Name: ..... ( ) Class: .....

MONTFORT SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2025

Secondary 4 Express
CHEMISTRY
Paper 2

6092/02
25 Aug 2025 (Mon)
1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a 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 24.

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

FOR EXAMINERS' USE ONLY	
SECTION A	70
SECTION C	10
TOTAL	80

This document consists of **23** printed pages and **1** blank page.

Setter: Ms Celine Peh

Section A

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

1 Fig. 1.1 shows the structures of seven substances, **A**, **B**, **C**, **D**, **E**, **F** and **G**.

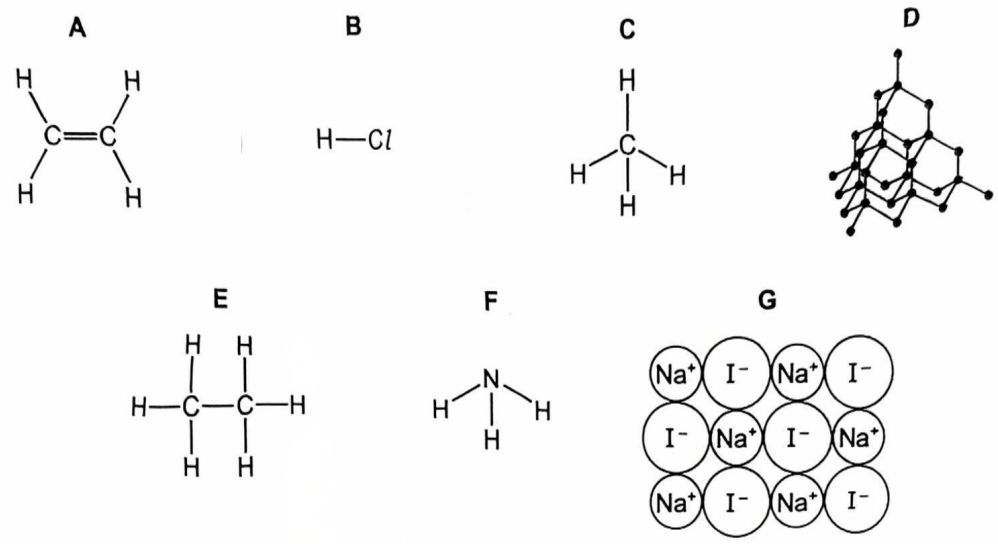


Fig. 1.1

(a) Answer the following questions using only the structures in Fig. 1.1.

Each structure may be used once, more than once or not at all.

State the structure that represents:

(i) a compound that is the main constituent of natural gas

..... [1]

(ii) the monomer used to produce poly(ethene)

..... [1]

(iii) a giant covalent structure

..... [1]

(iv) a compound that has a high melting point

..... [1]

(v) a waste gas from digestion in animals

..... [1]

(vi) a solid at room temperature that conducts electricity when dissolved in water.

..... [1]

(b) Draw the dot-and-cross diagram for structure **B**.

Show the outer electron shells only.

[1]

[Total: 7]

2 Aluminium carbide, Al_4C_3, reacts with water to form methane, CH_4, and aluminium hydroxide.

(a) Construct a balanced chemical equation for this reaction.

..... [2]

(b) Methane is a saturated hydrocarbon.

(i) Explain why methane is a saturated hydrocarbon.

.....

..... [2]

(ii) Methane reacts with chlorine in the presence of ultraviolet light.

State the formulae of two products of this reaction.

..... and ..... [2]

(c) The equation for the complete combustion of methane is shown.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

This reaction is exothermic.

(i) Explain, using ideas about bond breaking and bond making, why this reaction is exothermic.

.....

.....

..... [2]

(ii) Complete the reaction pathway diagram in Fig. 2.1 for the complete combustion of methane.

