Established in 1879

THE RAFFLES PROGRAMME

FOUNDED 1823

Name: _____

Class: 4 / _____ Register No: _____

CHEMISTRY
YEAR FOUR

Pen-and-Paper Assessment

Thursday **5 May 2016** **1 hour**

INSTRUCTIONS TO CANDIDATES

Section A – Answer **ALL** the questions and record your answers as instructed on the OMR answer sheet.

Section B – Answer **ALL** the questions and write your answers in the spaces provided.

Use only a black or dark blue pen, except for diagrams.

Do not use correction tape or fluid.

Omission of essential working or units, or expressing answers with incorrect significant figures will result in a loss of marks.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

The total number of marks for this paper is **45**.

A copy of the Periodic Table is provided for your reference.

For examiners' use	
Question	**Marks Obtained**
Section A	
B1	
B2	
B3	
B4	
B5	
B6	
Statement	
Units	
Significant figures	
Total	**45**

Parent's / Guardian's Name: _____

Signature: _____ Date: _____

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Section A – Multiple Choice Questions [10 marks]

*Four possible answers (**A**, **B**, **C**, and **D**) are given for each question. Choose the most appropriate answer and record your answer in the OMR form provided.*

1 Which of the following **cannot** be used to distinguish between aqueous lead(II) nitrate and aqueous aluminium chloride?

A silver nitrate solution
B potassium iodide solution
C aqueous ammonia
D sodium sulfate solution

2 **X** is a white powder. Upon heating, it gives off a colourless gas. The gas dissolves in water to give a solution which turns blue litmus red. The residue dissolves in dilute hydrochloric acid to form a colourless solution.

Which of the following substances is most likely to be **X**?

A aluminium nitrate
B sodium carbonate
C lead(II) carbonate
D zinc carbonate

3 The following list shows reactions in which copper(II) sulfate is either a reactant or a product.

1. addition of magnesium to aqueous copper(II) sulfate
2. addition of barium nitrate solution to aqueous copper(II) sulfate
3. reaction of copper(II) oxide with dilute sulfuric acid
4. electrolysis of aqueous copper(II) sulfate using copper electrodes

In which reactions are there no change in the oxidation state of copper?

A 1 and 4 only
B 2 and 3 only
C 3 and 4 only
D 2 and 4 only

Use the following information to answer questions 4 and 5.

Experiments were carried out on reactions of metals **P**, **Q**, **R** and **S** with cold water and dilute hydrochloric acid. The results are tabulated below.

Experiment	**P**	**Q**	**R**	**S**
Reaction with cold water	No change observed	No change observed	Reacts violently	Reacts very slowly
Reaction with dilute hydrochloric acid	No change observed	Reacts slowly	Reacts explosively	Reacts readily

4 Which of the following statements is correct?

A **P** reacts with steam.
B **Q** does not react with steam.
C **R** displaces **S** from its salt solution.
D **S** displaces potassium from its salt solution

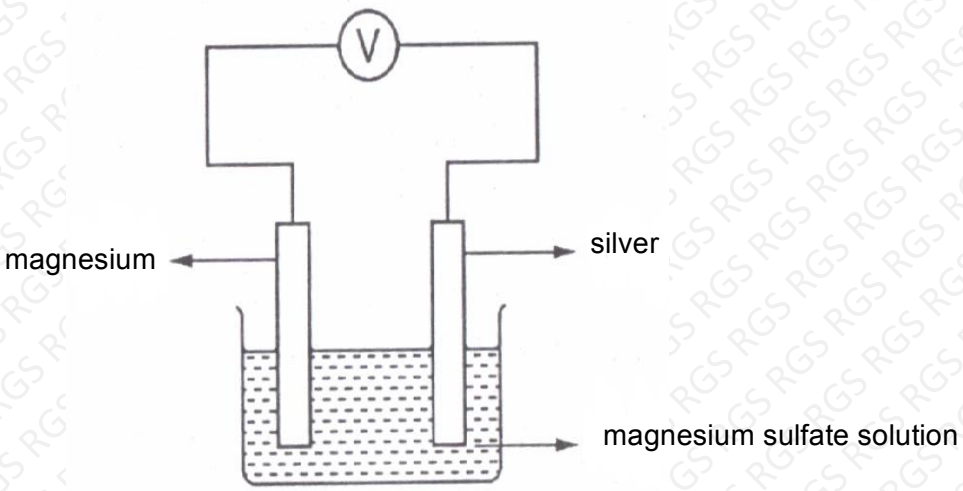
5 If metal **S** can only be extracted from its oxide by electrolysis, which of the metal above can only be extracted by electrolysis?

