Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5806414091

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2014**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

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

A copy of the Periodic Table is printed on page 20.
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 **20** printed pages.

CAMBRIDGE
International Examinations

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 The diagram shows part of the Periodic Table. Only some of the elements are shown.

							H										
													C	N		F	
													Si	P	S	Cl	
			Ti				Fe			Cu	Zn			As		Br	

(a) Answer each of the following questions using only those elements shown in the diagram. Each element may be used once, more than once or not at all.

Give one element which

(i) is a simple molecular solid at room temperature and pressure,

.....[1]

(ii) oxidises in the presence of water and air to form rust,

.....[1]

(iii) has an atom with three occupied electron shells, the outer of which has only 5 electrons,

.....[1]

(iv) has an oxide which is amphoteric,

.....[1]

(v) has a chloride of type XCl_3 whose aqueous solution forms a reddish-brown precipitate on addition of aqueous ammonia,

.....[1]

(vi) is a colourless diatomic gas.

.....[1]

(b) (i) Arsenic reacts with oxygen to form arsenic(III) oxide, As_2O_3.

Construct the equation for this reaction.

.....[1]

(ii) Arsenic(III) oxide is slightly soluble in water. A weak acid, arsenous acid, H_3AsO_3, is formed.

Use kinetic particle theory to explain why a 0.05 mol / dm^3 solution of arsenous acid reacts much more slowly with magnesium ribbon than a 0.05 mol / dm^3 solution of hydrochloric acid.

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.....

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.....[2]

[Total: 9]

A2 The table shows some properties of the Group I metals.

metal	density in g/cm^3	melting point /°C	boiling point /°C
lithium	0.53	181	1342
sodium	0.97	98	883
potassium	0.86	63	
rubidium	1.53	39	686
caesium	1.88	29	669

(a) (i) Describe the general trend in the density of the Group I metals.

.....[1]

(ii) Predict the boiling point of potassium.

.....[1]

(iii) What is the physical state of caesium at 35 °C? Explain your answer.

.....

.....[1]

(b) (i) Describe the trend in reactivity of the Group I metals with water.

.....[1]

(ii) Construct the equation for the reaction of rubidium with water.

.....[1]

(iii) The reaction of rubidium with water is exothermic.
What is meant by the term *exothermic*?

.....[1]

(c) Sodium and calcium form ionic hydrides containing the hydride ion, H^-.
Sodium and calcium hydrides react with water to form the hydroxide and hydrogen.

$$NaH + H_2O \rightarrow NaOH + H_2$$

$$CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + 2H_2$$

Deduce the general ionic equation for these reactions.

.....[1]

(d) Sodium is a soft metal with little catalytic activity.
Nickel is a hard metal which is often used as a catalyst.

(i) Describe two **other** differences in the physical properties of sodium and nickel.

1 .....

.....

2 .....

.....
[2]

(ii) State one industrial use of nickel as a catalyst.

.....[1]

(iii) Explain why an alloy of nickel and copper is less malleable than copper alone.

.....

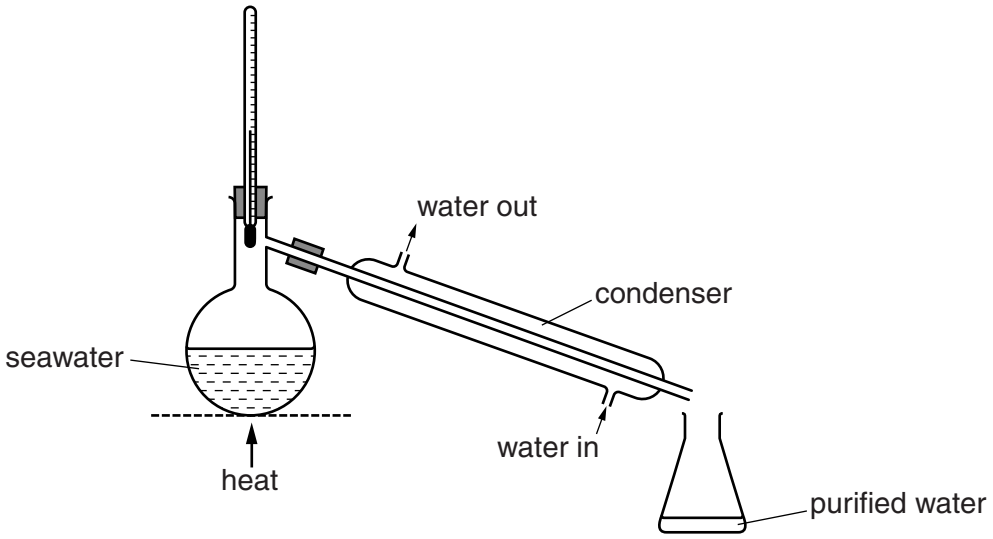
.....

