Class	Register Number	Name

南洋女子中学校
NANYANG GIRLS' HIGH SCHOOL

End-of-Year Examination 2020
Secondary Three

Chemistry

Paper 2 Theory Paper **1 hour 45 minutes**
Wednesday **07 October 2020** **0845 - 1030**
Additional materials: Writing paper

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, register number and class in the spaces at the top of this page and on any separate answer paper used.

Section A (40 marks)
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

Section B (30 marks)
Answer **all** questions including questions **B6**, **B7** and **B8** ***Either*** or **B8** ***Or***.
Write your answers on the separate writing paper provided.

At the end of the examination,
1. Fasten all your work securely together;
2. Circle **B8** ***Either*** (for Either) or **B8** ***Or*** (for Or) in the grid on the right to indicate the question you have answered;
3. Hand in Section A and Section B separately.

INFORMATION FOR CANDIDATES

The intended number of marks is given in the brackets [ ] at the end of each question or part question. You are advised to spend no longer than 60 minutes on Section A and no longer than 45 minutes on Section B.

The use of approved scientific calculators is allowed.

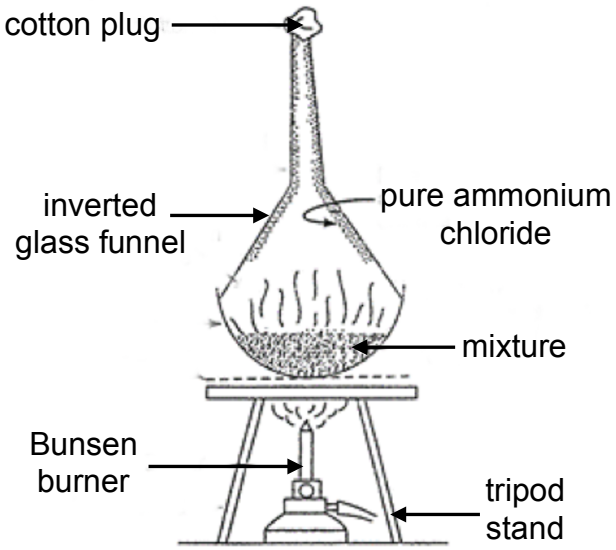
A copy of the periodic table is found on page 15.

Paper 1	**/ 30**
Paper 2	
Section A	**/ 40**
B6	**/ 10**
B7	**/ 10**
B8 *Either* / B8 *Or*	**/ 10**
Total	**/ 100**

Section A (40 marks)

Answer **all** questions. Write your answers in the spaces provided.

A1 Ammonium chloride is a white crystalline salt that is used mainly as a fertiliser and a flavouring agent. It is separated from a mixture with the setup below.



(a) What is the property of ammonium chloride that makes it suitable to be separated from the mixture with the setup above? [1]

_____

(b) The table below shows some properties of ammonium chloride.

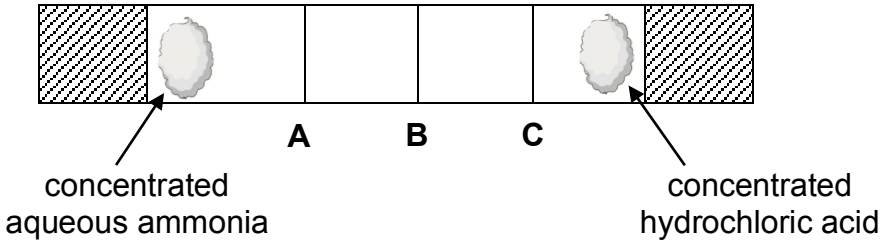
decomposition temperature	338 ^{o}C
solubility	highly soluble in water
electrical conductivity	conducts electricity in aqueous state

(i) State the type of bonding(s) found in ammonium chloride. [1]

_____

(ii) Ammonium chloride decomposes to form hydrogen chloride gas. Draw a dot-and-cross diagram to show the bonding in hydrogen chloride gas, showing only the valence electrons. [2]

(c) Plugs of cotton wool soaked respectively in concentrated aqueous ammonia and concentrated hydrochloric acid are inserted at the same time into the open ends of a horizontal tube as shown in the diagram below.