A **P**
B **P** and **Q** only
C **Q** and **R** only
D **R** only

6 Four electrolytes were electrolysed using platinum electrodes. Which set of data is **correct**?

	Electrolyte	**Product at**	
		Anode	**Cathode**
A	$Na_2SO_4(aq)$	oxygen	hydrogen
B	$KCl(aq)$	chlorine	potassium
C	$NaH(\ell)$	oxygen	hydrogen
D	$ZnBr_2(\ell)$	zinc	bromine

7 A simple cell is set-up as shown. What are the observations seen at the two electrodes?



	Magnesium Electrode	Silver Electrode
A	Magnesium dissolves in the magnesium sulfate solution.	Effervescence of a colourless gas is seen.
B	Magnesium dissolves in magnesium sulfate solution.	A grey solid is deposited.
C	Effervescence of a colourless gas is seen.	Effervescence of a colourless gas is seen.
D	Effervescence of a colourless gas is seen.	A grey solid is deposited.

8 Aqueous potassium sulfate is electrolysed using carbon electrodes. Which of the following gives the correct pH values of the solutions around the cathode and the anode after some time?

	pH of solution around the cathode	pH of solution around the anode
A	12	2
B	2	12
C	12	12
D	2	2

9 The enthalpy change of combustion (ΔH) of alcohol is the amount of heat given out when one mole of alcohol is completely burned in oxygen.

The enthalpy changes of combustion of some alcohols are given below.

Alcohol	Formula	ΔH / kJ mol^{-1}
methanol	CH_3OH	-750
ethanol	C_2H_5OH	-1380
propanol	C_3H_7OH	-2010
butanol	C_4H_9OH	-2640

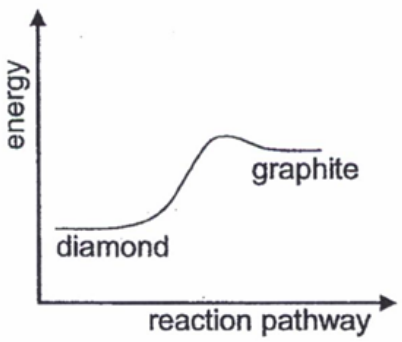
How many carbon and hydrogen atoms would there be in the formula of an alcohol that has an enthalpy change of combustion of -4530 kJ mol^{-1}?

	number of carbon atoms	number of hydrogen atoms
A	6	13
B	6	14
C	7	15
D	7	16

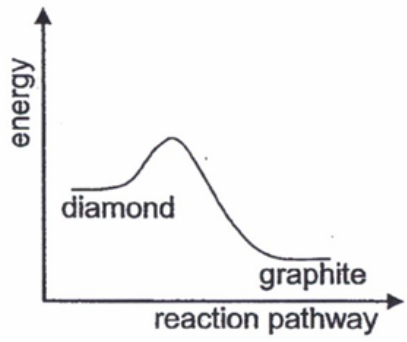
10 The conversion of diamond into graphite is exothermic (ΔH = -3 kJ mol^{-1}) and it does not take place readily.

Which energy profile diagram below best represents this conversion?

