



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

CANDIDATE
NAME

CENTER
NUMBER

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CANDIDATE
NUMBER

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CHEMISTRY (US)

0439/21

Paper 2

October/November 2013

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Center number, candidate number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may need to use a pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

A copy of the Periodic Table is printed on page 16.

You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

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

This document consists of **14** printed pages and **2** blank pages.



1 (a) Choose from the list of elements below to answer the following questions.

- calcium
- helium
- iodine
- nickel
- nitrogen
- sodium
- sulfur

Each element can be used once, more than once or not at all.

Which element:

- (i) is an element present in most fertilizers, [1]
- (ii) is in Group VI of the Periodic Table, [1]
- (iii) is in Period 5 of the Periodic Table, [1]
- (iv) has a single electron shell containing two electrons, [1]
- (v) is a transition element, [1]
- (vi) forms ions with a single negative charge? [1]

(b) What is the meaning of the term *element*?

.....
 [1]

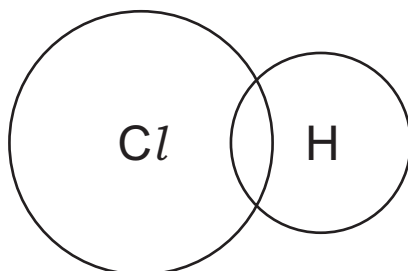
(c) Many of the elements in the Periodic Table have metallic properties. Describe **three** physical properties which are typical of most metals.

- 1.
- 2.
- 3. [3]

[Total: 10]

2 Hydrogen chloride is an acidic gas.

- (a) (i) Complete the dot and cross diagram to show the electronic structure of hydrogen chloride.



[2]

- (ii) Is hydrogen chloride a covalent or an ionic compound?
Give a reason for your answer.

..... [1]

- (b) Hydrogen chloride reacts with water to form hydrochloric acid.
Which one of the following is the most likely pH of hydrochloric acid?
Put a ring around the correct answer.

pH2 pH7 pH9 pH14

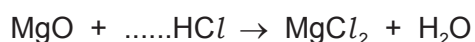
[1]

- (c) Hydrochloric acid reacts with both metal oxides and carbonates.

- (i) Complete the word equation for the reaction of hydrochloric acid with calcium carbonate.

