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

WOODLANDS SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2024

Level:	Secondary 4 Express	Marks:	80
Subject:	Pure Chemistry	Day:	Tuesday
Paper:	6092/02	Date:	20 August 2024
Duration:	1 hour 45 minutes	Time:	0750 – 0935 hours

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work that 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 24.

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

FOR EXAMINER'S USE		
Section A	**Section B**	**Total**
/70	**/10**	**/80**

DO NOT TURN THE PAGE UNTIL YOU ARE TOLD TO DO SO.
This document consists of **22** printed pages and **2** blank pages.

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Section A

Answer **all** questions.

1 Use the list of substances to answer the following questions.

magnesium oxide

silicon dioxide

sulfur dioxide

carbon monoxide

zinc oxide

carbon dioxide

(a) Name **all** substances which are ionic compounds.

.....[1]

(b) Which substance has a similar structure like diamond?

.....[1]

(c) Which substance is an amphoteric oxide?

.....[1]

(d) Which **two** substances can dissolve in water to form solutions with pH less than 7?

.....[1]

(e) Which gaseous substance is neutral?

.....[1]

[Total: 5]

2 When ammonia gas reacts with hydrogen chloride gas, white fumes of ammonium chloride are formed.

$$NH_3 + HCl \rightleftharpoons NH_4Cl$$

Fig. 2.1 shows watch-glasses of aqueous ammonia and concentrated hydrochloric acid being placed near each other on a table.

At first, no white fumes were seen.

After a short time, white fumes were seen between the watch-glasses and were seen nearer to the watch-glass of hydrochloric acid.

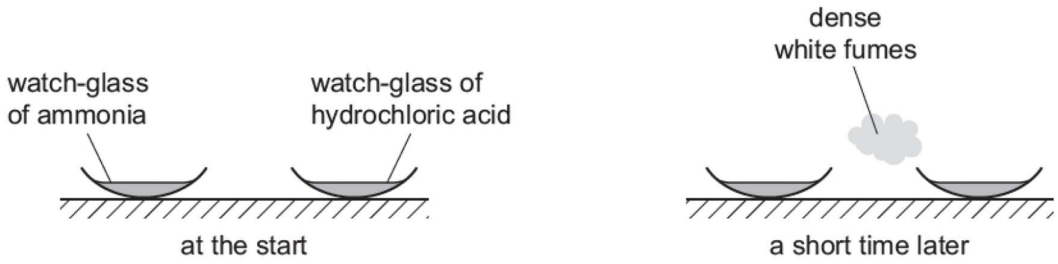


Fig. 2.1

(a) Explain these observations using the kinetic particle theory.

.....

.....

.....

.....[2]

(b) Draw a dot-and-cross diagram to show the bonding in ammonia.

Show only the outermost electrons.

[2]

[Total: 4]

3 Hydrogen fluoride, HF, has a simple molecular structure. It is soluble in water.

(a) Suggest **one** other physical property of hydrogen fluoride.

.....

.....[1]

(b) Hydrogen fluoride dissolves in water to form dilute hydrofluoric acid, a weak acid.

With the help of an equation, explain why hydrofluoric acid is a weak acid.

.....

.....

.....[2]

(c) Dilute hydrofluoric acid reacts with excess magnesium to form magnesium fluoride and hydrogen gas.

(i) Write a balanced chemical equation for the reaction.

.....[1]

(ii) Calculate the volume of gas produced if the acid solution contains 0.200 g of hydrofluoric acid.

volume = ... [2]

(d) Explain, in terms of structure and bonding, why magnesium fluoride has a high melting point.

.....

.....

