O

JURONG SECONDARY SCHOOL
2020 GRADUATION EXAMINATION
SECONDARY 4 EXPRESS

CANDIDATE NAME	

CLASS			INDEX NUMBER	

CHEMISTRY
PAPER 2

6092/02
26 August 2020
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use a 2B pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B.
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 21.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use		
Paper 1 (30%)	**MCQ [40 marks]**	
Paper 2 (50%)	**SECTION A [50 marks]**	
	SECTION B [30 marks]	
	SUB-TOTAL [80 marks]	
Paper 3 (20%)	**Practical [40 marks]**	
OVERALL %	**[100 %]**	

This document consists of **21** printed pages including this page.

[Turn over]

Section A (50 marks)

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

A1 The table shows some information for five different substances.

substance	melting point / °C	boiling point / °C	soluble in water?	electrical conductivity
A	-114	78	no	cannot conduct in any state
B	801	1465	yes	conducts in both molten and aqueous states
C	98	882	no	conducts in both solid and molten states
D	- 78	- 33	yes	conducts only in aqueous states
E	1538	2862	no	conducts in both solid and molten states

(a) Use the letters A to E to answer the following questions.

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

(i) Which substance is a liquid at 30 °C?

..... [1]

(ii) Which substance consists of ions held together by electrostatic forces?

..... [1]

(iii) Which substance may be used as a catalyst in a chemical reaction?

..... [1]

(iv) Which substance is most likely to be soft and malleable?

..... [1]

(b) Describe how the movement and arrangement of the particles in substance C will change when it is heated from 97 °C to 99 °C.

.....

.....

.....

..... [3]

(c) **(i)** Substance D is found to be hydrogen chloride.

Draw a 'dot-and-cross' diagram to show the bonding of hydrogen chloride. You should show only the electrons on the outermost shell.

[2]

(ii) Suggest a reason why hydrogen chloride can conduct electricity in aqueous state.

..... [1]

[Total: 10]

A2 The diagram below shows how various properties of an iron alloy change with increasing percentage (by mass) of carbon in the alloy.

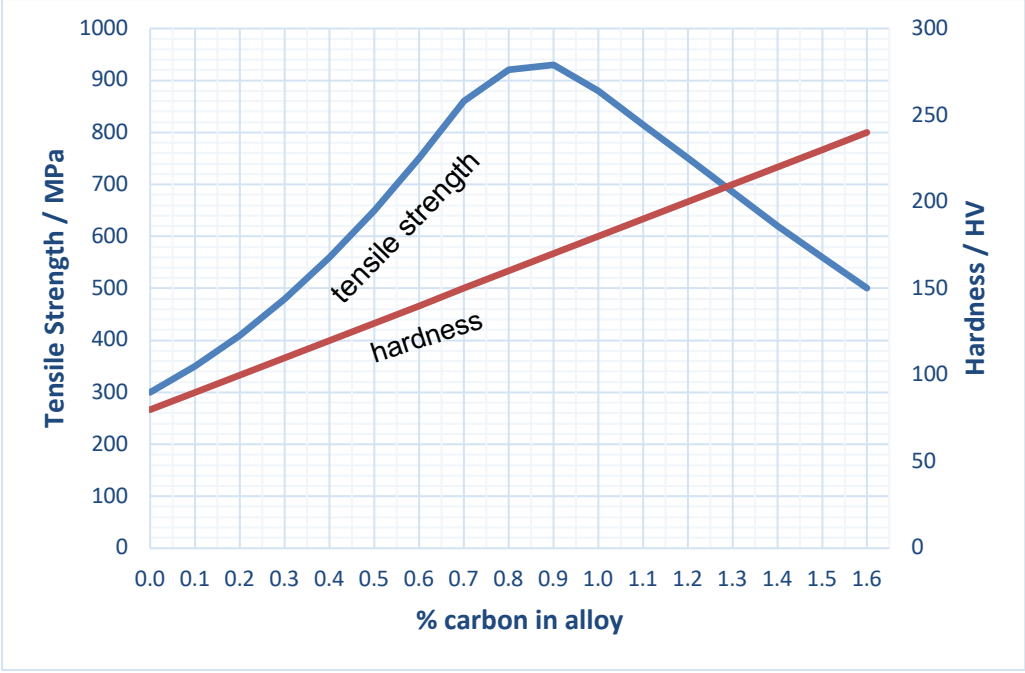


Fig. 2.1 – Properties of Iron Alloys
Data source: https://www.sciencedirect.com/topics/chemistry/carbon-steel

(a) Tensile strength is the minimum amount of force that needs to be applied to a material to cause it to fracture.