Label the:

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

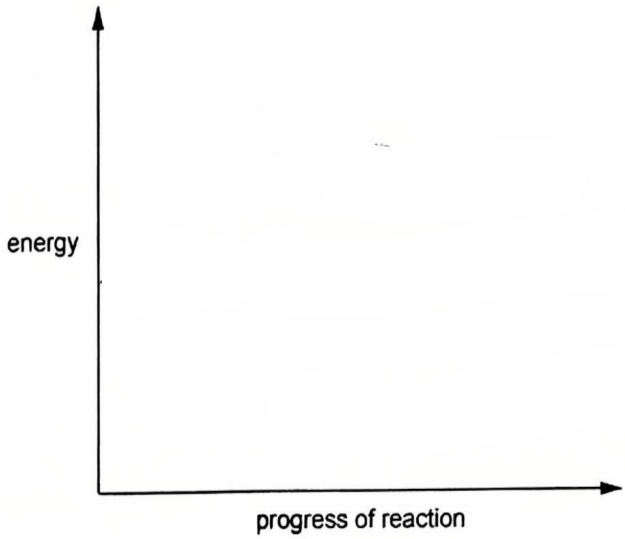


Fig. 2.1

[3]

[Total: 11]

3 Nitrogen(V) oxide decomposes on heating to form nitrogen(IV) oxide and oxygen.

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

(a) The table shows how the rate of reaction varies with the concentration of N_2O_5.

concentration of $N_2O_5(g)$ in mol/dm^3	rate in $mol/dm^3/s$
3.2	6.39
1.6	3.15
0.8	1.63

(i) Describe how the rate of this reaction changes with the concentration of N_2O_5.

.....

..... [1]

(ii) Explain your answer to **(a)(i)** in terms of collision theory.

.....

.....

..... [2]

(iii) Describe and explain the effect of increasing the temperature on the rate of this reaction.

.....

.....

..... [2]

(b) Sulfur dioxide is an atmospheric pollutant.

(i) Describe one source of the sulfur dioxide in the atmosphere.

..... [1]

(ii) The oxidation of sulfur dioxide to sulfur trioxide in the atmosphere is catalysed by nitrogen(IV) oxide.

$$SO_2 + NO_2 \rightarrow SO_3 + NO$$
$$NO + \tfrac{1}{2}O_2 \rightarrow NO_2$$

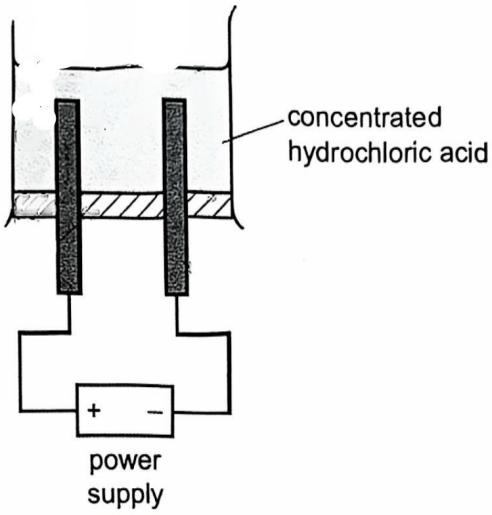
Nitrogen(IV) oxide speeds up the rate of reaction. Which other property of a catalyst is shown by these equations?

.....[1]

[Total: 7]

4 When concentrated hydrochloric acid is electrolysed, gases are produced at the electrodes.

The incomplete apparatus is shown.



(a) (i) Complete the diagram by:

- labelling the anode and cathode
- showing how the gases are collected. [2]

(ii) Predict the products of this electrolysis at the:

positive electrode .....

negative electrode ..... [2]

(iii) Graphite (carbon) electrodes are used in this electrolysis.

Suggest **one** other element that can be used as an electrode and give a reason, other than that it can conduct electricity.

element .....

reason .....

[1]

(b) Aqueous chlorine reacts with aqueous sodium iodide.

Using a balanced chemical equation for the reaction, explain why chlorine is more reactive than iodine.

.....

.....

.....

..... [2]

[Total: 7]

5 Molybdenum is a transition element which is used to make steel that is extremely hard.

It exhibits variable oxidation states and can be manufactured by heating together molybdenum(IV) oxide, MoO_2, and aluminium.

(a) Construct the equation for this reaction.

..... [1]

(b) **(i)** Complete the table to show the oxidation states of molybdenum and aluminium.

element	oxidation state in reactants	oxidation state in products
molybdenum		
aluminium		

[2]

(ii) In terms of oxidation states, explain why this is a redox reaction.

.....

.....

..... [2]

(c) Suggest which metal, molybdenum or aluminium, is less reactive. Explain your answer.

.....

..... [1]

(d) Molybdenum has a melting point of 2620 °C.

(i) With the help of a labelled diagram, describe the type of bonding that is present in molybdenum.

....

.... [2]

(ii) Suggest why molybdenum has a much higher melting point than aluminium.

