COMPASSVALE SECONDARY SCHOOL
Secondary Four Express
Preliminary Examination 2025

NAME

CENTRE NUMBER S | | | | | CLASS | | | | INDEX NUMBER | |

CHEMISTRY 6092/02

Paper 2 **20 August 2025**

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, 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.

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 21.

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

This document consists of **21** printed pages and **1** blank page.

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Section A

Answer **all** questions.

1 This question is about making salts.

For each salt, suggest the name of the missing reagent and briefly describe how to obtain the solid salt from the reaction mixture.

salt	barium sulfate	copper(II) nitrate
reagent 1	aqueous barium nitrate	dilute nitric acid
reagent 2		
description on how to obtain solid salt from reaction mixture		

[6]

[Total:6]

2 A sample of chlorine gas is placed in a gas syringe. It is connected to a glass tube that contains aqueous sodium bromide absorbed in cotton wool as shown in Fig. 2.1.

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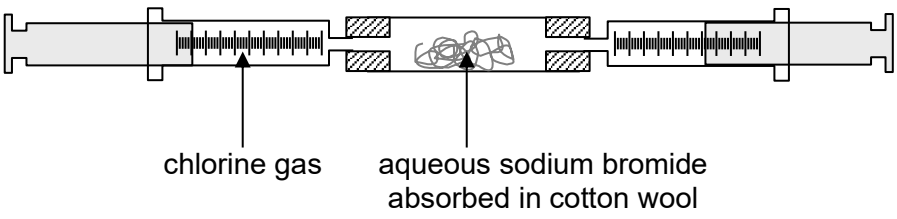

Fig. 2.1

The chlorine gas was passed over the cotton wool into the other syringe and then back again a few times until there was no further change in the volume.

(a) (i) Predict what you would expect to observe at the cotton wool.

…… [1]

(ii) Explain, with the aid of an ionic equation, the observation in **(a)(i)**.

……

……

…… [2]

(b) Suggest another sodium salt that can be used in this experiment.

…… [1]

[Total:4]

3 Boric acid, H_3BO_3, is an ingredient often found in eye wash products due to its mild antiseptic properties that can help inhibit the growth of bacteria.

The pH values of two separate samples of 0.05 mol/dm^3 boric acid and hydrochloric acid were taken using a data logger. The results are shown in Table 3.1.

Table 3.1

acid	pH
boric acid	5.25
hydrochloric acid	1.30

(a) Boric acid is also known as hydrogen borate.

Deduce the formula for borate ion.

…… [1]

(b) Use Table 3.1 to explain why boric acid has a higher pH than hydrochloric acid.

……

……

…… [2]

(c) Subsequently, these two samples of acids were each added in excess to 0.02 g of zinc granules separately.

(i) Effervescence was observed during the experiment and a gas was evolved.

Describe a test to identify the gas evolved.

test ……..

observation ……..

……. [2]

(ii) For both reactions, the mole ratio of zinc to gas evolved is the same.

A statement was made about both reactions:

'The final volume of gas produced in the reaction of zinc and boric acid would be less than the reaction of zinc and hydrochloric acid as it is a weaker acid.'

Do you agree with this statement?

Explain your reasoning.

…….

…….

…….

……. [2]

[Total:7]

4 Four amino acids **P**, **Q**, **R** and **S** were analysed using paper chromatography. Two solvents were used.

Table 4.1 shows the R_f values calculated for the four amino acids.

Table 4.1

amino acid	**P**	**Q**	**R**	**S**
R_f in solvent 1	0.30	0.00	0.60	0.90
R_f in solvent 2	0.60	0.52	0.25	0.85

(a) Amino acids are colourless.

Describe and explain how the amino acids can be analysed using paper chromatography.

……

…… [1]

(b) Which amino acid is the **most** soluble in both solvents?

Explain your choice.

……

……

…… [2]

(c) Which solvent is a better solvent to analyse these four amino acids?

Use information from Table 4.1 to explain your reasoning.

……

……

…… [2]

[Total:5]

5 Petrol is used as a fuel in cars. Petrol contains mainly octane, C_8H_{18}.

Two other alternative fuels for cars are propane and ethanol.

Table 5.1 shows some information about the various fuels used in cars.

