



Cambridge IGCSE™

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CHEMISTRY

0620/33

Paper 3 Theory (Core)

October/November 2023

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 list of substances is shown.

ammonia
calcium oxide
carbon monoxide
cobalt(II) chloride
ethane
ethanol
ethene
oxygen
potassium oxide
sodium sulfate
sulfuric acid
water

Answer the following questions using only the substances from the list.
Each substance may be used once, more than once or not at all.

Give the name of the substance that:

(a) is a product of photosynthesis

..... [1]

(b) is a member of the alkene homologous series

..... [1]

(c) has an ion with a charge of 1–

..... [1]

(d) is used to remove sulfur dioxide in flue gas desulfurisation

..... [1]

(e) is the product formed in a hydrogen–oxygen fuel cell

..... [1]

(f) is used to test for water.

..... [1]

[Total: 6]

3

2 Hydrocarbons are compounds of carbon and hydrogen.

(a) State the meaning of the term compound.

.....
 [2]

(b) Fig. 2.1 shows a fractionating column for separating petroleum into different hydrocarbon fractions.

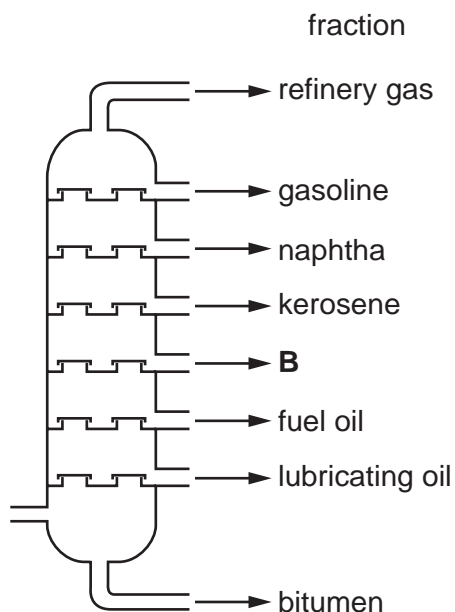


Fig. 2.1

(i) On Fig. 2.1, draw an **X** inside the column to show where the hydrocarbon with the highest boiling point collects. [1]

(ii) Name the fraction labelled **B** in Fig. 2.1.

..... [1]

(iii) State the name of the fraction which has hydrocarbons with the shortest chain length.

..... [1]

(iv) State **one** use of the naphtha fraction.

..... [1]

[Total: 6]

- 3 (a) Table 3.1 shows the average concentrations, in $\text{ng}/1000\text{cm}^3$, of air pollutants in four different years.

Table 3.1

year	concentration of air pollutant in $\text{ng}/1000\text{cm}^3$				
	carbon monoxide	hydrocarbons	oxides of nitrogen	particulates	sulfur dioxide
2019	5.3	22.0	15.6	19.0	20.0
2020	4.1	13.5	14.8	20.1	18.2
2021	5.8	14.8	22.7	23.5	16.2
2022	2.6	18.0	10.9	26.2	14.0

- (i) Name the pollutant which has the highest concentration in 2019.

..... [1]

- (ii) Name the pollutant that shows a continuous decrease in concentration from 2019 to 2022.

..... [1]

- (iii) Calculate the average mass, in ng, of hydrocarbons in a 200cm^3 sample of polluted air in 2019.

mass = ng [1]

- (b) (i) State **one** source of oxides of nitrogen in the air.

..... [1]

- (ii) Oxides of nitrogen contribute to acid rain.

Give one **other** effect of oxides of nitrogen in the air.

..... [1]

- (iii) Unpolluted water has a neutral pH.

Choose from the list the pH value of a neutral substance.

Draw a circle around your chosen answer.

pH1 pH6 pH7 pH14 [1]

(c) Nitrogen dioxide is an acidic oxide.

Choose an oxide from the list which is also an acidic oxide.

Tick (✓) **one** box.

copper(II) oxide	<input type="checkbox"/>
magnesium oxide	<input type="checkbox"/>
phosphorus(V) oxide	<input type="checkbox"/>
sodium oxide	<input type="checkbox"/>

[1]

(d) Sulfur dioxide reacts with oxygen to produce sulfur trioxide.

