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CHEMISTRY

0620/33

Paper 3 Theory (Core)

May/June 2022

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

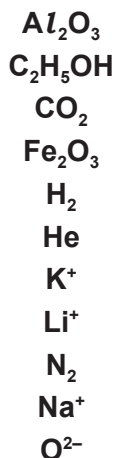
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **20** pages. Any blank pages are indicated.

1 (a) A list of symbols and formulae is shown.



Answer the following questions using these symbols or formulae.
 Each symbol or formula may be used once, more than once or not at all.

State which symbol or formula represents:

(i) an element that is monoatomic

..... [1]

(ii) an ion that gives a red colour in a flame test

..... [1]

(iii) an element that can be used as a fuel

..... [1]

(iv) a gas that contributes to climate change

..... [1]

(v) an ion that is formed when an atom gains electrons.

..... [1]

(b) Complete the table to show the relative charges of a proton, neutron and electron.

| type of particle | relative charge |
|------------------|-----------------|
| proton | |
| neutron | 0 |
| electron | |

[2]

- (c) Choose the two correct statements about nitrogen and hydrogen in a mixture.
Tick (✓) **two** boxes.

The nitrogen and hydrogen mixture can be separated by physical means.

The nitrogen and hydrogen mixture is liquid at room temperature.

The atoms of nitrogen and hydrogen in the mixture are chemically combined.

Air is mainly a mixture of nitrogen and hydrogen.

The bonding in both nitrogen and hydrogen molecules is covalent.

[2]

[Total: 9]

2 The table shows the masses of some ions in a 1000 cm^3 sample of toothpaste.

| name of ion | formula of ion | mass of ion in 1000 cm^3 of toothpaste/g |
|-------------|--------------------|---|
| | NH_4^+ | 0.2 |
| calcium | Ca^{2+} | 0.8 |
| | CO_3^{2-} | 0.7 |
| chloride | Cl^- | 0.9 |
| fluoride | F^- | 2.2 |
| magnesium | Mg^{2+} | 2.0 |
| phosphate | PO_4^{3-} | 24.4 |
| sodium | Na^+ | 34.2 |
| sulfate | SO_4^{2-} | 10.1 |
| tin(II) | Sn^{2+} | 0.4 |
| zinc | Zn^{2+} | 0.1 |

(a) Answer these questions using only the information in the table.

(i) State which negative ion has the highest mass in 1000 cm^3 of toothpaste.

..... [1]

(ii) Name the compound that contains NH_4^+ and CO_3^{2-} ions.

..... [1]

(iii) Calculate the mass of fluoride ions in 250 cm^3 of toothpaste.

mass = g [1]

(b) Describe the observations when aqueous ammonia is added drop by drop to a solution containing zinc ions until the ammonia is in excess.

observations with a few drops of ammonia

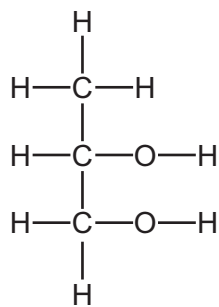
.....

observations with ammonia in excess

.....

[2]

- (c) Toothpaste also contains compound **A**.
The structure of compound **A** is shown.



Deduce the formula of compound **A** to show the number of atoms of carbon, hydrogen and oxygen.

..... [1]

- (d) Compound **A** is an alcohol.
Ethanol, C₂H₅OH, is also an alcohol.

- (i) Complete these sentences about ethanol using words from the list.

different formula group identical molecule similar

Ethanol is part of the alcohol homologous series.

Each member of the alcohol homologous series has the same functional

Members of the same homologous series have chemical properties that are [2]

- (ii) When ethanol undergoes incomplete combustion, a small amount of carbon dioxide is produced.

Name two **other** substances that are produced when ethanol undergoes incomplete combustion.

..... and [2]

[Total: 10]

3 This question is about Group I and Group VII elements.

(a) Deduce the number of electrons, neutrons and protons in one atom of the isotope of sodium shown.



number of electrons

number of neutrons

number of protons

[3]

(b) Sodium reacts with chlorine to produce sodium chloride.

(i) State the colour of chlorine gas.

..... [1]

(ii) Chlorine is a diatomic molecule.

State the meaning of the term *diatomic*.

..... [1]

(iii) Complete the chemical equation for the reaction of sodium with chlorine.



(iv) Sodium chloride is an ionic compound.

Describe **two** physical properties of ionic compounds.