Table 5.1

fuel	boiling point / °C	density at room temperature and pressure in g/dm^3	volume of 1 mol of fuel at room temperature and pressure / dm^3	enthalpy change of combustion / kJ per mol	enthalpy change of combustion / kJ per kg
octane	125	703		–5075	–44 518
propane	–42	1.81	24.3	–2220	–50 455
ethanol	78	789	0.0583	–1367	

(a) Calculate the volume of 1 mol of octane and the enthalpy change of combustion in kJ per kg for ethanol.

Show your workings clearly.

[3]

(b) Use the information in the table to evaluate the use of propane and ethanol as fuels.
Your answer should consider:

- the ease of storage,
- the energy content of the fuels,
- the source of fuels.

……

……

……

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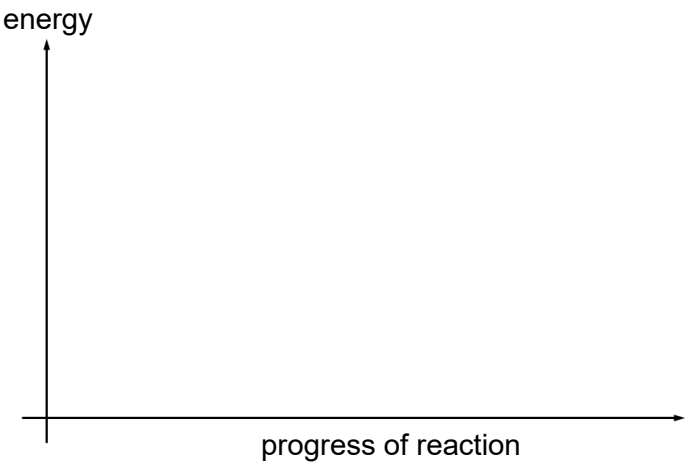
……

…… [3]

(c) Complete the energy profile diagram for the complete combustion of ethanol.

Your diagram should include:

- the chemical formulae of the reactants and products,
- the enthalpy change of reaction, ΔH
- the activation energy, E_a.



[3]

(d) The burning of fuels in cars contribute to the amount of carbon dioxide in the atmosphere.

Briefly describe a process in the carbon cycle that helps to regulate the amount of carbon dioxide in the atmosphere.

……

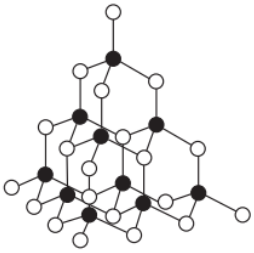
…… [1]

[Total:10]

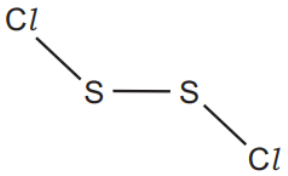
[Turn over

6 Fig. 6.1 shows the structures of zinc sulfide and disulfur dichloride.

Zinc sulfide has a structure similar to diamond.



zinc sulfide



disulfur dichloride

key

- zinc atoms
- sulfur atoms

Fig. 6.1

(a) With reference to Fig. 6.1, explain why zinc sulfide exists as a solid while disulfur dichloride exists as a liquid at room temperature and pressure.

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..... [4]

(b) Predict one **other** physical property of zinc sulfide.

..... [1]

(c) Draw 'dot-and-cross' diagram to show the bonding in disulfur dichloride.
Show outer electrons only.

[2]

[Total:7]

7 Two electrolysis experiments are carried out using aqueous copper(II) sulfate as the electrolyte as shown in Fig. 7.1. Experiment 1 uses electrodes **A** while experiment 2 uses electrodes **B**.

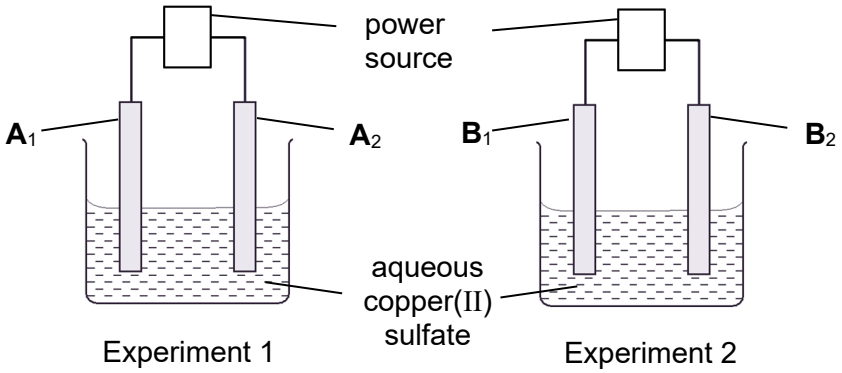

Fig. 7.1

Table 7.1 shows the observations for each experiment.