(i) Complete the symbol equation for this reaction.



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

..... [1]

(iii) Sulfur trioxide reacts with calcium oxide to produce calcium sulfate.

Describe a test for sulfate ions.

test

observations

[2]

[Total: 12]

4 Nitrogen is a gas at room temperature.

(a) State **two** general properties of a gas.

1

.....

2

.....

[2]

(b) Fig. 4.1 shows the physical states of nitrogen.

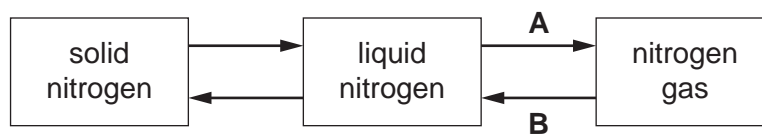


Fig. 4.1

Name the changes of physical states **A** and **B**.

A

B

[2]

(c) Describe solid nitrogen and nitrogen gas in terms of the arrangement and separation of the particles.

solid nitrogen

arrangement

.....

separation

.....

nitrogen gas

arrangement

.....

separation

.....

[4]

7

(d) A sealed gas syringe contains 80 cm^3 of nitrogen gas.

State how increasing the pressure affects the volume of nitrogen gas in the gas syringe when the temperature remains constant.

..... [1]

[Total: 9]

5 This question is about metals.

(a) Table 5.1 shows some properties of the Group I metals.

Table 5.1

metal	melting point in °C	boiling point in °C	atomic volume in cm ³ /mol	observations on reaction with water
lithium	181	1342	12.9	bubbles form slowly but no flame
sodium	98	883	23.7	
potassium	63	760		bubbles form very rapidly and flame seen
rubidium		686	55.8	explodes

Use the information in Table 5.1 to predict:

(i) the melting point of rubidium [1]

(ii) the atomic volume of potassium [1]

(iii) the observations when sodium reacts with water
..... [1]

(iv) the physical state of sodium at 1300°C. Give a reason for your answer.

physical state

reason

..... [2]

(b) Iron is extracted in a blast furnace by reduction of iron(III) oxide.

(i) In the first step, carbon burns in air to form carbon dioxide.

State the percentage of oxygen in clean, dry air.

..... [1]

(ii) In the second step, carbon monoxide is produced by the reaction of carbon dioxide with carbon.



Choose the correct statement about this reaction.

Tick (✓) **one** box.

- | | |
|--|--------------------------|
| the carbon dioxide is oxidised and the carbon is reduced | <input type="checkbox"/> |
| both carbon dioxide and carbon are oxidised | <input type="checkbox"/> |
| the carbon dioxide is reduced and the carbon is oxidised | <input type="checkbox"/> |
| both carbon dioxide and carbon are reduced | <input type="checkbox"/> |

[1]

(iii) In the third step, iron(III) oxide is reduced by carbon monoxide.
The reaction is exothermic.

State the meaning of the term exothermic.

.....

..... [2]

(c) Calcium carbonate is added to the blast furnace.
The calcium carbonate breaks down as shown.



(i) Name the type of chemical reaction that takes place.

..... [1]

(ii) Complete this sentence about the calcium oxide that is produced in the blast furnace.

Calcium oxide reacts with impurities in the iron ore to form [1]

(d) Table 5.2 gives the observations when four different metals react with air.

Table 5.2

metal	observations
cerium	forms an oxide layer slowly without heating
copper	forms an oxide layer only when heated
gold	does not form an oxide layer even when heated
rubidium	forms an oxide layer quickly without heating

Put the four metals in order of their reactivity.

Put the least reactive metal first.

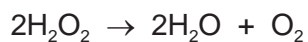
least reactive \longrightarrow most reactive

--	--	--	--

[2]

[Total: 13]

- 6 Hydrogen peroxide, H_2O_2 , breaks down slowly at 40°C to produce oxygen gas and water.



A student investigates the breakdown of hydrogen peroxide at 40°C in the presence of a catalyst.