.....[2]

[Total: 8]

4 A solid **E** was added to nitric acid. The tests and observations are outlined in Fig. 4.1.

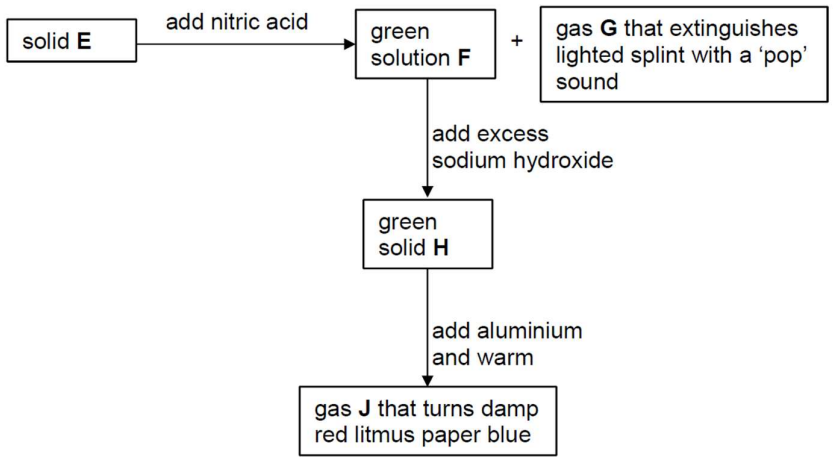


Fig. 4.1

(a) Identify the following substances.

(i) gas **G**

.....[1]

(ii) gas **J**

.....[1]

(iii) solid **E**

.....[1]

(b) Darren wanted to prepare a pure dry sample of zinc nitrate. He decided to use zinc oxide and nitric acid.

Using the reactants mentioned, describe the steps Darren must carry out in order to obtain a pure, dry sample of zinc nitrate.

.....

.....

.....

.....

.....[3]

[Total: 6]

5 Chlorine gas is bubbled into two solutions, potassium iodide and aqueous hydrogen peroxide, separately.

(a) Describe and explain what will be observed when chlorine gas is bubbled into potassium iodide solution.

.....

.....

.....

.....[2]

(b) The reaction between chlorine gas and hydrogen peroxide is shown below.

$$Cl_2 + H_2O_2 \rightarrow 2HCl + O_2$$

Explain, in terms of oxidation states, why this is a redox reaction.

.....

.....

.....

.....[2]

[Total: 4]

6 A student investigated the reactivity of four metals, copper, chromium, iron and manganese.

He carried out two different sets of experiments.

Fig. 6.1 shows the first set of experimental set-up.

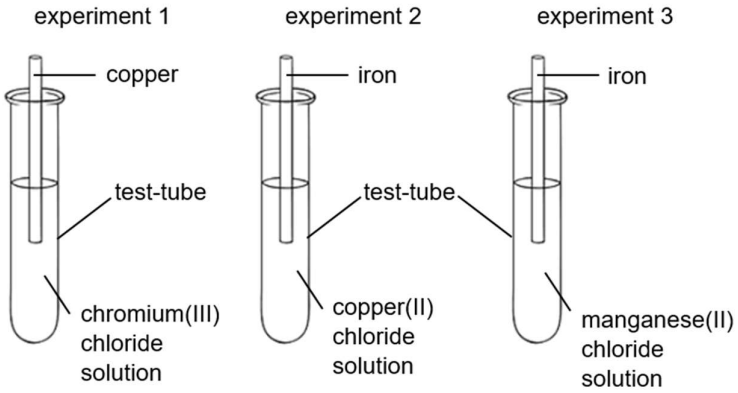


Fig. 6.1

Table 6.2 shows the results obtained in the first set of experiments.

Table 6.2

	experiment 1	**experiment 2**	**experiment 3**
changes to metal strip	reddish-brown metal remains unchanged		grey metal remains unchanged
changes to solution	green solution remains unchanged		colourless solution remains unchanged

(a) Complete Table 6.2 to show the observations made in **experiment 2**.

[2]

(b) In the second set of experiments, the student made use of dilute hydrochloric acid and samples of the metals.

He found out that chromium is the second most reactive metal.

(i) Other than effervescence, state **one** other observation made when chromium reacts with dilute hydrochloric acid.

.....

.....[1]

(ii) The student measures the volume of gas produced for a fixed duration of reaction to determine the reactivity of the metals.

