OCR
Oxford Cambridge and RSA

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Wednesday 15 June 2016 – Afternoon

GCSE TWENTY FIRST CENTURY SCIENCE CHEMISTRY A/ADDITIONAL SCIENCE A

A172/02 Modules C4 C5 C6 (Higher Tier)

Candidates answer on the Question Paper.
A calculator may be used for this paper.

OCR supplied materials:
None

Other materials required:
- Pencil
- Ruler (cm/mm)

Duration: 1 hour

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The quality of written communication is assessed in questions marked with a pencil (✎).
- 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 **60**.
- This document consists of **24** pages. Any blank pages are indicated.
- A list of qualitative tests for ions is printed on page **2**.
- The Periodic Table is printed on the back page.

Turn over

TWENTY FIRST CENTURY SCIENCE DATA SHEET

Qualitative analysis

Tests for ions with a positive charge

Ion	Test	Observation
calcium Ca^{2+}	add dilute sodium hydroxide	a white precipitate forms; the precipitate does not dissolve in excess sodium hydroxide
copper Cu^{2+}	add dilute sodium hydroxide	a light blue precipitate forms; the precipitate does not dissolve in excess sodium hydroxide
iron(II) Fe^{2+}	add dilute sodium hydroxide	a green precipitate forms; the precipitate does not dissolve in excess sodium hydroxide
iron(III) Fe^{3+}	add dilute sodium hydroxide	a red-brown precipitate forms; the precipitate does not dissolve in excess sodium hydroxide
zinc Zn^{2+}	add dilute sodium hydroxide	a white precipitate forms; the precipitate dissolves in excess sodium hydroxide

Tests for ions with a negative charge

Ion	Test	Observation
carbonate CO_3^{2-}	add dilute acid	the solution effervesces; carbon dioxide gas is produced (the gas turns lime water from colourless to milky)
chloride Cl^-	add dilute nitric acid, then add silver nitrate	a white precipitate forms
bromide Br^-	add dilute nitric acid, then add silver nitrate	a cream precipitate forms
iodide I^-	add dilute nitric acid, then add silver nitrate	a yellow precipitate forms
sulfate SO_4^{2-}	add dilute acid, then add barium chloride or barium nitrate	a white precipitate forms

Answer **all** the questions.

1 In 1864, a chemist called John Newlands had an idea of arranging the elements in order, depending on their chemical properties.

He called his idea the 'Law of Octaves'.

(a) Newlands put elements with similar properties together.

He put lithium, sodium and potassium together.

Give **two** ways that the properties of lithium, sodium and potassium are similar.

....

....

....

.... **[2]**

(b) The table shows Newlands' arrangement of some of the elements.

He put elements with similar properties into the same row of his table.

Row			
1	^{1}H	^{19}F	$^{35.5}Cl$
2	^{7}Li	^{23}Na	^{39}K
3	^{9}Gl	^{24}Mg	^{40}Ca
4	^{11}Bo	^{27}Al	^{52}Cr
5	^{12}C	^{28}Si	^{48}Ti
6	^{14}N	^{31}P	^{55}Mn
7	^{16}O	^{32}S	^{56}Fe

(i) The symbols that Newlands used for some of the elements are different to those on the Periodic Table today.

The numbers shown with each symbol give the atomic mass of each element.

What symbols do we use today for the elements ^{9}Gl and ^{11}Bo in Newlands' table?

^{9}Gl .... ^{11}Bo .... **[2]**

(ii) Nina and Marty discuss Newlands' table.

Nina

Marty

Explain why Marty is right. Use elements in row 5 to support your answer.

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.... **[2]**

(iii) Newlands' table does not include any elements from one of the groups in the Periodic Table.

Identify the missing group and suggest why Newlands could not include these elements in his table.
Use the Periodic Table to help you.

....

.... **[2]**

(c) Newlands' arrangement was based on putting the elements in order of their relative atomic masses.

Mendeleev improved Newlands' arrangement.
Mendeleev reversed the order of some elements and left gaps.
His arrangement worked for more elements.

(i) Why did reversing the order of some elements and leaving gaps make the arrangement work for more elements?

....

....

.... **[2]**

(ii) What decides the order of elements in the Periodic Table today?

