MARKER CODE				

Student Enrolment Number									

TONGA FORM SIX CERTIFICATES

2016

CHEMISTRY

QUESTION AND ANSWER BOOKLET

Time allowed: 2 Hours

INSTRUCTIONS

1. Write your **Student Enrolment Number (SEN)** on the top right-hand corner of this page.

QUESTIONS AND TOPICS	Pages	Time (mins)	Total
QUESTION 1 Electron Configuration and Periodic Trends	2	14	8
QUESTION 2 Titration and Molecular Formula	3 — 5	15	9
QUESTION 3 Lewis Structures and Physical Properties	6 — 9	16	10
QUESTION 4 Organic Compounds	10 — 13	17	13
QUESTION 5 Oxides and Unknown Inorganic Ions	14 — 16	14	8
QUESTION 6 Redox Reactions and Corrosion	17 — 19	14	8
QUESTION 7 Organic Reactions and Tri-esters	20 — 22	16	11
QUESTION 8 Equilibrium Principles and Rate of Reactions	23 — 25	14	8
TOTAL		**120**	**75**

2. Follow instructions and answer all questions in the spaces provided in this booklet.
3. Check that this booklet contains pages 2-27 in the correct order and that page 26 has been deliberately left blank.
4. Periodic table has been provided at the end of the booklet (page 27).

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR BEFORE YOU LEAVE THE EXAMINATION ROOM.

QUESTION ONE: Electron Configuration and Periodic Trends

a. Complete the following table.

Skill level 1	
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NR	

Symbol	Electron configuration (*s*, *p*, *d*, *f* notation)
S	
O^{2-}	

Skill level 1	
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NR	

b. Use the following data to explain the difference between the radii of the Cl atom and the Cl^- ion.

Atom or ion	Radius/ *pm*
O	60
O^{2-}	124

Skill level 3	
3	
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c. By taking note of the electronegativity of the oxygen atom and the sulfur atom, describe their probable types of bonds.

Atom	Electronegativity
O	3.44
S	2.58

Skill level 3	
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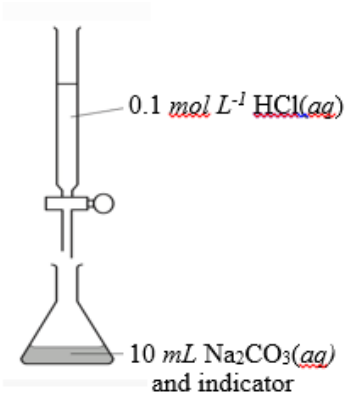
QUESTION TWO: Titration and Molecular Formula

Sodium carbonate solution can be added to the water in swimming pools to neutralise the acidic effects of chlorine.

A student carried out a titration experiment to determine the concentration of a sodium carbonate solution.

	Rough titre	**1st titre**	**2nd titre**
Initial burette reading/ *mL*	0.0	0.2	1.5
Final burette reading/ *mL*	16.5	16.1	17.6
Volume used/ *mL*	16.5	15.9	16.1



a. Using the results in the table, calculate the average volume, in *mL*, of hydrochloric acid required to neutralise the sodium carbonate solution.

Skill level 1	
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The equation for the reaction is

$2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$

b. Using your answer from part (a) calculate the concentration, in *mol* L^{-1}, of the sodium carbonate solution.
Show your working clearly.

Skill level 2	
2	
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c. A student carried out an experiment to determine the value of **x** in the formula of hydrated sodium bromide, $NaBr.\mathbf{x}H_2O$. Hydrated sodium bromide is heated until all the water of crystallization is removed. Anhydrous sodium bromide, NaBr, is formed. The student was given the following instructions.

- Weigh a sample of the hydrated sodium bromide crystals in a pre-weighed crucible.
- Heat the crucible containing the sample to remove the water of crystallization.
- Allow the crucible to cool and then reweigh the crucible.

The student's results are shown in the table below.

	Mass/ *g*
Mass of crucible empty	18.02
Mass of crucible + contents before heating	21.49
Mass of crucible + contents after heating	20.51
Mass of contents before heating	3.47

Calculate the value of **X**. Give your answer to significant two figures.

