BEATTY SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2020

SUBJECT	**:**	**CHEMISTRY**	**LEVEL**	**:**	**Sec 4 Express**
PAPER	**:**	**6092/02**	**DURATION**	**:**	**1 h 45 min**
SETTER	**:**	**Mdm Low Beng Hong**	**DATE**	**:**	**25 Aug 2020**

CLASS :	**NAME :**	**REG NO :**

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
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 20.

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

Section	Marks
A	
B8	
B9	
B10 **E** / **O**	
Total	**/ 80**

This paper consists of **20** printed pages (including this cover page).

[Turn over

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 The table shows some physical properties of four substances.

substance	melting point / °C	boiling point / °C	electrical conductivity	
			when solid	when molten
A	119	445	poor	poor
B	839	1484	good	good
C	1710	2230	poor	poor
D	501	950	poor	good

(a) Match **A** to **D** to the following substances:

lead, lead(II) chloride, silicon dioxide, sulfur

A: …… **B**: ……

C: …… **D**: …… [4]

(b) Lead forms another chloride compound, lead(IV) chloride. The melting point and boiling point of this chloride is −15 °C and 50 °C respectively.

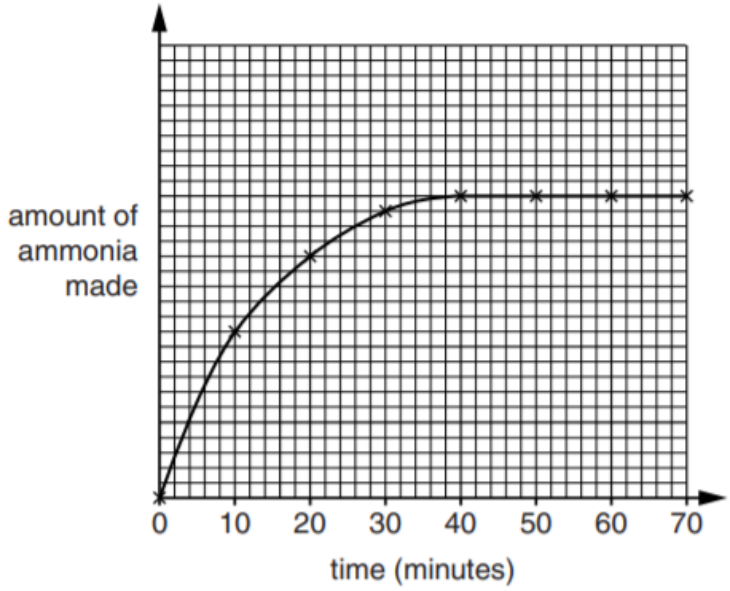
Draw the 'dot-and-cross' diagram to show the bonding in lead(IV) chloride. You need to draw the outer shell electrons only.

[1]

[Total: 5]

A2 In the Haber Process, nitrogen and hydrogen react to make ammonia, NH_3.

A chemist heats some nitrogen and hydrogen with a catalyst in a closed container.
She plots a graph to show how the amount of ammonia made changes with time.



(a) State the time that the amount of ammonia made stops increasing.

…….[1]

(b) The amount of ammonia made stops increasing when the reaction reaches equilibrium. At equilibrium, reaction is still going on.
Explain why the amount of ammonia made is not increasing even though the reaction is still going on.

……..

……..

……..

…….[2]

(c) Give **two** reasons to explain how the use of a catalyst reduces the cost of making ammonia.

……..

……..

……..

…….[2]

(d) Ammonia is used to manufacture nitric acid by a two-stage process.

Stage 1: $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
Stage 2: $4NO + 2H_2O + 3O_2 \rightarrow 4HNO_3$

Use the two equations to construct an overall equation for the conversion of ammonia to nitric acid.

…...……..[1]

[Total: 6]

A3 Both natural gas and charcoal are commonly used as fuels. Natural gas consists of mainly methane and is formed when layers of decomposing plant and animal matter are exposed to intense heat and pressure under the surface of the Earth over millions of years.

Charcoal consists of mainly carbon. It has been produced for many centuries by heating wood in the absence of oxygen.

(a) The values of some average bond enthalpies are shown in the table below.

bond	bond energy (kJ/mol)
C – C	348
C = O	799
O = O	495
O – O	142
O – H	463

Given the standard enthalpy change of combustion of methane is −889 kJ/mol, calculate the bond energy of a C – H bond.