.... [1]

[Total: 9]

6 Calcium hydroxide is often added to acidic soil to increase its pH for healthy plant growth.

Fertilisers containing nitrogen, phosphorus, and potassium which are primary nutrients for healthy plant growth are often added as well.

Table 6.1 shows some commonly used fertilisers.

Table 6.1

fertiliser	formula
ammonium nitrate	
sodium phosphate	Na_3PO_4
	Ca(NO3)2
potassium sulfate	K_2SO_4

(a) Complete Table 6.1 by filling in the missing information. [2]

(b) **(i)** Write an ionic equation for the reaction between calcium hydroxide and the excess acid in the soil.

..... [1]

(ii) A common fertiliser, urea, contains the elements carbon, oxygen, nitrogen, and hydrogen.

It contains 46.7% nitrogen, 6.7% hydrogen and 20% carbon.

Calculate the empirical formula of urea.

[3]

(c) Two farmers discovered that they have a plot of land that lacks nutrients and is too acidic for any healthy plant growth.

They wanted to add calcium hydroxide together with a fertiliser to the plot of land at the same time.

Farmer 1: Ammonium nitrate should be added together with calcium hydroxide to provide nitrogen for healthy plant growth.

Farmer 2: Calcium nitrate should be added together with calcium hydroxide to provide nitrogen for healthy plant growth.

Which farmer is correct? Explain your reasoning.

.....

.....

.....

.....

..... [3]

[Total: 9]

7 Ammonia is produced commercially via the catalytic reaction of nitrogen and hydrogen at high temperature and pressure.

Fig. 7.1 shows the graph of the reaction.

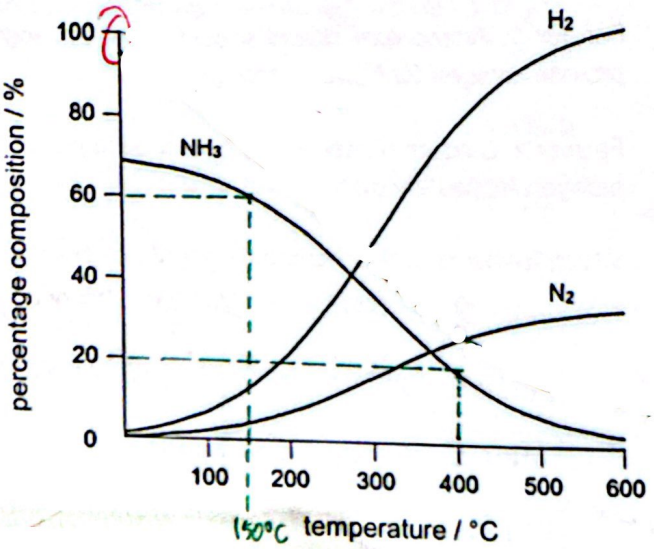


Fig. 7.1

(a) Using the information from the graph, state the relationship between temperature and the percentage yield of ammonia obtained.

..... [2]

(b) Suggest why the percentage composition of hydrogen and nitrogen increases when temperature is high.

[1]

(c) Sketch on Fig. 7.1 the expected graph for the percentage yield of ammonia at a higher pressure for the stated temperatures. Label your graph as (c). [1]

(d) In terms of collision theory, describe how increasing the pressure affects the rate of production of ammonia.

[3]

(e) Ammonia can be used to treat industrial waste gases containing nitrogen oxides.

The equation shows how the treatment converts nitrogen monoxide to nitrogen and water.

$$6NO + 4NH_3 \rightarrow 5N_2 + 6H_2O$$

(i) Use the equation provided, state the effect on the composition of the gases released into the atmosphere when an insufficient amount of ammonia was added to nitrogen monoxide.

.....

..... [1]

(ii) Describe how nitrogen monoxide affects the environment.

.....

.....

..... [2]

[Total: 10]

8 Fossil Fuels

Fossil fuels like crude oil are known to be non-renewable and are limited in supply. They are still used as fuels because getting energy from their combustion is still considered an economical and convenient method. To ensure that the supply of crude oil lasts longer for our use, we need to conserve crude oil.

Alternative Energy Source - Biogas

Biogas is a renewable fuel that is produced when organic matter, such as food or animal waste, is broken down by bacteria in the absence of oxygen. Biogas, that can be derived from cow dung from farms, contains biomethane.

Table 8.1 shows a typical composition of biogas.