Put a tick (✓) in the box next to the correct answer.

the number of neutrons in the atom ☐

the proton number ☐

the type of bonds the elements form ☐

the relative atomic mass ☐

[1]

[Total: 11]

2 Joe collects some samples of a mineral.

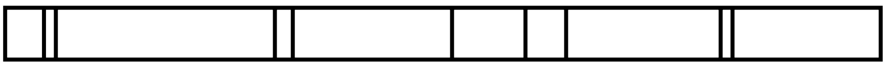
He thinks the mineral contains Group 1 elements.

He looks up the flame colours and the emission spectra for some Group 1 elements.

Element	**Flame colour**	**Emission spectrum**
lithium	red	
sodium	very strong yellow-orange	
potassium	pale purple	
rubidium	purple	

He does a flame test and records the emission spectrum produced by the mineral.

These are his results.

	Flame colour	**Emission spectrum**
mineral	yellow-orange	

What conclusions can you make about which elements the mineral **does** and **does not** contain? Give your reasons and explain why neither the flame test nor the emission spectra data can be used to identify **all** of the elements in the mineral. **[6]**

The quality of written communication will be assessed in your answer.

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[Total: 6]

3 The table gives some information about the elements in Group 7.

(a) Complete the table by filling in the missing information.

Element	**Normal state at room temperature**	**Colour at room temperature**
fluorine	gas	pale yellow
chlorine		
bromine		
iodine		grey

[2]

(b) Which statements about the atoms of the elements in Group 7 are true?

Put ticks (✓) in the boxes next to the two correct answers.

The all have the same number of electron shells. ☐

They all have the same number of outer shell electrons. ☐

They all form ions with the same charge. ☐

They all have the same charge on the nucleus. ☐

They all form ions by losing electrons. ☐

[2]

(c) Group 7 elements are *diatomic*.
What does this mean?

....

....

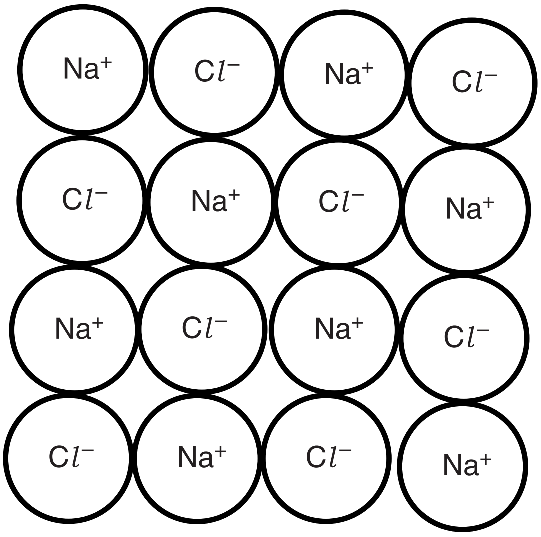
.... **[2]**

[Total: 6]

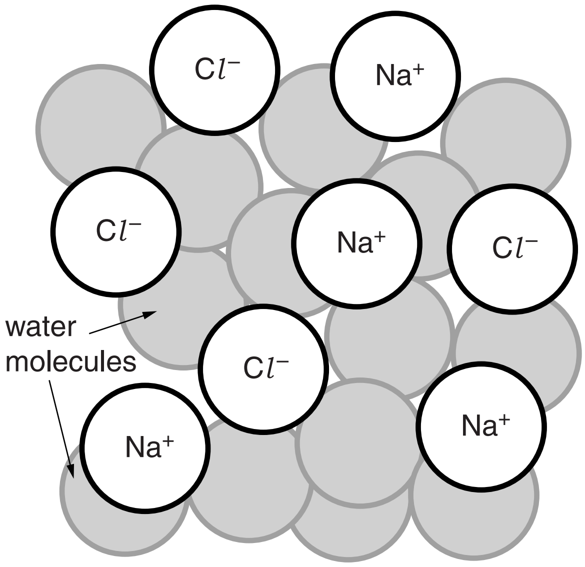
4 Sodium chloride is the main compound in common salt.

(a) Solid salt has very different properties compared to salt dissolved in water.

These diagrams show the structures of solid salt and salt dissolved in water (salt solution).



solid salt



salt solution

State and explain how the properties and structure of solid salt change when it dissolves in water, using ideas from the diagrams to support your answer.

The quality of written communication will be assessed in your answer.