- (a) Fig. 6.1 shows the volume of oxygen gas released as the reaction proceeds.

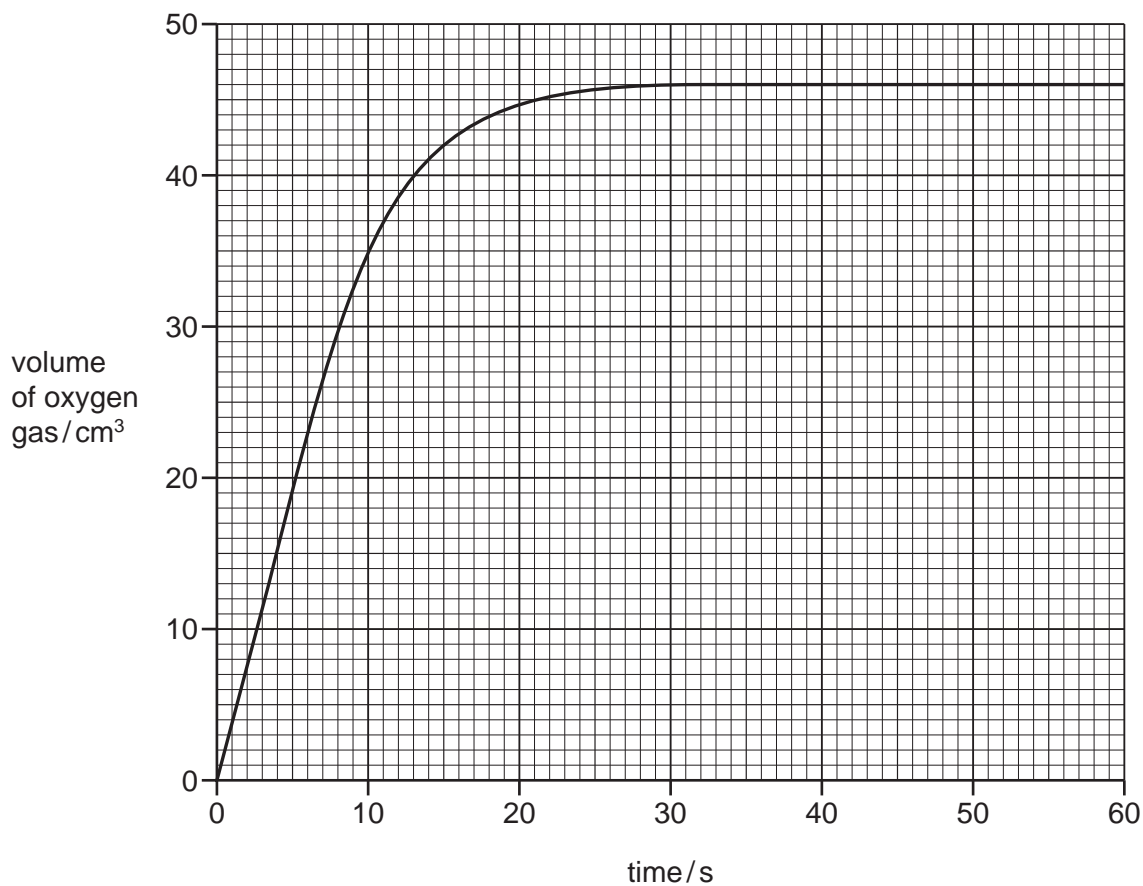


Fig. 6.1

- (i) Deduce the volume of oxygen gas released after 15 seconds.

volume of oxygen = cm^3 [1]

- (ii) The student repeats the experiment at 20°C .

All other conditions stay the same.

Draw a line on the grid in Fig. 6.1 to show how the volume of oxygen changes when a temperature of 20°C is used. [2]

(b) (i) The student repeats the experiment without a catalyst.

All other conditions stay the same.

Describe how the rate of reaction differs when no catalyst is used.

..... [1]

(ii) The student repeats the experiment using a lower concentration of hydrogen peroxide.

All other conditions stay the same.

Describe how the rate of reaction differs when a lower concentration of hydrogen peroxide is used.