Skill level 3	
3	
2	
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NR	

d. Sodium burns in oxygen to give a pale yellow solid **X**.

i. 1.73 *g* of sodium reacts with 1.20 *g* of oxygen.

Find the molecular formula of **X**.

Skill level 3	
3	
2	
1	
0	
NR	

QUESTION THREE: Lewis Structures and Physical Properties

a. Define first ionisation energy.

_____

_____

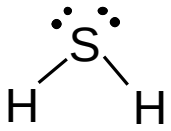
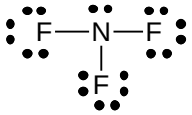
_____

_____

Skill level 1	
1	
0	
NR	

b. Sulfur and nitrogen both bond with hydrogen atoms and fluorine atoms to form H_2S and NF_3 respectively. However, the molecules have different shapes.

The following table shows the Lewis structures for the molecules H_2S and NF_3.

Molecule	H_2S	NF_3
Lewis structure		

Explain why these molecules have different shapes.
In your answer include:

- the shapes of H_2S and NF_3.
- factors that determine the shape of each molecule.

Skill level 3	
3	
2	
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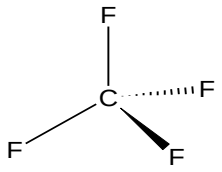
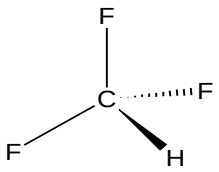
NR	

c. The 3-dimensional diagrams of two molecules are shown below.





Circle the word that describes the polarity of each of the molecules CF_4 and CHF_3.

CF_4	**Polar**	**Non-polar**
CHF_3	**Polar**	**Non-polar**

For each molecule, justify your choice.

Skill level 3	
3	
2	
1	
0	
NR	

d. Consider each of the solids lead, Pb, and iodine, I_2.

Complete the table below by identifying which of these solids have the listed physical properties:

Physical properties	Solid
The solid dissolves readily in water and is not ductile.	
The solid is insoluble water and is ductile.	

Justify your choices in terms of the particles, structure, and bonding of these solids. You may use diagrams in your justification.

Skill level 3	
3	
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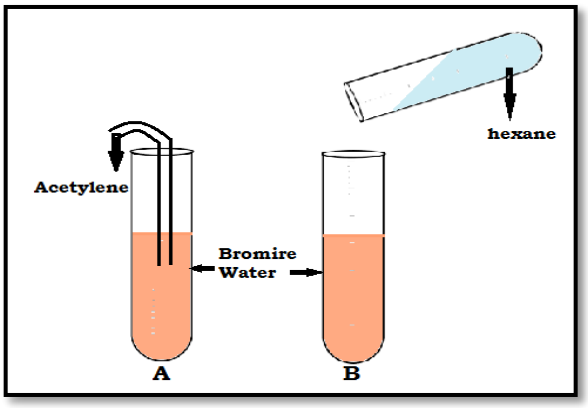
QUESTION FOUR: Organic Compounds

a. Acetylene (Ethyne) is bubbled into a bromine water test tube **A** and hexane liquid is poured into a bromine water test tube **B**.



Describe the expected observations in test tube **A** and **B**.

_____

_____

_____

Skill level 1	
1	
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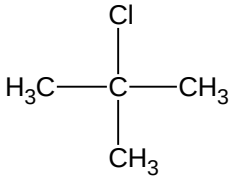
b. Complete the following table to show the structural formula and IUPAC (systematic) name for each compound.

Structural formula	IUPAC (systematic) name
	3-chloro-pentan-2-one
	

Skill level 2	
2	
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c. Name the **THREE** (3) types of alcohols giving an example of each.

Skill level 1	
1	
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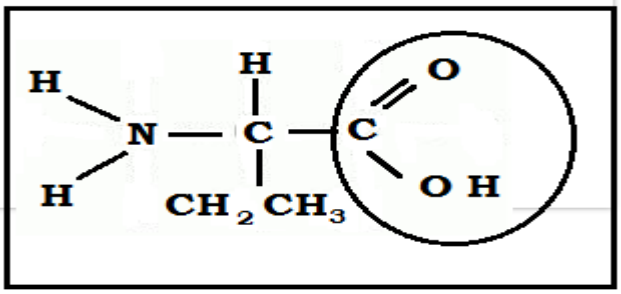
_____

_____

_____

d. Name the functional group that is circled below.