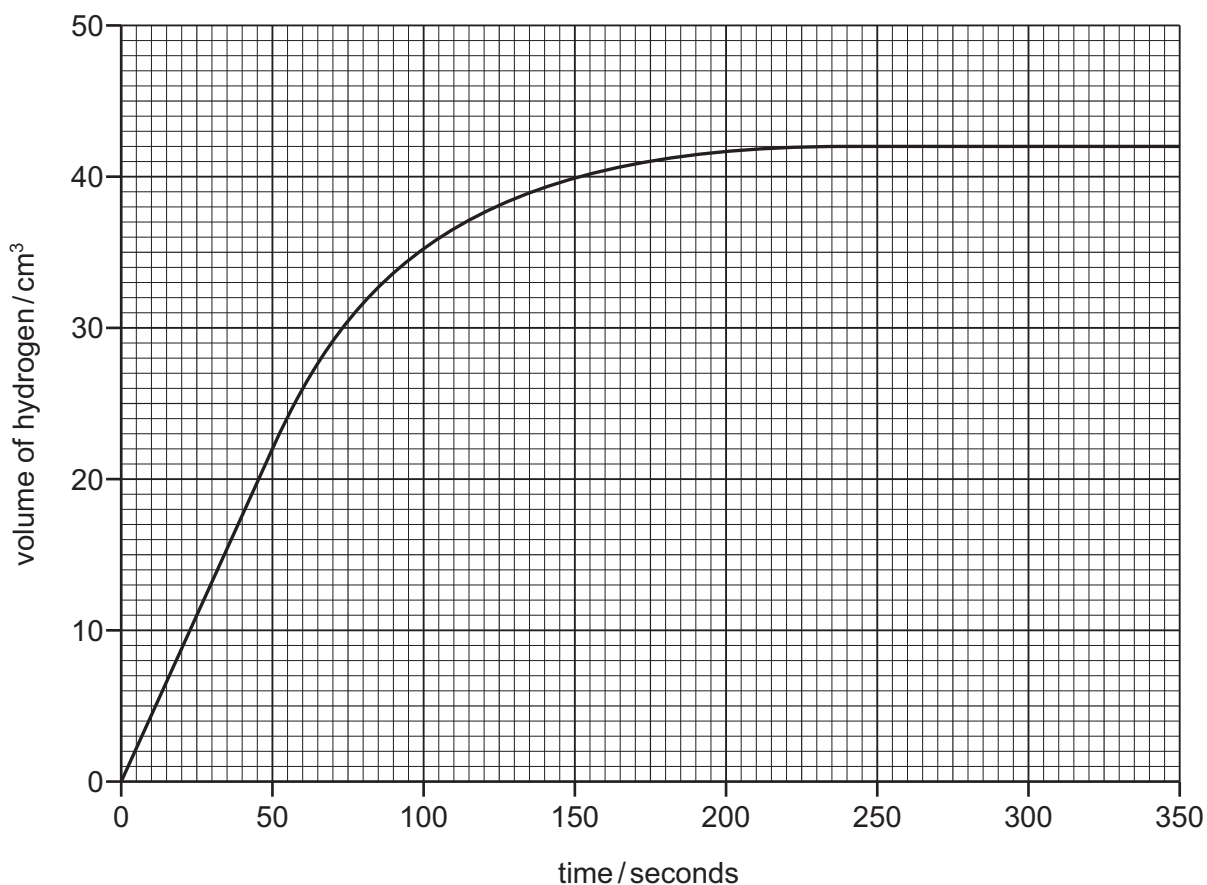
hydrochloric + calcium → + +
acid carbonate
..... [3]

- (ii) Complete the symbol equation for the reaction of magnesium oxide with hydrochloric acid. Name the salt which is formed.



name of salt [2]

- (d) A student reacted magnesium with hydrochloric acid to find out how concentration affects the rate of reaction. The magnesium was in excess. He measured the volume of hydrogen produced at various time intervals. The graph shows his results.



- (i) At what time had the reaction just finished?
 [1]
- (ii) What volume of hydrogen gas is given off during the first 50 seconds of the reaction?
 volume of hydrogen cm³ [1]
- (iii) The student repeated the experiment.
 State **two** factors, apart from the concentration of hydrochloric acid, that should be kept constant when repeating the experiment.
1.
2. [2]

[Total: 13]

3 Organic compounds can be put into groups called homologous series.

(a) Complete the following sentences about organic compounds and homologous series. Use words from the list below.

carbon chlorine different elements functional
hydrocarbon hydrogen oxide similar sulfur

Organic compounds usually contain atoms of and

Each homologous series contains compounds with chemical properties due to the presence of the same group. [4]

(b) Ethanol belongs to the alcohol homologous series.

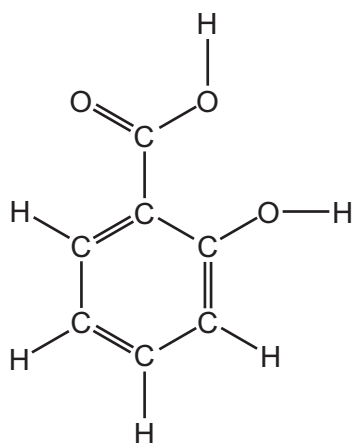
(i) Draw the structure of ethanol, showing all atoms and bonds.

[2]

(ii) State the name of the **two** compounds formed when ethanol burns in excess air.

