Candidate Name	Form Class	Index Number

ANG MO KIO SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2024
SECONDARY FOUR EXPRESS

CHEMISTRY **6092/02**
Paper 2
22 August 2024
1 hour 45 minutes

Setter: Mr Vincent Voo

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 provided at the top of this paper.
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 19.

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

For Examiner's use	
Section A	
Section B	
TOTAL	

This document consists of **19** printed pages and **1** blank page.

[Turn Over

Section A

Answer **all** questions.

1 Fig 1.1 shows the arrangement of atoms in four substances, W, X, Y and Z.

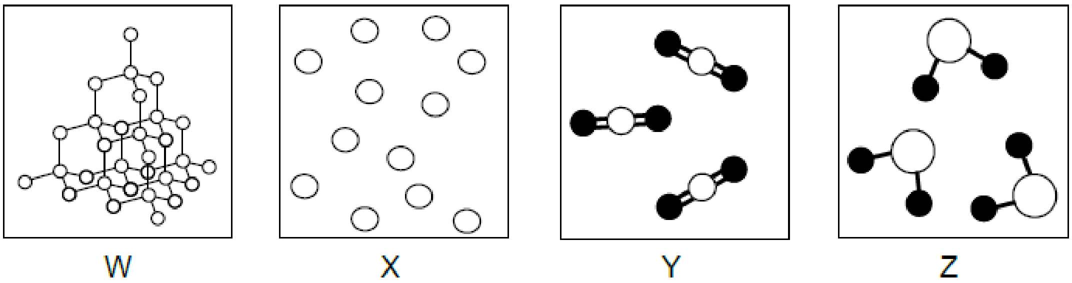


Fig. 1.1

(a) State and explain, in terms of structure and bonding, which substance is a noble gas.

....

....

.... [2]

(b) State and explain, in terms of structure and bonding, which substance is carbon dioxide gas.

....

....

.... [2]

(c) Explain, in terms of structure and bonding, why substance W has high melting and boiling points.

....

....

....

.... [2]

(d) Suggest one similarity between substances, W, X, Y and Z.

....

.... [1]

[Total: 7]

2 The reaction sequence below shows the formation of lead(II) sulfate from lead(II) oxide.

$$PbO \xrightarrow{\text{substance Y}} Pb(NO_3)_2 \xrightarrow{H_2SO_4(aq)} PbSO_4$$

(a) Lead(II) oxide is an amphoteric oxide.

Explain what is meant by the term 'amphoteric oxide'.

....

.... [1]

(b) Substance Y reacts with lead(II) oxide to form lead(II) nitrate.

Suggest what is substance Y.

.... [1]

(c) Explain why lead(II) sulfate cannot be prepared by adding dilute sulfuric acid to lead(II) oxide directly.

....

....

.... [2]

[Total: 4]

3 Sodium sufite, Na_2SO_3 is used as a preservative in some foods, such as meat patties used in burgers. The amount of sodium sulfite in a sample of burger meat can be determined using manganate(VII) titration. The reaction is shown in the equation.

$$5\ SO_3^{2-} + 2\ MnO_4^- + 6\ H^+ \rightarrow 5\ SO_4^{2-} + 2\ Mn^{2+} + 3\ H_2O$$

In an experiment, sodium sulfite from 1 kg of meat was acidified with dilute sulfuric acid and titrated against 0.02 mol/dm^3 aqueous potassium(VII) manganate, $KMnO_4$. 30 cm^3 of MnO_4^- was required to reach the end-point.

(a) Calculate the number of moles of MnO_4^- used to react completely with SO_3^{2-}.

Number of moles of MnO_4^- = ... mol [1]

(b) Calculate the number of moles of sodium sulfite present in 1 kg of meat.

Number of moles of sodium sulfite = …………………… mol [2]

(c) Identify the reducing agent in the reaction. Explain your answer in terms of oxidation number.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

[Total: 5]

4 Flerovium, symbol Fl is radioactive and has an atomic number of 114. It was first synthesised in 1998 and is classified as a metal.