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.... **[6]**

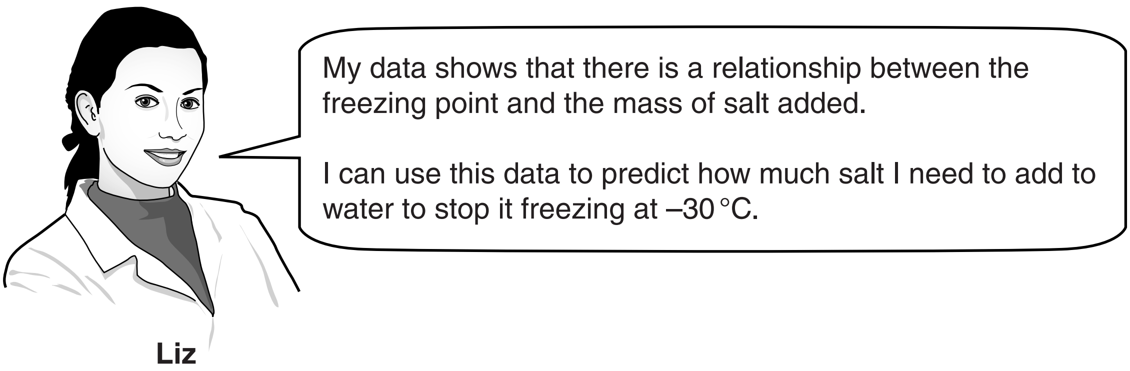
(b) Salt is put on roads in winter because it lowers the freezing point of water.

Liz does some experiments to investigate whether salt can be used to stop water from freezing in extreme weather conditions.

She adds different masses of salt to 100 cm^3 of water and records the temperature when the water freezes.
Here are her results.

Mass of salt added to 100 cm^3 water in g	Freezing point in °C
0.0	0
5.0	–3
10.0	–6
15.0	–9

Liz talks about her results.



(i) What is the relationship shown in this data between the mass of salt added and the freezing point?

....

....

.... **[2]**

(ii) Use the relationship to predict how much salt would need to be added to 100 cm^3 of water to lower the freezing point to –30 °C.

Show your working.

[2]

(c) Liz does some more experiments using two higher masses of salt.

These are her results.

Mass of salt added to 100 cm^3 water in g	**Freezing point in °C**
25.0	–15
35.0	–5

(i) Liz thinks that these results do not fully match predictions made based on the trend in the previous table.

Explain why she is right.

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....

.... **[3]**

(ii) Liz wants to investigate the relationship between mass of salt and the freezing point of water when she adds up to 50.0 g of salt.

Describe what experiments she should do.

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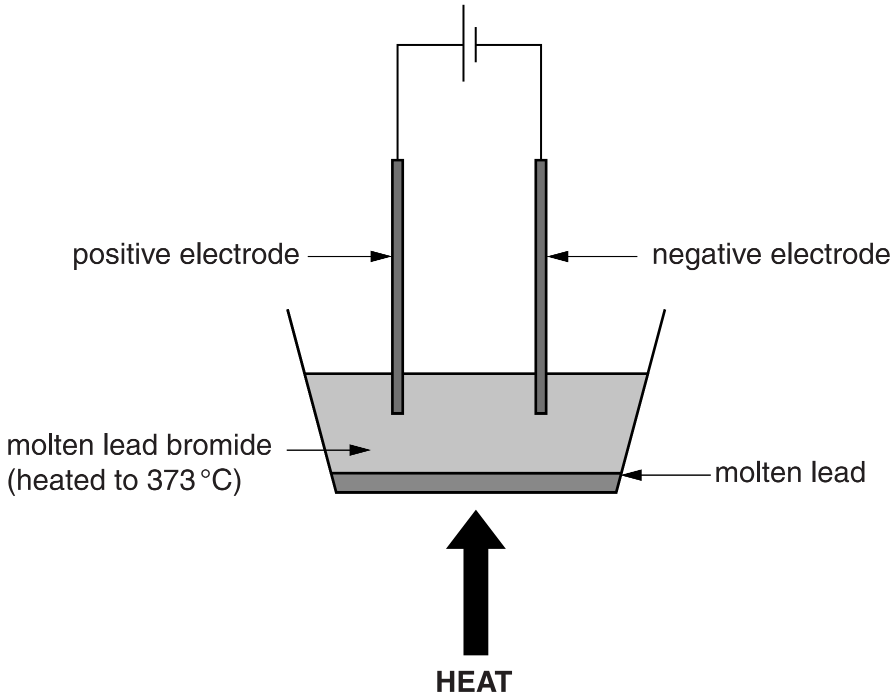
.... **[3]**

[Total: 16]

5 The melting point of lead bromide is 373 °C.

Molten lead bromide can be electrolysed using this apparatus.