.....[2]

[Total: 12]

A3 Seawater contains a variety of dissolved salts.

(a) The diagram shows a simple distillation apparatus that can be used to produce purified water from seawater.



Explain how distillation purifies seawater.

.....

.....

.....

.....[3]

(b) Magnesium chloride, $MgCl_2$, is present in seawater at a concentration of $1.26\,g/dm^3$.

(i) Write the formulae for the ions present in magnesium chloride.

.....[1]

(ii) Calculate the concentration of chloride ions, in mol/dm^3, arising from the magnesium chloride in seawater.

concentration = ... mol/dm^3 [1]

(iii) Aqueous silver nitrate is added to a small sample of seawater.
Describe what you would observe.

.....[1]

(c) The concentration of sulfate ions in seawater is $1.24\,g/dm^3$.
Excess aqueous barium chloride is added to a $50.0\,cm^3$ sample of seawater.

Calculate the mass of barium sulfate precipitated in this reaction.

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$$

mass = ... g [3]

[Total: 9]

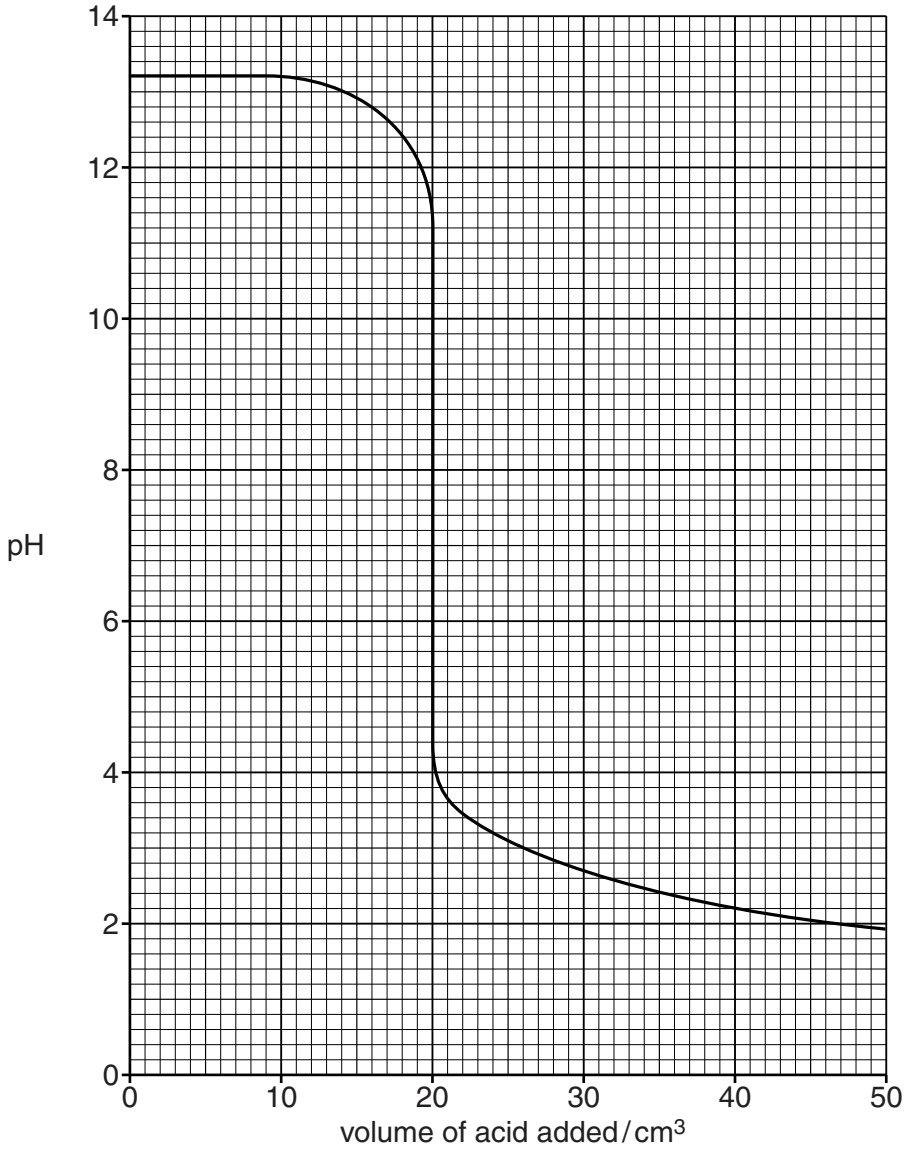
A4 Sulfuric acid reacts with the alkali sodium hydroxide.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

(a) Write the ionic equation for this reaction.

