Class	Centre/Index Number	Name

南洋女子中學校
Nanyang Girls' High School

Preliminary Examination 2022
Secondary 4

CHEMISTRY
6092/02

Paper 2

1 hour 45 minutes

Friday 26 August **0845 – 1030**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, register number and class in the spaces at the top of this page.
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 / tape.

Section A (50 marks)
Answer **all** questions in the spaces provided.

Section B (30 marks)
Answer all **three** questions, the last question is in the form either/or.
Indicate in the box to the right your choice of the either/or question.
Answer **all** questions 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 23.

Examiner's Use	
Paper 1	
Paper 2	
Indicate the question attempted for **B9** with a tick (✓). **Either** ☐ **Or** ☐	
Total	

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

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

Section A

Answer **all** questions.
Write your answers in the spaces provided on the question paper.

A1 Choose from the following substances to answer the questions below.
Each of these substances can be used once, more than once or not at all.

Al_2O_3	Ar
CaO	CH_4
CO_2	$Ba(NO_3)_2$
TiO_2	$Pb(NO_3)_2$

(a) Which substance forms approximately 1 % of clean, dry air?

..... [1]

(b) Which substance is the main constituent of natural gas?

..... [1]

(c) Which substance dissolves in water to form an aqueous solution which gives a white precipitate on addition of aqueous sodium chloride?

..... [1]

(d) Which substance reacts with both acids and alkalis?

..... [1]

(e) Which substance is most likely to be coloured and can be used as a catalyst?

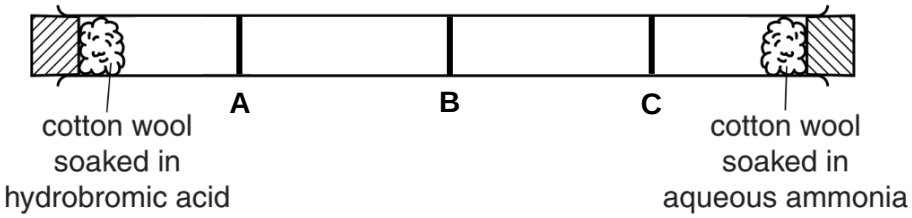
..... [1]

(f) Which two substances are the products of thermal decomposition of limestone?

..... [1]

[Total: 6]

A2 A student sets up a tube as shown in the diagram.



Concentrated hydrobromic acid produces fumes of hydrogen bromide.
Concentrated aqueous ammonia produces fumes of ammonia.

After sometime, solid ammonium bromide appeared on the walls of the tubes.

(a) **(i)** Calculate the relative molecular mass of hydrogen bromide and ammonia.

[1]

(ii) Hence, state the position (**A**, **B** or **C**) of where the solid ammonium bromide may appear in the tube above.

.....

[1]

(iii) Explain your answer to **(a)(ii)**.

.....

.....

.....

[2]

(b) Draw a 'dot-and-cross' diagram for ammonia.
Show only the outer electrons.

[2]

(c) Explain why ammonium bromide exists as a solid at room temperature and pressure.

[3]

[Total: 9]

A3 The analysis of compound **Y** shows that it has the following composition.

element	percentage by mass (%)
nitrogen	11.1
hydrogen	3.2
chromium	41.3
oxygen	44.4

(a) Show that **Y** has the empirical formula $N_2H_8Cr_2O_7$.

[3]

(b) An aqueous solution of **Y** is orange.

Deduce, with a simple reason, which element in **Y** is responsible for the orange colour.

.....

[1]

(c) An acidified aqueous solution of **Y** reacts with aqueous potassium iodide to form aqueous iodine.

(i) Write an ionic half-equation to show the formation of iodine from iodide ion.

.....

[1]

(ii) Using your answer in **(i)**, state and explain what you can conclude about the chemical nature of **Y**.

.....

.....

.....

[2]

[Turn over

(d) When aqueous sodium hydroxide is added to solid **Y** and warmed, ammonia gas is evolved.