Table 7.1

experiment 1	experiment 2
mass of $\mathbf{A}_1$ increased	mass of $\mathbf{B}_1$ increased
mass of $\mathbf{A}_2$ decreased	mass of $\mathbf{B}_2$ remained unchanged
no effervescence observed in the set-up	effervescence observed at $\mathbf{B}_2$

(a) Suggest possible identities of the electrodes used in each experiment.

experiment 1 ……

experiment 2 …… [2]

(b) Explain the observations for experiment 1 and experiment 2.

Your answer should:

- explain why each change occurs,
- give half-equations for the reaction at each electrode.

……

……

……

……

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…… [6]

(c) There is one more set of observation not recorded in Table 7.1.

Predict this set of observation and suggest how this observation differs in both experiments.

……

……

……

……

…… [3]

[Total:11]

8 Steel in our Daily Lives

Steel is one of the most widely used alloys in the world, composed mainly of iron and varying amounts of carbon and other elements like chromium, nickel, and molybdenum. Its properties can be adjusted by changing its composition, making it suitable for applications ranging from construction to kitchenware.

Carbon in Steel

Steel is primarily composed of iron, with a small percentage of carbon (typically less than 2.1%). The carbon content in steel plays a critical role in determining its properties, such as hardness, tensile strength and ductility. Steel can be categorised based on its carbon content, transitioning from low carbon steel to high carbon steel.

Table 8.1 shows the composition, approximate melting point and use of some common types of carbon steels.

Table 8.1

type of carbon steel	percentage of carbon	approximate melting point / ^{o}C	use
low carbon	0.05 – 0.30	~ 1464	car bodies
medium carbon	0.30 – 0.60	~ 1427	machinery
high carbon	0.60 – 1.00	~ 1353	wire ropes for suspension bridges

Fig. 8.1 shows the correlation between the percentage of carbon by weight in carbon steels and their tensile strength, hardness as well as ductility.

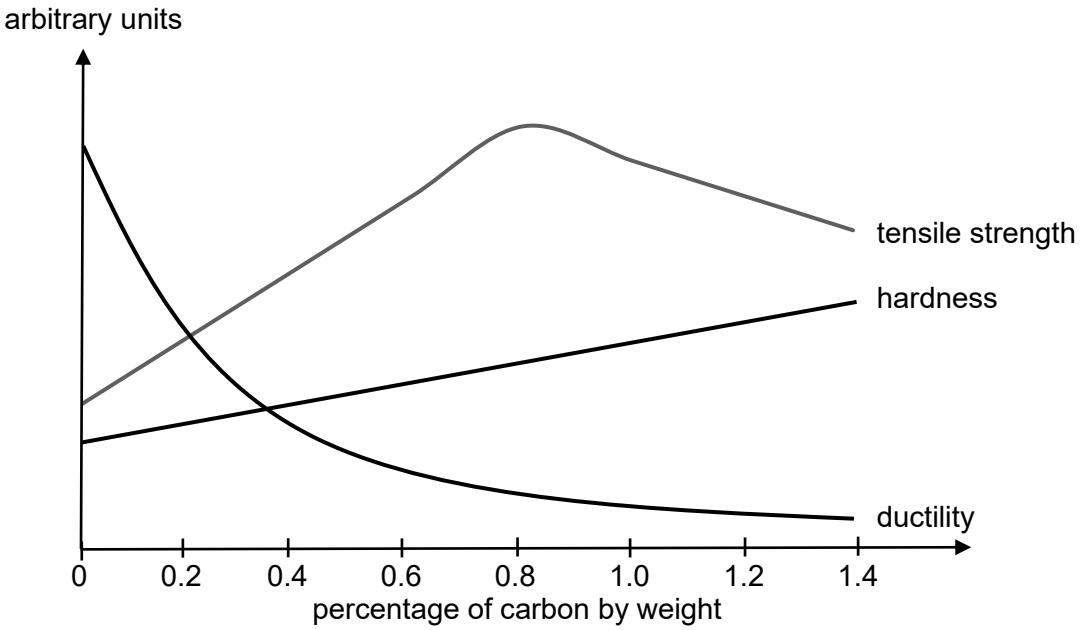


Fig. 8.1

Tensile strength can be used as an indicator of the strength of alloys. It is measured by the maximum stress that a material can withstand while being stretched or pulled before breaking.

