GAN ENG SENG SCHOOL

End-of-Year Examination 2023

CANDIDATE NAME			
CLASS		**INDEX NUMBER**	

CHEMISTRY
Paper 2

6092/02

6 October 2023
1 hour 45 minutes

Sec 3 Express

Candidates answer on the Question Paper.

Calculators are allowed in the examination.

READ THESE INSTRUCTIONS FIRST

Write your class, index 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/tape.

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

Section B
Answer **one** question.
Write your answers in the spaces provided.

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

A copy of the Periodic Table is printed on page 19.

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

	For Examiner's Use
Section A	
Section B	
Total	**80**

SECTION A [70 marks]

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

A1 Fig. 1.1 shows part of the Periodic Table.

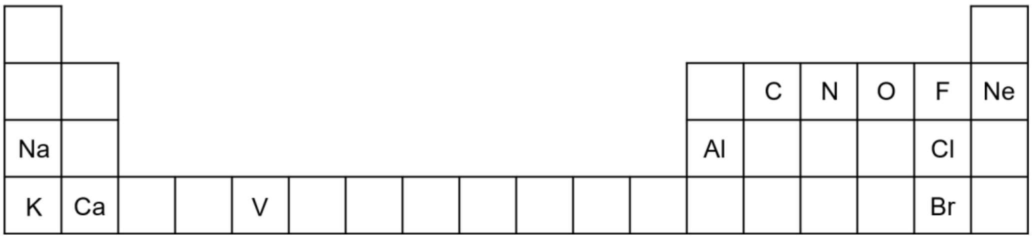


Fig. 1.1

Select elements from Fig. 1.1 to answer the following questions. You may use each element once, more than once or not at all.

Write down the atomic symbol for an element which

(a) has three electrons in its valence shell,

……………………………………………………………………………………….. [1]

(b) is metallic and forms coloured compounds,

……………………………………………………………………………………….. [1]

(c) forms a basic oxide,

……………………………………………………………………………………….. [1]

(d) has less than 20 protons and has four electron shells,

……………………………………………………………………………………….. [1]

(e) is an inert gas,

……………………………………………………………………………………….. [1]

(f) has a giant covalent structure,

……………………………………………………………………………………….. [1]

(g) is a liquid at room temperature,

……………………………………………………………………………………….. [1]

[Total: 7]

A2 Table 2.1 shows the distribution of some elements in three substances.

Table 2.1

	element		
substance	oxygen	iron	carbon
A	0%	90.4 – 95.6%	4.4 – 9.6%
B	52%	48%	0%
C	66.7%	0%	33.3%

Identify and explain, using data from Table 2.1, which substance is a mixture.

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

[Total: 2]

A3 Haematite, iron(III) oxide, is an iron ore that can be commonly found around the world.

(a) Haematite can be reduced with carbon to form two products. Write the balanced chemical equation, with state symbols, for this reaction.

………………………………………………………………………………….. [2]

(b) The reaction in **(a)** is said to be non-environmentally friendly. Suggest a reason why.

………………………………………………………………………………….. [1]

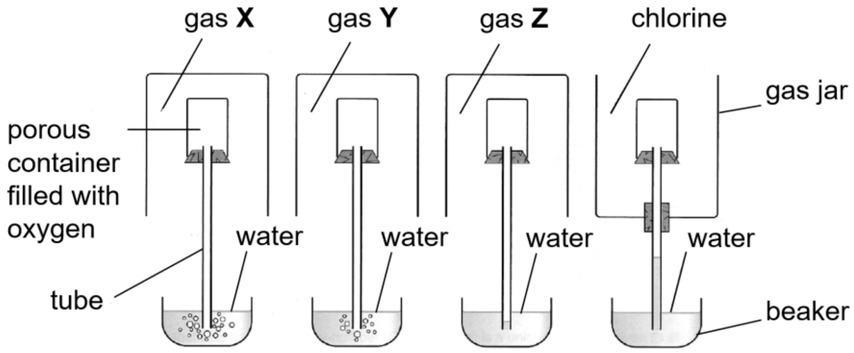
(c) A student, Harini, commented, "Iron(III) oxide can also be obtained in the laboratory via the fast reaction between iron metal and water at 5 ºC." Explain whether she is correct and write the chemical equation for the reaction that occurred, if any.