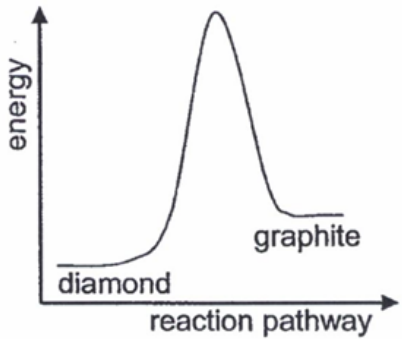
A



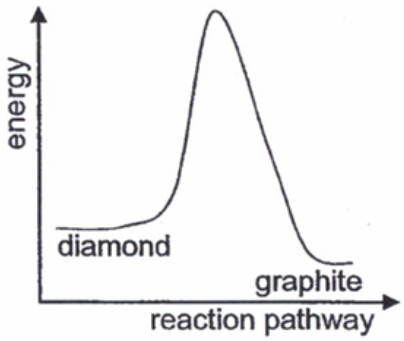
B



C



D

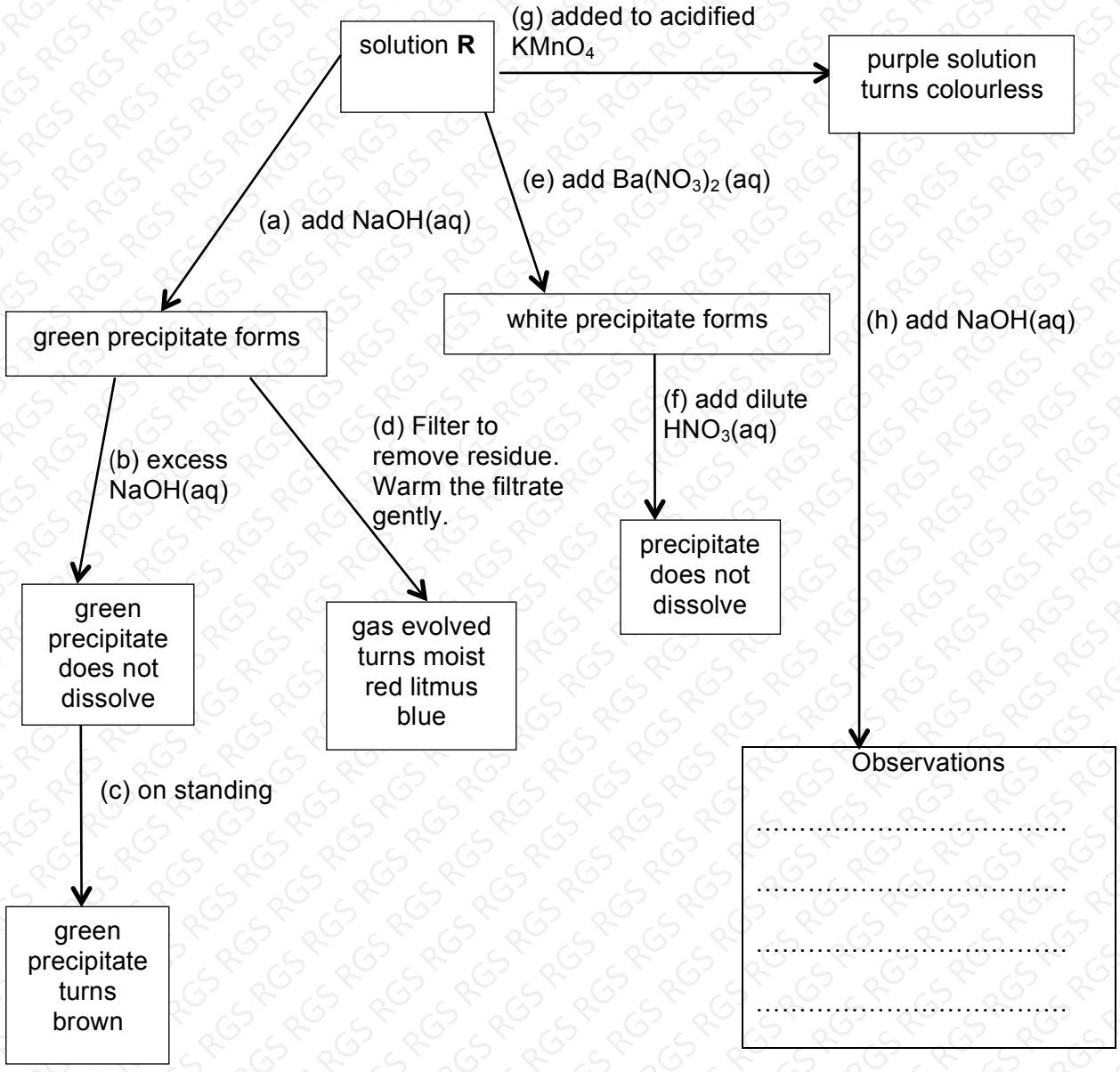


End of Section A

Section B [35 Marks]

*Answer **ALL** questions and write your answers in the spaces provided.*

B1 A student carried out a qualitative analytical test on an unknown solution **R** and drew the reaction scheme shown below:



Answer the following questions based on the reaction scheme.