The ends are sealed and after some time, white fumes of ammonium chloride are observed. At which position will the white fumes be observed? [1]

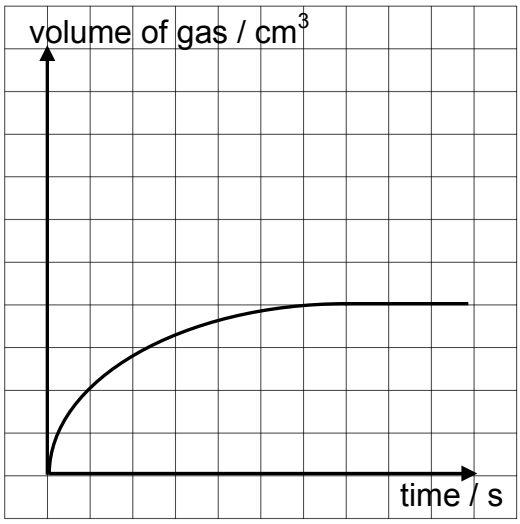
Total [5]

A2 This question is about the reaction of metal carbonates with acid.

(a) (i) Write an ionic equation for the reaction between nitric acid and silver carbonate. [2]

(ii) 8.00 g of silver carbonate reacts with 150 cm^3 of 0.200 mol dm^{-3} nitric acid. Calculate the volume of gas that is formed by this reaction. [3]

(iii) The graph for the reaction of 8.00 g of silver carbonate reacts with 150 cm^3 of 0.200 mol dm^{-3} nitric acid is shown below.



On the same axes, draw the graph when 8.00 g of silver carbonate is reacted with 150 cm^3 of 0.200 mol dm^{-3} hydrochloric acid. Label this graph as **A**.

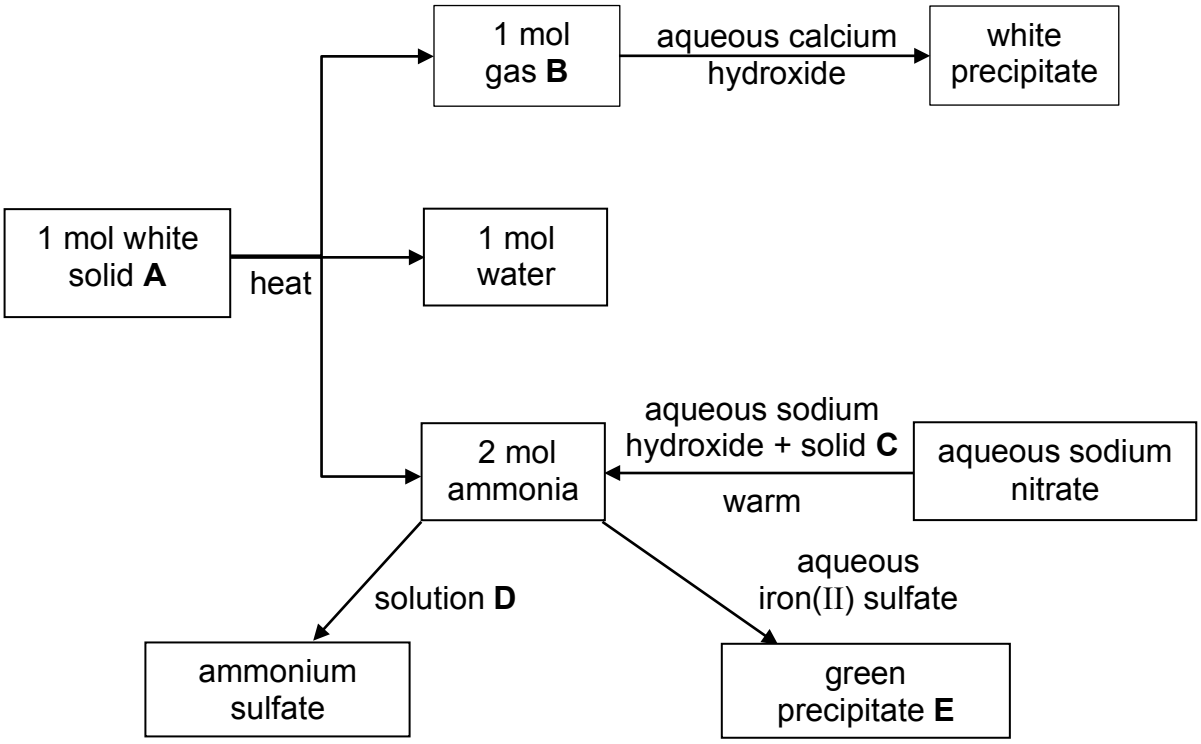
[2]