…………………………………………………………………………………..

………………………………………………………………………………….. [1]

[Total: 4]

A4 A student conducted an experiment with the apparatus set-up below. Three unknown gases, **X**, **Y**, **Z** and chlorine gas are compared to oxygen gas. All the porous containers are filled with oxygen gas.



(a) Explain why bubbles are observed in the water for the set-ups containing gases **X** and **Y**.

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………………………………………………………………………………….. [3]

(b) No bubbles were observed in the set-up containing gas **Z**. A small amount of water was seen to rise up the tube. Suggest a possible identity of gas **Z**.

………………………………………………………………………………….. [1]

(c) Suggest why the gas jar containing chlorine was arranged the opposite way from the other gas jars containing gases **X**, **Y** and **Z**.

…………………………………………………………………………………..

………………………………………………………………………………….. [1]

(d) The experiment was conducted at 25 ºC. State and explain what would be observed if the experiment was conducted at 50 ºC instead.

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…………………………………………………………………………………..

…………………………………………………………………………………..

………………………………………………………………………………….. [3]

[Total: 8]

A5 **(a)** Table 4.1 describes the properties of some sub-atomic particles.

Complete Table 4.1.

Table 4.1

	relative mass	relative charge
proton		
neutron		
electron		

[2]

(b) The symbol of an atom of aluminium is shown below.

$^{27}_{13}\mathrm{A}l$

(i) State the number of neutrons it has.

……………………………………………………………………………….. [1]

(ii) Write the electronic configuration for this atom of aluminium.

……………………………………………………………………………….. [1]

(iii) The symbol for another atom of aluminium is $^{26}_{13}\mathrm{A}l$.

State and explain the relationship between these two atoms of aluminium.

………………………………………………………………………………..

……………………………………………………………………………….. [1]

[Total: 5]

A6 A student, Yu Kai, was conducting an experiment to determine the physical properties of some substances. He recorded his results in Table 5.1 but accidentally spilled some water on a portion of his table.

Table 5.1

substance	melting point/ ºC	boiling point/ ºC	electrical conductivity	solubility in water
potassium chloride	770	1420		yes
calcium chloride	772	1935		yes
carbon	3550	4830	no	no

(a) Draw the 'dot-and-cross' diagram to show the bonding in calcium chloride. Show outer electrons only.

[2]

(b) Calcium chloride has a melting point of 772 ºC.

(i) Explain calcium chloride's high melting point in terms of its structure and bonding.

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………………………………………………………………………………..

……………………………………………………………………………….. [3]

(ii) Suggest and explain why calcium chloride has a higher melting point than potassium chloride.

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…………………………………………………………………………………..

………………………………………………………………………………….. [3]

(c) Carbon can exist in different forms with different structural arrangements of its atoms.

(i) State the term used to describe such different forms of carbon.

………………………………………………………………………………….. [1]

(ii) By referring to Table 5.1, suggest and explain which form of carbon Yu Kai likely experimented on.

…………………………………………………………………………………..

………………………………………………………………………………….. [2]

(iii) Compare the electrical conductivity between potassium chloride and this form of carbon. Explain your answer.

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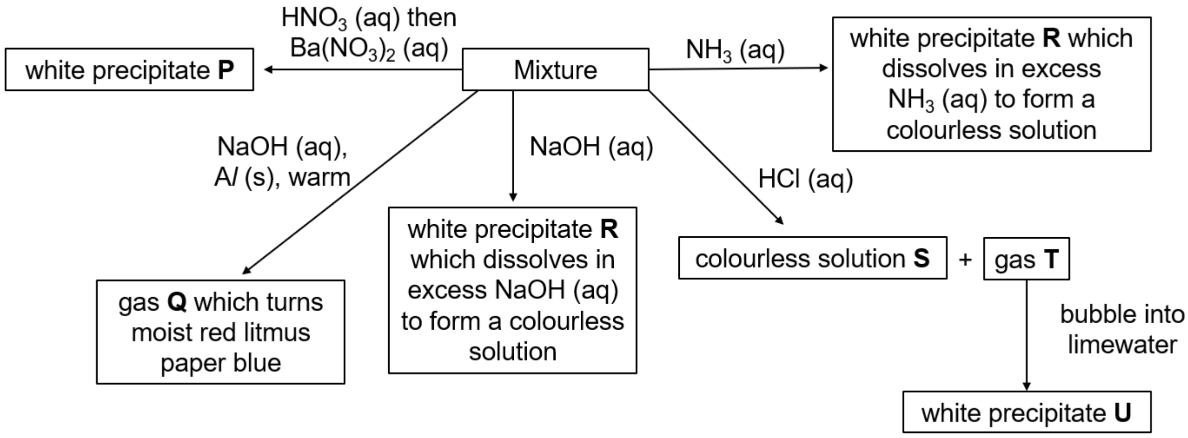
………………………………………………………………………………….. [4]

