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6530378816

PHYSICAL SCIENCE **0652/41**

Paper 4 Theory (Extended) **October/November 2021**

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 **24** pages. Any blank pages are indicated.

DC (RW/CB) 212508/5

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1 A skydiver of mass 85 kg jumps out of an aircraft and initially falls freely under gravity.

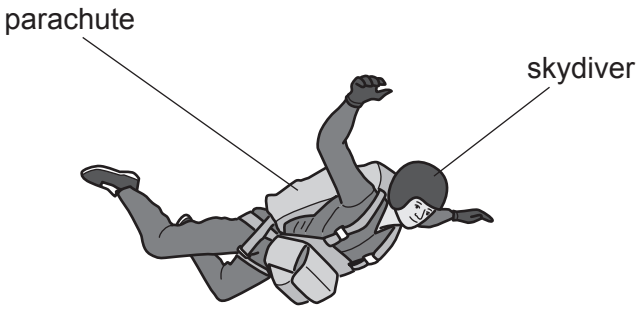

Fig. 1.1

(a) **(i)** Calculate the force due to gravity acting on the skydiver.
[g = 10 N / kg]

force = ... N [2]

(ii) Deduce the initial acceleration of the skydiver.

acceleration = ... m/s^2 [1]

(b) The acceleration of the skydiver decreases as she falls, even though she does **not** open her parachute.

Explain why her acceleration decreases.

.....

..... [2]

(c) The graph in Fig. 1.2 shows how the speed of the skydiver changes as she falls before opening her parachute.

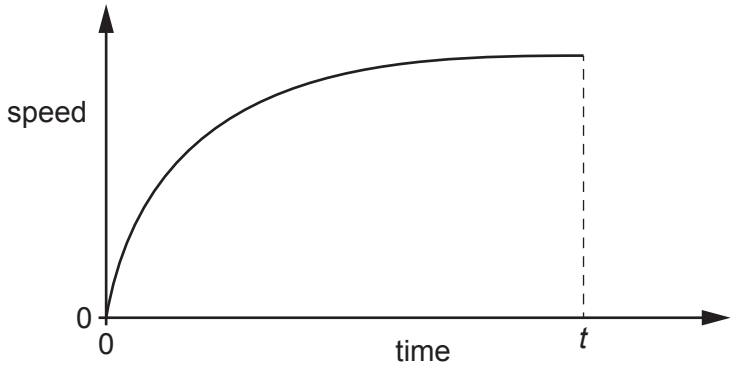

Fig. 1.2

(i) At time *t* the skydiver is falling with constant speed.

State the term used to describe this constant speed.

..... [1]

(ii) State the magnitude of the resultant force on the skydiver when her speed is constant.

magnitude of resultant force = ... [1]

[Total: 7]

2 The formulae of some substances are shown in Fig. 2.1.

CaO	CH_3CH_2OH	CH_3OH	C_2H_4
C_2H_6	Cl_2	CO	CO_2

Fig. 2.1

(a) Answer the following questions by selecting from the substances shown in Fig. 2.1.

Each substance may be used once, more than once or not at all.

State the formula for a substance which:

(i) is a diatomic gas at room temperature

..... [1]

(ii) is used to reduce emissions of sulfur dioxide

..... [1]

(iii) is a solvent produced during a reaction involving yeast and glucose

..... [1]

(iv) turns aqueous bromine colourless

..... [1]

(v) is a neutral oxide

..... [1]

(vi) is a gas produced during the catalytic removal of nitrogen monoxide from exhaust emissions.

..... [1]

(b) CH_3OH is a covalent molecule.

Complete the dot-and-cross diagram in Fig. 2.2 to show the bonding in one molecule of CH_3OH.

Show the outer electrons only.