Explain how the volume of gas produced relates to the reactivity of the metals and suggest a reason why the loss in mass for a fixed duration of reaction is **not** a recommended method.

.....

.....

.....

.....[2]

(iii) Assuming all the experimental conditions remain the same, describe how will the measurements collected in **(b)(ii)** change if dilute ethanoic acid is used instead of dilute hydrochloric acid.

Explain your answer.

.....

.....

.....

.....[2]

[Total: 7]

7 Ammonia reacts with oxygen as shown.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

(a) Calculate the volume of oxygen at room temperature and pressure that reacts with 4.80 dm^3 of ammonia.

volume = ... [2]

(b) Hence, calculate the volume of air at room temperature and pressure that is required for complete reaction with 4.80 dm^3 of ammonia.

Give your answer to 3 significant figures.

volume = ... [1]

(c) The chemical equation for the overall reaction can be represented as shown.

The table shows some bond energies.

bond	N — H	O = O	N = O	O — H
bond energy in kJ/mol	391	498	587	464

(i) With the information provided in the table, calculate the enthalpy change, ΔH, for the overall reaction.

ΔH = ... kJ/mol [3]

(ii) Draw the energy profile diagram for the overall reaction between ammonia and oxygen.

Indicate the enthalpy change, ΔH and activation energy, E_a on the diagram clearly.

[3]

[Total: 9]