..... and [2]

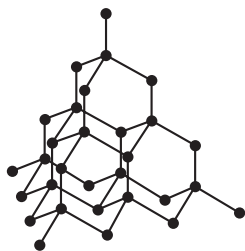
- (c) Salicylic acid is used to make aspirin.
The structure of salicylic acid is shown below.



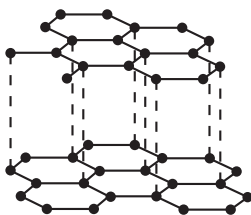
- (i) On this structure, put a ring around the carboxylic acid functional group. [1]
- (ii) How many carbon atoms are there in one molecule of salicylic acid?
..... [1]
- (iii) When making drugs and medicines, it is important that the chemicals used are pure.
State **one** other area of everyday life where purity is important.
..... [1]

[Total: 11]

4 The structures of diamond and graphite are shown below.



diamond



graphite

• = carbon atom

(a) Describe the similarities and differences between these structures.

.....

.....

.....

.....

.....

..... [4]

(b) Graphite burns in excess air to form carbon dioxide.
Describe a test for carbon dioxide.

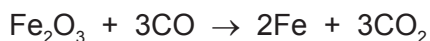
test

result [2]

(c) When graphite is burnt in a limited supply of air, carbon monoxide is formed.
State **one** adverse effect of carbon monoxide on health.

..... [1]

(d) In the blast furnace for the production of iron, carbon monoxide reduces iron(III) oxide.



How does this equation show that carbon monoxide is acting as a reducing agent?
..... [1]

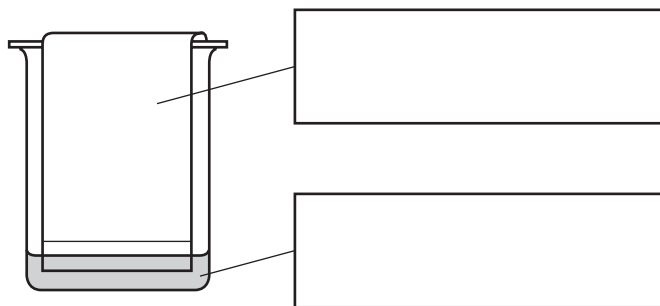
(e) Iron(III) oxide and coke (carbon) are raw materials used in the production of iron.
State the names of **two** other raw materials used in the blast furnace for the production of iron.

1.

2. [2]

[Total: 10]

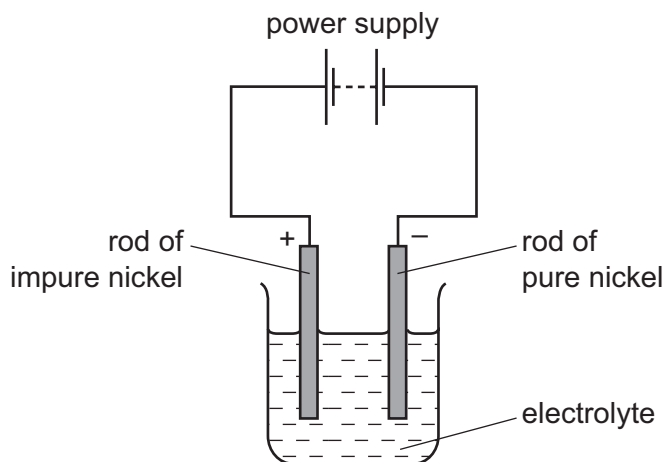
- 5 Many plants contain colored pigments. A student crushes some plant leaves in alcohol to extract the pigments. She then separates the pigments using the apparatus shown below.



- (a) Write the correct labels in the boxes in the diagram above. [2]
- (b) Draw an **X** on the diagram above to show where a drop of the pigment solution is placed at the start of the experiment. [1]
- (c) After leaving the apparatus for half an hour, the pigments separated from each other. State the name given to this method of separating pigments.

..... [1]

- (d) Some plants can absorb nickel from the ground. The nickel can then be extracted from the plants and purified by electrolysis.