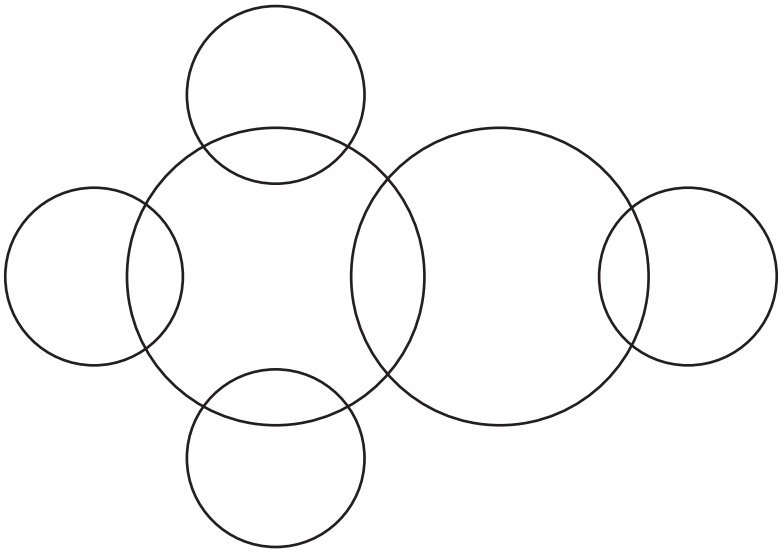

Fig. 2.2

[2]

[Total: 8]

3 Fig. 3.1 shows a mechanic using a wrench to tighten a nut on the wheel of a car.

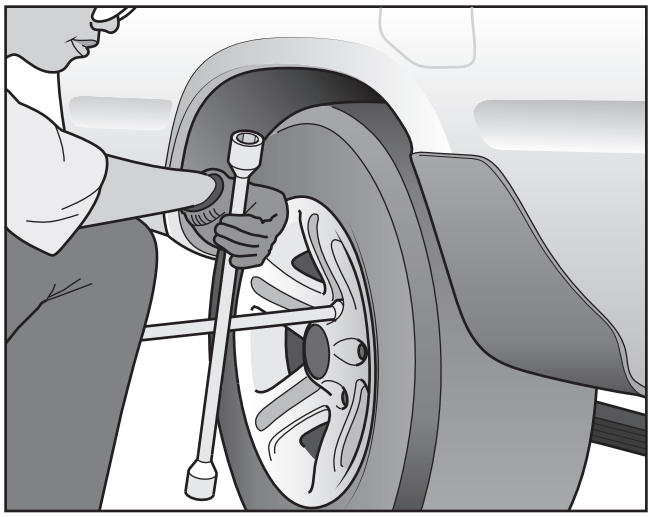

Fig. 3.1

The nut acts as a pivot.

Fig. 3.2 shows the front view of the wrench.

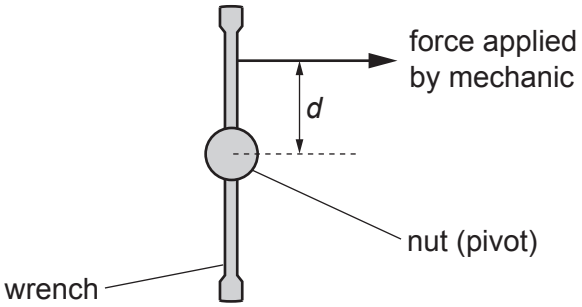

Fig. 3.2

(a) The force applied by the mechanic is a steady 240 N. The distance *d* of the force from the centre of the nut (pivot) is 0.45 m.

(i) Calculate the moment produced about the centre of the nut (pivot).

moment = ... N m [2]

(ii) Describe how the moment about the nut (pivot) can be increased without changing the magnitude of the force.

.....

..... [1]

(b) The 240 N force rotates the wrench through 360°. The distance moved by the force is 2.8 m.

Calculate the work done by the force. State the unit.

work done = ... unit ..... [3]

[Total: 6]

[Turn over

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4 Sodium chloride is an ionic compound.

(a) In an experiment, molten sodium chloride is electrolysed.

(i) Explain the meaning of *electrolysis*.

.....

.....

..... [2]

(ii) Predict the products formed at each electrode during the electrolysis of molten sodium chloride.

anode .....

cathode .....
[2]

(iii) Describe what happens, in terms of electrons, to the cations in sodium chloride during electrolysis.

.....

..... [1]

(iv) The sodium chloride in this experiment is molten. This is shown by using the state symbol (l) in the formula NaC*l*(l).

Complete the formula to show sodium chloride in the **other** state in which it can be electrolysed.

NaC*l*(.....) [1]

(b) Describe **two** features of the structure of ionic compounds such as sodium chloride.

1 .....

.....

2 .....

.....
[2]

[Total: 8]

5 A rectangular block of wood vibrates to produce waves in a ripple tank. The wavefronts travel towards a narrow gap in a barrier, as shown in Fig. 5.1.