Table 8.1

compound	formula	percentage by volume	additional information
biomethane	CH_4	50 - 80	colourless, odourless
carbon dioxide	CO_2	15 - 50	colourless, odourless
nitrogen	N_2	0 - 10	colourless, odourless
hydrogen sulfide	H_2S	0 – 1	colourless, pungent, toxic

The biogas produced on the farm contains traces of hydrogen sulfide. To prolong the lifespan of the metal machinery parts, hydrogen sulfide must be removed from the biogas, otherwise when it is combusted, it produces sulfur dioxide and sulfuric acid.

Burning biomethane releases greenhouse gases like carbon dioxide but allowing cow dung to degrade naturally also releases methane. Converting cow dung into biomethane to be used as biofuel instead of letting it degrade naturally is found to cut down greenhouse gases by 4%. This is because methane has a much greater global-warming power than carbon dioxide. To reduce the carbon impact, that source of destructive pollution must be transformed into a cleaner fuel. Most of the biomethane produced at the farm can be used to generate sufficient electricity to power several homes. The remaining is then used as fertiliser on the farm, allowing for a reduction in the use of synthetic fertilisers made from fossil fuels.

Biomethane produced from cow dung is a biofuel with high performance and high purity. Obtaining biomethane from cow dung starts right on the farm, where cow dung is collected and put into an on-site biodigester. A biodigester is a sealed container where the bacteria breaks down cow dung into biomethane and fertiliser through a natural process. The biomethane then spins a power generator to produce electricity. The fertiliser produced from the biodigester can also be readily used by farmers.

Fig. 8.1 shows the process of obtaining biomethane.

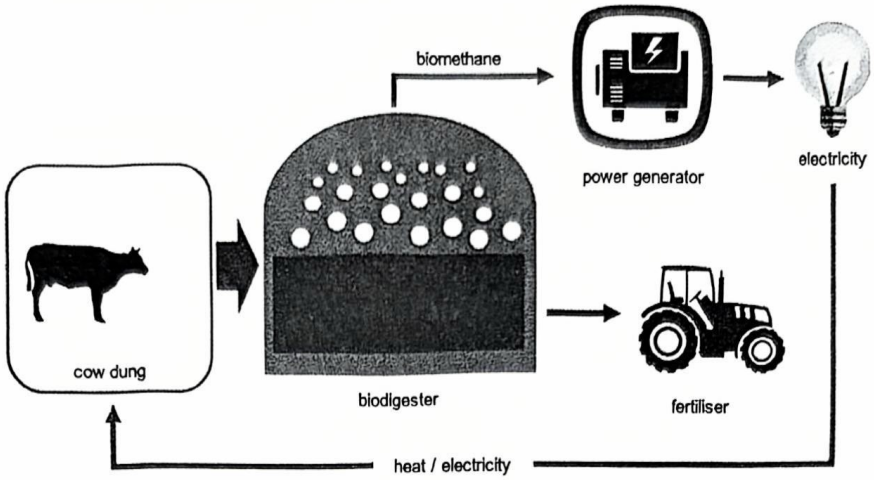


Fig. 8.1

Alternative Energy Source - Metal Powders

Using tiny metal particles to power external-combustion engines is novel. Unlike the internal-combustion engines used in petrol-powered cars, external-combustion engines use heat from an outside source to drive an engine. For decades, the idea of burning metal powders has been used in fireworks and in rocket propellants, such as the solid-fuel booster rockets of space shuttles.

The potential for metal powders to be used as a recyclable fuel in a wide range of applications has been largely overlooked by scientists. When metal powders are burned, they react with air to form a non-toxic solid oxide product that can be easily collected for recycling, unlike the carbon dioxide emission produced from the burning of fossil fuels that escape into the atmosphere. Iron could be the primary candidate for this purpose as millions of tonnes of iron powders are already produced annually for the chemical and electronic industries. However, more research needs to be done to avoid carbon dioxide emissions associated with traditional iron production using coal. While not perfected and commercialised yet, the use of low-cost metallic fuels, like iron powder, is a worthy alternative to petrol and diesel fuels.

(a) **(i)** Farmers can easily detect when levels of hydrogen sulfide in the biogas increase.

Explain why this is so.

.....

..... [1]

(ii) Explain why hydrogen sulfide must be removed from the biogas.

.....

.....

..... [2]

[Turn Over

(b) Burning biomethane from cow dung also produces greenhouse gases.

However, many people still think that it is worth using cow dung to generate electricity on the farms.

Use the information provided to suggest **environmental** and **economical** reasons why many people think so.