..... [1]

(c) Hydrogen peroxide can act as a reducing agent in the presence of an alkali.

(i) State the meaning of the term alkali.

..... [1]

(ii) Give the formula of the ion that is present in all alkaline solutions.

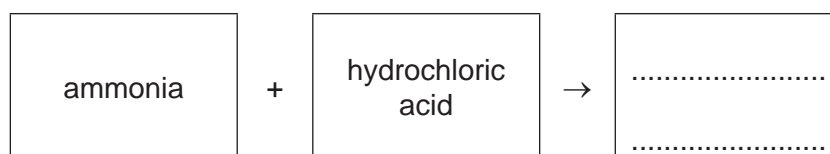
..... [1]

(iii) State the colour of methyl orange in an alkaline solution.

..... [1]

(iv) Aqueous ammonia is an alkali.

Complete the word equation for the reaction of aqueous ammonia with hydrochloric acid.

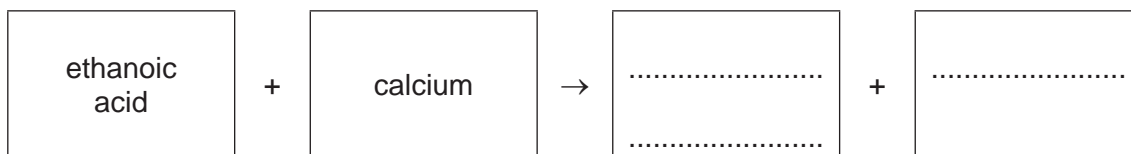


[1]

[Total: 9]

7 Ethanoic acid and methacrylic acid are both carboxylic acids.

(a) Complete the word equation for the reaction of ethanoic acid with calcium.



[2]

(b) Ethanoic acid can be reduced to ethanol.

(i) Name the homologous series that includes ethanol.

..... [1]

(ii) Ethanol can be manufactured by fermentation.

Describe **two** conditions needed for fermentation.

1

2

[2]

(c) Fig. 7.1 shows the displayed formula of methacrylic acid.

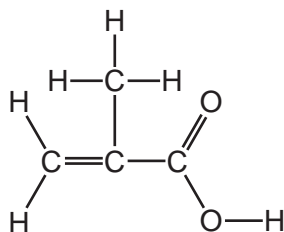


Fig. 7.1

(i) On Fig. 7.1, draw a circle around the functional group which reacts with aqueous bromine. [1]

(ii) State the colour of aqueous bromine.

..... [1]

(iii) Deduce the molecular formula of methacrylic acid.

..... [1]

- (d) Methacrylic acid can be converted to methyl methacrylate.
The molecular formula of methyl methacrylate is $C_5H_8O_2$.

Complete Table 7.1 to calculate the relative molecular mass of methyl methacrylate.

Table 7.1

atom	number of atoms	relative atomic mass	
carbon	5	12	$5 \times 12 = 60$
hydrogen		1	
oxygen		16	

relative molecular mass = [2]

- (e) Methyl methacrylate can be polymerised to produce a plastic.

Describe **two** environmental problems caused by plastics.

1

2

[2]

- (f) Poly(ethene) is a polymer.

Draw the displayed formula of the monomer used to make poly(ethene).

[1]

[Total: 13]

8 Potassium chloride is an ionic compound.

(a) Complete Fig. 8.1 to show:

- the electronic configuration of a potassium ion
- the charge on the ion.

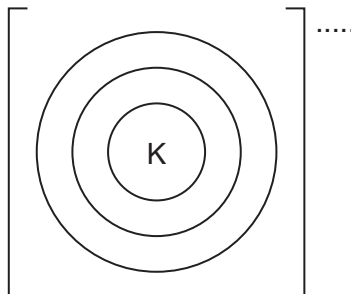


Fig. 8.1

[2]

(b) Deduce the number of protons and neutrons in the chloride ion shown.



number of protons

number of neutrons

[2]

(c) Molten potassium chloride is electrolysed using graphite electrodes.

(i) Define the term electrolysis.