[3]

(b) The enthalpy changes of combustion of charcoal (carbon) and methane are in the table below.

substance	enthalpy changes of combustion kJ/mol
charcoal (carbon)	−394
methane	−889

Two students were discussing the use of charcoal and methane as fuels.

Student 1: 'Methane produces more heat per gram when burned so it is a better fuel.'
Student 2: 'The use of charcoal contributes less to the overall increase of carbon dioxide levels in the atmosphere.'

(i) Show that student 1 is correct in stating that methane produces more heat per gram.

[1]

(ii) With the help of chemical equations, show if charcoal produces less carbon dioxide compared to methane.

……..

……..…[2]

(iii) Hence, explain how student 2 comes to his conclusion.

……..

……..

……..

……..

……..[2]

[Total: 8]

A4 Cerium is a lanthanoid metal that shows similar chemical reactions to some elements in the third period. Most of cerium's compounds contain Ce^{3+} or Ce^{4+} ions.

(a) Cerium reacts slowly with cold water and quickly with hot water forming cerium(III) hydroxide and hydrogen gas.
Place the order of reactivity of cerium among the Period 3 metals, starting with the most reactive metal.

……..[1]

(b) Cerium tarnishes slowly in air forming cerium(IV) oxide.

(i) State the formula of cerium(IV) oxide.

……..[1]

(ii) Cerium(IV) oxide reacts with aqueous sodium hydroxide to form a salt called sodium cerate, Na_2CeO_3.

State what type of oxide cerium(IV) oxide is.

……..[1]

(iii) Cerium(IV) oxide is a ceramic. Suggest **two** physical properties of cerium(IV) oxide.

1……

2……[2]

(c) Suggest if cerium compounds are suitable to be used as catalysts. Explain your reasoning.

……..

…...……..[1]

(d) Cerium is a better electrical conductor than sodium. Explain why.

……..

……..

…...……..[1]

(e) The melting point of the Period 3 elements from Group II to Group IV is given in the table below.

	magnesium	**aluminium**	**silicon**
melting point/ °C	639	660	1410

Explain the trend of the melting points of the three elements in the table.

……..

……..

……..

……..

……..

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……..…[3]

[Total: 10]

A5 Coal has helped powered America for decades. The burning of coal results in the production of sulfur dioxide.

(a) Describe how this leads to environmental problems when released into the atmosphere.

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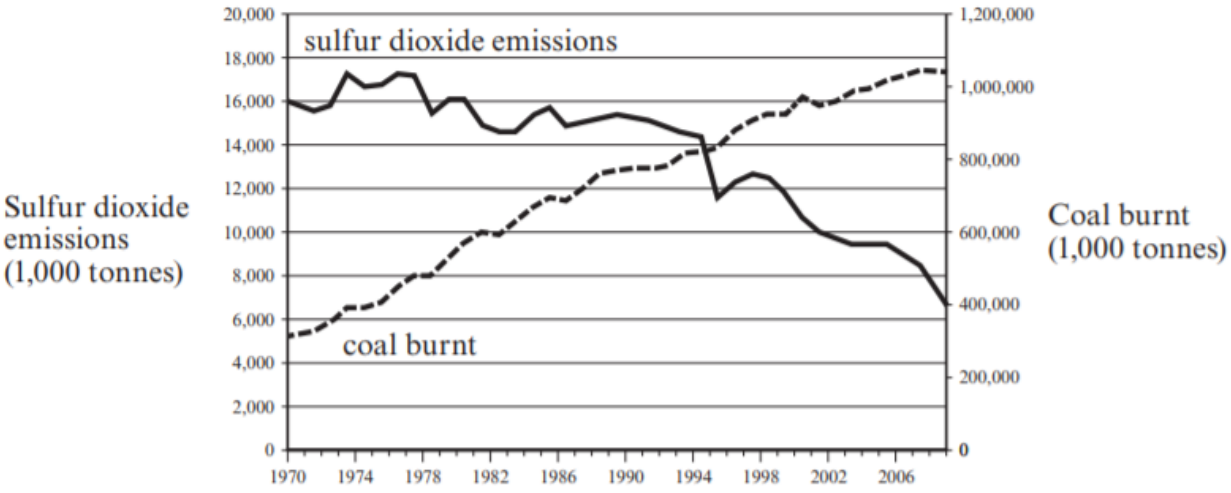
……..[2]

(b) The following graph shows the amount of coal burnt and sulfur dioxide emissions in the USA between 1970 and 2008.