[Total: 15]

A7 The following reaction scheme describes some of the reaction carried out on an unknown mixture. This mixture contains three different salts.



(a) Identify the following substances.

P: ……………………………………………………………………………………

Q: ……………………………………………………………………………………

R: ……………………………………………………………………………………

S: ……………………………………………………………………………………

T: ……………………………………………………………………………………

U: …………………………………………………………………………………… [6]

(b) Suggest two of the salts that the mixture contains.

salt 1: ……………………………………………………………………………..

salt 2: …………………………………………………………………………….. [2]

[Total: 8]

A8 Fig. 7.1 shows the heating curve for a substance **X**.

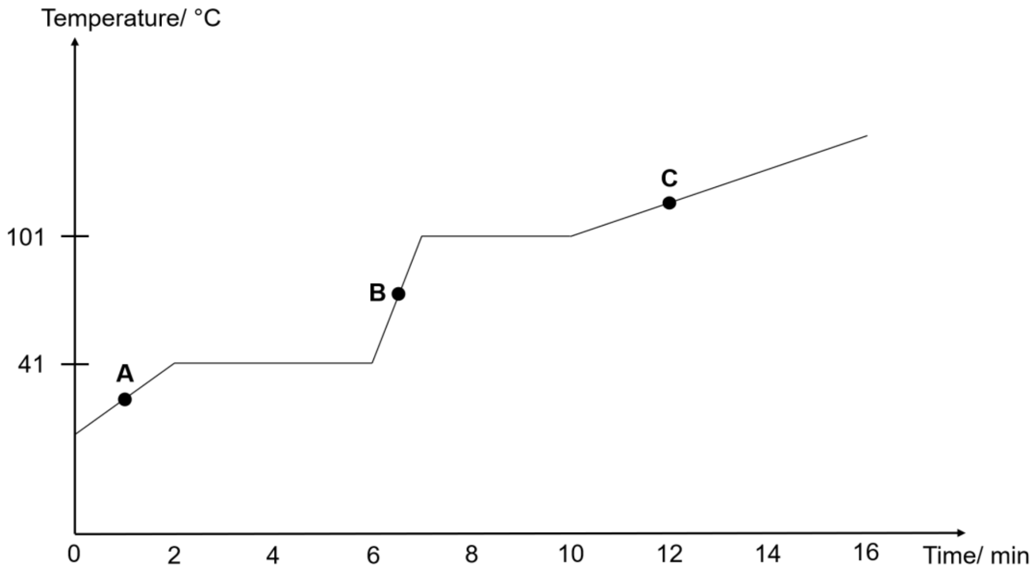


Fig. 7.1

(a) Describe, in terms of the kinetic particle theory, the movement and arrangement of the particles of substance **X** at point **A**.

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………….. [2]

(b) State how long it took for substance **X** to completely change from a solid into a gas.

…………………………………………………………………………………….. [1]

(c) Compare the forces of attraction between the particles and the kinetic energy of the particles at point **B** and at point **C**.

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………….. [2]

[Total: 5]

A9 Wollastonite, $CaSiO_3$, can be produced from the reaction between calcium phosphate and silicon dioxide.

$$2Ca_3(PO_4)_2 + 6SiO_2 \rightarrow P_4O_{10} + 6CaSiO_3$$

100 g of calcium phosphate, $Ca_3(PO_4)_2$, was used in this reaction. The actual mass of wollastonite produced was 87 g.

Calculate the percentage yield of wollastonite.