Suggest the cation present in **Y** that gave the above observation.

.....

[1]

(e) Solid **Y** is a compound with the molecular formula, $N_2H_8Cr_2O_7$.

When solid **Y** is heated strongly, it decomposes to only chromium(III) oxide, water and nitrogen gas.

Write a balanced chemical equation to show this decomposition.
State symbols are not required.

.....

[2]

[Total: 10]

A4 Iron(II) sulfide is a compound that can be made by heating iron filings with sulfur powder.

(a) For each of the statements below, put a tick (✓) in one box in each row that corresponds with a **mixture** of iron and sulfur or a **compound** of iron and sulfur.

	statement	mixture	compound
(i)	Chemical properties are the same as those of its components.		
(ii)	During its formation, energy change is involved.		
(iii)	Has fixed composition.		
(iv)	Components can be separated by magnetism.		

[2]

(b) The enthalpy change of the reaction between iron and sulfur to form iron(II) sulfide is -100 kJ/mol.

Complete the energy profile diagram for this reaction.

You should include

- the formula of the product,
- a label for the activation energy,
- a label for the enthalpy change of reaction.

[3]

(c) Iron(II) sulfide reacts with hydrochloric acid to form hydrogen sulfide.
An aqueous solution of hydrogen sulfide behaves as a weak acid.

Explain what is meant by the term *weak acid*.

.....

.....

[1]

(d) Iron(II) sulfate can be prepared by reacting iron with dilute sulfuric acid.

$$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$$

(i) Write an ionic equation for this reaction.

.....

[2]

(ii) A student claimed that she could obtain pure, dry iron(II) sulfate by adding an equal volume of aqueous sodium hydroxide into iron(II) sulfate solution before filtering to obtain its residue.

State the observation upon addition of aqueous sodium hydroxide and explain why the student is incorrect.

.....

.....

.....

[2]

(iii) Describe how you would obtain crystals of pure, dry iron(II) sulfate from iron(II) sulfate solution.

.....

.....

.....

.....

[2]

[Total: 12]

A5 The table below shows some information about the extraction of metals from molten electrolytes using electrolysis.

metal extracted	electrolyte	amount of electrons needed to extract 10 g of the metal/ mol
sodium	molten sodium chloride	0.435
calcium	molten calcium chloride	
magnesium	molten magnesium chloride	0.833

(a) In the space below, construct a simple diagram to represent the set up for an electrolytic cell using molten sodium chloride as the electrolyte.

Include on the diagram suitable electrodes that can be used for this cell, as well as the direction of electron flow.

[2]

(b) **(i)** State the electrode where calcium metal is formed at.

.....

[1]

(ii) With the help of a suitable ionic half-equation, calculate the amount of electrons needed to form 10 g of calcium metal.

amount of electrons = ...

[2]

(c) A student suggested using aqueous magnesium chloride as an electrolyte to extract magnesium metal.

With reference to the ions present, explain why the student would not be able to obtain any magnesium metal.

.....

.....