Describe how the tensile strength of iron alloys change with percentage of carbon.

.....

..... [2]

(b) Explain why the hardness of the iron alloy increases as the percentage of carbon in the alloy increases.

.....

.....

.....

..... [3]

(c) The crude molten iron (also known as pig iron) from the Blast Furnace contains 4 to 5% carbon by mass.

Explain why pig iron contains such a high proportion of carbon.

.....

..... [1]

(d) Using information from **Fig. 2.1**, explain why pig iron is usually treated to reduce the carbon content to around 1% before it can be used by the industry.

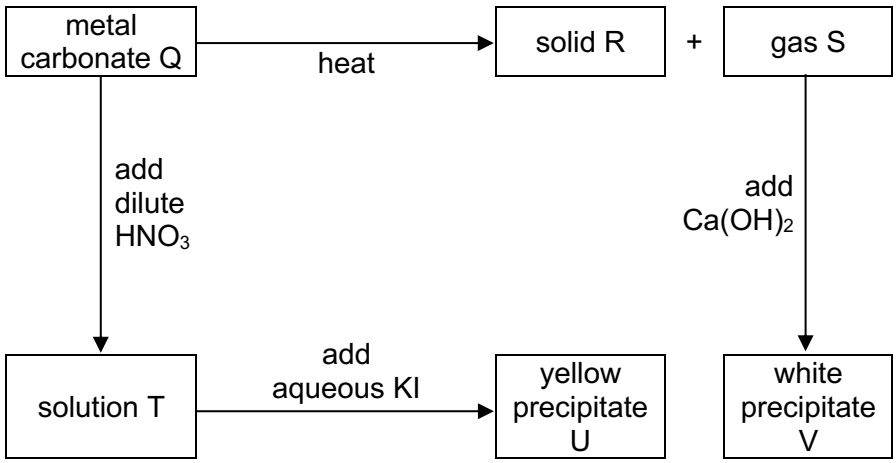
.....

.....

..... [2]

[Total: 8]

A3 A student conducted the following tests on metal carbonate Q.



(a) Name the following solids:

solid R: .....

yellow precipitate U: .....

white precipitate V: ..... [3]

(b) Describe what would be observed when aqueous sodium hydroxide is added to solution T dropwise, and then in excess.

.....

..... [1]

[Total: 4]

A4 Calcium hydroxide and ammonium sulfate are chemicals commonly used in the agricultural industry.

(a) State a use of calcium hydroxide and ammonium sulfate in agriculture.

.....

.....

..... [2]

(b) When it rains, the calcium hydroxide and ammonium sulfate in the soil react to produce a white solid.

(i) Write the chemical equation for this reaction, including state symbols.

..... [2]

(ii) Use the equation in **(b)(i)** to explain why calcium hydroxide and ammonium sulfate should **not** be added to the soil at the same time.

.....

..... [1]

(c) Concentrated sulfuric acid is sprayed in a tank of ammonia gas to produce ammonium sulfate powder.

(i) What type of reaction is this? ..... [1]

(ii) One of the steps in the production of sulfuric acid is the oxidation of sulfur dioxide to sulfur trioxide with V_2O_5 as a catalyst:

$$2SO_2\,(g) + O_2\,(g) \underset{V_2O_5\text{ catalyst}}{\overset{400\text{-}450\ °C,\ 1\text{-}2\ atm}{\rightleftharpoons}} 2SO_3\,(g)$$

State **two** similarities and **two** differences between the production of sulfur trioxide and the Haber Process.

similarity 1: .....

.....

similarity 2: .....

.....

difference 1: .....

.....

difference 2: .....

..... [4]

[Total: 10]

A5 The two tables show the data of the atomic radii and 1st ionisation energy of the atoms of Group I and Group VII elements.

1st ionisation energy is the energy that is required to remove the first electron from its gaseous atom to form an ion.

Group I		
atom	atomic radius / pm	1st ionisation energy / kJ per mol
lithium	167	526
sodium	190	504
potassium	243	425
rubidium	265	410

Group VII		
atom	atomic radius / pm	1st ionisation energy / kJ per mol
fluorine	42	1690
chlorine	79	1260
bromine	94	1150
iodine	115	1020

(a) **(i)** Using the data from the two tables, suggest why there is a decrease in the 1st ionisation energy down the group.

.....

.....

.....

.....

..... [3]

(ii) Using the knowledge of atomic structure, suggest a reason why Group 0 elements have very high 1st ionisation energy.

.....

.....

..... [2]

(b) Group VII elements exist as diatomic molecules and they react readily with other salt solutions containing halide ions.

