + tube /g	29.53
mass of tube + residue/g	28.65
mass of FB2 used/g	0.88

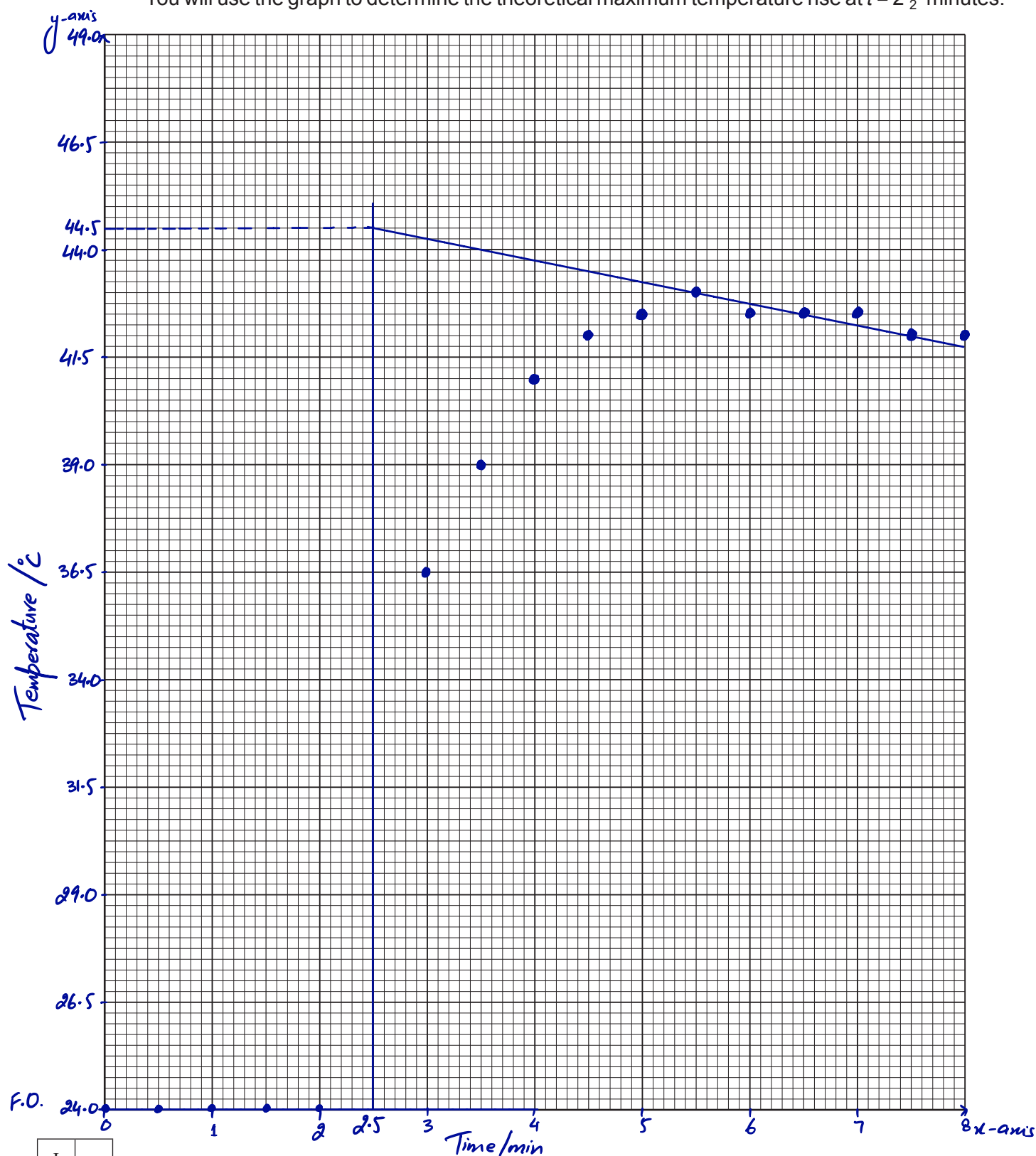
Temperature

Time /min	Temperature /°C	Time /min	Temperature /°C
0	24.0	4½	42.0
½	24.0	5	42.5
1	24.0	5½	43.0
1½	24.0	6	42.5
2	24.0	6½	42.5
3	36.5	7	42.5
3½	39.0	7½	42.0
4	41.0	8	42.0

I	
II	
III	
IV	

[4]

- (b) Plot a graph of temperature on the y-axis against time on the x-axis on the grid below. The scale for temperature should extend 3 °C above your highest recorded temperature. You will use the graph to determine the theoretical maximum temperature rise at $t = 2\frac{1}{2}$ minutes.