On the same axes, draw the graph when 8.00 g of silver carbonate is reacted with 150 cm^3 of 0.150 mol dm^{-3} sulfuric acid. Label this graph as **B**.

(b) State a variable other than concentration of acid and temperature that can increase the rate of the reaction between silver carbonate with nitric acid, explaining your answer in terms of collision between particles. [3]

Total [10]

A3 Study the reaction scheme given below.



(a) Identify unknowns **A** to **E**, shown in the reaction scheme above. [5]

A _____ **D** _____

B _____ **E** _____

C _____

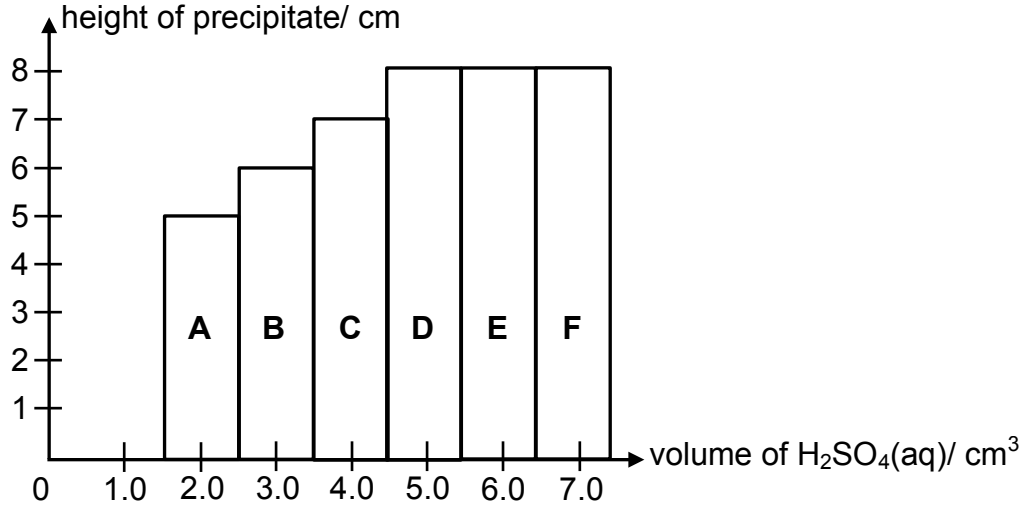
(b) Write a chemical equation, including state symbols when gas **B** is bubbled into aqueous calcium hydroxide to form a white precipitate. [2]

_____

Total [7]

A4 A precipitation reaction between aqueous barium hydroxide and dilute sulfuric acid is investigated.

Six test tubes, **A** to **F** contain 10.0 cm^3 of 0.500 mol dm^{-3} aqueous barium hydroxide and different volumes of 1.00 mol dm^{-3} dilute sulfuric acid were added. Precipitation occurs in all test tubes and the height of the precipitate in each test tube is measured and recorded in the graph below.