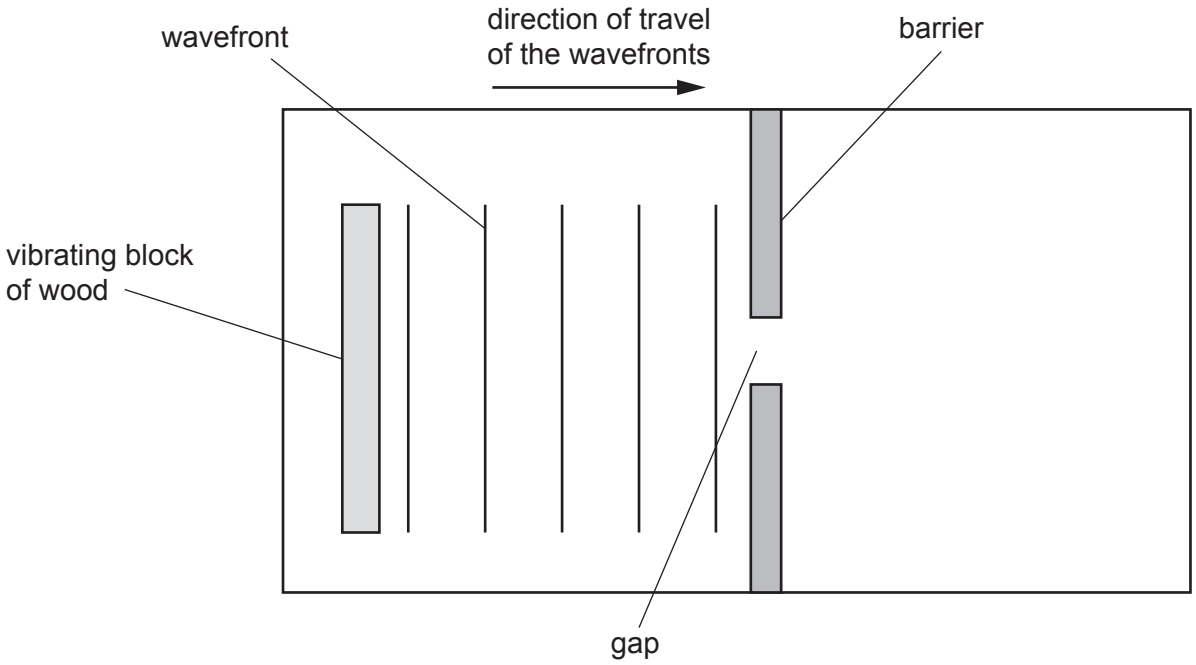

Fig. 5.1

(a) (i) On Fig. 5.1 draw a double-headed arrow (↔) to show one wavelength of the waves. [1]

(ii) Name the process that occurs as the waves go through the gap in the barrier.

..... [1]

(iii) On Fig. 5.1, draw **three** wavefronts after they have passed through the gap. [3]

(b) (i) The vibrating block of wood is 28 cm from the barrier.

Each wavefront takes 0.80 s to travel from the block to the barrier.

Calculate the speed of the wave.

speed = ... cm / s [2]

(ii) The wavelength of the waves is 5.6 cm. Use your answer to **(b)(i)** to calculate the frequency of the waves.

frequency = ... Hz [2]

[Total: 9]

6 **(a)** Complete Table 6.1 to show the number of protons, neutrons and electrons in one atom of sodium.

Table 6.1

	number of protons	number of neutrons	number of electrons
$^{23}_{11}Na$			

[2]

(b) There are several different isotopes of sodium.

Explain why isotopes of an element have the same properties.

.....

..... [1]

[Total: 3]

7 A metal sphere is suspended by a plastic thread.

A conducting wire is attached to the positive terminal of a power supply and placed near to the sphere as shown in Fig. 7.1.