.....
 [2]

(ii) State the names of the products at each electrode and give the observations at the positive electrode.

product at the negative electrode

product at the positive electrode

observations at the positive electrode

[3]

(d) Graphite electrodes are inert.

Name one **other** inert electrode.

..... [1]

(e) Graphite and diamond are two forms of carbon.

Fig. 8.2 shows the structure of diamond.

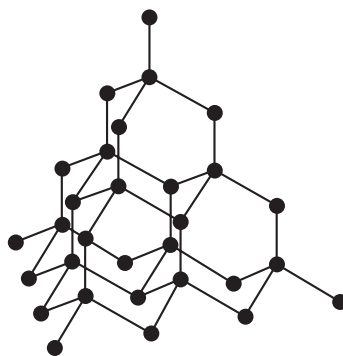


Fig. 8.2

(i) Name the type of bonding in diamond.

..... [1]

(ii) Use Fig. 8.2 to explain why diamond is used in cutting tools.

..... [1]

[Total: 12]

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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	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	36 Kr krypton 84	37 Rb rubidium 85
37 Rb rubidium 85	38 Sr strontium 88	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84	54 Xe xenon 131	55 Cs caesium 133
55 Cs caesium 133	56 Ba barium 137	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	52 Te tellurium 128	87 Fr francium —
87 Fr francium —	88 Ra radium —	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	86 Rn radon —	85 Po polonium —	86 Rn radon —
89–103 actinoids	lanthanoids	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium —	118 Og oganesson —	116 Lv livermorium —	117 Ts tennessine —
104 Rf rutherfordium —	105 Db dubnium —	112 Cn copernicium —	113 Nh nihonium —	114 Fl flerovium —	115 Mc moscovium —	116 Lv livermorium —	118 Og oganesson —	116 Lv livermorium —	117 Ts tennessine —
106 Sg seaborgium —	107 Bh bohrium —	111 Rg roentgenium —	112 Cn copernicium —	114 Fl flerovium —	115 Mc moscovium —	116 Lv livermorium —	118 Og oganesson —	116 Lv livermorium —	117 Ts tennessine —
108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	112 Cn copernicium —	114 Fl flerovium —	115 Mc moscovium —	116 Lv livermorium —	118 Og oganesson —	116 Lv livermorium —	117 Ts tennessine —
110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —	112 Cn copernicium —	114 Fl flerovium —	115 Mc moscovium —	116 Lv livermorium —	118 Og oganesson —	116 Lv livermorium —	117 Ts tennessine —
118 Og oganesson —	119 Uue ununoctium —	120 Uub unbinilium —	122 Cn copernicium —	124 Fl flerovium —	125 Mc moscovium —	126 Lv livermorium —	128 Og oganesson —	126 Lv livermorium —	127 Ts tennessine —
126 Lv livermorium —	127 Ts tennessine —	128 Og oganesson —	128 Og oganesson —	130 Uu untrium —	131 Uub unbinilium —	132 Uuc untrium —	134 Og oganesson —	132 Uuc untrium —	133 Uub unbinilium —
134 Og oganesson —	135 Uu untrium —	136 Uub unbinilium —	138 Og oganesson —	140 Uu untrium —	141 Uub unbinilium —	142 Uuc untrium —	144 Og oganesson —	142 Uuc untrium —	143 Uub unbinilium —
146 Og oganesson —	147 Uu untrium —	148 Uub unbinilium —	150 Og oganesson —	152 Uu untrium —	153 Uub unbinilium —	154 Uuc untrium —	156 Og oganesson —	154 Uuc untrium —	155 Uub unbinilium —
158 Og oganesson —	159 Uu untrium —	160 Uub unbinilium —	162 Og oganesson —	164 Uu untrium —	165 Uub unbinilium —	166 Uuc untrium —	168 Og oganesson —	166 Uuc untrium —	167 Uub unbinilium —