To make flerovium, atoms of plutonium (atomic number 94) are bombarded with ions of element X contained in a beam. The nucleus of one atom of plutonium combines with the nucleus of one atom of element X. This forms the nucleus of one atom of Flerovium.

(a) Suggest the identity of element X.

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

(b) By referring to the Periodic Table on page 19,

(i) state the period that Flerovium belongs to;

……………………………………………………………………………………… [1]

(ii) predict the number of outer electrons in an atom of Flerovium.

……………………………………………………………………………………… [1]

(c) Two isotopes of Flerovium, Fl−286 ad Fl−289 are discovered.

Complete the table to show the number of protons, neutrons and electrons in atoms of the isotopes.

isotope	number of protons	number of neutrons	number of electrons
Fl−286			
Fl−289			

[2]

(d) Only a few atoms of flerovium have ever been made, and they are only used in scientific study. It has been suggested that Flerovium is a typical metal.

(i) Suggest one physical property of Flerovium.

.... [1]

(ii) Suggest one chemical property of flerovium oxide.

.... [1]

[Total: 7]

5 The Haber Process is used in the manufacturing of ammonia from nitrogen and hydrogen. The process can be demonstrated in the laboratory using the set-up shown in Fig. 5.1.

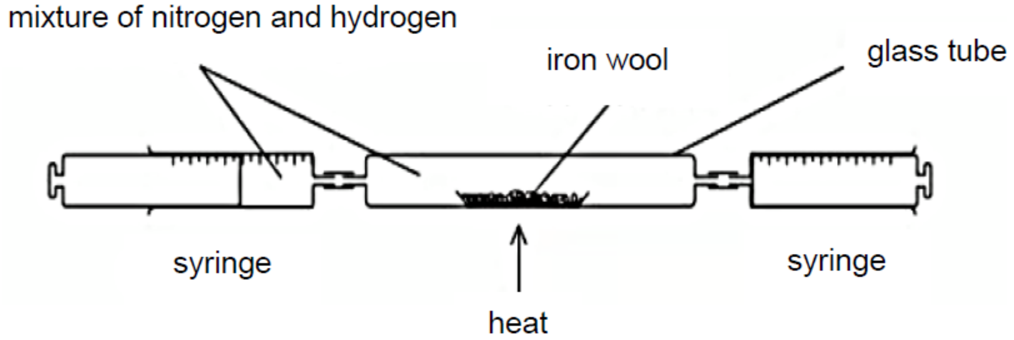


Fig. 5.1

The mixture of nitrogen and hydrogen is passed back and forth over the hot iron wool until there is no further reaction.

The equation for the reaction is as shown.

$$3\ H_2\ (g)\ +\ N_2\ (g)\ \rightarrow\ 2\ NH_3\ (g)$$

Table 5.1 shows some bond energies, measured in kilojoules per mole.

bond	bond energy / kJ/mol
N−H	391
H−H	436
N≡N	945

Table 5.1

(a) Suggest why it is important to ensure that no air is present in the apparatus shown in Fig. 5.1.

....

.... [1]

(b) Using the bond energies given in Table 5.1, calculate the energy change, ΔH involved in the manufacture of ammonia.

Energy change, ΔH = …………………… kJ [2]

(c) Is the chemical reaction in the Haber Process an exothermic or endothermic reaction?

Explain your answer in terms of bond-breaking and bond-forming.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(d) Draw an energy profile diagram to represent the chemical reaction in the Haber Process.

[3]

(e) The rate of forming ammonia from nitrogen and hydrogen can be increased by adding iron catalyst as shown in Fig. 5.1.