- (i) Which one of the following is the most suitable electrolyte for this electrolysis. Tick **one** box.

- | | |
|----------------------------|--------------------------|
| aqueous copper(II) sulfate | <input type="checkbox"/> |
| aqueous nickel(II) sulfate | <input type="checkbox"/> |
| solid nickel(II) sulfate | <input type="checkbox"/> |
| water | <input type="checkbox"/> |

[1]

- (ii) Which one of the following elements is most likely to be formed at the negative electrode during this electrolysis?
Put a ring around the correct answer.

chlorine nickel sulfur oxygen

[1]

- (iii) The positive electrode is called the anode.
State the name of the negative electrode.

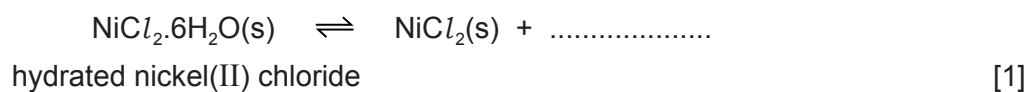
..... [1]

- (e) Electroplating is used to put a thin layer of one metal on top of another by electrolysis.
Give **two** reasons for electroplating metals.

1.

2. [2]

- (f) (i) Hydrated nickel(II) chloride is green in color.
When hydrated nickel(II) chloride is heated gently, it changes color from green to white.
Complete the symbol equation for this reaction.



- (ii) What does the sign \rightleftharpoons mean?

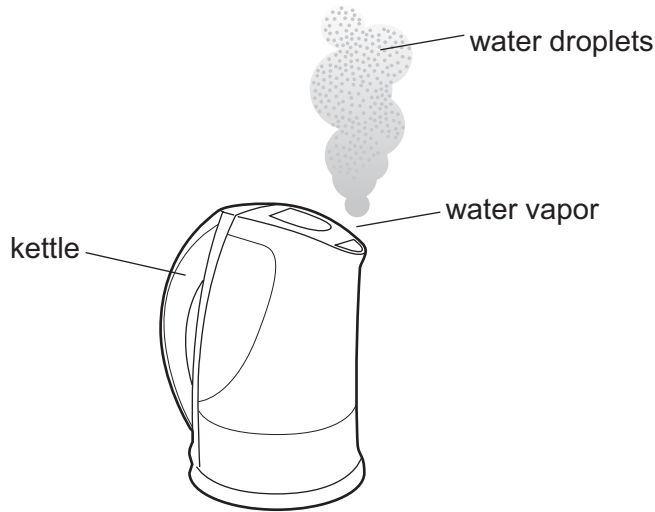
..... [1]

- (iii) How can you obtain a sample of green nickel(II) chloride starting with white nickel(II) chloride?

..... [1]

[Total: 12]

6 The diagram shows a kettle of boiling water.



As the water vapor cools it turns back to water droplets.

(a) Describe this change of state in terms of the kinetic particle theory. In your answer, include

- the difference in the closeness of the water molecules as the water vapor changes to water,
- the difference in the motion of the water molecules as the water vapor changes to water.

.....

.....

.....

.....

.....

..... [4]

(b) Water is a common solvent in the laboratory.

(i) What is meant by the term *solvent*?

..... [1]

(ii) State the name of the solvent whose formula is C₂H₅OH.

..... [1]

(c) When ammonium chloride dissolves in water the temperature of the solution falls. State the name of the energy change which results in the temperature falling.

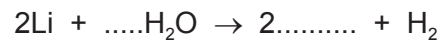
..... [1]

- (d) Which one of the following conducts electricity.
Tick **one** box.

aqueous ammonium chloride	<input type="checkbox"/>
solid ammonium chloride	<input type="checkbox"/>
ammonia gas	<input type="checkbox"/>
chlorine gas	<input type="checkbox"/>

[1]

- (e) (i) Complete the symbol equation for the reaction of lithium with water to form lithium hydroxide and hydrogen.