I	
II	
III	
IV	

Draw two lines of best fit through the points on your graph, the first for the temperature before adding **FB 2** and the second for the temperature of the mixture after addition of **FB 2**.

Extrapolate the lines to $t = 2\frac{1}{2}$ minutes and determine the theoretical maximum temperature rise, ΔT .

$$44.5 - 24.0 =$$

theoretical maximum temperature rise at $t = 2\frac{1}{2}$ minutes, $\Delta T = 20.5$ °C [4]

(c) Calculations

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

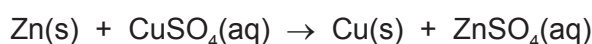
- (i) Use your answer to (b) to calculate the heat energy, in J, given out when **FB 2** was added to the **FB 1** in the cup.
(Assume that 4.2 J of heat energy raises the temperature of 1.0 cm³ of the mixture by 1.0 °C.)

$$Q = mc \Delta T$$

$$= 25 \times 4.2 \times 20.5$$

heat energy given out = 2153 J

- (ii) Use your answer to (i) and the Periodic Table on page 11 to calculate the enthalpy change, in kJ mol^{-1} , for the displacement reaction.



You should assume that **FB 2** was pure zinc for this calculation.

$$\frac{0.88}{65.4} = 0.0135 \text{ mol} \quad \frac{0.0135 \text{ mol}}{1 \text{ mol}} \times \frac{2153 \text{ J}}{\text{mol}} \times \frac{159482}{1000} = 159.5 \text{ kJ/mol}$$

enthalpy change, $\Delta H = \dots\dots\dots$ kJ mol⁻¹
(sign) (value)

[3]

- (d)** The accepted value for the enthalpy change of this reaction is -217 kJ mol^{-1} .

Assuming no heat loss and that the other metals present in **FB 2** do not react with aqueous copper(II) sulfate, calculate the percentage of zinc present in **FB 2**.

$$\frac{160}{217} \times 100$$

percentage of Zn = 73.7 % [1]

- (e) A student carried out the same experiment but used pieces of zinc instead of zinc powder. All quantities and the initial temperature of the aqueous copper(II) sulfate remained the same.

State and explain what effects this change would have on the graph plotted.

Longer time to reach the maximum temperature due to less surface area, reaction will be slow.

Maximum temperature will OR remain same as number of mole of zinc is the same. [2]

[Total: 14]

- 2 Solid hydrated copper(II) sulfate has the formula $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ where x is the number of moles of water of crystallisation present in 1 mole of compound.

You will determine the equation for the reaction that occurs when hydrated copper(II) sulfate is heated to remove the water of crystallisation producing anhydrous copper(II) sulfate.

FB 3 is hydrated copper(II) sulfate $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$.

(a) Method

Record all masses in the space below.

- Weigh the crucible and add 2.2–2.4 g of **FB 3**.
- Weigh the crucible plus **FB 3**.
- Place the crucible on the pipe-clay triangle and heat it gently for approximately 4 minutes.
- Leave the crucible to cool and reweigh the crucible plus residue.

Keep the crucible and residue for test (c).

mass of crucible /g	23.51
mass of crucible + FB3 /g	25.81
mass of FB3 before heating /g	2.30
mass of crucible + FB3 after heating /g	24.98

I	
II	
III	
IV	

[4]

(b) Calculations

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

- (i) Calculate the mass of anhydrous copper(II) sulfate, CuSO_4 , produced after heating.

$$24.98 - 23.51$$

$$\text{mass of CuSO}_4 = 1.47 \text{ g}$$

- (ii) Calculate the mass of water lost by heating.

$$25.81 - 24.98$$

$$\text{mass of water} = 0.83 \text{ g}$$

- (iii) Use your answers to (i) and (ii) and the Periodic Table on page 11 to deduce the value of x in the formula $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$.

$$\text{H}_2\text{O} = \frac{0.83}{18} = 0.0461 \text{ mol}$$

$$\text{CuSO}_4 = \frac{1.47}{159.6} = 0.00921 \text{ mol}$$

$$\begin{array}{r} 0.00921 \quad \text{---} \quad 0.0461 \\ 1 \quad \quad \quad x \\ \hline x \end{array}$$

$$x = 5.01 \approx 5$$

x is 5

- (iv) Use your answer to (iii) to complete the equation for the reaction that occurs when hydrated copper(II) sulfate is heated. You should include state symbols.