(a) Write a balanced chemical equation, including state symbols for the reaction between aqueous barium hydroxide and dilute sulfuric acid. [2]

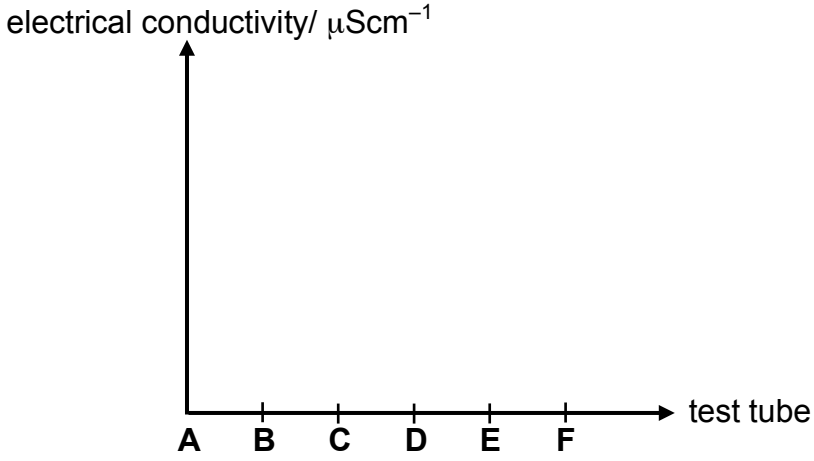
_____

(b) Two drops of Universal indicator are added to each test tube. State the colour of the Universal indicator in the following test tubes.

(i) test tube **B** _____ [1]

(ii) test tube **E** _____ [1]

(c) The electrical conductivity of each test tube is measured after the reaction. Sketch a graph to show the change of electrical conductivity from test tube **A** to test tube **F**. [2]



Total [6]

A5 4.21 g of a solid mixture containing sodium ethanedioate, $Na_2C_2O_4$ and ethanedioic acid dihydrate, $H_2C_2O_4 \cdot 2H_2O$ was placed in a volumetric flask and made up to 250 cm^3. This solution was labeled **P**.

Two separate titrations were carried out using this solution **P**.

(a) In the first titration, 25.0 cm^3 of solution **P** was titrated with 0.200 mol dm^{-3} acidified potassium manganate(VII) solution.

When 26.50 cm^3 of acidified potassium manganate(VII) solution was added, the solution in the conical flask changed colour.

The ionic equation for this titration reaction is as follows:

$$2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

(i) State the colour change of acidified potassium manganate(VII) when a few drops of it was added to solution **P**. [1]

(ii) Write the half ionic equation when ethanedioate ions, $C_2O_4^{2-}$ forms carbon dioxide, CO_2. [2]

(iii) Calculate the number of moles of manganate(VII) ions, MnO_4^- added. [1]

(iv) Calculate the number of moles of ethanedioate ions, $C_2O_4^{2-}$ reacted. [1]

(b) In the second titration, 25.0 cm^3 of solution **P** was titrated with 0.100 mol dm^{-3} solution of sodium hydroxide. 10.45 cm^3 of sodium hydroxide solution was needed for complete neutralisation.

The equation for this reaction is as follows:

$$H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$$

(i) State and explain whether the reaction is a redox reaction. [2]

(ii) Calculate the number of moles of sodium hydroxide added. [1]

(iii) Calculate the number of moles of ethanedioic acid, $H_2C_2O_4$ reacted. [1]

(iv) Calculate the percentage by mass of ethanedioic acid dihydrate, $H_2C_2O_4 \cdot 2H_2O$ in the solid. [3]

Total [12]

Section B

Answer all **three** questions from this section on the writing paper provided.
The last question is in the form of either/or and only **one** of the alternatives should be attempted.