(i) Describe the trends shown in the graph.

……..

……..[1]

(ii) Suggest and explain how a possible measure put in place leads to the trend in sulfur dioxide emissions.

……..

……..

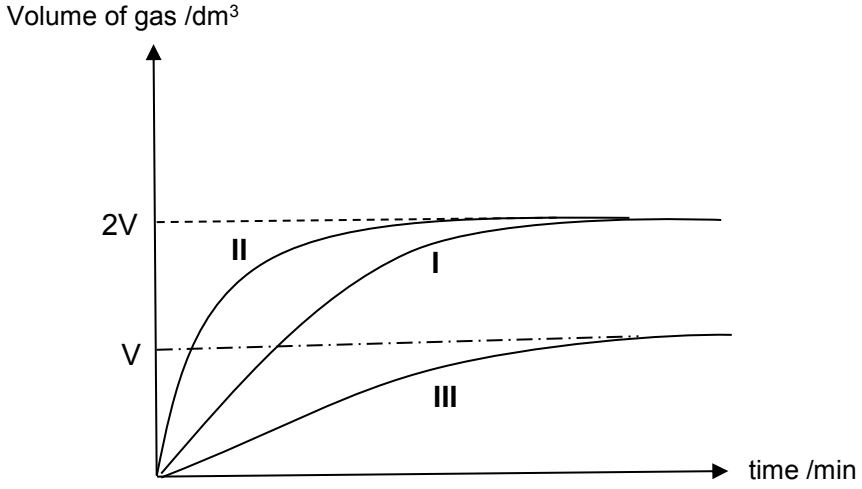
……..

……..[2]

[Total: 5]

A6 An experiment is carried out to investigate the rate of reaction of zinc with hydrochloric acid. Excess zinc powder, 3.00 g, is added to 50 cm^3 of 1.0 mol/dm^3 hydrochloric acid. The volume of gas produced is collected at regular intervals.

The experiment was repeated to study the factors affecting the rate of reaction. The diagram below shows the results of the experiments, with Graph **I** obtained from using 50 cm^3 of 1.0 mol/dm^3 hydrochloric acid.



(a) Identify the conditions used to obtain Graphs **II** and **III**.

Graph **II**: ……

Graph **III**: …… [1]

(b) Explain, in terms of collisions between the particles, how using zinc powder instead of a piece of zinc metal affects the rate of reaction.

……..

……..

……..

…...…….[2]

(c) Sketch on the diagram above, the graph that would be obtained if the experiment was repeated using 50 cm^3 of 1.0 mol/dm^3 ethanoic acid. Label your graph as **IV**. [1]

Explain your reasoning.

……..

……..

……..

……..

…...…….[2]

(d) Briefly describe how you would carry out the experiment to obtain Graph **III.**

……..

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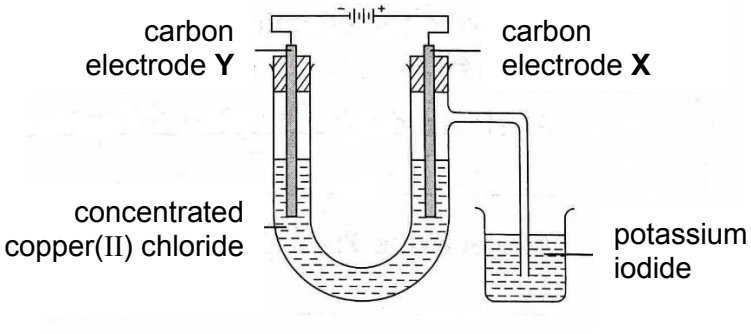
…...…….[3]

[Total: 9]

A7 An experiment on electrolysis was carried out using the apparatus as shown below.



(a) Describe what was observed at electrodes **X** and **Y**.

Electrode **X**: ……..…[1]

Electrode **Y**: ……..[1]

(b) What was the colour change in the electrolyte after electrolysis had been carried out for some time? Explain your reasoning.

……..

……..

……..

…...…….[2]

(c) Explain whether there would be any difference in the colour change of the electrolyte if the anode was replaced by copper electrode.