(a) Solution **R** contains two cations and one anion. Write the formula of the three ions present in **R**.

…… [3]

(b) Fill in the blank with the expected observation for step (h).

[1]

(c) **(i)** Which ion in **R** is responsible for the colour change in step (g)?

…… [1]

(ii) In step (g), manganate(VII) ions, MnO_4^-, in the presence of hydrogen ion, H^+, are reduced to manganese(II) ions, Mn^{2+}. The other product of this reduction reaction is water.

Write the half equation, with state symbols, to show the reduction reaction of manganate(VII) ions.

…… [2]

(d) Write an ionic equation for one of the reactions from **either** step (a) **or** (e) in the reaction scheme.

[1]

……

B2 Manganese(II) sulfate is typically added to manganese-deficient soil as a fertilizer. It dissolves in water to form a pale pink solution. Manganese(II) sulfate can be made by treating manganese dioxide with sulfur dioxide as shown in the equation below.

$$MnO_2(s) + SO_2(g) \rightarrow MnSO_4(s)$$

(a) Write the oxidation states of the **underlined** elements in the boxes below.

Reactants	Oxidation Number	Product	Oxidation Number
MnO_2		**Mn**SO_4	
SO_2		Mn**S**O_4	

[2]

(b) Identify the reducing agent and explain your answer in terms of oxidation states.

……

……

…… [2]

(c) When a piece of aluminium foil is added to a solution of manganese(II) sulfate, the mass of aluminium decreases over time.

(i) Write the chemical equation for the reaction above.

…… [1]

(ii) A piece of manganese metal reacts with dilute nitric acid to give off a gas that extinguishes a lighted splint with a "pop" sound.

Predict **two** observations when manganese metal is placed in a solution of copper(II) sulfate.

……

……

……

…… [2]

B3 Aluminium is one of the most common element on Earth.

(a) Give a reason why the recycling of aluminium is necessary for sustainable development.

……

……

…… [1]

(b) Aluminium is extracted by the electrolysis of molten aluminium oxide. Suggest why cryolite is added to the electrolytic cell in the extraction of aluminium.

……

……

…… [1]

(c) A student carried out a series of experiments to deduce the order of reactivity of four metals: iron, metals **X**, **Y** and **Z**.

Reaction 1: A yellowish brown solution was formed when iron was placed in a colourless salt solution of **X**.

Reaction 2: On heating the metal carbonate of **Z**, a gas that formed a white precipitate in limewater was evolved. There was no observable change on heating the metal carbonate of **Y**.

Reaction 3: **Z** cannot be extracted from its oxide by reduction using carbon.

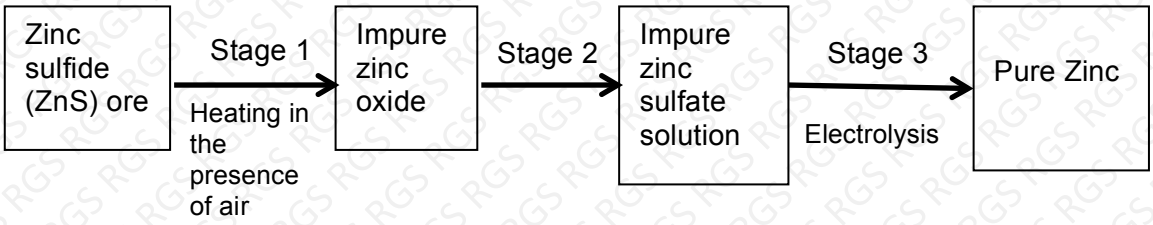
(i) Arrange the four metals in decreasing reactivity.