.....[1]

(b) The graph below shows how the pH changes when aqueous sulfuric acid is added slowly to 45.0 cm^3 of 0.150 mol/dm^3 sodium hydroxide until the acid is in excess.



(i) What volume of acid has been added when the pH is 7?

.....[1]

(ii) Use your answer to part **(i)** to calculate the concentration, in mol/dm^3, of the sulfuric acid.

concentration = ... mol/dm^3 [3]

(c) The experiment was repeated using ethanoic acid of the same concentration as the sulfuric acid. The same volume and concentration of aqueous sodium hydroxide was used.

(i) The volume of ethanoic acid required to neutralise the aqueous sodium hydroxide was twice as great compared with the volume of sulfuric acid.

Explain why.

.....

.....[1]

(ii) Suggest the value of the pH after excess ethanoic acid has been added.

.....[1]

(d) Sulfuric acid is one of the acids present in acid rain.

(i) Suggest how sulfuric acid is formed in the atmosphere.

.....

.....

.....[2]

(ii) State one effect of acid rain on human health.

.....[1]

[Total: 10]

A5 The table below shows the reactivity of five metals with either cold water or steam or with both.

metal	reactivity
barium	reacts rapidly with cold water
copper	no reaction with steam or cold water
magnesium	reacts very slowly with cold water but reacts with steam
sodium	reacts very rapidly with cold water
nickel	only reacts when powdered and heated strongly in steam

(a) Deduce the order of reactivity of these metals using the information in the table.

most reactive .....

.....

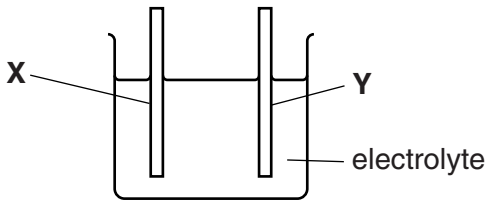
.....

.....

least reactive ..... [1]

(b) A simple electrochemical cell contains two electrodes in an electrolyte.

(i) Complete the diagram below to show how you could measure the voltage between the two different metal electrodes **X** and **Y**.



[1]

(ii) The order of reactivity of some metals is shown below.

iron	cobalt	tin	copper	silver
most reactive	←			least reactive

Which combination of metals from this list would produce the highest voltage when used as electrodes in an electrochemical cell?

.....[1]

(c) Strips of zinc can be attached to the hull of a ship to stop the steel from rusting.
Explain how these strips of zinc stop the steel from rusting.

.....

.....

.....[2]

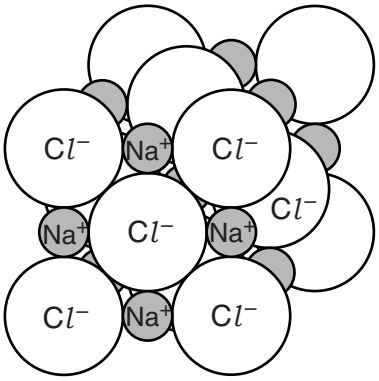
[Total: 5]

Section B

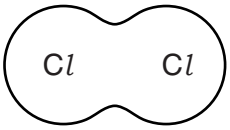
Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B6 The structures of sodium chloride and chlorine are shown below.



sodium chloride



chlorine

(a) The melting point of sodium chloride is 801 °C.
The melting point of chlorine is –101 °C.

Explain, in terms of structure and bonding, the difference between the melting points of these two substances.

.....

.....

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.....

.....

.....[4]

(b) Explain why molten sodium chloride conducts electricity but solid sodium chloride does not.

.....

.....

.....[1]

(c) Draw a 'dot-and-cross' diagram for sodium chloride, showing all the electron shells.

[2]

(d) The electrode reactions occurring when molten sodium chloride is electrolysed are shown below.

negative electrode $Na^+ + e^- \longrightarrow Na$

positive electrode $2Cl^- \longrightarrow Cl_2 + 2e^-$

Refer to these equations to explain why this electrolysis involves both oxidation and reduction.

.....

.....

.....[2]

(e) Chlorine reacts with excess ammonia, NH_3, to form hydrogen chloride and nitrogen. Construct an equation for this reaction.