1

2

[2]

(c) The table shows some properties of four Group I elements.

| element | melting point /°C | boiling point /°C | atomic radius /nm |
|-----------|-------------------|-------------------|-------------------|
| lithium | 181 | 1342 | 0.157 |
| sodium | 98 | 883 | |
| potassium | | 760 | 0.235 |
| rubidium | 39 | 686 | 0.250 |

- (i) Complete the table by predicting:
- the melting point of potassium
 - the atomic radius of sodium.

[2]

- (ii) Predict the physical state of rubidium at 700 °C.
Give a reason for your answer.

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

- (iii) Give **two** physical properties of Group I metals that are different from transition elements and state how they are different.

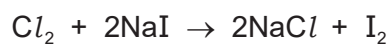
1

.....

2

..... [2]

(d) Aqueous chlorine reacts with aqueous sodium iodide.



Explain how this equation shows that chlorine is more reactive than iodine.

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

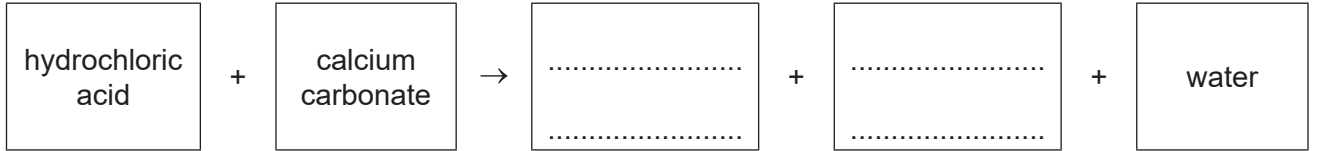
[Total: 16]

4 This question is about acids and carbonates.

(a) Describe the colour change when excess acid is added to a solution of methyl orange in alkaline solution.

from to [2]

(b) Complete the word equation for the reaction of hydrochloric acid with calcium carbonate.



[2]

(c) Calcium carbonate decomposes when heated.



(i) Calcium carbonate is used in the manufacture of lime (calcium oxide).

State one **other** use of calcium carbonate.

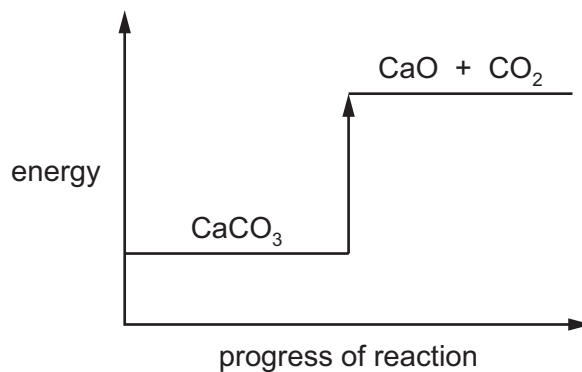
..... [1]

(ii) The decomposition of calcium carbonate is endothermic.

State the meaning of the term *endothermic*.

..... [1]

(iii) The energy level diagram for the decomposition of calcium carbonate is shown.



Explain how the energy level diagram shows that this reaction is endothermic.

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

(iv) When 0.50 g of calcium carbonate decomposes, 120 cm³ of carbon dioxide gas is produced.

Calculate the volume of carbon dioxide gas produced when 0.10 g of calcium carbonate is used.

volume of carbon dioxide gas = cm³ [1]

[Total: 8]

5 This question is about Group VI elements and their compounds.

(a) Name the changes of physical state when:

- oxygen gas is converted to liquid oxygen

.....

- solid sulfur is converted directly to sulfur gas.

.....

[2]

(b) Use the kinetic particle model to describe the differences between solid sulfur and sulfur gas in terms of:

- the arrangement of the particles

.....

.....

- the motion of the particles.

.....

.....

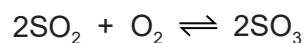
[4]

(c) Deduce the electronic structure of sulfur.

Use the Periodic Table to help you.

..... [1]

(d) Sulfur is used in the manufacture of sulfuric acid.
The equation shows one of the reactions.



(i) State the meaning of the symbol \rightleftharpoons .

..... [1]

(ii) Give **one** use of sulfur dioxide other than in making sulfuric acid.

..... [1]

(e) Acid rain is formed when sulfur dioxide reacts with water vapour in the atmosphere.

(i) Choose the pH value which is acidic.

Draw a circle around your chosen answer.