[4]

- (c) Place the cooled crucible, with the residue, **on a heatproof mat** and carefully add a few drops of water.

- (i) Note your observations.

Solid turns off-white to blue and steam given off. Temperature rises.

- (ii) Explain your observations in (i) in terms of the reaction occurring.

Anhydrous CuSO_4 turns to hydrated $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$.
Reaction is exothermic.

[3]

- (d) Two students carried out the experiment in (a) and obtained values for x that did not agree with the accepted value. One student calculated a value that was less than the accepted value and the other student calculated a value that was more than the accepted value.

In each case, suggest a reason for the error and an improvement that could be made to minimise it. You can assume that the calculations were correctly carried out.

Value less than accepted value

error Not all water removed

improvement heat to get constant mass

Value more than accepted value

error anhydrous salt may decomposes

improvement Heat gently or use a thermostatically controlled oven

[2]

[Total: 13]

3 Qualitative Analysis

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

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations.**

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

No additional tests for ions present should be attempted.

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

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

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

(a) **FB 4** and **FB 5** are aqueous solutions of equal concentrations, in mol dm^{-3} . Each contains one anion and one cation. The cation is the same in both **FB 4** and **FB 5**.

Half fill the 250 cm^3 beaker with water. Heat the water to about 80°C and then turn off the Bunsen burner. This is the hot water bath needed in the tests below.

To about a 2 cm depth of aqueous silver nitrate in a test-tube, add a few drops of aqueous sodium hydroxide to give a grey/brown precipitate. Then add aqueous ammonia dropwise until the precipitate **just** disappears. This solution is Tollens' reagent and is needed in a test below.

(i) Carry out the tests on separate samples of **FB 4** and **FB 5** and complete the table.

test	observations	
	FB 4	FB 5
To a 1 cm depth of solution in a test-tube in a test-tube rack, add a spatula measure of sodium carbonate.	<i>fizzing, a colorless gas which formed white ppt. with lime water.</i>	<i>fizzing, a colorless gas which formed white ppt. with lime water.</i>
To a 1 cm depth of solution in a test-tube, add a few drops of acidified potassium manganate(VII). Place the test-tube in the hot water bath.	<i>purple solution of KMnO_4 turned colorless</i>	<i>no change</i>
To a 1 cm depth of Tollens' reagent in a test-tube, add a few drops of solution. Place the test-tube in the hot water bath and leave for several minutes.	<i>Black ppt. / Silver mirror formed</i>	<i>white ppt. formed</i>

- (ii) From your observations in (i), identify the cation present in **both FB 4 and FB 5**.

cation H^+ / acid

- (iii) From your observations in (i), what can be deduced about the anion present in **FB 4**?

..... $-CHO$ group or can be oxidized or a reducing agent

- (iv) Place a 1 cm depth of **FB 4** and **FB 5** separately in two test-tubes.

Measure and record the temperature of the two solutions.

FB 4 26.0 $^{\circ}C$ **FB 5** 26.0 $^{\circ}C$

To each solution, add an approximately 2 cm length of magnesium ribbon. Measure and record the maximum temperature reached in each test-tube.

FB 4 + Mg 29.0 $^{\circ}C$ **FB 5** + Mg 33.0 $^{\circ}C$

- (v) Explain why there is a difference in the temperature rise for the reactions of magnesium with solutions **FB 4** and **FB 5**.

..... $FB4$ is a weaker acid than $FB5$.

..... Energy is needed to break (O to H) bond, so less is released.

[8]

(b) **FB 6** is a solid that contains two cations from those listed on page 9.