Skill level 1	
1	
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NR	

_____

e. The structures of the three organic compounds are shown below.

Compound **A**	$CH_3—CCl=CCl—CH_3$
Compound **B**	$CH_3—CH_2—CCl=CCl_2$
Compound **C**	$CH_3—CH_2—CCl_2—CH_3$

Explain why compound **A** can exist as geometric (*cis* and *trans*) isomers, but compounds **B** and **C** cannot.

In your answer you should:

- draw the geometric (*cis* and *trans*) isomers of compound **A** in the boxes below
- explain the requirements for geometric (*cis* and *trans*) isomers by referring to compounds **A**, **B** and **C**.

cis isomer

trans isomer

Skill level 3	
3	
2	
1	
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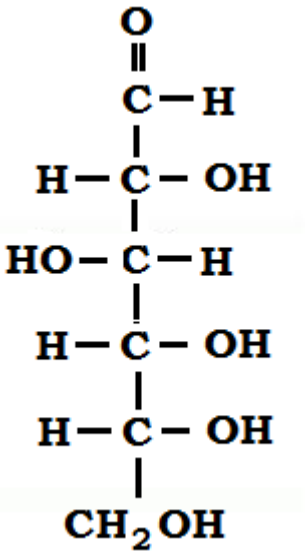
NR	

f. The following is the open glucose structure:



Describe how to test for the presence of the aldehyde group.

For your answer:

- identify the reagent to use
- describe any observations that would be made
- identify the type of reaction that occurs
- identify the organic product of any reaction.

Skill level 3	
3	
2	
1	
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QUESTION FIVE: Oxides and Unknown Inorganic Ions

a. One of the most important aspects of the properties of oxides is their acid-base properties. If we list the oxides of a given period, e.g. Period 3, we find an orderly progression of their acid-base character

i. List: Na_2O MgO Al_2O_3 SiO_2 SO_2 SO_3

Describe the orderly progression of their acid-base character.

_____

_____

_____

_____

_____

_____

Skill level 2	
2	
1	
0	
NR	

ii. Write equation for the reaction of aluminium oxide, Al_2O_3, with

sodium hydroxide:

_____

Skill level 1	
1	
0	
NR	

hydrochloric acid:

_____

Skill level 1	
1	
0	
NR	

b. A sample of water is required to be tested for the presence of

- aluminium ions, Al^{3+}
- zinc ions, Zn^{+2}
- iron(II) ions, Fe^{2+}
- copper (II) ions, Cu^{2+}

It is known that the sample of water does not contain any other positive ions or cations.
The only available reagent is aqueous ammonia, $NH_3(aq)$.
Design a method that could be carried out to distinguish the above cations.
In your answer, you should:

- identify any precipitates formed or complex ions formed linked these to any observations that would be made
- identify the type of reaction that occur
- explain how the results are used to determine which ions are present or absent
- equations showing the precipitates or complex ions formed

Skill level 4	
4	
3	
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QUESTION 6: Redox Reactions and Corrosion

a. When sulfur dioxide gas (SO_2) is bubbled into a solution of acidified potassium dichromate solution, a colour change is observed. The unbalanced equation for this reaction is given below.

$$Cr_2O_7^{2-} + SO_2 \rightarrow SO_4^{2-} + Cr^{3+}$$

i. Identify the reductant and oxidant in this reaction.

Reductant: _____

Oxidant: _____

_____

_____

_____

Skill level 1	
1	
0	
NR	

ii. Write the redox equation for the overall reaction given above.