B6 The properties of some substances are shown in the table below

substance	melting point / °C	electrical conductivity
hydrogen iodide	–51	
X	714	does not conduct in solid state, conduct in liquid state
Y	1710	does not conduct in solid state or liquid state
aluminium chloride	192	does not conduct in solid state or liquid state

(a) **(i)** In hydrogen iodide, the hydrogen and iodine atoms are held together by covalent bonds. Define *covalent bond*. [2]

(ii) Given that hydrogen iodide is a strong acid, predict and explain its electrical conductivity in the aqueous state. Illustrate your answer with an equation. [2]

(b) Explain the difference in electrical conductivity of substance **X** in the solid and liquid states. [3]

(c) Explain why substance **Y** has a high melting point. [2]

(d) Explain what is unusual about the bonding present in aluminium chloride. [1]

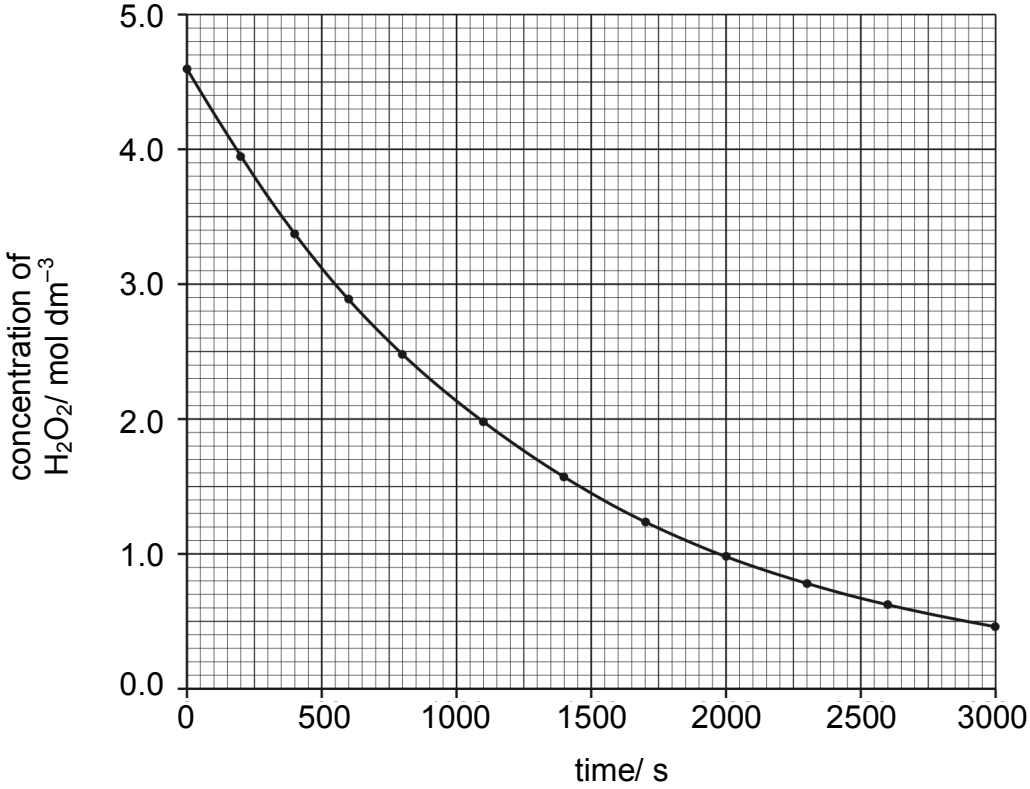
Total [10]

B7 Aqueous solutions of hydrogen peroxide, $H_2O_2(aq)$, decompose as follows:

$$2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$$

The decomposition of hydrogen peroxide was investigated by measuring the concentration of hydrogen peroxide over time.

From the results, the concentration-time graph was plotted.