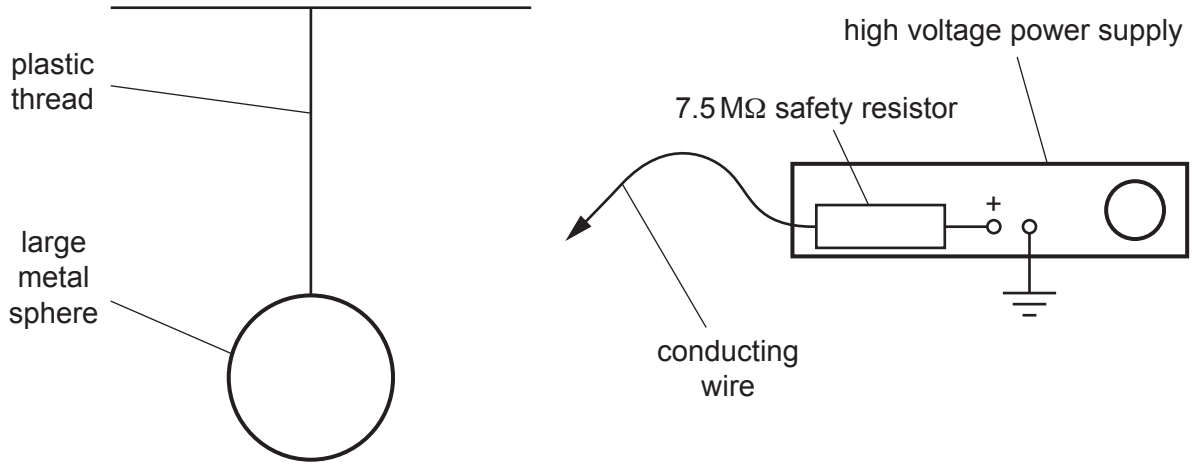

Fig. 7.1

(a) The electromotive force (e.m.f.) of the high voltage power supply is 5000 V.

A safety resistor of resistance 7.5 MΩ is connected between the conducting wire and the positive terminal of the power supply.

Explain why this resistor enables the power supply to be used safely.

.....

..... [1]

(b) The conducting wire is connected to the metal sphere. There is an average current of 0.67 mA for a time of 0.25 ms.

Calculate the charge transferred to the metal sphere.

charge = ... C [2]

(c) A small charged sphere is held near the large metal sphere after the conducting wire is removed.

The small sphere is repelled by the electric field of the large sphere.

Explain what is meant by an electric field.

.....

.....

..... [1]

(d) Suggest why the large metal sphere is suspended by a plastic thread rather than a copper wire.

.....

..... [2]

[Total: 6]

8 Carbon is an element in Group IV and Period 2 of the Periodic Table.

(a) The position of carbon in the Periodic Table gives two pieces of information about its electronic structure.

State these **two** pieces of information.

1 .....

2 .....
[2]

(b) Graphite is a form of carbon.

Explain, in terms of structure, why graphite can be used as a lubricant.

.....

.....

.....

..... [2]

(c) Carbon is used in the extraction of iron from its ore in a blast furnace.

Carbon reacts with oxygen in the blast furnace to form carbon dioxide.

$$C + O_2 \rightarrow CO_2$$

Write **two** other equations for essential reactions that occur in the blast furnace to extract iron from its ore.

1 .....

2 .....
[2]

(d) Zinc blende is an ore of zinc. It contains ZnS.

Before zinc metal is extracted, its ore is crushed and heated in air.

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

Calculate the mass of ZnO that is produced from 6.5 tonnes of ZnS.

[A_r: Zn, 65; S, 32; O, 16; and 1 tonne = 1000 kg]

Give your answer to two significant figures.

mass of ZnO = ... tonnes [3]

(e) Steel alloys contain iron. Steel is stronger and harder than iron.

(i) State the meaning of *alloy*.

.....

..... [1]

(ii) Fig. 8.1 is a diagram of a model of the atoms in pure iron metal.

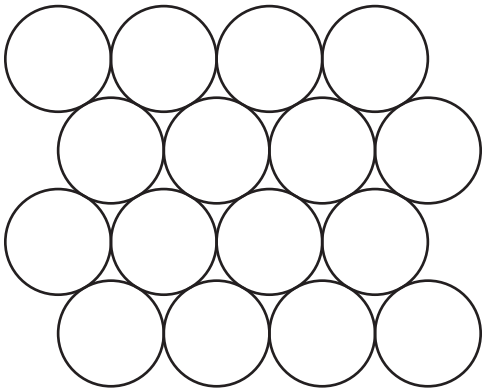

Fig. 8.1

Draw a diagram in the box to show a model of the atoms in an alloy of iron.

[1]

[Total: 11]

9 Fig. 9.1 is a circuit diagram containing a battery of electromotive force (e.m.f.) 6.0 V, a resistor of resistance 2.2 Ω, an ammeter, a switch and a lamp.

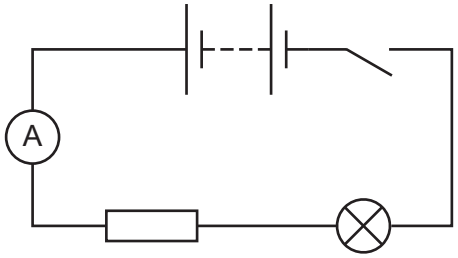

Fig. 9.1

When the switch is closed the reading on the ammeter is 1.2 A.