_____

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Skill level 3	
3	
2	
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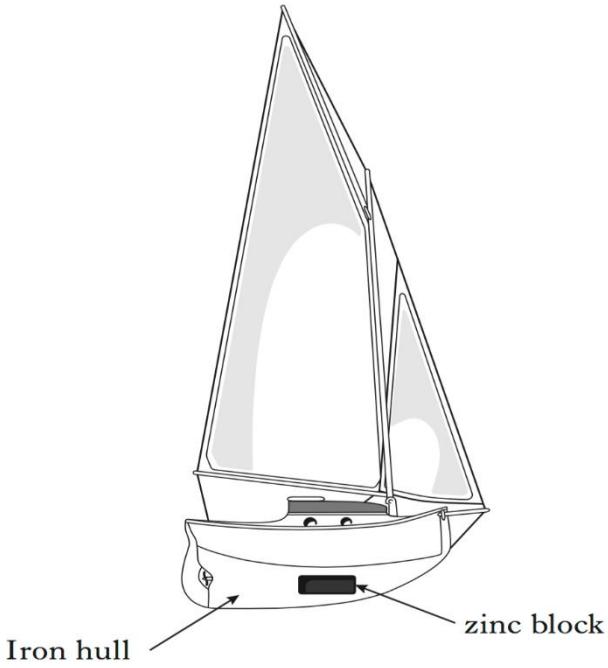
b. A boat builder attached zinc blocks to the iron hull of his boat.



The boat builder wrote his observation in a log book that:

- the rate of corrosion increased when his iron boat was in sea water
- zinc blocks attached to iron boat helped prevent corrosion

Discuss the occurrence of corrosion of iron in the setting given above.
In your answer, you should:

- identify any products formed and link these to any observations that bodybuilder made
- identify the type of reaction that occurs
- explain why the rate of corrosion increase when iron boats are in sea water
- explain why the attaching zinc blocks to iron boats help prevent corrosion
- include any related equations

Skill level 4	
4	
3	
2	
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NR	

QUESTION 7: Organic Reactions and Tri-ester

a. Write the balanced chemical equations for the reactions of:

i. Hydrochloric acid and ethene.

Skill level 2	
2	
1	
0	
NR	

ii. propene and chlorine then propyne and water.

Skill level 3	
3	
2	
1	
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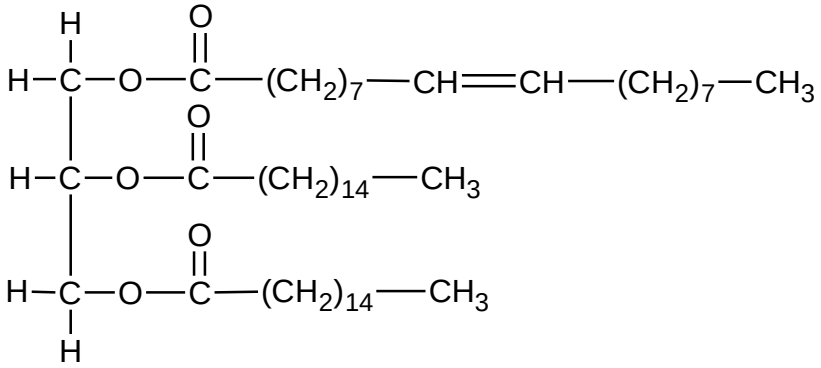
b. A tri-ester has the following structure:



This tri-ester is described as unsaturated.

i. Describe a chemical test that can be used to show that the molecule is unsaturated. Give any observations, and state the type of reaction occurring.

_____

_____

_____

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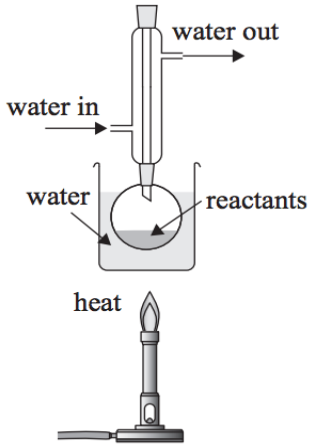
Skill level 2	
2	
1	
0	
NR	

ii. Draw the structural formulae of the organic products formed by hydrolysis of this tri-ester using aqueous sodium hydroxide solution.

Skill level 2	
2	
1	
0	
NR	

iii. Describe why the equipment below is used for hydrolysis of the tri-ester.



Skill level 2	
2	
1	
0	
NR	

QUESTION 8: Equilibrium Principles and Rate of Reactions

a. The following chemical equation represents a reaction that is part of the Contact Process which produces sulfuric acid.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\Delta H = -200 \text{ kJ mol}^{-1}$, $K_c = 4.32$ at 600°C

i. The reaction above was carried out again at 400°C.

Describe, using equilibrium principles, how the change in temperature will affect:

- the value of K_c
- the position of equilibrium.