What is Steel Scrap and Why it is Important

Scrap steel is the discarded steel that is generated from manufacturing of steel products (also known as 'pre-consumer scrap') and from recovered steel in buildings, vehicles and products discarded at their end of life (also known as 'post-consumer scrap'). Due to its inherent magnetism, steel is very easy to separate and recycle. Melting steel scrap at the end of its life allows it to be recycled to create new steels by adjusting the chemistry and shape of the new product.

Raw Materials for Steel Manufacturing

In the manufacturing of steel, extracted iron and scrap steel are used as part of its raw material mix. Iron can be extracted from its iron ore, haematite. Haematite contains iron(III) oxide, mixed with impurities such as sand and clay. The equation below illustrates the extraction of iron from its ore.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

Extracted iron contains carbon as an impurity. To remove the carbon, oxygen is blown on the molten iron in a large vessel known as a converter. The carbon is then converted to carbon dioxide.

Scrap steel, on the other hand, can be recycled by using it as a source of iron. The addition of scrap steel helps to absorb excess heat from the exothermic process by acting as a cooling agent, and reduces global warming as well as production of air pollutants.

(a) Which carbon steel from Table 8.1 is the hardest?

Explain your reasoning, using ideas about structure.

……

……

……

……

……

…… [4]

(b) Use relevant data from Fig. 8.1 to explain why low carbon steel and high carbon steel are suitable for their respective uses.

low carbon steel ……

……

……

high carbon steel ……

……

…… [2]

(c) **(i)** Explain why the extraction of iron from iron(III) oxide is a redox reaction.

……

……

……

…… [2]

(ii) When oxygen is blown onto molten iron, the temperature of the molten iron increases.

Suggest why this happens.

…… [1]

(iii) Some molten iron may be converted back to iron(III) oxide during the oxygen blow.

Write a balanced chemical equation for this reaction.

…… [1]

(d) Explain how the use of scrap steel in the manufacturing of steel, instead of solely pure iron, helps to reduce global warming and production of air pollutants.

……

……

……

…… [2]

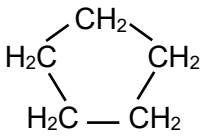
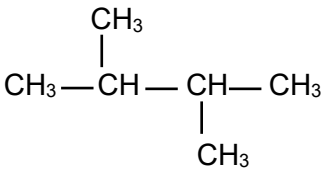
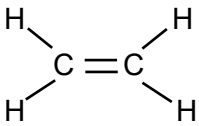
[Total: 12]

9 Crude oil contains a mixture of hydrocarbons which can be separated using fractional distillation in a petrol refinery.

After fractional distillation, some molecules undergo further processes, **A**, **B** and **C**, in the refinery. Each process forms a range of different products.

Table 9.1 shows some molecules used in each process with an example of a product formed.

Table 9.1

process	molecule used in process	example of product formed in process
A	$CH_3—CH_2—CH_2—CH_2—CH_3$ **pentane**	
B	$CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$ **hexane**	
C	$CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$ **heptane**	

One of the processes is cracking.

Another process forms isomers of the molecules that are used in the process. This is called isomerisation.

(a) Identify and explain which process in the table is cracking, which is isomerisation and which process is neither.

Include references to molecular formulae, where relevant, in your answer.

……

……

……

……

……

……

…… [4]

(b) Draw the structure of another possible isomer that can be formed from the isomerisation process mentioned in **(a)**.

[1]

(c) Describe and explain what happens when the examples of product formed in processes **A** and **C** were added to aqueous bromine separately.

……

……

……

…… [2]

(d) State a reason why cracking is important to the oil industry.

……

…… [1]

[Total: 8]

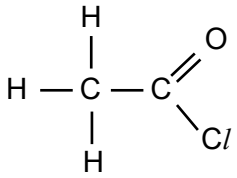
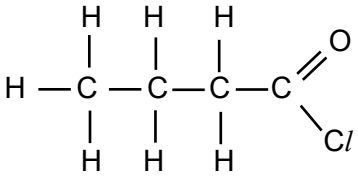
Section B

Answer **one** question from this section.