.....[1]

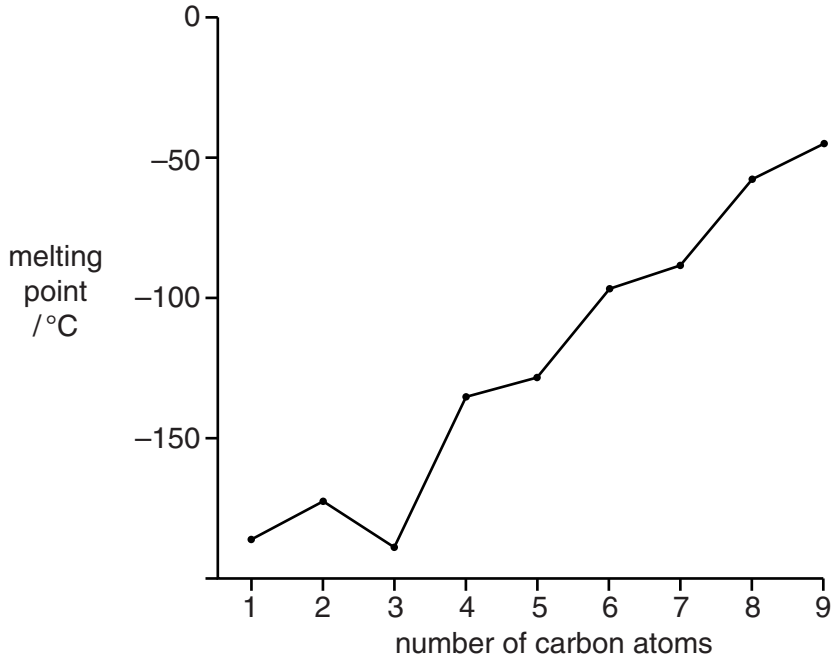
[Total: 10]

B7 The alkanes are a homologous series of hydrocarbons.

(a) Give the name of another homologous series of hydrocarbons.

.....[1]

(b) The graph below shows how the melting points of the first nine alkanes vary with the number of carbon atoms.



Describe how the melting points of the alkanes with more than two carbon atoms vary as the number of carbon atoms increases.

.....

.....

.....[2]

(c) Nonane is an alkane with nine carbon atoms.
Give the molecular formula for nonane.

.....[1]

(d) One mole of undecane, $C_{11}H_{24}$, is cracked to form a mixture containing one mole of ethene, one mole of propene and one mole of another hydrocarbon.

(i) Construct the equation for this reaction.

.....[1]

(ii) Explain why oil companies crack the longer chain hydrocarbons.

.....

.....

.....[2]

(e) Hydrogen cyanide, HCN, is manufactured by reacting methane with ammonia and oxygen.

$$2CH_4 + 2NH_3 + 3O_2 \rightarrow 2HCN + 6H_2O$$

(i) Calculate the mass of hydrogen cyanide that can be formed from 500 g of methane if the percentage yield of hydrogen cyanide is 65%.

mass = ...g [2]

(ii) Hydrogen cyanide reacts with calcium hydroxide to form calcium cyanide and water. The formula of the cyanide ion is CN^-.

Construct the equation for this reaction.