8 Fig. 8.1 shows how the concentration of hydrochloric acid changes as the reaction proceeds.

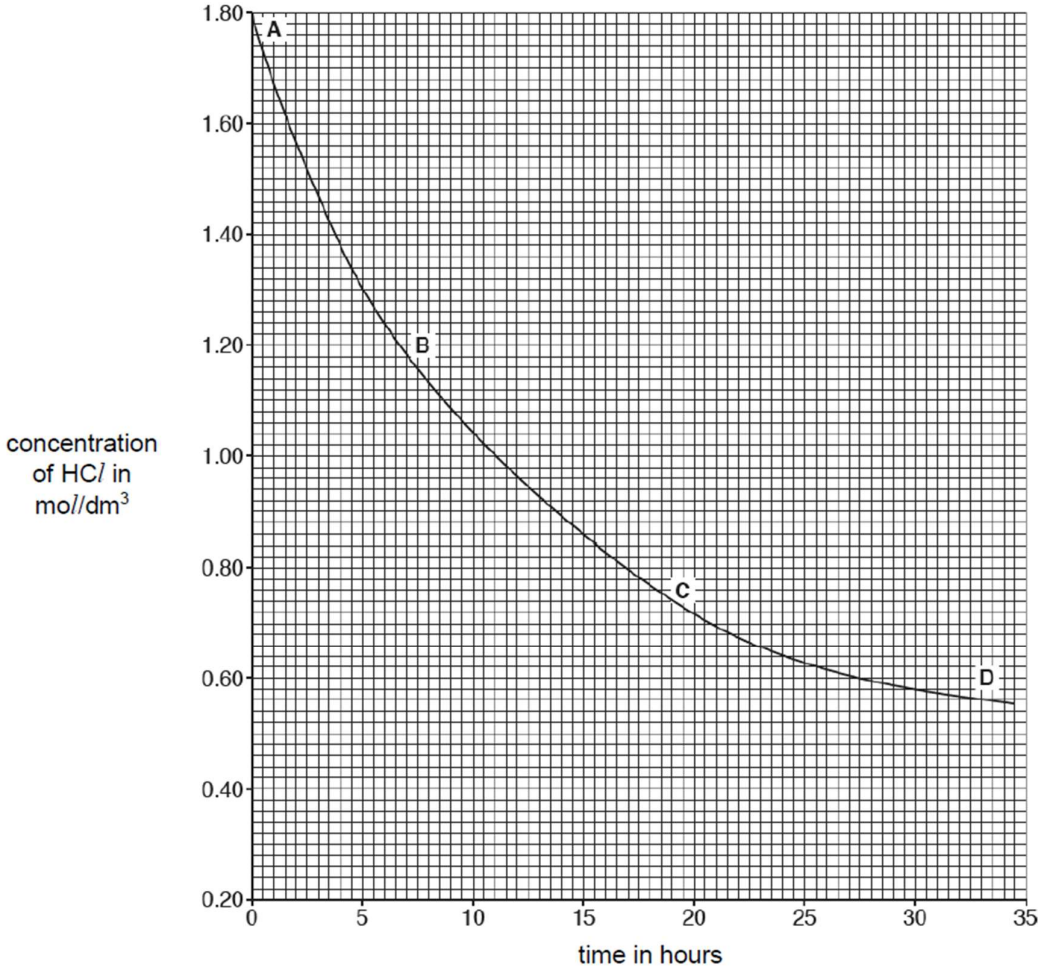


Fig. 8.1

(a) Describe how the rate of reaction changes with time.

.....

.....

.....

.....

.....[3]

(b) Sketch the graph in Fig. 8.1 when the temperature is decreased. Label your graph "**Y**".

[1]

(c) Describe and explain, using ideas about collisions between particles, how the rate of a reaction changes when the temperature is decreased. All other conditions stay the same.

.....

.....

.....

.....

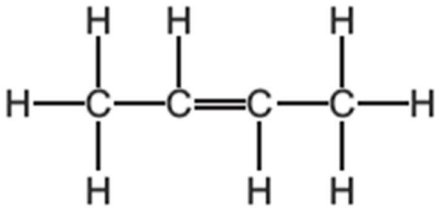
.....

.....[3]

[Total: 7]

9 **(a)** This question is about but-2-ene and butanoic acid.

The structure of but-2-ene is shown below.



(i) Describe the colour change seen when but-2-ene is added to aqueous bromine.

.....[1]

(ii) Draw a full structural formula of an *isomer* of but-2-ene.

[1]

(b) Butanoic acid, $CH_3CH_2CH_2COOH$, can be formed from but-2-ene in a series of chemical reactions.

(i) Deduce the empirical formula of butanoic acid.

.....[1]

(ii) Butanoic acid reacts with methanol to form an organic compound.

Name the organic compound formed.

.....[1]

(iii) Draw the full structural formula of the organic compound formed.

[1]

(c) But-2-ene can also undergo addition polymerisation to form a polymer.

Draw the structure of the addition polymer, showing **two** repeating units.

[1]

(d) Explain why the disposal of the polymer in **(c)** can cause land pollution.

.....

.....[1]

(e) The polymer in **(c)** can be recycled.

Describe one method of recycling the polymer in **(c)**.

.....

.....

.....[1]

(f) Bioethanol can be used as a biofuel during the recycling process.

Explain why bioethanol is more environmentally sustainable in terms of carbon dioxide emission as compared to fossil fuels.

.....

.....

.....

.....

.....[2]

[Total: 10]

10 History of electrochemistry

The first electrochemical series

Alessandro Volta was an Italian chemist who is credited as the inventor of the electric battery by proving that electricity could be generated chemically. Volta discovered that when two different metals touch a piece of paper soaked in brine (aqueous sodium chloride), electricity is generated. Changing the metals produced different electrical effects. Volta then ranked the metals according to the strength of their electrical effects, where the metals furthest apart would produce the strongest effects when placed in contact. This ranking, as shown in Fig. 10.1, later became known as the “electrochemical series”.

magnesium
zinc
iron
tin
lead
copper
silver

Fig. 10.1

The first electrical battery – the voltaic pile

The voltaic pile was the first electrical battery that could continuously provide an electric current to a circuit. It was invented by Volta who published his experiments in 1799. Volta demonstrated that when two different metals and brine-soaked cloth or cardboard are arranged in a circuit, they can produce an electric current.

Volta stacked several pairs of alternating copper and zinc discs (electrodes) separated by cloth or cardboard soaked in brine. When the top and bottom contacts were connected by a wire, an electric current flowed through the voltaic pile and the connecting wire.