(a) During the electrolysis lead forms at one electrode.
The lead collects as a liquid at the bottom of the container.

What does this tell you about the melting point of lead?

....

.... **[1]**

(b) At which electrode would you expect lead to form?
Explain your reasoning.

....

.... **[1]**

(c) The formula for lead bromide is $PbBr_2$.

This is the half equation that shows what happens to the bromide ions during the electrolysis.

$$2Br^- \rightarrow Br_2 + 2e^-$$

Write a half equation to show what happens to the lead ions during the electrolysis.

[2]

[Total: 4]

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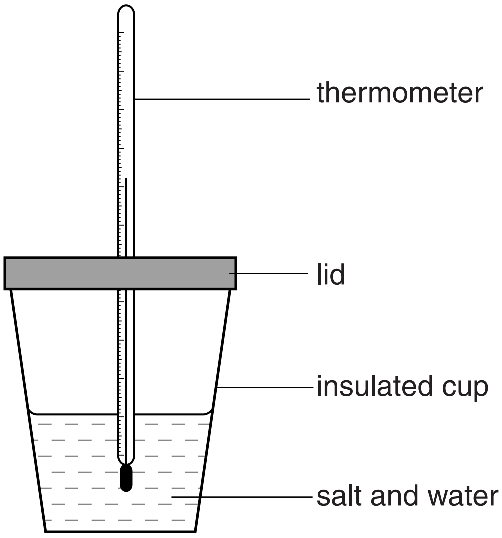
6 Rose investigates the energy changes when three salts dissolve in water.

She adds the same amount of each salt to the same amount of water.

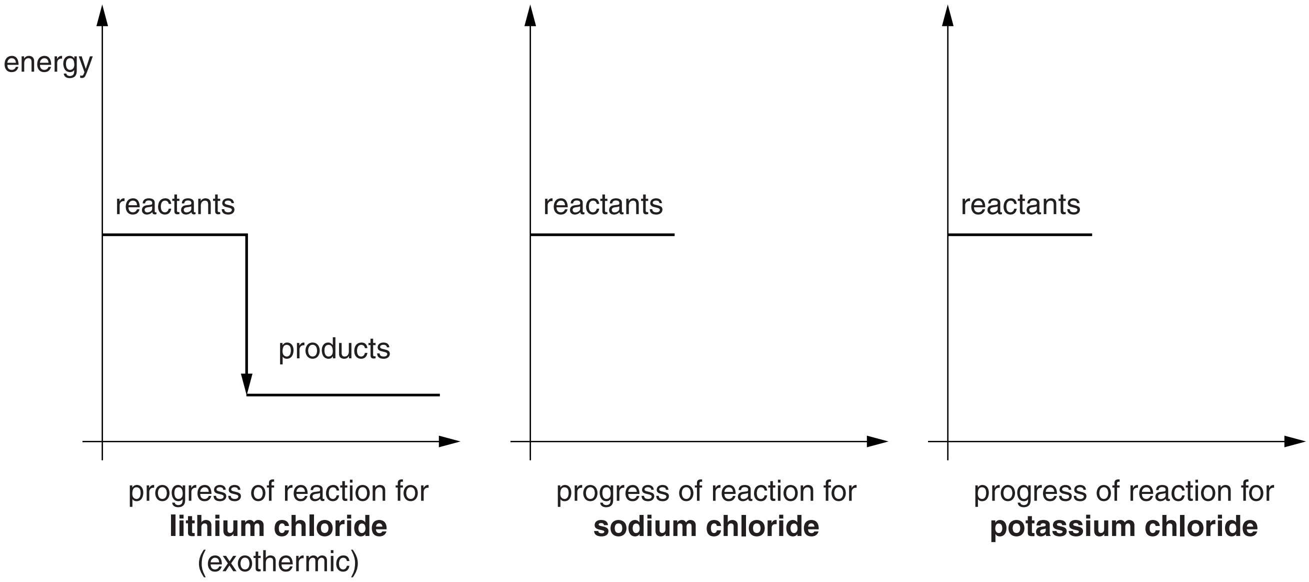
She measures the maximum temperature change when each salt dissolves.