(i) State two physical trends of Group VII elements.

.....

..... [2]

(ii) Fluorine gas is bubbled through a solution containing sodium bromide. After some time, the solution turns reddish-brown.

Explain the observation, supporting your answer with a balanced chemical equation.

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.....

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..... [3]

[Total: 10]

A6 The reaction of iron(III) sulfate with potassium iodide is a redox reaction.

$$Fe_2(SO_4)_3 + 2KI \rightarrow 2FeSO_4 + I_2 + \textbf{product X}$$

(a) Give the formula and name of **product X**.

formula .....

name ..... [2]

(b) At the end of the reaction, the solution appears brown.

Explain why.

..... [1]

(c) When molten potassium iodide is electrolysed, the product at the anode also appears brown.

Predict the observation at the *cathode* and explain the reaction that takes place.

.....

..... [2]

(d) **(i)** Complete the table to show the oxidation states of iron and iodine in the redox reaction.

element	oxidation state in reactants	oxidation state in products
iron		
iodine		

[2]

(ii) Which element is reduced in the reaction?

Use ideas about electron transfer to explain your answer.

.....

..... [1]

[Total: 8]

Section B

Answer all **three** questions from this section.

The last question is in the form either/or and only **one** of the alternatives should be attempted.

B7 Preparation of Useful Cobalt Compounds

1. The Difficulty of Cobalt Extraction

Cobalt is a metal used in many devices in modern living. However, extracting cobalt is extremely difficult and costly.

In nature, cobalt metal is obtained from ores such as carrollite ($Co_2Cu_2S_4$) and cobaltite (CoAsS), which are found in rocks that mostly contain haematite and silicon dioxide. As a result, rocks from a cobalt mine often have only 0.4% cobalt by mass.

Besides the low concentration of cobalt in rocks, cobalt has similar reactivity as iron and nickel. This makes it very difficult to separate cobalt from iron and nickel, causing the cost of cobalt to remain relatively high.

2. Cobalt(II) chloride – a test for water

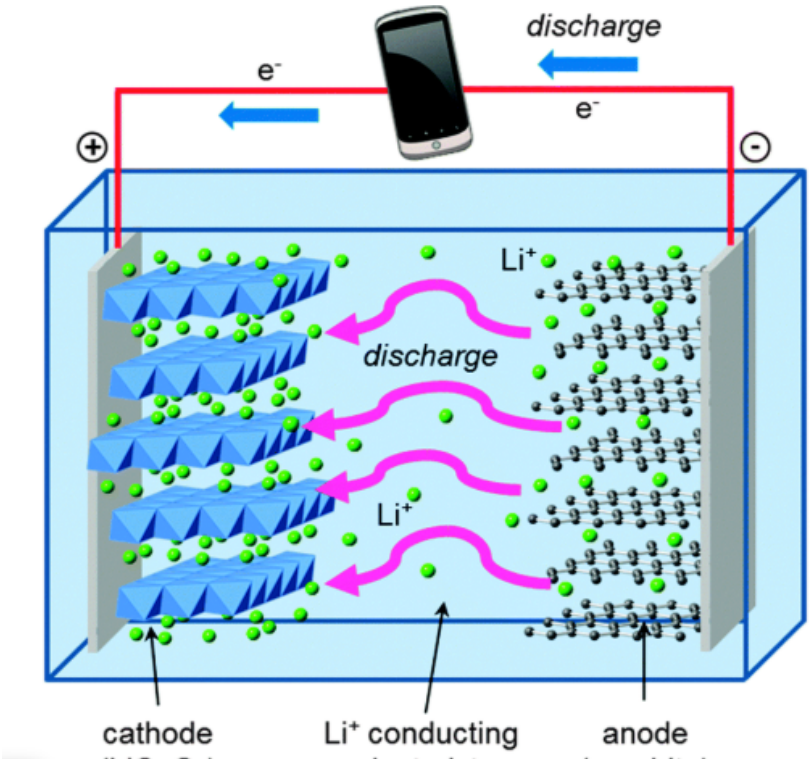
Cobalt(II) chloride can be synthesized from cobalt metal and chlorine gas.

Blue, crystalline cobalt(II) chloride is a very quick test for the presence of water (moisture) in the air. This colour change enables food manufacturers to determine if water has entered the packaging of dry foodstuffs. If beads of silica gel beads coated with cobalt(II) chloride turn pink, it shows that water has entered the packaging and the food should not be eaten.

$$\underset{\textit{blue}}{CoCl_2} + 6H_2O \rightarrow \underset{\textit{pink}}{CoCl_2 \cdot 6H_2O}$$

3. Lithium cobalt oxide (LCO) in portable batteries

Cobalt is also a key component in lithium-ion batteries. LCO is used as the cathode in these batteries, with coke or graphite as the anode.