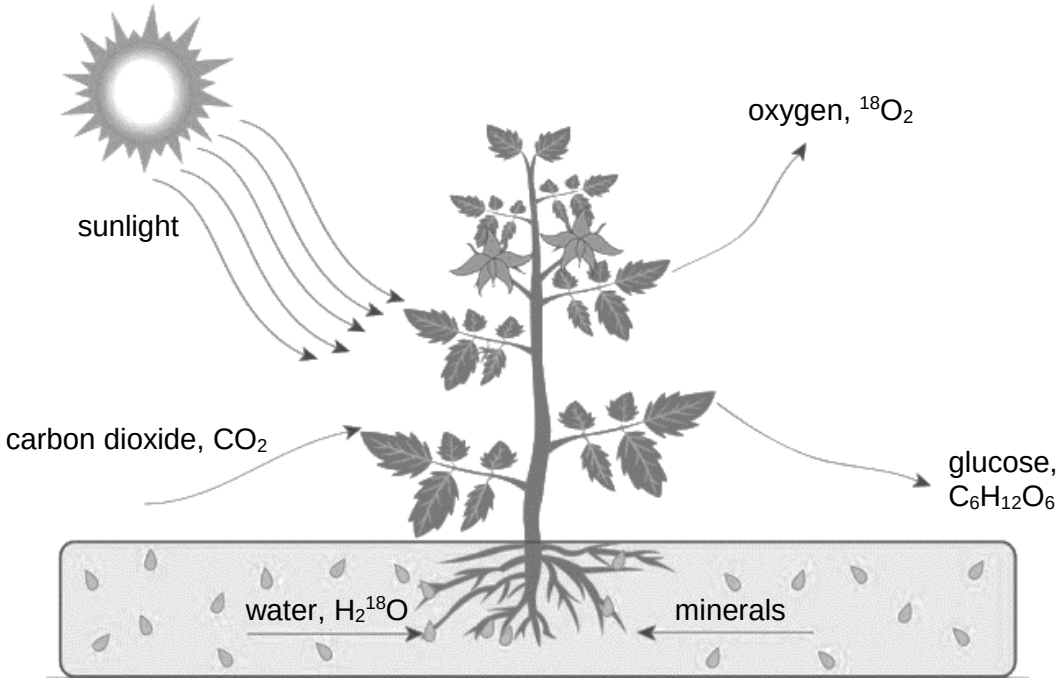
.....

.....

[2]

[Total: 7]

A6 The diagram below shows how plants undergo photosynthesis, one of the main processes in the carbon cycle. Water containing the radioactive isotope ^{18}O is fed to a plant.



(a) Define *isotope*.

.....

.....

[1]

(b) The resulting radioactivity in the products of photosynthesis is shown in the equation below.

$$6CO_2 + 6H_2{}^{18}O \rightarrow C_6H_{12}O_6 + 6{}^{18}O_2$$

Complete the table below to state the source of the oxygen in each of the products.

products	source
glucose, $C_6H_{12}O_6$	
oxygen, $^{18}O_2$	

[1]

(c) Which other process in the carbon cycle is not shown above?

.....

[1]

(d) *Land cover class* is a term that classifies land according to the amount of trees covering the area.

A comparison of surface temperatures for each land cover class is shown in the table below.

land cover class	surface temperature / °C
bare earth	29.1 to 32.4
moderately-densed forests	25.2 to 25.5
highly-densed forests	24.5 to 24.9

(i) Describe the trend shown in the data above.

.....

.....

[1]

(ii) Suggest how planting more trees on Earth could potentially reduce the effects of global warming.

.....

.....

.....

.....

[2]

[Total: 6]

Section B

Answer all **three** questions in this section.
The last question is in the form of either/or and only one of the alternatives should be attempted.

B7 The Nature of a Chemical Bond

The formulae and the type of bonding of the oxides and chlorides of the elements across Period 3 are shown in **Table 7.1** below.

Table 7.1

element	metal/non-metal	formula of main oxide	bonding in oxide	formula in chloride	bonding in chloride
Na	metal	Na_2O	ionic	NaCl	ionic
Mg	metal	MgO	ionic	$MgCl_2$	ionic
Al	metal	Al_2O_3	ionic	$AlCl_3$	covalent
Si	non-metal	SiO_2	covalent	$SiCl_4$	covalent
P	non-metal	P_4O_{10}	covalent	PCl_3	covalent
S	non-metal	SO_3	covalent	S_2Cl_2	covalent
Cl	non-metal	Cl_2O_7	covalent	Cl_2	covalent

Electronegativity is a measurement of the tendency of an atom to attract a bonding pair of electrons. A bonding pair of electrons is the pair of electrons shared in a chemical bond. The higher the electronegativity, the greater the tendency of an atom to attract the bonding pairs of electrons towards itself.

The Pauling scale is used to measure the electronegativity of elements. It ranges from 0.7 to 4.0, with a higher value representing greater electronegativity. **Table 7.2** shows the electronegativity values of some elements in the Periodic Table.