The table shows her results.

Salt	Temperature change in °C	Type of energy change
lithium chloride	+7.0	exothermic
sodium chloride	–0.5	endothermic
potassium chloride	–4.0	endothermic

Complete and label the energy level diagrams. Compare the changes in temperature and energy that happen when each salt dissolves.



The quality of written communication will be assessed in your answer.

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.... **[6]**

[Total: 6]

7 Matt finds out some information about the bonding in some compounds and the ions that they produce when they dissolve in water.
He dissolves the compounds in water and tests their pH values.

The table shows his results.

Compound	**Bonding in compound**	**When dissolved in water**		
		Positive ion	**Negative ion**	**pH**
sodium hydroxide	ionic	sodium	hydroxide	14
calcium bromide	ionic	calcium	bromide	7
ammonia	covalent	ammonium	hydroxide	9
hydrogen chloride	covalent	hydrogen	chloride	1
ethanoic acid	covalent	hydrogen	ethanoate	3
calcium hydroxide	ionic	calcium	hydroxide	12
citric acid	covalent	hydrogen	citrate	3

(a) Which compounds in the table are acidic?
Put a tick (✓) in the boxes next to each correct answer.

sodium hydroxide ☐

calcium bromide ☐

ammonia ☐

hydrogen chloride ☐

ethanoic acid ☐

calcium hydroxide ☐

citric acid ☐

[1]

(b) Matt looks at the information and puts forward this idea.

I can identify the alkalis from their pH values. I think all alkalis are ionic and one of the ions they produce is always the same.

Does the data support Matt's ideas?

Explain your reasoning.

....

....

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.... **[2]**

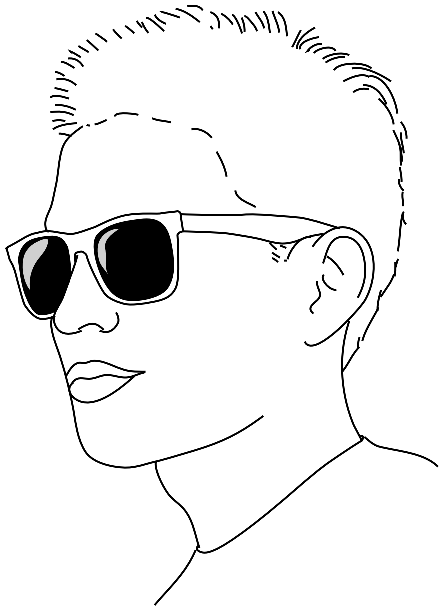
(c) Draw straight lines to show the state of pure ethanoic acid and pure citric acid at room temperature.

	solid
ethanoic acid	
	liquid
citric acid	
	gas

[2]

[Total: 5]

8 Silver chloride is a salt that is used to make lenses that darken in bright light.



(a) Silver chloride can be made from silver nitrate in a precipitation reaction.

This is the symbol equation for the reaction.

$$AgNO_3(aq) \quad + \quad NaCl(aq) \quad \rightarrow \quad AgCl(s) \quad + \quad NaNO_3(aq)$$

(i) Explain how this equation shows that silver chloride forms as a precipitate.

....

.... **[1]**

(ii) Write a word equation for the reaction.

[1]

(b) When light shines on silver chloride, Ag*Cl*, a solid forms which makes the lenses go dark.

The solid is silver metal.

Suggest the name of the **other** element that forms in the reaction.

.... **[1]**

(c) Silver chloride is made using precipitation.
Sodium chloride can be made using titration. Sodium chloride is a soluble salt.

What techniques are needed to produce pure, dry samples of solid silver chloride and solid sodium chloride?
Put a tick (✓) in one box in each row.

Technique	Needed for silver chloride	Needed for sodium chloride	Needed for both
filtration of reaction mixture			
heating strongly to evaporate water			
leaving in a warm oven			

[3]

[Total: 6]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

The Periodic Table of the Elements

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1	2											3	4	5	6	7	0
						1 **H** hydrogen 1											4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **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	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

***** *The lanthanoids (atomic numbers 58-71) and the actinoids (atomic numbers 90-103) have been omitted.*

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.