On the same energy profile diagram in (d), draw the profile of energy level for a catalysed reaction in the Haber Process. Label it as "catalysed reaction". [1]

[Total: 9]

6 Fig. 6.1 shows an experiment that was carried out to investigate the rate of decomposition of hydrogen peroxide. A catalyst, manganese(IV) oxide, was added to a conical flask containing 50.0 cm^3 of aqueous hydrogen peroxide. The mass of the flask was measured using an electronic balance. The results were recorded and used to plot a graph labelled X in Graph 6.1.

The student has three glasses. He picks up the first glass containing colourless solution **X** which he said is ‘water’.

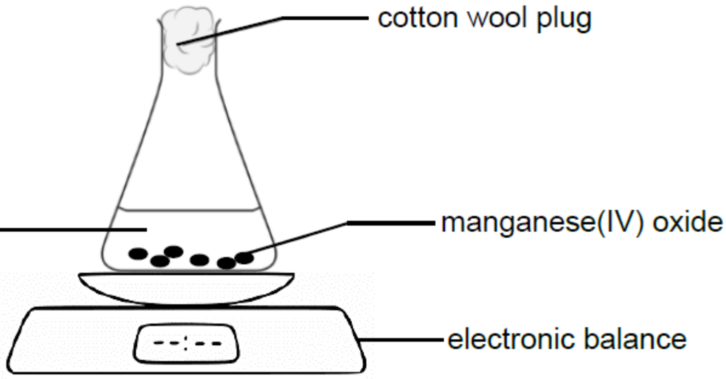
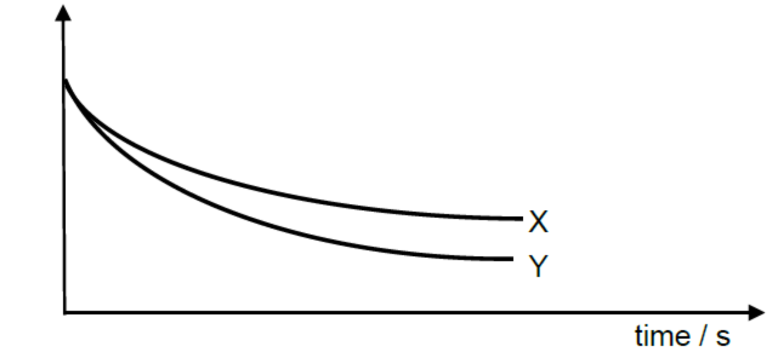


Fig. 6.1



Graph 6.1

(a) Write the chemical equation for the decomposition of hydrogen peroxide.

.... [1]

(b) Suggest the use of the cotton wool plug.

.... [1]

(c) In Graph 6.1, graph Y shows the theoretical results expected.

Explain the difference between the actual results, Graph X and the theoretical results, Graph Y.

....

....

.... [2]

(d) State one other way in which the rate of decomposition of aqueous hydrogen peroxide can be increased without changing the mass of reactant or catalyst used.

.... [1]

(e) Describe what you would do to show that manganese(IV) oxide is acting as a catalyst in the decomposition of hydrogen peroxide.

....

....

....

....

.... [3]

[Total: 8]

7 Fig. 7.1 shows the apparatus used to investigate the relative reactivity of four metals, W, X, Y and Z. Metal strips W, X, Y and Z and a copper plate were first cleaned with sandpaper. Strips of these metals were connected in turn with the wet filter paper resting on the copper plate and the voltmeter reading was recorded in Table 7.1.