[2]

- (ii) When 14 g of lithium react with water, 4 g of hydrogen are formed.
Calculate the mass of hydrogen formed when 70 g of lithium react with water.

[1]

[Total: 11]

7 The table shows some properties of seven different substances.

substance	density /g per cm ³	relative strength	relative electrical conductivity	relative thermal conductivity
aluminum	2.7	15	42	200.0
ceramic	2.5	15	does not conduct	1.6
copper	8.9	20	63	385.0
iron	7.9	25	11	80.0
lead	11.4	15	5	38.0
poly(ethene)	0.9	1	does not conduct	0.3
steel	7.8	90	2	25.0

(a) Use the information in this table to answer the following questions.

(i) Which substance is the best conductor of heat?

..... [1]

(ii) Suggest why copper is preferred to iron for electrical wiring in houses.

..... [1]

(iii) What property of ceramic makes it a good electrical insulator?

..... [1]

(iv) Which pure metal in the table conducts electricity least well?

..... [1]

(v) Suggest why steel rather than iron is used in making machinery.

..... [1]

(vi) Which metal in the table is the most dense?

..... [1]

(b) A solution of a metal salt reacts with aqueous sodium hydroxide to form a white precipitate. The white precipitate is soluble in excess aqueous sodium hydroxide.

(i) Which one of the following ions is most likely to be present in the salt?
Put a ring around the correct answer.

- calcium copper(II) iron(II) zinc**

[1]

(ii) State the name of the white precipitate.

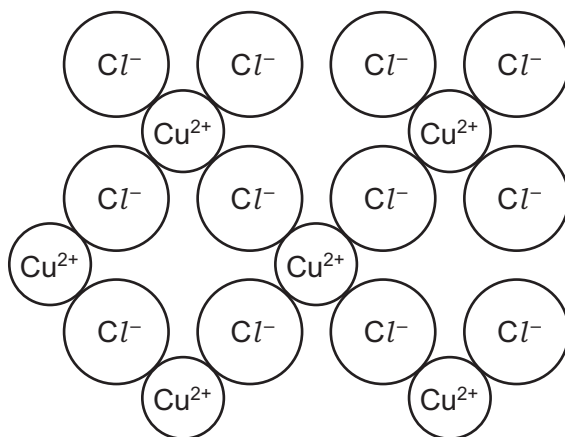
..... [1]

- (c) Copper(II) chloride can be made by the action of hydrochloric acid on copper(II) oxide. Put the statements, **A**, **B**, **C** and **D**, about this preparation in the correct order.

- A** Leave the saturated solution to crystallize.
B Filter the solution to remove excess copper(II) oxide.
C Add excess copper(II) oxide to hydrochloric acid and warm.
D Evaporate the filtrate to the crystallization point.

..... [1]

- (d) The structure of copper(II) chloride is shown below.



Write the simplest formula for copper(II) chloride.

..... [1]

- (e) Suggest the product formed at each electrode when molten copper(II) chloride is electrolyzed.

at the positive electrode

at the negative electrode [2]

- (f) When copper(II) chloride is heated strongly, a gas is given off. The gas is green in color and bleaches litmus paper. State the name of this gas.

..... [1]

[Total: 13]