[4]

[Total: 4]

A10 Separation of crude oil for everyday use

How crude oil is separated

Crude oil is a naturally occurring viscous black oil. The raw material is made up of complex organic hydrocarbon structures and is formed from living matter that existed many millions of years ago. In that time, that matter has been processed by geological forces to create its current form of black oil. While it is sometimes found at surface level, crude oil is mostly obtained by drilling for oil in the ground at oil wells on land, and at oil rigs at sea.

In oil industries, crude oil can be separated to obtain all the various petroleum products that we rely on in everyday life. A diagram of this separation technique is shown in Fig. 9.1.

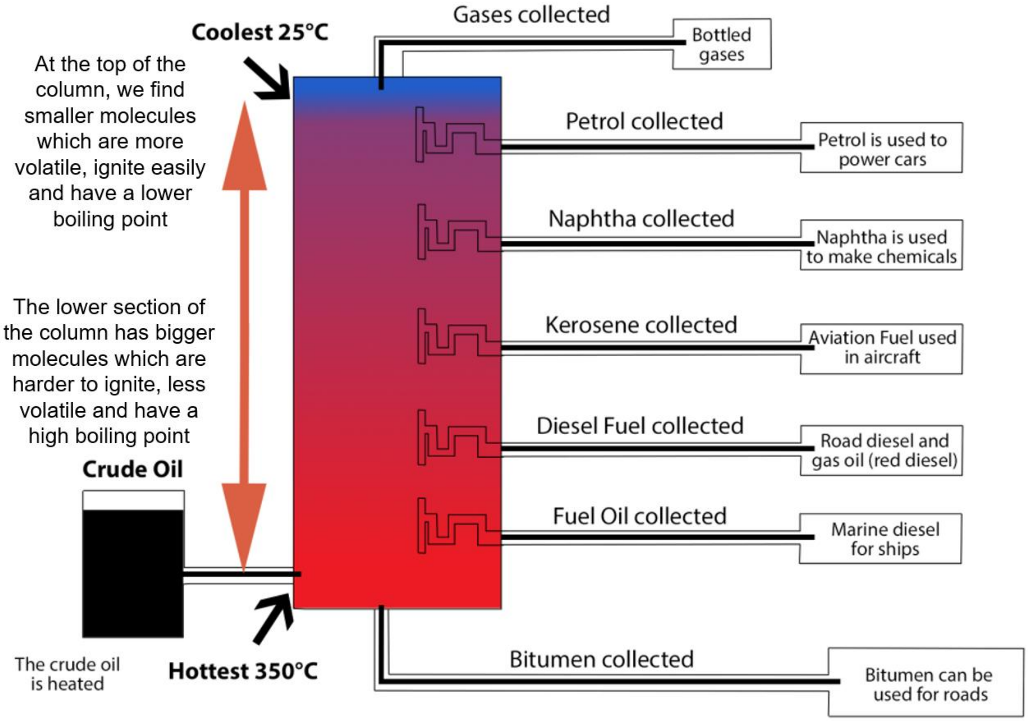


Fig. 9.1

Crude oil is heated and its components turn into vapour. They are subsequently cooled, condensed back into liquids, and collected as different fractions. Each fraction contains different hydrocarbons.

The top of the column gives rise to gases and liquids that have short carbon chains in their composition. While these products are often used as fuels, many have industrial and chemical uses too.

Hydrocarbons like butane, propane and other petroleum gases are formed right at the top of the tower, where it is coolest at a very mild 25°C. The temperature range that forms these gases is between 25°C and 50°C. These gases are the lightest products formed in this separation process and are flammable gases.

These gases, being the lightest products formed and flammable gases too, are then processed into Liquified Petroleum Gas (LPG), which is usually a mixture of propane and butane. LPG is used for heating applications and for hot air balloons in the case of propane.

The petroleum gases have four or five hydrocarbons in their chain. For these distillates, hydrocarbon chains are made up of three carbon atoms in the case of propane (C_3H_8), and four carbon atoms in the case of butane (C_4H_{10}).

Everyday use of the components of crude oil

Internal combustion engine fuels such as petrol or diesel fuels our cars' engines, gas oil powers machinery and furnaces, kerosene fuels aircraft, and domestic and commercial heating oil keeps our homes and workplaces warm.