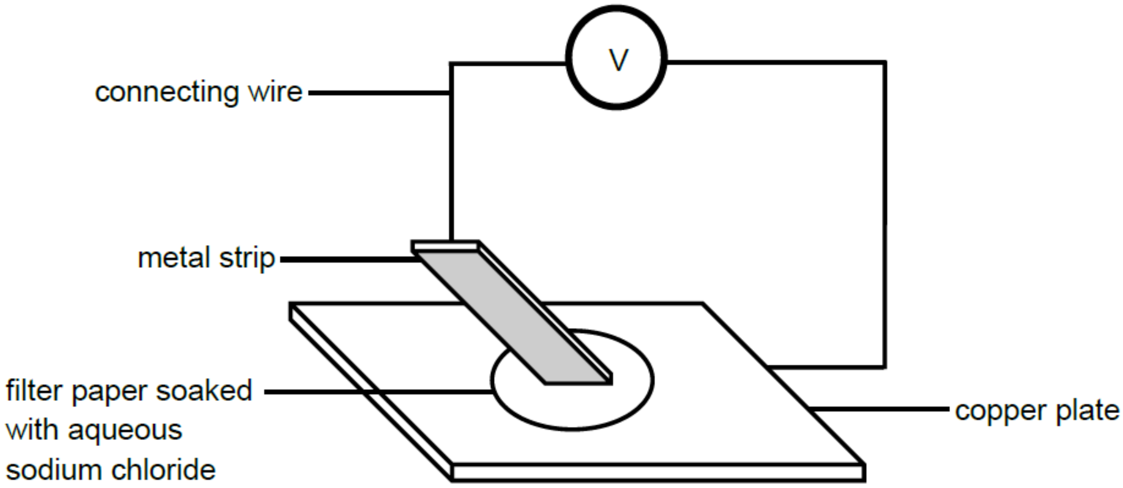


Fig. 7.1

metal	direction of electron flow in the external circuit	voltmeter reading / V
W	W to Cu	+0.85
X	X to Cu	+1.45
Y	Cu to Y	−0.93
Z	Z to Cu	+0.49

Table 7.1

(a) Suggest a reason why the metal strips and copper plate must first be cleaned with sandpaper.

…………………………………………………………………………………………….

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

(b) With reference to Table 7.1, arrange the five metals, W, X, Y, Z and copper in deceasing order of reactivity.

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

(c) State how the positions of the metals in the reactivity series affect the magnitude of voltage.

……………………………………………………………………………………………

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

(d) State and explain any difference in the voltmeter readings if the experiment is repeated using filter paper soaked with organic solvent methylbenzene.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(e) X is a metal in Group II of the Periodic Table.

(i) Describe the observations when metal X is placed in copper(II) sulfate solution.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) Write an ionic equation, with state symbols, for the reaction.

…………………………………………………………………………………… [2]

[Total: 10]

8 Modern vehicles with internal combustion engines are fitted with catalytic converters that reduce the pollution they produced.

Table 8.1 shows information about the composition of the mixtures of exhaust gases emitted from two cars, one fitted with a catalytic converter and the other without.

substance in exhaust gases	percentage by volume / %	
	car fitted with catalytic converter	car not fitted with catalytic converter
nitrogen	67.65	67.60
carbon dioxide	12.25	12.00
water vapour	11.10	11.00
oxygen	9.00	9.00
carbon monoxide	0	0.20
oxides of nitrogen	0	0.15
unburnt hydrocarbons	0	0.05

Table 8.1

(a) State how carbon monoxide is formed in the internal combustion engines of cars.

....

.... [1]

(b) Using the information in Table 8.1, suggest with the help of a suitable equation, how a catalytic converter helps to reduce air pollution from cars.

....

....

....

....

....

.... [3]

(c) One of the car exhaust gases is a greenhouse gas and contributes to global warming.

(i) Name this exhaust gas.

.... [1]

(ii) State one environmental consequence of climate change due to global warming.

.... [1]

(d) An environmentalist suggests that planting more trees along the roadside can improve air quality by changing the percentage of carbon dioxide and oxygen in air.

(i) Explain how trees along the roadside can change the percentages of carbon dioxide and oxygen in air.

....

.... [2]

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

[2]

[Total: 10]

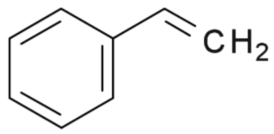
9 Styrene is an aromatic hydrocarbon compound. The major uses for styrene are the manufacture of polystyrene, an important plastic, latex paints and coating, synthetic rubber and polyesters and styrene-alkyd coatings.