.....

.....

.....

.....

.....

.....

and ..... [5]

(c) Iron powder burns in air to form iron(III) oxide, which can be easily collected and then converted back to iron.

(i) Suggest a reactant to convert iron(III) oxide back to iron.

..... [1]

(ii) Use the information provided to explain why iron powder is considered a recyclable fuel as compared to fossil fuels.

.....

..... [1]

[Total: 10]

Section B

Answer **one** question from this section.

9 The table shows some properties of five esters.

name	structure	relative molecular mass	melting point °C	boiling point / °C
methyl ethanoate	CH_3COOCH_3	74	−98	57
ethyl ethanoate	$CH_3COOCH_2CH_3$	88	−84	77
propyl ethanoate	$CH_3COOCH_2CH_2CH_3$	102	−95	102
butyl ethanoate	$CH_3COOCH_2CH_2CH_2CH_3$	116	−78	126
pentyl ethanoate	$CH_3COOCH_2CH_2CH_2CH_2CH_3$	130	−71	148

(a) These esters are part of a homologous series.

Using the data given, state two characteristics of a homologous series.

1. .....

.....

2. .....

.....

[2]

(b) The next member of the homologous series is hexyl ethanoate.

Explain why it is more difficult to predict the melting point than the boiling point of hexyl ethanoate.

.....

.....

.....

..... [2]

(c) At 25 °C, ethyl ethanoate is a liquid.

Explain how the data in the table shows this.

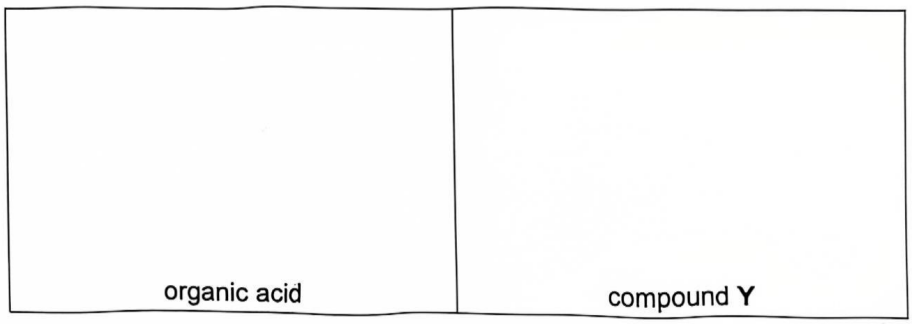
.....

.....

..... [2]

(d) **(i)** Methyl ethanoate can be made from an organic acid and compound **Y**.

Draw the structures of the two compounds from which methyl ethanoate is made.



[2]

(ii) Hence, calculate the maximum mass of methyl ethanoate that can be made from 1.20 g of organic acid and excess compound **Y**.

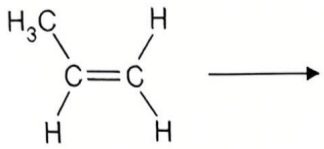
[2]

[Total: 10]

10 Food packaging used in industries produces a lot of waste which includes both glass and plastic.

(a) One of the plastics that is commonly used in food packaging is polypropene which is formed by addition polymerisation.

(i) Complete the equation by drawing the structure of polypropene.

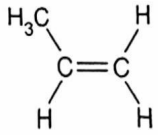


[1]

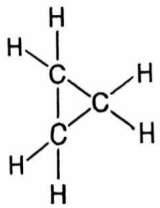
(ii) With the aid of an equation, calculate the percentage yield of carbon dioxide if 4800 dm^3 of carbon dioxide is released when 4.2 kg of propene is burnt.

[2]

(b) Propene and cyclopropane are isomers.



propene



cyclopropane

(i) Suggest how the structures of propene and cyclopropane show that they are isomers.

.....

..... [1]

(ii) Describe a chemical test that can distinguish propene from cyclopropane.

.....

.....

..... [2]

(c) The glass waste from food packaging can be melted at high temperatures and then made into new objects.

(i) Using the movement of particles, describe the changes in movement and arrangement of the particles when melting occurs.

.....

.....

.....

..... [2]

(ii) Glass waste contains SiO_2.

In terms of structure and bonding, explain why this melting takes place at high temperatures.

.....

.....

.....

..... [2]

[Total: 10]

The Periodic Table of Elements

Group 2												Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
											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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

proton (atomic) number
atomic symbol
name
relative atomic mass

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