…… [1]

(ii) Suggest a possible identity for metal **Z**.

…… [1]

B4 The diagram below shows the stages involved in the extraction of zinc from mined zinc sulfide ores.



(a) The zinc sulfate solution obtained in Stage 2 includes ions of other metals. Besides zinc ions, suggest a possible metal ion which could be also discharged in Stage 3. Explain why.

……

……..

…….. [2]

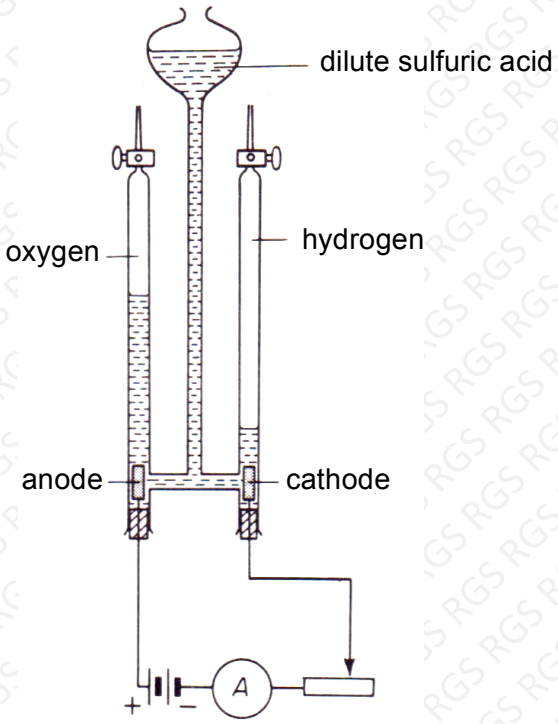
(b) Suggest another method to convert zinc oxide to zinc metal.

…….. [1]

(c) In Stage 3, electrolysis is carried out on zinc sulfate solution using inert electrodes to extract zinc metal. Write the half equation for the reaction occurring at the anode.

Anode: …….. [1]

B5 The diagram below shows the Hofmann's voltameter that is used to electrolyse dilute sulfuric acid.



(a) During the reaction, 12.3 cm^3 of oxygen was collected at the anode. Calculate the mass of oxygen collected at room temperature and pressure.

[2]

(b) Deduce the volume of hydrogen collected at the cathode. Explain your deduction using the overall equation of the reaction.

Volume of hydrogen : ……..

Equation: ……

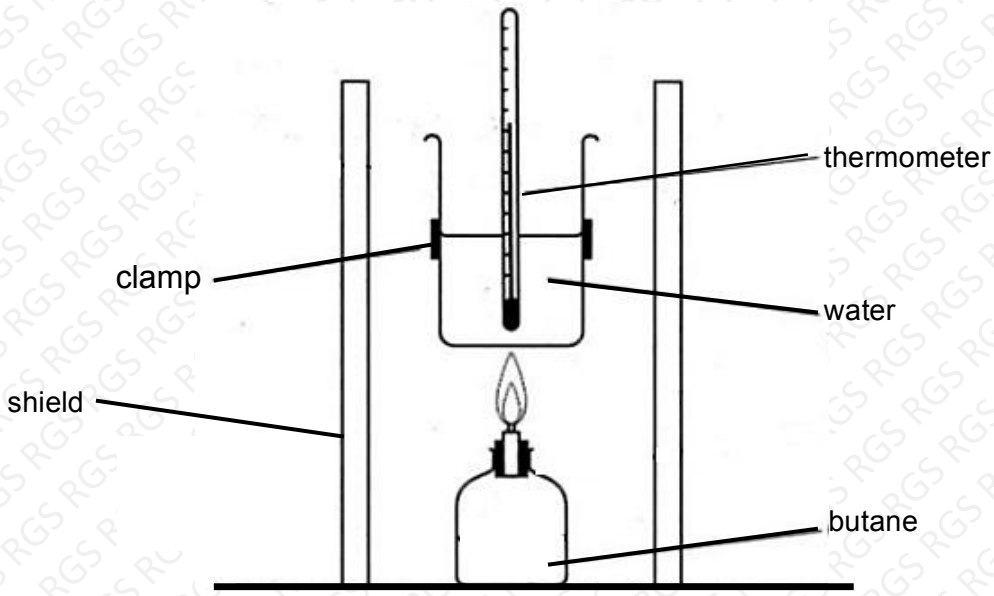
Explanation: ……..