Pure styrene is a colourless, oily and flammable liquid which evaporates easily and has a sweet smell. Its melting and boiling points are −30.6 °C and 145 °C respectively.

Styrene tends to polymerise spontaneously during storage unless it is treated with inhibitor chemicals. It is slightly toxic to the nervous system if ingested or inhaled. Contact with the skin and eyes can cause irritation.

Styrene is a member of a group of chemical compounds broadly categorised as vinyl-organic compounds. Its structure consists of a vinyl side chain with a double bond between two carbon atoms substituent on a single benzene ring. The benzene ring, C_6H_6, is an aromatic functional group characterised by a ring of six carbon atoms, bonded by alternating single and double bonds. As a benzene ring has three double bonds, it is an electron rich molecule with delocalised electrons above and below the plane of the ring. The presence of the delocalised electrons makes the benzene ring particularly stable. Hence, a benzene ring resists addition reactions because that would involve breaking the delocalisation and losing that stability.

The chemical formula of styrene is C_8H_8 but its structural formula, $C_6H_5CH{=}CH_2$ more clearly reveals the sources of its commercially useful properties.



structural formula of styrene

Fig. 9.1

Industrial production of styrene from ethylbenzene

Most of the styrene is produced from ethylbenzene, and almost all ethylbenzene produced worldwide is intended for styrene production. Therefore, the two production processes are often highly integrated. Ethylbenzene has a boiling point of 136 °C.

Around 80% of styrene is produced by the dehydrogenation of ethylbenzene. This is achieved using superheated steam of up to 600 °C over an iron(III) oxide catalyst. The reaction is highly endothermic and reversible, with a typical yield of 88% to 94%.

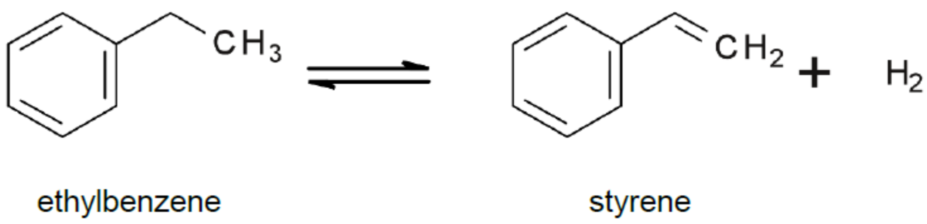


Fig 9.2

The crude ethylbenzene–styrene mixture is` then purified by distillation using very tall distillation towers and high return/reflux ratio. At its distillation temperatures, styrene tends to polymerise. To minimise this problem, early styrene plants added elemental sulfur to inhibit the polymerisation process.

Laboratory synthesis of styrene

Styrene was first synthesised from the decarboxylation of cinnamic acid.

$$C_6H_5CH{=}CHCOOH \rightarrow C_6H_5CH{=}CH_2 + CO_2$$

(a) Explain, in terms of structure and bonding, why styrene has a low melting point of −30.6 ^oC.

....

....

....

.... [2]

(b) Draw a dot-and-cross diagram of a benzene ring. Show only the outer electrons.

[2]

(c) Explain the overall enthalpy change in terms of energy change for the production of styrene from the dehydrogenation of ethylbenzene.

....

.... [1]

(d) Explain why tall distillation towers are necessary for the separation of styrene and ethylbenzene from the crude styrene-ethylbenzene mixture.

……………………………………………………………………………………………

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

(e) What type of polymerisation does styrene undergo to form polystyrene?

Explain your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(f) Draw the structure of polystyrene with three repeating units.

[2]

[Total: 10]

END OF SECTION A

Section B

Answer **one** question from this section.