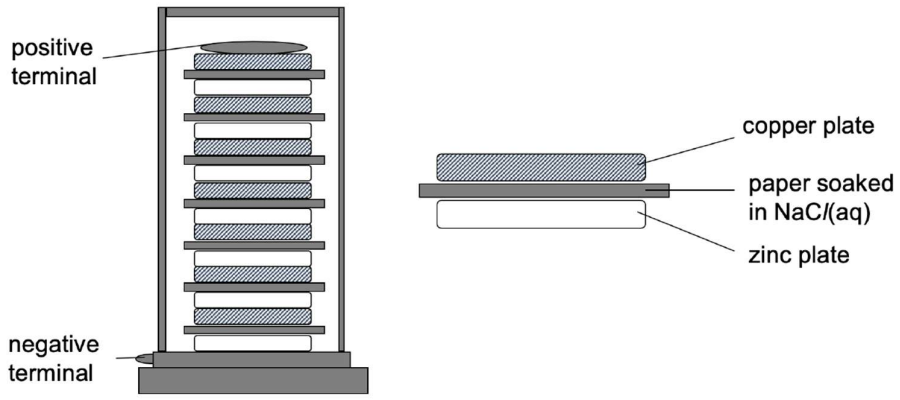


Fig. 10.2

The discovery of reactive metals with electrolysis

Using Volta's invention, Sir Humphry Davy, a British chemist, tried to use the voltaic pile on aqueous potassium carbonate with platinum electrodes in 1801. However, he only observed effervescence on both electrodes and did not obtain potassium metal.

Later, he used the voltaic pile on molten potassium hydroxide, and observe small silvery globules forming on one electrode. Hence, he managed to discover potassium in 1807 and it was the first metal that was isolated by electrolysis. He went on to discover many metals in a similar manner with electrolysis: sodium, magnesium, calcium, strontium and barium.

(a) Tin is included in Volta's electrochemical series. It reacts with steam to give tin(IV) oxide and a gas.

Write the chemical equation for this reaction.

.....[1]

(b) Write the half equations of the reactions taking place at the zinc and copper discs in the voltaic pile.

Zinc: .....

Copper: .....

[2]

(c) Using Fig. 10.1, state a pair of metals that would produce a larger voltage than zinc and copper.

Explain your choice.

.....

.....

.....

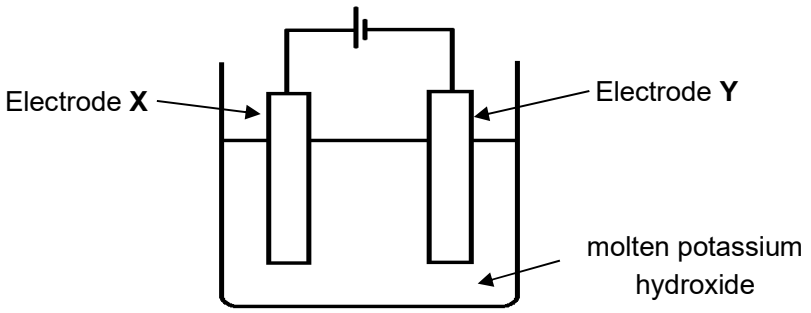
.....[2]

(d) Suggest one possible disadvantage of the voltaic pile.

.....

.....[1]

(e) The following diagram shows the simplified set-up that Davy used to form potassium metal with platinum electrodes:



(i) Which electrode will potassium be formed?

.....[1]

(ii) Effervescence is observed on the other electrode.

Suggest how you would test for the gas.

.....

.....[1]

(iii) Explain why potassium cannot be formed initially when Davy uses electrolysis on aqueous potassium carbonate.

.....

.....

.....

.....[2]

[Total: 10]

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Section B

Answer **one** question from this section.

11 Instead of carrying many tanks of oxygen and adding to the mass of the submarine, which makes it inefficient to move, naval forces sometimes make use of chemistry to constantly generate sufficient oxygen for the soldiers in the submarine to breathe. One such method is the electrolysis of aqueous sodium hydroxide. Fig. 11.1 shows the schematic diagram of a set-up used for this purpose.