(a) (i) Calculate the total resistance in the circuit.

total resistance = ... Ω [2]

(ii) Calculate the resistance of the lamp.

resistance of the lamp = ... Ω [1]

(b) The circuit is reconnected so that the lamp and the resistor are connected in parallel with each other.

Explain why the lamp now shines more brightly than when connected in the circuit shown in Fig. 9.1.

.....

.....

..... [2]

[Total: 5]

10 **(a)** Calcium carbonate reacts with dilute hydrochloric acid.

Define, by referring to proton transfer, what is meant by acid.

..... [1]

(b) One of the products of the reaction between calcium carbonate and dilute hydrochloric acid is carbon dioxide gas.

(i) Write the symbol equation for this reaction.

..... [2]

(ii) The rate of this reaction is measured by recording the volume of gas produced every 30 seconds.

Draw a labelled diagram to show the apparatus used to collect and measure the volume of gas produced. Your diagram must show how the apparatus is arranged.

[2]

(c) Fig. 10.1 is a graph to show the results when calcium carbonate and dilute hydrochloric acid react at room temperature.

The experiment is repeated with the dilute hydrochloric acid at a higher temperature. All other conditions remain the same.

Sketch on Fig. 10.1 the graph of the results for the experiment at a higher temperature of acid.

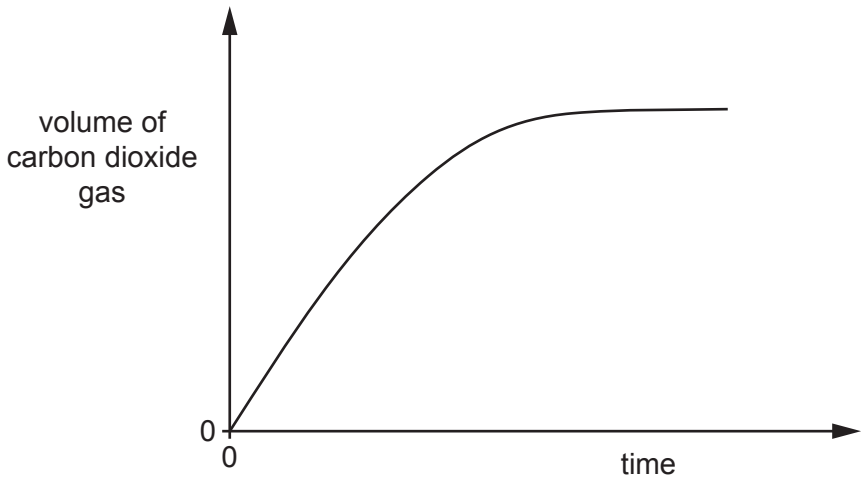

Fig. 10.1

[2]

(d) The reaction between calcium carbonate and dilute hydrochloric acid is exothermic. Energy is transferred to the surroundings during this reaction.

Describe in terms of bond breaking and bond forming why a reaction is exothermic.

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

11 The isotope of sulfur $^{38}_{16}S$ decays to an element X by emitting a β-particle. Symbol X is **not** the chemical symbol of the element.

(a) (i) Complete the equation showing this process.

$$^{38}_{16}S \rightarrow {}^{\ldots\ldots}_{\ldots\ldots}X + {}^{\ldots\ldots}_{\ldots\ldots}\beta$$

[2]

(ii) Complete the sentence by using the Periodic Table on page 24 to identify element X.

Element X is ..... . [1]

(b) A scientist investigates the half-life of the isotope $^{38}_{16}S$.
Table 11.1 shows results from the scientist's notebook.

Table 11.1

time / h	reading on detector / s	corrected reading / s
0	42	40
0.5	37	35
1.0	32	30
1.5	29	27
2.0	26	24
2.5	23	21
3.0	21	19
3.5	18	16
4.0	16	14

(i) Deduce the background count.

background count = ... / s [1]

(ii) State **one** source of background radiation.

.....

..... [1]

(iii) Use Table 11.1 to estimate the half-life of $^{38}_{16}S$.

half-life = ... h [2]

[Total: 7]

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The Periodic Table of Elements

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

Key

atomic number
atomic symbol
name
relative atomic mass

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.).