Skill level 2	
2	
1	
0	
NR	

b. Hydrochloric acid was reacted with calcium in an experiment to investigate factors affecting the rate of a chemical reaction.

Three experiments were carried out.

Experiment	Temperature/ °C	Size
1	25	lump
2	40	lump
3	25	powder

i. Compare **Experiment 1** and **Experiment 2**.

In your answer, you should:

- identify the factor being changed, and the effect this will have on the rate of reaction
- explain the effect on the rate of reaction by referring to the collision of particles and activation energy, where appropriate.

Skill level 3	
3	
2	
1	
0	
NR	

ii. Compare **Experiment 1** and **Experiment 3**.

In your answer, you should:

- identify the factor being changed, and the effect this will have on the rate of reaction
- explain the effect on the rate of reaction by referring to the collision of particles and activation energy, where appropriate.

Skill level 3	
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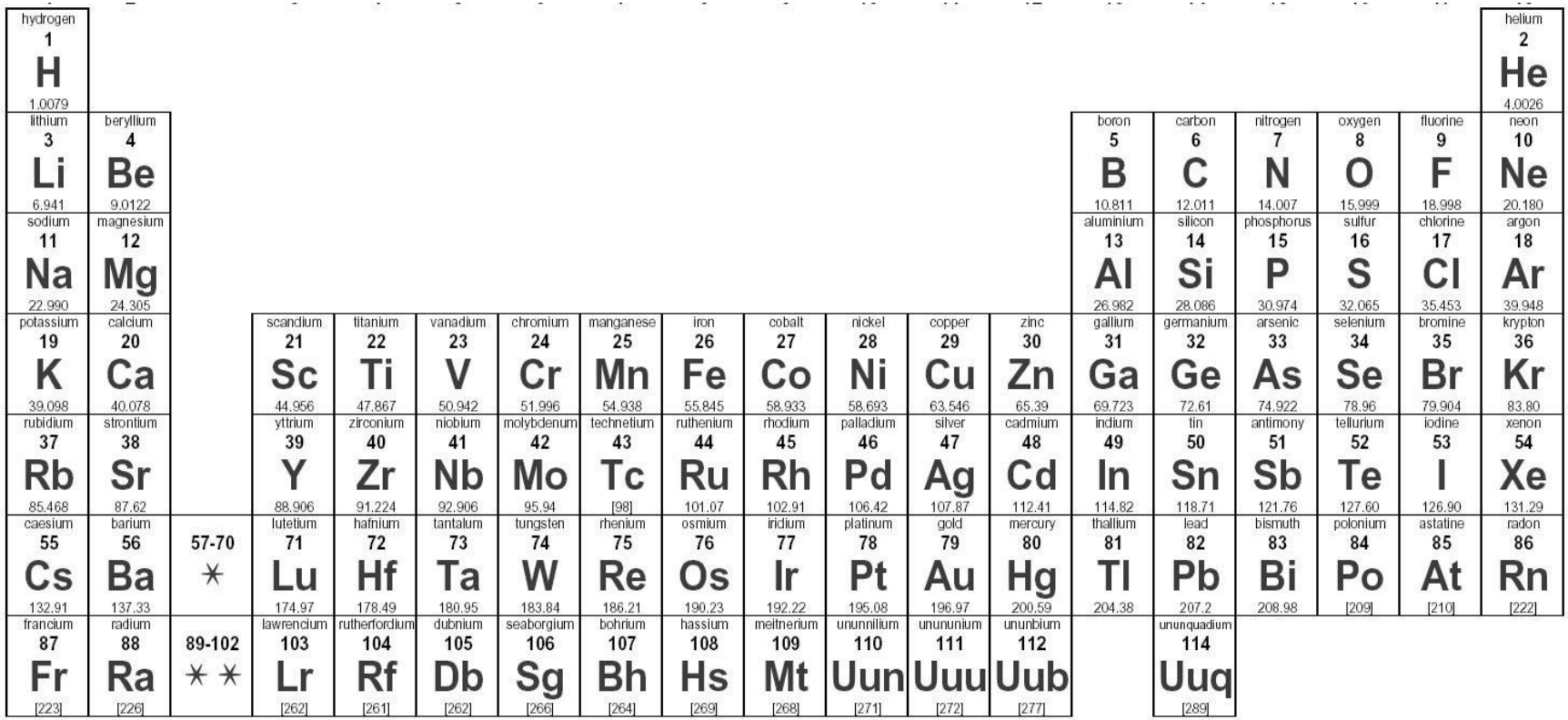
hydrogen 1 H 1.0079
helium 2 He 4.0026
lithium 3 Li 6.941
beryllium 4 Be 9.0122
boron 5 B 10.811
carbon 6 C 12.011
nitrogen 7 N 14.007
oxygen 8 O 15.999
fluorine 9 F 18.998
neon 10 Ne 20.180
sodium 11 Na 22.990
magnesium 12 Mg 24.305
aluminium 13 Al 26.982
silicon 14 Si 28.086
phosphorus 15 P 30.974
sulfur 16 S 32.065
chlorine 17 Cl 35.453
argon 18 Ar 39.948
potassium 19 K 39.098
calcium 20 Ca 40.078
scandium 21 Sc 44.956
titanium 22 Ti 47.867
vanadium 23 V 50.942
chromium 24 Cr 51.996
manganese 25 Mn 54.938
iron 26 Fe 55.845
cobalt 27 Co 58.933
nickel 28 Ni 58.693
copper 29 Cu 63.546
zinc 30 Zn 65.39
gallium 31 Ga 69.723
germanium 32 Ge 72.61
arsenic 33 As 74.922
selenium 34 Se 78.96
bromine 35 Br 79.904
krypton 36 Kr 83.80
rubidium 37 Rb 85.468