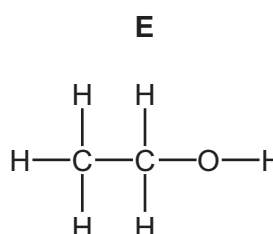
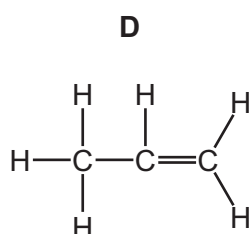
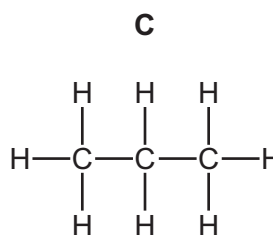
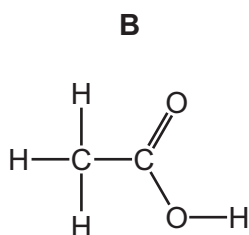
pH 4 pH 7 pH 10 pH 14 [1]

(ii) Describe **one** effect of acid rain on buildings.

..... [1]

[Total: 11]

- 6 (a) The structures of four organic compounds, **B**, **C**, **D** and **E**, are shown.



- (i) State which compound, **B**, **C**, **D** or **E**, dissolves in water to form an acidic solution.
 [1]
- (ii) State which compound, **B**, **C**, **D** or **E**, is a saturated hydrocarbon.
 [1]
- (iii) State which compound, **B**, **C**, **D** or **E**, is an unreactive compound except in terms of burning.
 [1]
- (iv) State which compound, **B**, **C**, **D** or **E**, decolourises aqueous bromine.
 [1]

- (b) Ethanol can be manufactured from ethene and one other reactant.

Describe the manufacture of ethanol from ethene to include:

- the formula of ethene

.....

- the name of the other reactant

.....

- the conditions needed.

.....

.....

[4]

(c) Complete the table to show the name and uses of some petroleum fractions.

| name of fraction | use of fraction |
|------------------|------------------|
| | making chemicals |
| kerosene | |
| fuel oil | |

[3]

[Total: 11]

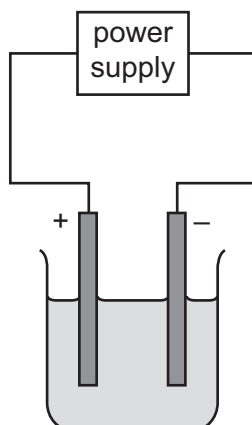
7 This question is about lithium and compounds of lithium.

(a) Lithium reacts with nitrogen to produce lithium nitride, Li_3N .

Complete the chemical equation for this reaction.



(b) Molten lithium bromide is electrolysed using carbon electrodes. The apparatus is shown.



(i) Complete the diagram by labelling:

- the anode
- the electrolyte.

[2]

(ii) Name the products formed at each electrode.

positive electrode

negative electrode

[2]

(iii) The carbon electrodes conduct electricity.

Give one **other** property that these electrodes must have.

..... [1]

(c) A compound of lithium has the formula $C_3H_5O_2Li_2$.

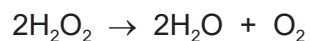
Complete the table to calculate the relative molecular mass of $C_3H_5O_2Li_2$.

| atom | number of atoms | relative atomic mass | |
|----------|-----------------|----------------------|--------------------|
| carbon | 3 | 12 | $3 \times 12 = 36$ |
| hydrogen | | 1 | |
| oxygen | | 16 | |
| lithium | | 7 | |

relative molecular mass = [2]