10 Acyl chlorides are a homologous series of organic compounds.

Table 10.1 shows the names, chemical formulae and structural formulae of some acyl chlorides.

Table 10.1

name	chemical formula	full structural formula
ethanoyl chloride	CH_3COCl	
	C_2H_5COCl	
butanoyl chloride	C_3H_7COCl	

(a) Complete Table 10.1 with the name and full structural formula of the acyl chloride that occurs between ethanoyl chloride and butanoyl chloride in the homologous series. [2]

(b) Use the information in Table 10.1 to give **two** reasons that suggest that the acyl chlorides are a homologous series.

……..

……..

…….. [2]

(c) Ethanoyl chloride reacts with propanol spontaneously to form compound **X** and hydrogen chloride gas as shown in the equation.

$$CH_3COCl + C_3H_7OH \rightarrow \underset{\text{compound } \mathbf{X}}{CH_3COOC_3H_7} + HCl$$

(i) Name compound **X**.

……. [1]

(ii) Compound **X** can also be formed from the reaction of ethanoic acid with propanol.

State **two** differences, other than the type of reactants used, between these two reactions in the formation of compound **X**.

……

……

……

…… [2]

(d) Acyl chlorides can be prepared using a carboxylic acid and phosphorus(V) chloride.

An equation to illustrate this reaction is shown.

$$\mathbf{R}COOH + PCl_5 \rightarrow \mathbf{R}COCl + POCl_3 + HCl$$

R represents any hydrocarbon group

Table 10.2 shows the composition of a particular carboxylic acid.

Table 10.2

element	carbon	hydrogen	oxygen
percentage composition by mass	40.2%	6.70%	53.1%

(i) Calculate the empirical formula of this carboxylic acid.

[2]

(ii) Hence, identify the acyl chloride that is formed from this carboxylic acid.

…… [1]

[Total: 10]

11 A student investigates how different conditions affect the rate of reaction between aqueous calcium chloride and aqueous sodium carbonate. The experimental set-up is shown in Fig. 11.1.

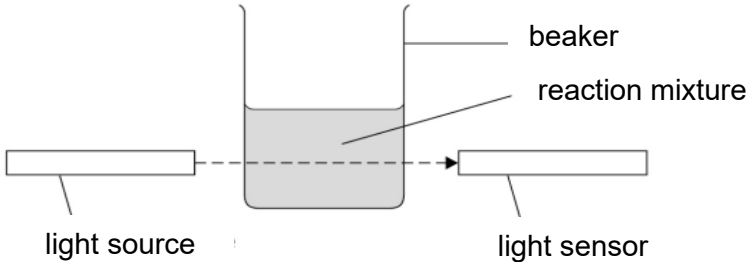


Fig. 11.1

The conditions of the reaction are varied by changing the concentrations of both solutions or by varying the temperature.

These changes affect the time taken for the light sensor to not being able to detect the light from the light source.

Table 11.1 shows the conditions and results for a series of experiments.

Table 11.1

experiment	concentration of calcium chloride in mol/dm³	concentration of sodium carbonate in mol/dm³	temperature / °C	time taken for light to be blocked / s
1	0.30	0.05	25	28
2	0.30	0.10	25	20
3	0.30	0.10	35	12
4	0.50	0.10	25	14

(a) One of the experiments is used as a reference to compare the effect of the variables.

Which experiment is used as a reference?

Explain your choice.

……..

……..

……..

……..

……..

…….. [2]

(b) Use ideas about collisions between particles to explain why changing the concentrations and temperature changes the time taken for the light to be blocked.

……..

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…….. [3]

(c) The chemical equation for the reaction is as follows.

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$$

In every experiment, the volumes of aqueous calcium chloride and aqueous sodium carbonate used are 25.0 cm^3.

Given that the limiting reagent is the same for all four experiments, use the information in Table 11.1 to identify the limiting reagent at the start of each experiment.

Show your working.

[2]

(d) Both aqueous calcium chloride and aqueous sodium carbonate are colourless.

Describe a test to distinguish between both solutions.

……..

……..

…….. [2]

(e) Experiment 1 is repeated using sodium nitrate instead of sodium carbonate.

Predict and explain what would happen to the result obtained.

……..

…….. [1]

[Total: 10]

End of paper

The Periodic Table of Elements

Group																	
1	2											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	3	4	5	6	7	8	9	10	11	12	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, $L = 6.02 \times 10^{23}\ mol^{-1}$.

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