strontium 38 Sr 87.62
yttrium 39 Y 88.906
zirconium 40 Zr 91.224
niobium 41 Nb 92.906
molybdenum 42 Mo 95.94
technetium 43 Tc [98]
ruthenium 44 Ru 101.07
rhodium 45 Rh 102.91
palladium 46 Pd 106.42
silver 47 Ag 107.87
cadmium 48 Cd 112.41
indium 49 In 114.82
tin 50 Sn 118.71
antimony 51 Sb 121.76
tellurium 52 Te 127.60
iodine 53 I 126.90
xenon 54 Xe 131.29
caesium 55 Cs 132.91
barium 56 Ba 137.33
57-70 ✶
lutetium 71 Lu 174.97
hafnium 72 Hf 178.49
tantalum 73 Ta 180.95
tungsten 74 W 183.84
rhenium 75 Re 186.21
osmium 76 Os 190.23
iridium 77 Ir 192.22
platinum 78 Pt 195.08
gold 79 Au 196.97
mercury 80 Hg 200.59
thallium 81 Tl 204.38
lead 82 Pb 207.2
bismuth 83 Bi 208.98
polonium 84 Po [209]
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radon 86 Rn [222]
francium 87 Fr [223]
radium 88 Ra [226]
89-102 ✶ ✶
lawrencium 103 Lr [262]
rutherfordium 104 Rf [261]
dubnium 105 Db [262]
seaborgium 106 Sg [266]
bohrium 107 Bh [264]
hassium 108 Hs [269]
meitnerium 109 Mt [268]
ununnilium 110 Uun [271]
unununium 111 Uuu [272]
ununbium 112 Uub [277]
ununquadium 114 Uuq [289]
*Lanthanide series
lanthanum 57 La 138.91
cerium 58 Ce 140.12
praseodymium 59 Pr 140.91
neodymium 60 Nd 144.24
promethium 61 Pm [145]
samarium 62 Sm 150.36
europium 63 Eu 151.96
gadolinium 64 Gd 157.25
terbium 65 Tb 158.93
dysprosium 66 Dy 162.50
holmium 67 Ho 164.93
erbium 68 Er 167.26
thulium 69 Tm 168.93
ytterbium 70 Yb 173.04
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thorium 90 Th 232.04
protactinium 91 Pa 231.04
uranium 92 U 238.03
neptunium 93 Np [237]
plutonium 94 Pu [244]
americium 95 Am [243]
curium 96 Cm [247]
berkelium 97 Bk [247]
californium 98 Cf [251]
einsteinium 99 Es [252]
fermium 100 Fm [257]
mendelevium 101 Md [258]
nobelium 102 No [259]