Source: https://lithium-news.com/2018/03/08/lithium-cobalt-and-vanadium/

In the lithium-ion battery, lithium ions move from the LCO electrode to the graphite electrode when discharging, and back to the LCO electrode when re-charging.

The mass of the elements in each of the electrodes in a lithium-ion battery used in a battery-powered vehicle are measured for a new battery, an "empty" battery and a "recharged" battery, and are shown in Table 7.1.

Table 7.1: Mass of elements in the electrodes of a lithium-ion battery

	mass of elements in LCO electrode (kg)			mass of elements in graphite electrode (kg)	
	lithium	**cobalt**	**oxygen**	**lithium**	**carbon**
new battery	3.1	50.5	27.4	2.9	30.0
"empty" battery	6.0	50.5	27.4	0.0	30.0
"recharged" battery	3.1	50.5	27.4	2.9	30.0

Source: https://www.sciencedirect.com/topics/chemical-engineering/cobalt

One important feature of the LCO electrode is that the recharged battery is chemically identical to a new battery. This means that the battery can be discharged and charged hundreds of times.

(a) Complete the table to show how cobalt(II) chloride can be prepared in the laboratory, and suggest one disadvantage of each method.

	method 1	method 2
reactants	cobalt; chlorine gas	
disadvantage		

[3]

(b) Briefly explain why cobalt(II) chloride cannot be prepared by mixing cobalt(II) carbonate with sodium chloride

.....

..... [1]

(c) Calculate the empirical formulae of the LCO electrodes in the new battery and the "empty" battery.

empirical formula of LCO in new battery .....

empirical formula of LCO in "empty" battery ..... [3]

(d) The "new" battery contains a mixture of cobalt ions of two different charges.

Using your answer from part **(c)**, deduce the possible charges of the cobalt ions in the "new" battery.

charges of cobalt ions ..... [1]

(e) Estimate the minimum mass of rock that needs to be dug from the cobalt mine to obtain sufficient cobalt for a new battery.

mass of rock ..... [1]

(f) "Extraction of metals is preferred over recycling metals."

Discuss whether this statement is true for cobalt.

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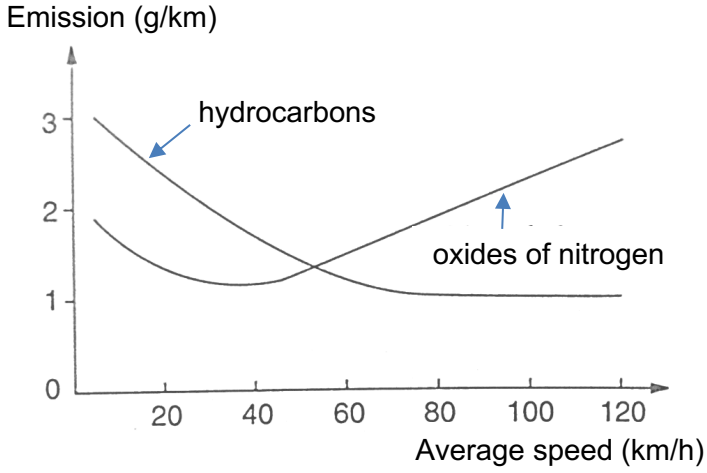
.....

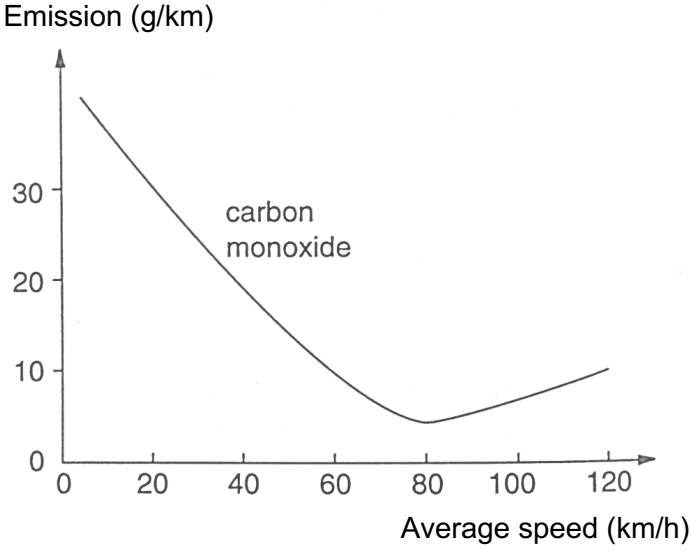
.....