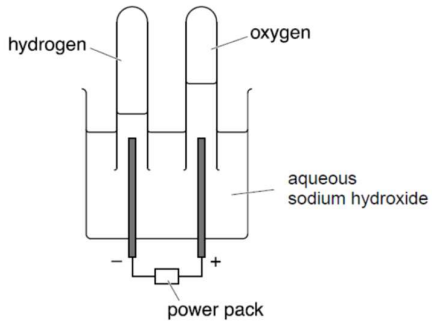


Fig. 11.1

(a) State how the composition of the electrolyte changes after the electrolysis has been running for some time.

.....

.....[1]

(b) After some time, the power pack can be replaced by a voltmeter. Fig. 11.2 shows the diagram of a set-up which acts like a hydrogen fuel cell.

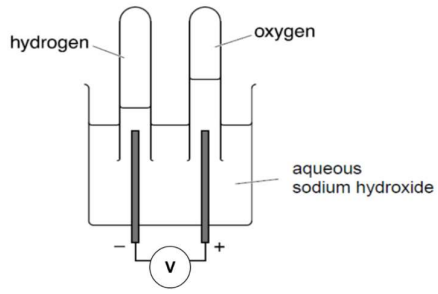


Fig. 11.2

(i) State the direction of the electron flow in the external circuit.

.....[1]

(ii) Write an overall equation of the reaction that occurs in the hydrogen fuel cell.

.....[1]

(c) Other than submarines, cars can also be fitted with an engine powered by a hydrogen fuel cell or a conventional petrol engine. One of the advantages of hydrogen fuel cells over the use of petrol in cars is that the only by-product is water, making it a clean fuel. A hydrogen fuel cell in operation, however, can sometimes achieve temperatures that are comparable to the conventional petrol engine.

(i) Suggest and explain an environmental disadvantage of using petrol to power car engines.

.....

.....

.....[2]

(ii) Suggest why hydrogen as a fuel (in the fuel cell) may **not** be that economically viable.

.....

.....

.....

.....[2]

(iii) Explain why it is possible for nitrogen oxides to be produced in **both** types of car engines.

.....

.....

.....

.....[2]

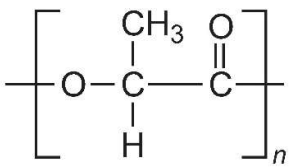
(iv) Suggest why a catalytic converter installed in a car powered by a hydrogen fuel cell, will fail to reduce nitrogen oxide levels as compared to that in a car powered by petrol.

.....

.....[1]

[Total: 10]

12 Polylactic acid (PLA) is a polymer that is derived from renewable sources such as corn starch, tapioca roots and sugarcane. Its structure is shown below.



polylactic acid (PLA)

(a) State the type of linkage that is present in PLA.

.....[1]

(b) Draw the structural formula of the monomer of PLA in the space below.

[1]

(c) A molecule has a molecular formula of $C_2H_4O_3$.

Comment on whether it could belong to the **same** homologous series as the monomer you have drawn in **(b)**. Explain your answer.

.....

.....

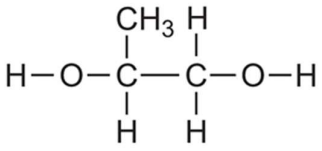
.....[1]

(d) The monomer in **(b)** can be formed during the hydration reaction between molecule **X** and steam.

Draw the structural formula of molecule **X**.

[1]

(e) Sarah says that the monomer in **(b)** can also be made by oxidising molecule **Y** shown below with suitable reagents.



molecule **Y**

(i) State the reagent and condition necessary for oxidation.

.....

.....[2]

(ii) With reference to the functional group(s) involved in the reaction, suggest if Sarah's method is suitable for making the monomer in **(b).**

.....

.....

.....

.....[2]

(f) Propane has the same number of carbon atoms as molecule **Y**. It can be made by cracking nonane, an alkane with 9 carbon atoms. There is only one by-product besides propane.

(i) Write the chemical equation for the cracking reaction of nonane.

.....[1]

(ii) Explain one reason why cracking is important.

.....

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