DATA SHEET
The Periodic Table of the Elements

		Group																																																																																															
I	II	III	IV	V	VI	VII	0																																																																																										
7 Li Lithium 3	9 Be Beryllium 4	1 H Hydrogen 1	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 Aluminum 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	64 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	101 Ru Ruthenium 44	101 Rh Rhodium 45	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	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	212 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86																																																																																	
87 Fr Francium	226 Ra Radium	227 Ac Actinium																																																																																															
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		<table border="1" style="width: 100%; text-align: center;"> <tr> <td style="width: 20px;">a</td> <td style="width: 20px;">X</td> </tr> <tr> <td style="width: 20px;">b</td> <td style="width: 20px;"></td> </tr> </table>										a	X	b		<table border="1" style="width: 100%; text-align: center;"> <tr> <td style="width: 20px;">140</td> <td style="width: 20px;">Ce</td> <td style="width: 20px;">141</td> <td style="width: 20px;">Pr</td> <td style="width: 20px;">144</td> <td style="width: 20px;">Nd</td> <td style="width: 20px;">150</td> <td style="width: 20px;">Sm</td> <td style="width: 20px;">152</td> <td style="width: 20px;">Eu</td> <td style="width: 20px;">157</td> <td style="width: 20px;">Gd</td> <td style="width: 20px;">162</td> <td style="width: 20px;">Dy</td> <td style="width: 20px;">165</td> <td style="width: 20px;">Ho</td> <td style="width: 20px;">167</td> <td style="width: 20px;">Er</td> <td style="width: 20px;">169</td> <td style="width: 20px;">Tm</td> <td style="width: 20px;">173</td> <td style="width: 20px;">Yb</td> <td style="width: 20px;">175</td> <td style="width: 20px;">Lu</td> </tr> <tr> <td style="width: 20px;">58</td> <td style="width: 20px;">Cerium</td> <td style="width: 20px;">59</td> <td style="width: 20px;">Praseodymium</td> <td style="width: 20px;">60</td> <td style="width: 20px;">Neodymium</td> <td style="width: 20px;">62</td> <td style="width: 20px;">Samarium</td> <td style="width: 20px;">63</td> <td style="width: 20px;">Europium</td> <td style="width: 20px;">64</td> <td style="width: 20px;">Gadolinium</td> <td style="width: 20px;">66</td> <td style="width: 20px;">Dysprosium</td> <td style="width: 20px;">67</td> <td style="width: 20px;">Holmium</td> <td style="width: 20px;">68</td> <td style="width: 20px;">Erbium</td> <td style="width: 20px;">69</td> <td style="width: 20px;">Thulium</td> <td style="width: 20px;">70</td> <td style="width: 20px;">Ytterbium</td> <td style="width: 20px;">71</td> <td style="width: 20px;">Lutetium</td> </tr> <tr> <td style="width: 20px;">90</td> <td style="width: 20px;">Thorium</td> <td style="width: 20px;">91</td> <td style="width: 20px;">Protactinium</td> <td style="width: 20px;">92</td> <td style="width: 20px;">Uranium</td> <td style="width: 20px;">94</td> <td style="width: 20px;">Plutonium</td> <td style="width: 20px;">95</td> <td style="width: 20px;">Americium</td> <td style="width: 20px;">96</td> <td style="width: 20px;">Curium</td> <td style="width: 20px;">98</td> <td style="width: 20px;">Californium</td> <td style="width: 20px;">99</td> <td style="width: 20px;">Einsteinium</td> <td style="width: 20px;">100</td> <td style="width: 20px;">Fermium</td> <td style="width: 20px;">101</td> <td style="width: 20px;">Mendelevium</td> <td style="width: 20px;">102</td> <td style="width: 20px;">Nobelium</td> <td style="width: 20px;">103</td> <td style="width: 20px;">Lawrencium</td> </tr> </table>										140	Ce	141	Pr	144	Nd	150	Sm	152	Eu	157	Gd	162	Dy	165	Ho	167	Er	169	Tm	173	Yb	175	Lu	58	Cerium	59	Praseodymium	60	Neodymium	62	Samarium	63	Europium	64	Gadolinium	66	Dysprosium	67	Holmium	68	Erbium	69	Thulium	70	Ytterbium	71	Lutetium	90	Thorium	91	Protactinium	92	Uranium	94	Plutonium	95	Americium	96	Curium	98	Californium	99	Einsteinium	100	Fermium	101	Mendelevium	102	Nobelium	103	Lawrencium
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		Key										a = relative atomic mass x = atomic symbol b = proton (atomic) number																																																																																					

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

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