Table 7.2

proton number	element	Pauling Scale of electronegativity
8	O	3.4
9	F	4.0
10	Ne	undefined
11	Na	0.9
12	Mg	1.3
13	Al	1.6
14	Si	1.9
15	P	2.2
16	S	2.6
17	Cl	3.2
18	Ar	undefined

The difference in electronegativity between two elements involved in a chemical bond, X, can be calculated by the following equation:

X = larger electronegativity value – smaller electronegativity value

For example, the electronegativity between sodium and oxygen in Na_2O is calculated as

$X = 3.4 - 0.9 = 2.5$

X gives an indication of whether a chemical bond formed between two elements is ionic or covalent. It is said that if the X is greater than 2.0, the chemical bond formed between two elements is ionic.

The Pauling scale is also closely related to the strength of a bond, which can be measured by its bond energy. Bond energy is the amount of energy needed to break a mole of a particular bond. It is a measure of the strength of a chemical bond. Bond lengths are the distances between the nuclei of bonded atoms.

Table 7.3 shows the bond lengths and bond energies of some bonds.

Table 7.3

bond	bond length (pm)	bond energy (kJ / mol)
C–C	154	348
C=C	134	614
C≡C	120	839
Si–C*l*	202	381
P–C*l*	203	326
S–C*l*	207	253
C*l*–C*l*	199	243

Note: pm = picometers (10^{-12} m)

Source: http://www.science.uwaterloo.ca/~cchieh/cact/c120/bondel.html

(a) Use the data to describe the trend in the electronegativity values of the Period 3 elements.

.....

..... [1]

(b) Suggest a reason why the electronegativity values of argon and neon are 'undefined'.

.....

..... [2]

(c) The following statement is extracted from the information given.

"It is said that if the X is greater than 2.0, the chemical bond formed between two elements is ionic."

A student commented that this statement is true for most oxides and chlorides but there are exceptions to the statement.

Use data from **Table 7.1 and 7.2** to support your ideas for the following questions.

(i) Select one oxide or chloride that supports that the statement is true.

Calculate the value of X for this compound and use it to explain your answer. Show your working clearly.

.....

..... [2]

(ii) Select one oxide or chloride that is an exception to the statement.

Calculate the value of X for this compound and use it to explain your answer. Show your working clearly.

.....

..... [2]

(d) Describe the general relationship between bond length and bond energy.

.....

..... [1]

(e) How is the strength of a bond affected by the number of bonds between atoms?

Use data from **Table 7.3** to explain your answer.

.....