..... [3]

[Total: 12]

B8 The graphs below show approximately how the emissions of unburnt hydrocarbons, oxides of nitrogen and carbon monoxide vary with speed of motor vehicles. Emission is measured in g/km, but note that the scale of carbon monoxide emissions is ten times more than the other two pollutant gases.





(a) Describe how oxides of nitrogen and carbon monoxide form in the engines of motor vehicles.

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..... [2]

(b) Describe and explain how the average speed of vehicles affects the amount of emissions in the two graphs.

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..... [3]

(c) One way to reduce the emissions of oxides of nitrogen and carbon monoxide is to use a catalytic converter.

With the aid of an equation, explain how this can be achieved as a redox reaction.

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..... [3]

[Total: 8]

EITHER

B9 Four different experiments are carried out using excess calcium carbonate and 100 cm^3 of 1.0 mol/dm^3 hydrochloric acid. The surface area of the calcium carbonate and the temperature of the acid are different for each experiment as shown in the table.

experiment	particle size of calcium carbonate	temperature of acid / °C
I	lumps	30
II	powder	30
III	powder	40
IV	lumps	40

(a) Sketch and label on the same axes two graphs that show how temperature can affect the rate of the reaction.

[2]

(b) State and explain, using the collision theory, which two experiments can be used to show the effect of particle size on the speed of reaction.

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.....

.....

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..... [3]

(c) Difference in concentrations can also affect the speed of the above chemical reaction. Describe a suitable experiment that you can carry out to illustrate this. Include all relevant apparatus and chemicals and how you can process your data to draw a conclusion. You may include a diagram of the experimental set-up.

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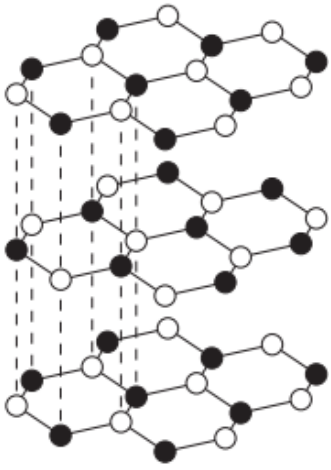
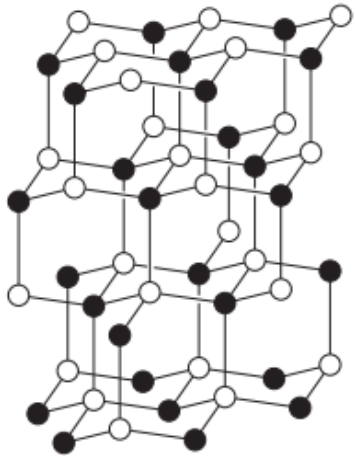
[5]

OR

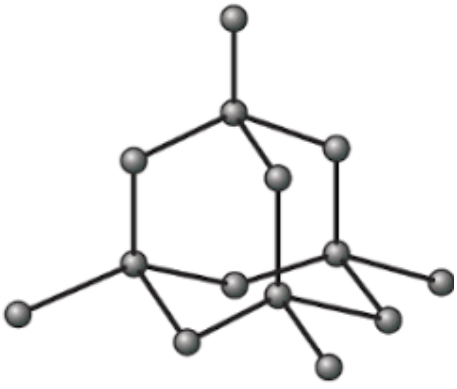
B9 The diagrams show four different macromolecules.



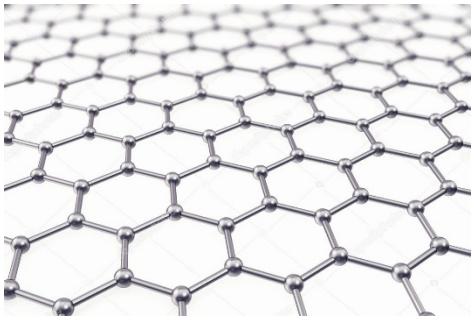
macromolecule A



macromolecule B



macromolecule C



macromolecule D

(a) From the diagrams, describe one similarity and one difference between macromolecule A and macromolecule D.

.....

.....

..... [2]

(b) All the four macromolecules are found to have very high melting points.

Explain the reason.

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..... [2]

(c) Macromolecules B and C have similar structures.

(i) Suggest a possible use for the two macromolecules.

..... [1]

(ii) Explain your reason.

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..... [2]

(d) State and explain the electrical conductivity of macromolecule A.

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..... [3]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

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