……..

……..

……..

…...…….[2]

(d) Describe what colour change would be observed in the beaker containing aqueous potassium iodide after some time.

…...…….[1]

[Total: 7]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Hard water and soft water

Hard water is water that has high mineral content, made up of largely calcium and magnesium ions in water. The metal ions make the water hard. The hardness of water causes a build-up of lime-scale in kettles, boilers and water pipes. This lime-scale on the heating element of kettles make it inefficient as the scale acts as an insulator.

Soft water contains low concentration of calcium and magnesium ions and therefore does not cause a build-up of lime-scale. However, drinking soft water will not provide the essential minerals for bone growth.

Types of water hardness

Temporary hardness in water is due to the presence of thermally unstable magnesium hydrogen carbonate or calcium hydrogen carbonate dissolved in the water. These minerals come from geological formations like limestone.

Permanent hardness in water is due to the presence of dissolved sulfates, hydrogen carbonates or chlorides of calcium and magnesium.

Methods of softening water

The temporary hardness in water can be removed by boiling.

On the other hand, permanent hard water cannot be softened by boiling. In order to soften water, the metal ions that cause hardness must be removed. One way to do this is to add sodium carbonate into the water to precipitate out the calcium or magnesium ions.

The soap test

Hard water does not lather easily.

Soft water lathers readily, and therefore requires less soap for the same cleaning effort.

Tim investigates the hardness of different water samples. He uses distilled water and two other water samples labelled **A** and **B**.

He adds soap solution to 100 cm^3 of each sample until a lasting lather is formed.

Tim next boils fresh 100 cm^3 samples of distilled water, sample **A** and sample **B**. He repeats the test with soap solution on the boiled samples.

The table below shows his results.

sample	volume of soap solution needed to give a lather using	
	unboiled water in cm^3	boiled water in cm^3
distilled water	1.0	1.0
A	9.5	1.0
B	13.0	7.0

(a) Tim concludes that sample **A** contains only temporary hardness, while sample **B** contains both temporary and permanent hardness.
Suggest how the data above supports his claim.

……..

……..

……..

……..

……..

……..

…...……..[3]

(b) Explain clearly how the data above shows that sample **B** contains equal amount of temporary and permanent hardness.

[3]

(c) Using an equation, explain how temporary hardness can be removed by boiling. Include state symbols in your equation.

Equation: ……

……..

……..

…...……..[3]

(d) Suggest another method that can remove permanent and temporary hardness in water.

…….[1]

(e) Hardness of water can be a disadvantage as it causes a build-up of limescale in water pipes. However, there is an advantage of this limescale in water pipes. Suggest what this advantage is.

……..

……..

…….[1]

(f) Explain why water treated with sodium carbonate to remove permanent hardness may not be suitable for crops that grow well in slightly acidic soils.

……..

……..

…….[1]

[Total: 12]

B9 The table below shows the percentage abundance and date of discovery for different metals in the Earth's crust.

metal	**percentage by mass in Earth's crust**	**date of discovery (b.p = years before present)**
aluminium	8.1	1825
iron	5.0	about 4000 b.p
calcium	3.6	1808
potassium	2.6	1807
magnesium	2.1	1775
zinc	0.11	1500
copper	0.01	about 5000 b.p
silver	0.00003	about 5000 b.p
gold	less than 0.000001	at least 8000 b.p

(a) The price of three metals are given below.

Aluminium = US$ 0.00148 / g
Zinc = US$ 0.00192 / g
Gold = US$ 54.4 / g

Explain why gold is much more expensive than aluminium or zinc.

……

……[1]

(b) Use information from the table to explain whether the more abundant metals in the Earth's crust were discovered first.

……

……

……

……

……

……[3]

(c) Suggest when sodium was discovered.

……[1]

(d) Explain the relationship between the reactivity of the metals and their date of discovery.

……

……

……[2]

(e) Suggest why aluminium was discovered later than potassium or calcium.

……

……

……[1]

[Total: 8]

Either

B10 Magnesium is a valuable, light-weight metal, used as a structural material as well as in alloys, in batteries and in synthesis of other chemical products.

Magnesium forms the second most abundant cation in the sea, and it is cheaper to 'mine' magnesium from sea water than earth crust.