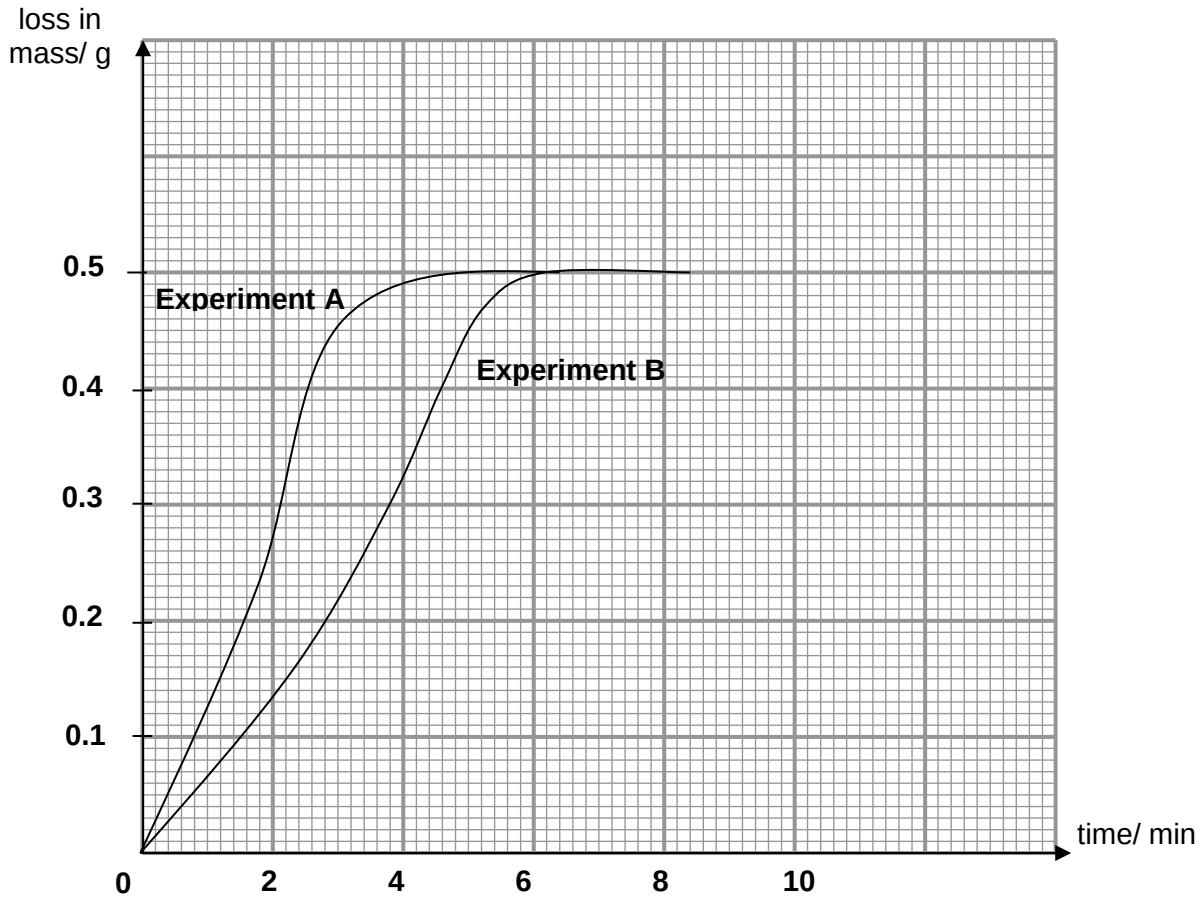
..... [2]

[Total: 10]

B8 Lead(II) carbonate reacts with dilute nitric acid as shown by the equation below:

$$PbCO_3(s) + 2HNO_3(aq) \rightarrow CO_2(g) + Pb(NO_3)_2(aq) + H_2O(l)$$

Two experiments are carried out at 30 °C and 40 °C using excess dilute nitric acid. All other experimental conditions were kept constant. The results are shown in the graphs below.



(a) With reference to the shape of the graph, state which experiment was carried out at 40 °C. Explain your answer in terms of collisions between particles.

[4]

(b) Explain why there was a loss in mass over time.

.....

[1]

(c) Calculate the mass of lead(II) carbonate used in each experiment.

mass of lead(II) carbonate = ...

[3]

(d) If temperature was kept constant at 30 °C for both experiments **A** and **B**, what other conditions could have resulted in the results shown in the graphs?

.....

.....

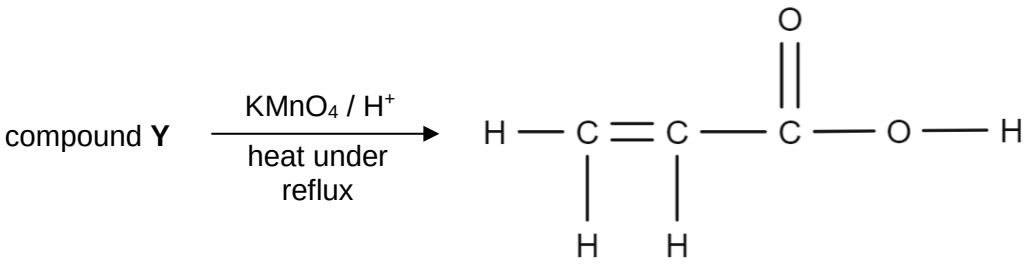
[1]

(e) Experiment **B** is repeated using half the mass of lead(II) carbonate. All other conditions are kept constant.