You are to plan a series of experiments that will enable you to identify the cations present. You should then carry out your plan, record all the observations you made in a suitable table and identify the cations present.

tests	Observations
(i) To 1cm depth of solution add 1cm depth of aq. NaOH	white ppt.
add aq. NaOH in excess	soluble in excess
warm the mixture	a colorless gas produced, which turned damp red Litmus paper blue.
(ii) To 1cm depth of solution, add 1cm depth of aq. NH ₃	white ppt.
add aq. NH ₃ in excess	soluble in excess

cations present are Zn^{2+} and NH_4^+

[5]

[Total: 13]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

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)	no ppt. (if 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; NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown NO_2 in air)
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													13	14	15	16	17	18						
<div><div>1</div><div>H</div><div>hydrogen</div><div>1.0</div></div>																		<div><div>2</div><div>He</div><div>helium</div><div>4.0</div></div>							
<div><div>Key</div><div>atomic number</div><div>atomic symbol</div><div>name</div><div>relative atomic mass</div></div>																		<div><div>5</div><div>B</div><div>boron</div><div>10.8</div></div>		<div><div>6</div><div>C</div><div>carbon</div><div>12.0</div></div>	<div><div>7</div><div>N</div><div>nitrogen</div><div>14.0</div></div>	<div><div>8</div><div>O</div><div>oxygen</div><div>16.0</div></div>	<div><div>9</div><div>F</div><div>fluorine</div><div>19.0</div></div>	<div><div>10</div><div>Ne</div><div>neon</div><div>20.2</div></div>	
<div><div>11</div><div>Na</div><div>sodium</div><div>23.0</div></div>	<div><div>12</div><div>Mg</div><div>magnesium</div><div>24.3</div></div>													<div><div>13</div><div>Al</div><div>aluminium</div><div>27.0</div></div>	<div><div>14</div><div>Si</div><div>silicon</div><div>28.1</div></div>	<div><div>15</div><div>P</div><div>phosphorus</div><div>31.0</div></div>	<div><div>16</div><div>S</div><div>sulfur</div><div>32.1</div></div>	<div><div>17</div><div>Cl</div><div>chlorine</div><div>35.5</div></div>	<div><div>18</div><div>Ar</div><div>argon</div><div>39.9</div></div>						
<div><div>19</div><div>K</div><div>potassium</div><div>39.1</div></div>	<div><div>20</div><div>Ca</div><div>calcium</div><div>40.1</div></div>	<div><div>21</div><div>Sc</div><div>scandium</div><div>45.0</div></div>	<div><div>22</div><div>Ti</div><div>titanium</div><div>47.9</div></div>	<div><div>23</div><div>V</div><div>vanadium</div><div>50.9</div></div>	<div><div>24</div><div>Cr</div><div>chromium</div><div>52.0</div></div>	<div><div>25</div><div>Mn</div><div>manganese</div><div>54.9</div></div>	<div><div>26</div><div>Fe</div><div>iron</div><div>55.8</div></div>	<div><div>27</div><div>Co</div><div>cobalt</div><div>58.9</div></div>	<div><div>28</div><div>Ni</div><div>nickel</div><div>58.7</div></div>	<div><div>29</div><div>Cu</div><div>copper</div><div>63.5</div></div>	<div><div>30</div><div>Zn</div><div>zinc</div><div>65.4</div></div>	<div><div>31</div><div>Ga</div><div>gallium</div><div>69.7</div></div>	<div><div>32</div><div>Ge</div><div>germanium</div><div>72.6</div></div>	<div><div>33</div><div>As</div><div>arsenic</div><div>74.9</div></div>	<div><div>34</div><div>Se</div><div>selenium</div><div>79.0</div></div>	<div><div>35</div><div>Br</div><div>bromine</div><div>79.9</div></div>	<div><div>36</div><div>Kr</div><div>krypton</div><div>83.8</div></div>								