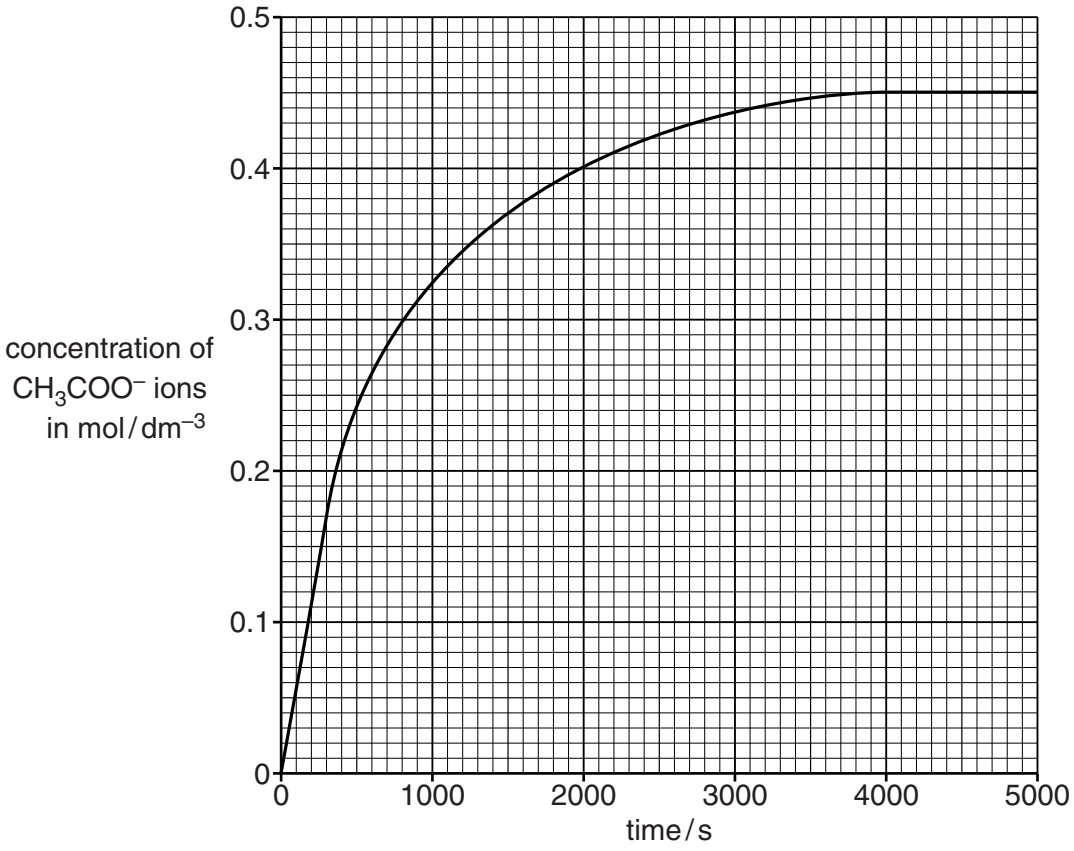
.....[1]

[Total: 10]

B8 The ester, ethyl ethanoate, reacts with hydroxide ions to form ethanoate ions and ethanol.

$$\underset{\text{ethyl ethanoate}}{CH_3COOC_2H_5} + OH^- \rightarrow \underset{\text{ethanoate ions}}{CH_3COO^-} + C_2H_5OH$$

(a) The graph shows how the concentration of ethanoate ions, CH_3COO^-, changes as the reaction proceeds.



(i) Use the information in the graph to deduce the mass of ethanoate ions in 200 cm^3 of solution when the reaction is complete.

mass = ...g [2]

(ii) Use the information in the graph to calculate the average rate of reaction, in mol/dm^3/s, during the first 300 seconds.

average rate of reaction .....mol/dm^3/s [1]

(iii) Describe and explain, using the kinetic particle theory, the change in the rate of reaction with time.

.....

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.....

.....

.....[3]

(b) Aqueous sodium hydroxide reacts with aqueous iron(II) sulfate, $FeSO_4$.
Construct the ionic equation, with state symbols, for this reaction.

.....[2]

(c) Iron(II) sulfate can be prepared by reacting excess iron powder with sulfuric acid.
Describe the essential practical details to prepare pure dry crystals of iron(II) sulfate.

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.....[2]

[Total: 10]

B9 Ammonia is manufactured by the Haber process.

$$N_2 + 3H_2 \overset{\text{Fe catalyst}}{\rightleftharpoons} 2NH_3 \qquad \Delta H = -92.4\,\text{kJ/mol}$$

The table below shows how the percentage yield of ammonia at equilibrium varies with both temperature and pressure.

pressure /atmospheres	% yield at 200 °C	% yield at 300 °C	% yield at 400 °C	% yield at 500 °C
30	68	32	11	4
100	81	51	25	10
200	86	63	36	18
300	88	69	40	24

(a) Describe how, and explain why, the percentage yield of ammonia at equilibrium changes with temperature.

.....

.....

.....[2]

(b) Describe how, and explain why, the percentage yield of ammonia at equilibrium changes with pressure.

.....

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.....[2]

(c) Explain why the conditions for the synthesis of ammonia in most chemical plants are between 350–450 °C and 200–300 atmospheres pressure.

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.....[2]

(d) Explain how using a catalyst in the Haber process has an economic advantage.

.....

.....

.....[2]

(e) Ammonia is used to make fertilisers such as ammonium phosphate, $(NH_4)_3PO_4$.
Calculate the percentage by mass of nitrogen in ammonium phosphate.

[2]

[Total: 10]

DATA SHEET
The Periodic Table of the Elements

Group I	Group II						Group III	Group IV	Group V	Group VI	Group VII	Group 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	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	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 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	244 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	247 Bk Berkelium 97	251 Cf Californium 98	252 Es Einsteinium 99	257 Fm Fermium 100	258 Md Mendelevium 101	259 No Nobelium 102	260 Lr Lawrencium 103

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key: a = relative atomic mass; X = atomic symbol; b = atomic (proton) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).