(a) (i) Suggest an apparatus that would allow the gas volumes to be measured. [1]

(ii) Given that 25.0 cm^3 of hydrogen peroxide is used, calculate the total volume of oxygen gas that is expected at 2000 s. [3]

(b) In another investigation, hydrogen peroxide is reacted with iodide ions as shown in the equation as follows:

$$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

Several experiments at the same temperature were carried out to determine the effect of concentration on the rate of the reaction.

The results are shown below.

experiment	initial concentrations			rate/ 10^{-6} mol dm^{-3} s^{-1}
	$[H_2O_2]$/ mol dm^{-3}	$[I^-]$/ mol dm^{-3}	$[H^+]$/ mol dm^{-3}	
1	0.0200	0.0200	0.200	4.00
2	0.0200	0.0400	0.200	8.00
3	0.0400	0.0200	0.200	8.00
4	0.0400	0.0200	0.400	8.00

By identifying a pair of experiments that you have compared from the above table, describe the effect of the following changes on the rate of reaction:

(i) varying the concentration of H_2O_2 [2]

(ii) varying the concentration of H^+ [2]

(iii) State a method to monitor the rate of reaction between hydrogen peroxide and iodide ions. Explain the reason for using the method. [2]

Total [10]

B8 EITHER

Gunpowder is the earliest known chemical explosive. It consists of a mixture of sulfur, carbon, and potassium nitrate.

(a) The simplified chemical equation for the combustion of gunpowder is shown below.

$$2KNO_3(s) + S(s) + 3C(s) \rightarrow K_2S(s) + N_2(g) + 3CO_2(g)$$

(i) Identify the two substances reduced and the substance oxidised during the combustion of gunpowder.

Explain your answer in terms of oxidation states. [3]

(ii) The substances in the gunpower mixture will not react if they are simply mixed together. However, the mixture can ignite when a shock is delivered. Using your knowledge of chemical reactions, suggest why this happens. [1]

(b) The composition of the substances in gunpowder can vary. A gunpowder that was used historically comprises of 75.0 g of potassium nitrate, 12.5 g of sulfur, and 12.5 g of carbon in a 100 g mixture.

(i) Calculate the number of moles of potassium nitrate, sulfur and carbon in the 100 g mixture. [2]

(ii) Determine the limiting reactant and explain your answer. [2]

(iii) The total volume of gases collected at the end of the reaction is 20 dm^3. Calculate the percentage yield. [2]

Total [10]

B8 OR

Safety matches contain red phosphorus, P_4 and an impurity on the matchbox cover and potassium chlorate(V), $KClO_3$ on the match head.

(a) When the match is struck on the matchbox cover, the chemicals react accordingly to the following equation.

$$3P_4 + 10KClO_3 \rightarrow 3P_4O_{10} + 10KCl$$

(i) Explain why the above reaction is a redox reaction in terms of oxidation states. [3]

(ii) Red phosphorus and potassium chlorate(V) do not react when mixed. However, when a match is struck on the matchbox cover, a reaction occurs. Using your knowledge of chemical reactions, suggest why this happens. [1]

(b) After the reaction in **(a)**, water was added to the reaction mixture to react with P_4O_{10} to form a tribasic acid. 25 cm^3 of the tribasic acid solution required 20.0 cm^3 of 1.00 mol dm^{-3} of potassium hydroxide for complete neutralisation.

(i) Given that one mole of P_4O_{10} forms four moles of the tribasic acid, write the chemical equation for the reaction of tetraphosphorus decoxide with water. [1]

(ii) Calculate the number of moles of P_4O_{10} formed by the reaction between red phosphorus and potassium chlorate(V). [2]

(iii) State an assumption that you made when doing the calculations in part **(b)(ii)**. [1]

(iv) Calculate the mass of the limiting reactant, potassium chlorate(V), in the reaction between red phosphorus and potassium chlorate(V). [2]

Total [10]

END OF PAPER

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The Periodic Table of Elements

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

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	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
actinoids	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 –

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