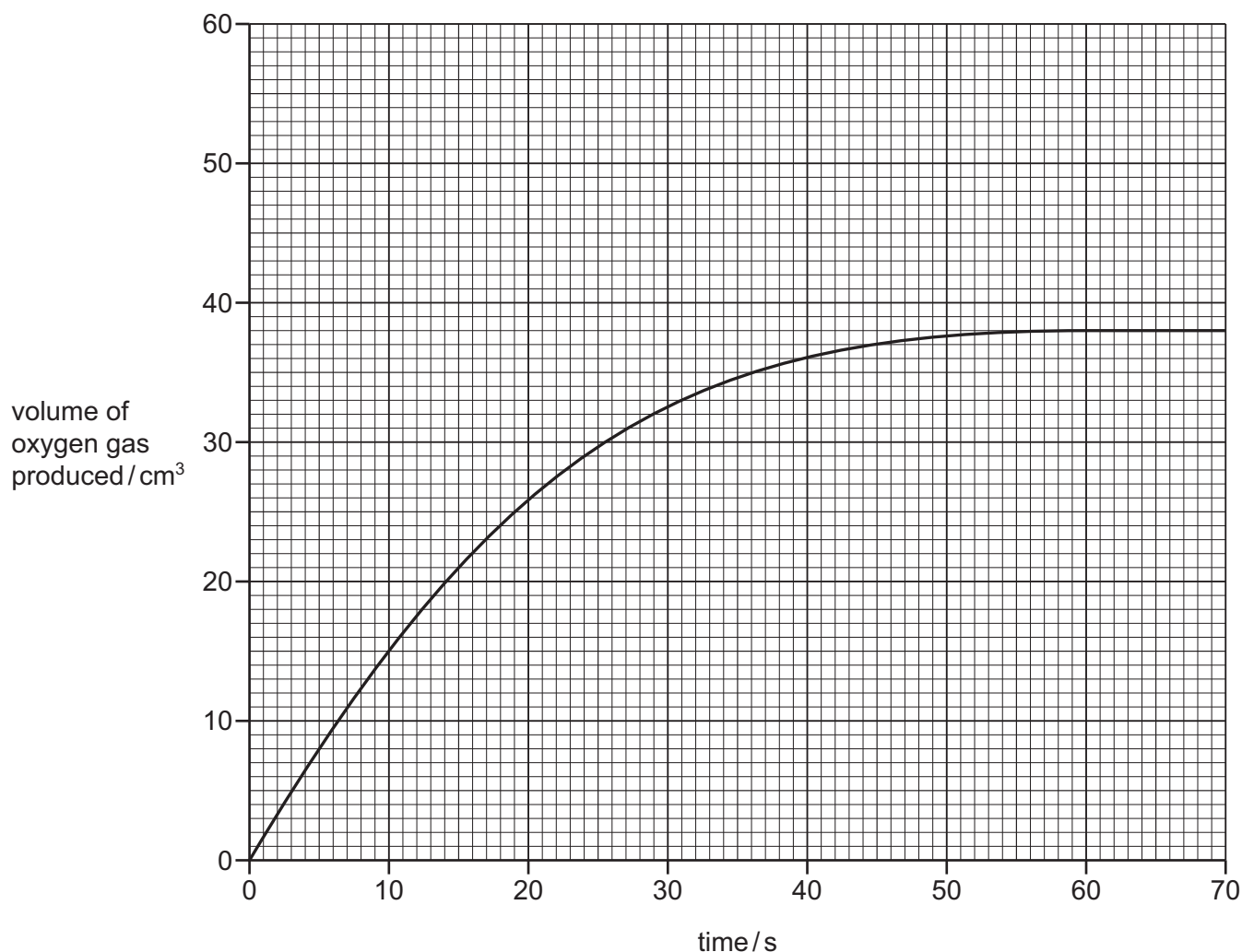
[Total: 9]

- 8 A student investigates the rate of decomposition of aqueous hydrogen peroxide using 0.2g of a catalyst.



The rate of reaction is found by measuring the volume of oxygen gas produced as time increases.

The results are shown on the graph.



- (a) Deduce the time taken to collect 35 cm³ of oxygen gas.

time = s [1]

- (b) The experiment is repeated using 0.2g of smaller pieces of the catalyst.

All other conditions stay the same.

Draw a line **on the grid** to show how the volume of oxygen gas produced changes as time increases. [2]

(c) Describe the effect each of the following has on the rate of decomposition of hydrogen peroxide.

All other conditions stay the same.

- The reaction is carried out at a higher temperature.

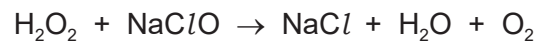
.....

- The reaction is carried out using a lower concentration of hydrogen peroxide.

.....

[2]

(d) Hydrogen peroxide reduces sodium chlorate(I), NaClO , to sodium chloride.



Describe how this equation shows that sodium chlorate(I) has been reduced.

..... [1]

[Total: 6]

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The Periodic Table of Elements