In such combustion reactions, hydrocarbons react with oxygen in the air to produce carbon dioxide and water.

(a) **(i)** Name the separation technique used to separate crude oil.

……………………………………………………………………………….. [1]

(ii) Explain how the physical property of the components of crude oil allows them to be separated by this separation technique.

……………………………………………………………………………….. [1]

(iii) Suggest and explain if oil industries can use separating funnels to separate the components of crude oil.

……………………………………………………………………………….. [1]

(b) Propene, C_3H_6, is a hydrocarbon that is a possible by-product of this separation technique.

(i) Suggest what is meant by the term *hydrocarbon*.

……………………………………………………………………………….. [1]

(ii) Draw a 'dot-and-cross' diagram to show the bonding in propene. Show the outer shell electrons only.

[2]

(iii) Substances that produce ions when dissolved in water are called electrolytes. Electrolytes are used as mediums to conduct electricity in electrolysis reactions.

Suggest and explain whether propene can be used as an electrolyte.

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………………………………………………………………………………….. [1]

(iv) Write a balanced chemical equation for the combustion reaction of propene.

………………………………………………………………………………….. [1]

(v) Other than using chromatography, explain how the purity of propene obtained from the separation can be determined.

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………………………………………………………………………………….. [1]

(c) Chromatography was performed on a sample of crude oil. The results are shown in Fig. 9.2.

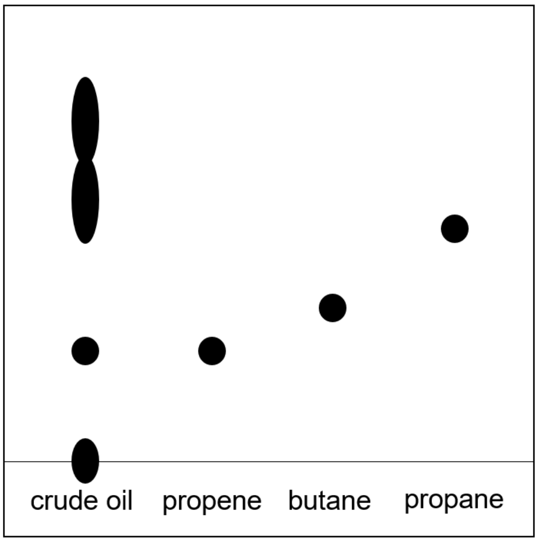

Fig 9.2

State three conclusions that can be drawn by using evidence from Fig 9.2.

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[Total: 12]

SECTION B [10 marks]

Answer **one** question from this section.

B11 25.0 cm^3 of 0.40 mol/dm^3 sulfuric acid was reacted with exactly 35 cm^3 of sodium hydroxide.

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

(a) Calculate the concentration of sodium hydroxide used.

[2]

(b) Write the ionic equation, with state symbols, for this reaction.

………………………………………………………………………………….. [1]

(c) Sodium sulfate solution is obtained at the end of the reaction.

(i) Describe what would be observed if a few drops of universal indicator were added to the sodium sulfate solution.

…………………………………………………………………………….. [1]

(ii) Describe the concentration of H^+ and OH^- ions present in the sodium sulfate solution at the end of the reaction.

…………………………………………………………………………….. [1]

(d) Describe the steps to prepare pure and dry sodium sulfate crystals from sulfuric acid and sodium hydroxide.

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[Total: 10]

B12 30.0 cm^3 of 0.80 mol/dm^3 nitric acid was reacted with 10 g of magnesium.

(a) Calculate the mass of magnesium nitrate produced.

[3]

(b) A gas was produced in this reaction. Describe the test and observation to confirm the identity of the gas.

………………………………………………………………………………………..

……………………………………………………………………………………….. [1]

(c) Suggest a change in observation if nitric acid was replaced with ethanoic acid, CH_3COOH, for this reaction. Explain why.

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………………………………………………………………………………………..

……………………………………………………………………………………….. [2]

(d) Describe the steps to prepare pure and dry magnesium nitrate crystals from nitric acid and magnesium.

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………………………………………………………………………………………….. [4]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			**Key** proton (atomic) number atomic symbol name relative atomic mass								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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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.).

The Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}