On the graph, draw a graph to show the results you would expect to obtain. Label this graph as Experiment **C**. [1]

[Total: 10]

B9 Either Organic compound **Y** was heated under reflux with acidified potassium manganate(VII) solution to form compound **Z**. The reaction is show below.



compound **Z**

(a) **(i)** Name the reaction above.

.....

Describe the observation seen.

.....

.....

[2]

(ii) Hence, draw the full structural formula of compound **Y**.

[1]

(b) A few drops of liquid bromine were added to compound **Z**.

(i) Name the reaction and describe the observation seen.

.....

.....

[2]

(ii) Hence, draw the full structural formula of the product formed.

[1]

(c) On warming **Z** with ethanol and a few drops of concentrated sulfuric acid, a sweet smelling substance was formed.

Draw the full structural formula and circle the functional group that gave the compound the sweet smell.

[2]

(d) Under suitable conditions, compound **Z** undergoes addition polymerisation.

(i) State the conditions necessary for compound **Z** to undergo addition polymerisation.

.....

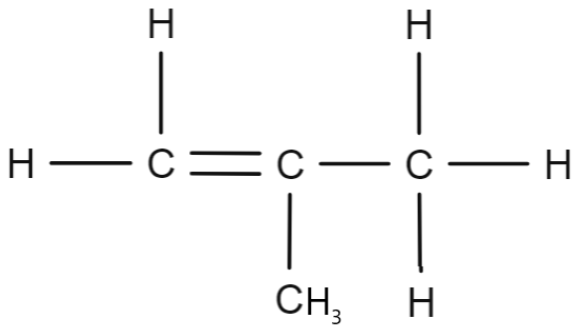
[1]

(ii) Draw the structural formula of the polymer formed, showing three repeating units.

[1]

[Total: 10]

B9 Or The World Cup soccer ball's innermost layer is a spherical bladder formed from butyl rubber. Butyl rubber is composed mostly of isobutylene. The structure of isobutylene is shown below.



isobutylene

(a) **(i)** Name the homologous series that isobutylene belongs to and state its general formula.

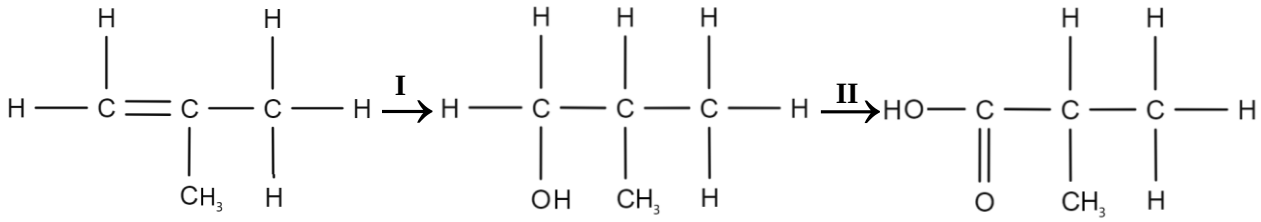
.....

[2]

(ii) Draw an isomer of isobutylene.

[1]

(b) The following shows a reaction scheme to obtain the final product, compound **X**.



isobutylene

compound **X**

(i) State the reagent and conditions necessary for reaction **I**.

.....

..... [2]

(ii) Describe a test to differentiate between isobutylene and compound **X**.

.....

..... [2]

(c) Once the bladder has been formed into a sphere, it is wound with several thousand metres of nylon thread.

(i) Draw the structural formula of the linkage present in nylon in the space below and state its name.

[2]

(ii) Describe one environmental problem associated with using plastics like nylon.

.....

..... [1]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							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											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 –		114 Fl flerovium –		116 Lv livermorium –		

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.).

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