| | | Group | | | | | | | |
|-------------------------------------|------------------------------------|--|--|---------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|---------------------------------------|
| I | II | III | IV | V | VI | VII | VIII | | |
| 3 Li lithium 7 | 4 Be beryllium 9 | 1 H hydrogen 1 | 5 B boron 11 | 6 C carbon 12 | 7 N nitrogen 14 | 8 O oxygen 16 | 9 F fluorine 19 | 10 Ne neon 20 | 2 |
| 11 Na sodium 23 | 12 Mg magnesium 24 | Key atomic number atomic symbol name relative atomic mass | | | | | | | |
| 19 K potassium 39 | 20 Ca calcium 40 | 26 Fe iron 56 | 27 Co cobalt 59 | 28 Ni nickel 59 | 29 Cu copper 64 | 30 Zn zinc 65 | 31 Al aluminium 27 | 32 Si silicon 28 | 33 P phosphorus 31 |
| 37 Rb rubidium 85 | 38 Sr strontium 88 | 44 Ru ruthenium 101 | 45 Rh rhodium 103 | 46 Pd palladium 106 | 47 Ag silver 108 | 48 Cd cadmium 112 | 13 Al aluminium 27 | 14 Si silicon 28 | 15 P phosphorus 31 |
| 55 Cs caesium 133 | 56 Ba barium 137 | 76 Os osmium 190 | 77 Ir iridium 192 | 78 Pt platinum 195 | 79 Au gold 197 | 80 Hg mercury 201 | 13 Al aluminium 27 | 14 Si silicon 28 | 15 P phosphorus 31 |
| 87 Fr francium — | 88 Ra radium — | 108 Hs hassium — | 109 Mt meitnerium — | 110 Ds darmstadtium — | 111 Rg roentgenium — | 112 Cn copernicium — | 116 Lv livermorium — | 117 Tl thallium 204 | 118 Xe xenon 131 |
| 57 La lanthanum 139 | 58 Ce cerium 140 | 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 |
| 89 Ac actinium — | 90 Th thorium 232 | 94 Pu plutonium — | 95 Am americium — | 96 Cm curium — | 97 Bk berkelium — | 98 Cf californium — | 99 Es einsteinium — | 100 Fm fermium — | 101 Md mendelevium — |
| | | 60 Nd neodymium 144 | 61 Pm promethium — | 62 Gd gadolinium 157 | 63 Tb terbium 159 | 64 Dy dysprosium 163 | 65 Ho holmium 165 | 66 Er erbium 167 | 67 Tm thulium 169 |
| | | 92 U uranium 238 | 93 Np neptunium — | 94 Pu plutonium — | 95 Am americium — | 96 Cm curium — | 97 Bk berkelium — | 98 Cf californium — | 99 Md mendelevium — |
| | | 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 |
| | | 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 — |
| | | 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 |
| | | 89 Th thorium 232 | 90 Pa protactinium 231 | 91 U uranium 238 | 92 Np neptunium — | 93 Pu plutonium — | 94 Am americium — | 95 Cm curium — | 96 Bk berkelium — |
| | | 71 Lu lutetium 175 | 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 |
| | | 103 Lr lawrencium — | 104 Rf rutherfordium — | 105 Db dubnium — | 106 Sg seaborgium — | 107 Bh bohrium — | 108 Hs hassium — | 109 Mt meitnerium — | 110 Ds darmstadtium — |
| | | — | — | — | — | — | — | — | — |
| | | 86 Rn radon — | 87 Fr francium — | 88 Ra radium — | 89–103 actinoids | 89–103 actinoids | 89–103 actinoids | 89–103 actinoids | 89–103 actinoids |
| | | 84 Kr krypton 84 | 85 Rb rubidium 85 | 86 Ba barium 137 | 87 Cs caesium 133 | 88 Sr strontium 88 | 89 Y yttrium 89 | 90 Zr zirconium 91 | 91 Nb niobium 93 |
| | | 82 Pb lead 207 | 83 Bi bismuth 209 | 84 Po polonium — | 85 At astatine — | 86 Rn radon — | 87 Fr francium — | 88 Ra radium — | 89 Ac actinium — |
| | | 54 Xe xenon 131 | 55 Cs caesium 133 | 56 Ba barium 137 | 57–71 lanthanoids | 57–71 lanthanoids | 57–71 lanthanoids | 57–71 lanthanoids | 57–71 lanthanoids |
| | | 52 Te tellurium 128 | 53 I iodine 127 | 54 Xe xenon 131 | 55 Cs caesium 133 | 56 Ba barium 137 | 57–71 lanthanoids | 57–71 lanthanoids | 57–71 lanthanoids |
| | | 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 — |
| | | 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 |
| | | 32 S sulfur 32 | 33 P phosphorus 31 | 34 Se selenium 79 | 35 Br bromine 80 | 36 Kr krypton 84 | 37 Rb rubidium 85 | 38 Sr strontium 88 | 39 Y yttrium 89 |
| | | 18 Ar argon 40 | 19 F fluorine 19 | 20 Ne neon 20 | 21 Sc scandium 45 | 22 Ti titanium 48 | 23 V vanadium 51 | 24 Cr chromium 52 | 25 Mn manganese 55 |
| | | 16 S sulfur 32 | 17 Cl chlorine 35.5 | 18 Ar argon 40 | 19 F fluorine 19 | 20 Ne neon 20 | 21 Sc scandium 45 | 22 Ti titanium 48 | 23 V vanadium 51 |
| | | 16 S sulfur 32 | 17 Cl chlorine 35.5 | 18 Ar argon 40 | 19 F fluorine 19 | 20 Ne neon 20 | 21 Sc scandium 45 | 22 Ti titanium 48 | 23 V vanadium 51 |

lanthanoids

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).