10 Fig. 10.1 shows the apparatus used in the electrolysis of concentrated aqueous hydrochloric acid.

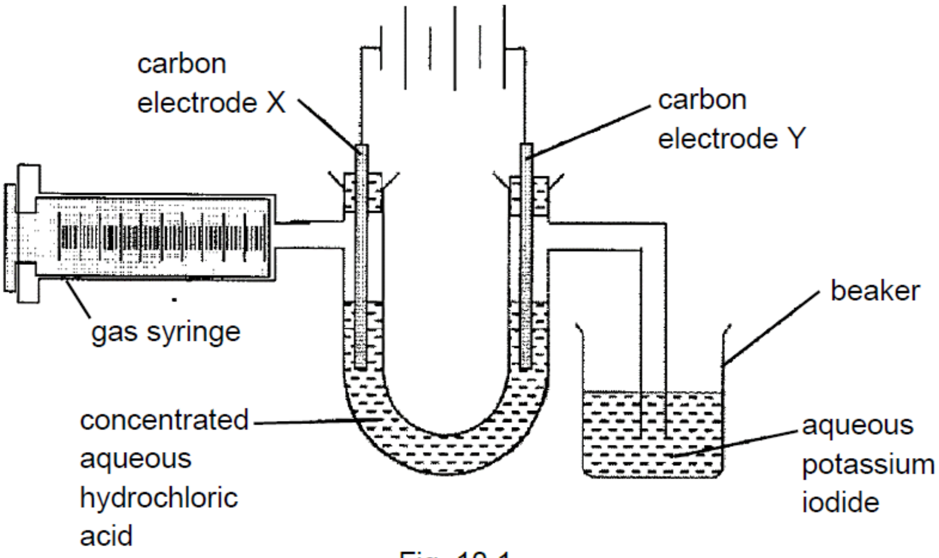


Fig. 10.1

(a) Write the half equations, with state symbols for the reactions at the electrodes.

carbon electrode X: ……………………………………………………………………….

carbon electrode Y: ……………………………………………………………........ [2]

(b) As shown in Fig. 10.1, the gas discharged at electrode Y is bubbled into a beaker containing aqueous potassium iodide.

With the aid of a chemical equation, describe and explain what you would observe in the beaker.

………………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

……………………………………………………………………………………………….. [3]

(c) After the electrolysis was allowed to proceed for some time, it was observed that a new product was formed at carbon electrode Y.

State the identity of this new product and explain why it is formed.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(d) Another experiment was carried out to electrolyse copper(II) sulfate solution using copper electrodes.

Student A commented that the colour intensity of the blue copper(II) sulfate solution will remain unchanged throughout the experiment.

Student B commented that the colour intensity of the blue copper(II) sulfate solution will start to fade away throughout the experiment.

Which student is correct? Explain your answer with the help of half equations.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

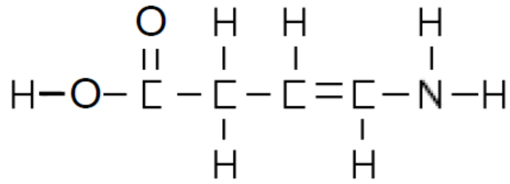
…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [3]

[Total: 10]

11 The structure of organic compound X is shown below.



(a) When compound X is warmed with propanol and concentrated sulfuric acid, a new organic compound Y is formed.

(i) State one other product that is formed beside compound Y during the reaction.

………………………………………………………………………………….. [1]

(ii) State one physical property that is characteristic of compound Y.

………………………………………………………………………………….. [1]

(iii) Draw the structural formula of compound Y.

[2]

(b) Compound X can undergo condensation polymerisation to form a polymer Z.

Draw the polymer with 2 repeating units.

[2]

(c) State the type of linkages that join the repeating units in polymer Z.

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

(d) State whether compound X is a saturated or unsaturated compound.

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

(e) Describe and explain what would be observed when a few drops of aqueous bromine are added to compound X.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

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

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

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

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