<div><div>37</div><div>Rb</div><div>rubidium</div><div>85.5</div></div>	<div><div>38</div><div>Sr</div><div>strontium</div><div>87.6</div></div>	<div><div>39</div><div>Y</div><div>yttrium</div><div>88.9</div></div>	<div><div>40</div><div>Zr</div><div>zirconium</div><div>91.2</div></div>	<div><div>41</div><div>Nb</div><div>niobium</div><div>92.9</div></div>	<div><div>42</div><div>Mo</div><div>molybdenum</div><div>95.9</div></div>	<div><div>43</div><div>Tc</div><div>technetium</div><div>—</div></div>	<div><div>44</div><div>Ru</div><div>ruthenium</div><div>101.1</div></div>	<div><div>45</div><div>Rh</div><div>rhodium</div><div>102.9</div></div>	<div><div>46</div><div>Pd</div><div>palladium</div><div>106.4</div></div>	<div><div>47</div><div>Ag</div><div>silver</div><div>107.9</div></div>	<div><div>48</div><div>Cd</div><div>cadmium</div><div>112.4</div></div>	<div><div>49</div><div>In</div><div>indium</div><div>114.8</div></div>	<div><div>50</div><div>Sn</div><div>tin</div><div>118.7</div></div>	<div><div>51</div><div>Sb</div><div>antimony</div><div>121.8</div></div>	<div><div>52</div><div>Te</div><div>tellurium</div><div>127.6</div></div>	<div><div>53</div><div>I</div><div>iodine</div><div>126.9</div></div>	<div><div>54</div><div>Xe</div><div>xenon</div><div>131.3</div></div>								
<div><div>55</div><div>Cs</div><div>caesium</div><div>132.9</div></div>	<div><div>56</div><div>Ba</div><div>barium</div><div>137.3</div></div>	lanthanoids		<div><div>72</div><div>Hf</div><div>hafnium</div><div>178.5</div></div>	<div><div>73</div><div>Ta</div><div>tantalum</div><div>180.9</div></div>	<div><div>74</div><div>W</div><div>tungsten</div><div>183.8</div></div>	<div><div>75</div><div>Re</div><div>rhenium</div><div>186.2</div></div>	<div><div>76</div><div>Os</div><div>osmium</div><div>190.2</div></div>	<div><div>77</div><div>Ir</div><div>iridium</div><div>192.2</div></div>	<div><div>78</div><div>Pt</div><div>platinum</div><div>195.1</div></div>	<div><div>79</div><div>Au</div><div>gold</div><div>197.0</div></div>	<div><div>80</div><div>Hg</div><div>mercury</div><div>200.6</div></div>	<div><div>81</div><div>Tl</div><div>thallium</div><div>204.4</div></div>	<div><div>82</div><div>Pb</div><div>lead</div><div>207.2</div></div>	<div><div>83</div><div>Bi</div><div>bismuth</div><div>209.0</div></div>	<div><div>84</div><div>Po</div><div>polonium</div><div>—</div></div>	<div><div>85</div><div>At</div><div>astatine</div><div>—</div></div>	<div><div>86</div><div>Rn</div><div>radon</div><div>—</div></div>							
<div><div>87</div><div>Fr</div><div>francium</div><div>—</div></div>	<div><div>88</div><div>Ra</div><div>radium</div><div>—</div></div>	actinoids		<div><div>104</div><div>Rf</div><div>rutherfordium</div><div>—</div></div>	<div><div>105</div><div>Db</div><div>dubnium</div><div>—</div></div>	<div><div>106</div><div>Sg</div><div>seaborgium</div><div>—</div></div>	<div><div>107</div><div>Bh</div><div>bohrium</div><div>—</div></div>	<div><div>108</div><div>Hs</div><div>hassium</div><div>—</div></div>	<div><div>109</div><div>Mt</div><div>meitnerium</div><div>—</div></div>	<div><div>110</div><div>Ds</div><div>darmstadtium</div><div>—</div></div>	<div><div>111</div><div>Rg</div><div>roentgenium</div><div>—</div></div>	<div><div>112</div><div>Cn</div><div>copernicium</div><div>—</div></div>	<div><div>114</div><div>Fl</div><div>flerovium</div><div>—</div></div>		<div><div>116</div><div>Lv</div><div>livermorium</div><div>—</div></div>										

lanthanoids

actinoids

57	La	58	Ce	59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb	71	Lu
	lanthanum		cerium		praseodymium		neodymium		promethium		samarium		europium		gadolinium		terbium		dysprosium		holmium		erbium		thulium		ytterbium		lutetium
	138.9		140.1		140.9		144.4		—		150.4		152.0		157.3		158.9		162.5		164.9		167.3		168.9		173.1		175.0

89	Ac	90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm	101	Md	102	No	103	Lr
	actinium		thorium		protactinium		uranium		neptunium		plutonium		americium		curium		berkelium		californium		einsteinium		fermium		mendelevium		nobelium		lawrencium
	—		232.0		231.0		238.0		—		—		—		—		—		—		—		—		—		—		—