In the first stage of the extraction of magnesium, calcium carbonate is heated at high temperatures to produce quicklime or calcium oxide. When calcium oxide is treated with seawater, it forms calcium hydroxide, which is slightly soluble and ionises to give calcium and hydroxide ions.
The hydroxide ions formed would then cause the precipitation of magnesium ions from seawater.

(a) Write an ionic equation for the reaction of calcium oxide with seawater.

…….[2]

(b) Suggest why magnesium hydroxide is precipitated instead of calcium hydroxide.

…….[1]

(c) The precipitate is filtered and reacted with hydrochloric acid to form magnesium chloride solution.

$$Mg(OH)_2(s) + 2HCl \rightarrow H_2O(l) + MgCl_2(aq)$$

Briefly describe how solid magnesium chloride can be obtained from the mixture.

……..

……..

…….[2]

(d) In the second stage of the extraction of magnesium, some sodium chloride and calcium chloride are added to the solid magnesium chloride and the mixture is melted in an electrolytic cell. The mixture of sodium chloride and calcium chloride lowers the melting point of magnesium chloride.

Suggest why zinc chloride **cannot** be added into the electrolytic cell to lower the melting point.

……..

……..

…….[2]

(e) Write the half equations for the reactions happening at the anode and cathode.

Anode: …….

Cathode: …….[2]

(f) Chlorine gas, a by-product of this reaction is dissolved in water to produce hydrochloric acid.

$$Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HOCl(aq)$$

A student claims that chlorine is only oxidised in this reaction. Explain if you agree with this claim.

……..

…...……..[1]

[Total: 10]

Or

B10 Ethanedioic acid (oxalic acid) has the formula $(COOH)_2$. It can be made in the laboratory by oxidising sugar with a powerful oxidising agent.

After purification, the oxalic acid is produced as white crystals of a hydrate, $(COOH)_2.xH_2O$. On heating this hydrate, water is lost, leaving anhydrous oxalic acid.

$$(COOH)_2.xH_2O(s) \rightarrow (COOH)_2(s) + xH_2O(g)$$

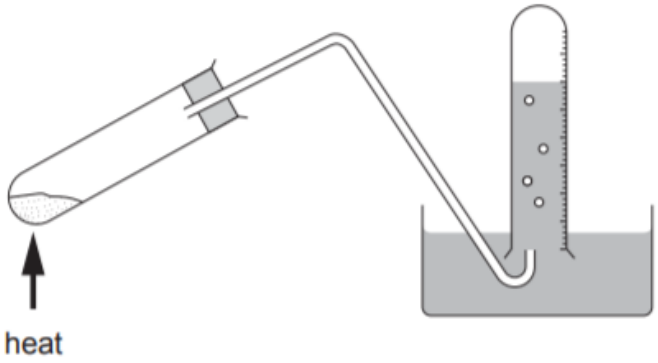
(a) In an experiment 5.67 g of the hydrate were heated to constant mass, giving 4.05 g of the anhydrous acid. Calculate the value of x in $(COOH)_2.xH_2O$.

[3]

(b) Another method of producing oxalic acid in the laboratory is to heat potassium methanoate, HCOOK. This produces potassium oxalate, which is then acidified to give the acid.

$$2HCOOK \rightarrow (COOK)_2 + H_2$$

Some students carried out this experiment using the apparatus below. They collected the hydrogen gas produced over water.



A few students obtained a smaller volume of hydrogen than expected. Suggest **two** practical reasons why this may have occurred, apart from leaks.

1……

……..[1]

2……

……..[1]

(c) Bob was asked to analyse a mixture of potassium methanoate and potassium oxalate. He weighed out 4.69 g of the mixture and carried out the separation technique below.

- The mixture was completely dissolved in distilled water.
- Calcium chloride solution was added to this solution to precipitate out calcium oxalate.
- The mixture was then filtered and the precipitated calcium oxalate was washed and dried.

(i) Suggest how Bob would know whether sufficient calcium chloride solution had been added to react with all of the potassium oxalate present.

……..

……..

……..

……..[2]

(ii) In his experiment, Bob obtained 2.49 g of pure and dry calcium oxalate.

$$(COOK)_2 + CaCl_2 \longrightarrow (COO)_2Ca + 2KCl$$

Calculate the percentage of potassium oxalate in the mixture.
[M_r :$(COOK)_2$,166; $(COO)_2Ca$, 128]

[3]

[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.).