170 Og oganesson —	171 Uu untrium —	172 Uub unbinilium —	174 Og oganesson —	176 Uu untrium —	177 Uub unbinilium —	178 Uuc untrium —	180 Og oganesson —	178 Uuc untrium —	179 Uub unbinilium —
182 Og oganesson —	183 Uu untrium —	184 Uub unbinilium —	186 Og oganesson —	188 Uu untrium —	189 Uub unbinilium —	190 Uuc untrium —	192 Og oganesson —	190 Uuc untrium —	191 Uub unbinilium —
194 Og oganesson —	195 Uu untrium —	196 Uub unbinilium —	198 Og oganesson —	200 Uu untrium —	201 Uub unbinilium —	202 Uuc untrium —	204 Og oganesson —	202 Uuc untrium —	203 Uub unbinilium —
206 Og oganesson —	207 Uu untrium —	208 Uub unbinilium —	210 Og oganesson —	212 Uu untrium —	213 Uub unbinilium —	214 Uuc untrium —	216 Og oganesson —	214 Uuc untrium —	215 Uub unbinilium —
218 Og oganesson —	219 Uu untrium —	220 Uub unbinilium —	222 Og oganesson —	224 Uu untrium —	225 Uub unbinilium —	226 Uuc untrium —	228 Og oganesson —	226 Uuc untrium —	227 Uub unbinilium —
230 Og oganesson —	231 Uu untrium —	232 Uub unbinilium —	234 Og oganesson —	236 Uu untrium —	237 Uub unbinilium —	238 Uuc untrium —	240 Og oganesson —	238 Uuc untrium —	239 Uub unbinilium —
242 Og oganesson —	243 Uu untrium —	244 Uub unbinilium —	246 Og oganesson —	248 Uu untrium —	249 Uub unbinilium —	250 Uuc untrium —	252 Og oganesson —	250 Uuc untrium —	251 Uub unbinilium —
254 Og oganesson —	255 Uu untrium —	256 Uub unbinilium —	258 Og oganesson —	260 Uu untrium —	261 Uub unbinilium —	262 Uuc untrium —	264 Og oganesson —	262 Uuc untrium —	263 Uub unbinilium —
266 Og oganesson —	267 Uu untrium —	268 Uub unbinilium —	270 Og oganesson —	272 Uu untrium —	273 Uub unbinilium —	274 Uuc untrium —	276 Og oganesson —	274 Uuc untrium —	275 Uub unbinilium —
278 Og oganesson —	279 Uu untrium —	280 Uub unbinilium —	282 Og oganesson —	284 Uu untrium —	285 Uub unbinilium —	286 Uuc untrium —	288 Og oganesson —	286 Uuc untrium —	287 Uub unbinilium —
290 Og oganesson —	291 Uu untrium —	292 Uub unbinilium —	294 Og oganesson —	296 Uu untrium —	297 Uub unbinilium —	298 Uuc untrium —	300 Og oganesson —	298 Uuc untrium —	299 Uub unbinilium —
302 Og oganesson —	303 Uu untrium —	304 Uub unbinilium —	306 Og oganesson —	308 Uu untrium —	309 Uub unbinilium —	310 Uuc untrium —	312 Og oganesson —	310 Uuc untrium —	311 Uub unbinilium —
314 Og oganesson —	315 Uu untrium —	316 Uub unbinilium —	318 Og oganesson —	320 Uu untrium —	321 Uub unbinilium —	322 Uuc untrium —	324 Og oganesson —	322 Uuc untrium —	323 Uub unbinilium —
326 Og oganesson —	327 Uu untrium —	328 Uub unbinilium —	330 Og oganesson —	332 Uu untrium —	333 Uub unbinilium —	334 Uuc untrium —	336 Og oganesson —	334 Uuc untrium —	335 Uub unbinilium —
338 Og oganesson —	339 Uu untrium —	340 Uub unbinilium —	342 Og oganesson —	344 Uu untrium —	345 Uub unbinilium —	346 Uuc untrium —	348 Og oganesson —	346 Uuc untrium —	347 Uub unbinilium —