……..

……....

…….. [3]

B6 The enthalpy change or heat change during the combustion of butane, C_4H_{10} can be determined with the setup of the apparatus shown below.



During combustion of butane, heat is given out. The quantity of heat given out can be measured by heating water. The quantity of heat given out to heat the water can be calculated using the following formula:

The quantity of heat given = **mcΔT**

m is the mass of water in grams, g.
c is the specific heat capacity of water, which is 4.2 J g^{-1} K^{-1}
ΔT is the change in temperature in Kelvin, K.

Note: Specific heat capacity of water is defined as the amount of heat required to raise the temperature of one gram of water by one Kelvin.

(a) (i) When 1.45 g of butane, C_4H_{10}, was burned to heat a beaker of 250 g of water, the temperature of the water increased by 40.0 K. Calculate the quantity of heat absorbed by the water.

[1]

(ii) Calculate the number of moles of butane in 1.45 g of butane.

[1]

(iii) Hence, calculate the enthalpy change from burning 1 mole of butane. Express your answer in kJ mol^{-1}.

[1]

(b) State one assumption made in this experimental method.

……

…… [1]

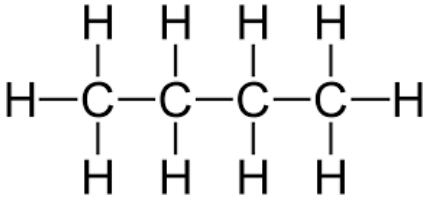
(c) The enthalpy change of burning 1 mole of butane could also be determined by calculating the energy change in bond breaking and bond forming using the following equation:

$$C_4H_{10} + \frac{13}{2} O_2 \rightarrow 4CO_2 + 5H_2O$$

The table below shows the bond energy in some bonds.

Bond	Bond Energy/ kJ mol^{-1}
C-H	410
C-C	350
C-O	360
C=O	740
O-H	460
O-O	150
O=O	496

The structural formula of butane is:



Using the relevant bond energies, calculate the enthalpy change when 1 mole of butane is burned completely. Express your answer in kJ mol^{-1}.

[3]

End of Paper

The Periodic Table of the Elements

Group																	
I	II											III	IV	V	VI	VII	0
							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	– Tc technetium 43	101 Ru ruthenium 44	103 Rh rhodium 45	106 Pd palladium 46	108 Ag silver 47	112 Cd cadmium 48	115 In indium 49	119 Sn tin 50	122 Sb antimony 51	128 Te tellurium 52	127 I iodine 53	131 Xe xenon 54
133 Cs caesium 55	137 Ba barium 56	139 La lanthanum 57 *	178 Hf hafnium 72	181 Ta tantalum 73	184 W tungsten 74	186 Re rhenium 75	190 Os osmium 76	192 Ir iridium 77	195 Pt platinum 78	197 Au gold 79	201 Hg mercury 80	204 Tl thallium 81	207 Pb lead 82	209 Bi bismuth 83	– Po polonium 84	– At astatine 85	– Rn radon 86
– Fr francium 87	– Ra radium 88	– Ac actinium 89 *	– Rf rutherfordium 104 *	– Db dubnium 105	– Sg seaborgium 106	– Bh bohrium 107	– Hs hassium 108	– Mt meitnerium 109	– Uun ununnilium 110	– Uuu unununium 111	– Uub ununbium 112		– Uuq ununquadium 114		– Uuh ununhexium 116		– Uuo ununoctium 118

Key

relative atomic mass
atomic symbol
name
atomic number

lanthanides *	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	– 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
actinides *	– Th thorium 90	– Pa protactinium 91	– U uranium 92	– Np neptunium 93	– Pu plutonium 94	– Am americium 95	– Cm curium 96	– Bk berkelium 97	– Cf californium 98	– Es einsteinium 99	– Fm fermium 100	– Md mendelevium 101	– No nobelium 102	– Lw lawrencium 103