350 Og oganesson —	351 Uu untrium —	352 Uub unbinilium —	354 Og oganesson —	356 Uu untrium —	357 Uub unbinilium —	358 Uuc untrium —	360 Og oganesson —	358 Uuc untrium —	359 Uub unbinilium —
362 Og oganesson —	363 Uu untrium —	364 Uub unbinilium —	366 Og oganesson —	368 Uu untrium —	369 Uub unbinilium —	370 Uuc untrium —	372 Og oganesson —	370 Uuc untrium —	371 Uub unbinilium —
374 Og oganesson —	375 Uu untrium —	376 Uub unbinilium —	378 Og oganesson —	380 Uu untrium —	381 Uub unbinilium —	382 Uuc untrium —	384 Og oganesson —	382 Uuc untrium —	383 Uub unbinilium —
386 Og oganesson —	387 Uu untrium —	388 Uub unbinilium —	390 Og oganesson —	392 Uu untrium —	393 Uub unbinilium —	394 Uuc untrium —	396 Og oganesson —	394 Uuc untrium —	395 Uub unbinilium —
398 Og oganesson —	399 Uu untrium —	400 Uub unbinilium —	402 Og oganesson —	404 Uu untrium —	405 Uub unbinilium —	406 Uuc untrium —	408 Og oganesson —	406 Uuc untrium —	407 Uub unbinilium —
410 Og oganesson —	411 Uu untrium —	412 Uub unbinilium —	414 Og oganesson —	416 Uu untrium —	417 Uub unbinilium —	418 Uuc untrium —	420 Og oganesson —	418 Uuc untrium —	419 Uub unbinilium —
422 Og oganesson —	423 Uu untrium —	424 Uub unbinilium —	426 Og oganesson —	428 Uu untrium —	429 Uub unbinilium —	430 Uuc untrium —	432 Og oganesson —	430 Uuc untrium —	431 Uub unbinilium —
434 Og oganesson —	435 Uu untrium —	436 Uub unbinilium —	438 Og oganesson —	440 Uu untrium —	441 Uub unbinilium —	442 Uuc untrium —	444 Og oganesson —	442 Uuc untrium —	443 Uub unbinilium —
446 Og oganesson —	447 Uu untrium —	448 Uub unbinilium —	450 Og oganesson —	452 Uu untrium —	453 Uub unbinilium —	454 Uuc untrium —	456 Og oganesson —	454 Uuc untrium —	455 Uub unbinilium —
458 Og oganesson —	459 Uu untrium —	460 Uub unbinilium —	462 Og oganesson —	464 Uu untrium —	465 Uub unbinilium —	466 Uuc untrium —	468 Og oganesson —	466 Uuc untrium —	467 Uub unbinilium —
470 Og oganesson —	471 Uu untrium —	472 Uub unbinilium —	474 Og oganesson —	476 Uu untrium —	477 Uub unbinilium —	478 Uuc untrium —	480 Og oganesson —	478 Uuc untrium —	479 Uub unbinilium —
482 Og oganesson —	483 Uu untrium —	484 Uub unbinilium —	486 Og oganesson —	488 Uu untrium —	489 Uub unbinilium —	490 Uuc untrium —	492 Og oganesson —	490 Uuc untrium —	491 Uub unbinilium —
494 Og oganesson —	495 Uu untrium —	496 Uub unbinilium —	498 Og oganesson —	500 Uu untrium —	501 Uub unbinilium —	502 Uuc untrium —	504 Og oganesson —	502 Uuc untrium —	503 Uub unbinilium —
506 Og oganesson —	507 Uu untrium —	508 Uub unbinilium —	510 Og oganesson —	512 Uu untrium —	513 Uub unbinilium —	514 Uuc untrium —	516 Og oganesson —	514 Uuc untrium —	515 Uub unbinilium —
518 Og oganesson —	519 Uu untrium —	520 Uub unbinilium —	522 Og oganesson —	524 Uu untrium —	525 Uub unbinilium —	526 Uuc untrium —	528 Og oganesson —	526 Uuc untrium —	527 Uub unbinilium —
530 Og oganesson —	531 Uu untrium —	532 Uub unbinilium —	534 Og oganesson —	536 Uu untrium —	537 Uub unbinilium —	538 Uuc untrium —	540 Og oganesson —	538 Uuc untrium —	539 Uub unbinilium —
542 Og oganesson —	543 								