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CHEMISTRY

0620/43

Paper 4 Theory (Extended)

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 **16** pages. Any blank pages are indicated.



1 A list of substances is shown.

barium nitrate
carbon monoxide
hydrated cobalt(II) chloride
copper(II) oxide
anhydrous copper(II) sulfate
ethane
potassium iodide
propene
sodium bromide
sulfur dioxide
zinc oxide

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) gives a lilac colour in a flame test

..... [1]

(b) forms a cream precipitate when its aqueous solution reacts with acidified aqueous silver nitrate

..... [1]

(c) is an acidic oxide

..... [1]

(d) is an unsaturated hydrocarbon

..... [1]

(e) is a product of incomplete combustion of fossil fuels

..... [1]

(f) is used to test for the presence of water.

..... [1]

[Total: 6]

2 Table 2.1 gives information about particles **A**, **B**, **C**, **D**, **E** and **F**.

Table 2.1

particle	number of electrons	number of neutrons	number of protons
A	5	6	5
B	10	11	10
C	10	14	13
D	18	17	16
E	18	17	17
F	15	16	15

(a) Give the letters of **all** the particles which are:

(i) atoms

..... [1]

(ii) ions with a charge of 2-

..... [1]

(iii) cations.

..... [1]

(b) State the atomic number of **A**.

..... [1]

(c) Determine the number of nucleons in **D**.

..... [1]

(d) State the electronic configuration of **D**.

..... [1]

(e) State the group number of **F**.

..... [1]

(f) State the period number of **B**.

..... [1]

[Total: 8]

3 This question is about nitrogen and some of its compounds.

(a) Nitrogen is converted into ammonia, NH_3 , in the Haber process.

(i) Nitrogen is obtained from air.

State the percentage of nitrogen in clean, dry air.

..... [1]

(ii) State the source of hydrogen for the Haber process.

..... [1]

(iii) Complete the dot-and-cross diagram in Fig. 3.1 for a molecule of ammonia.

Show the outer shell electrons only.

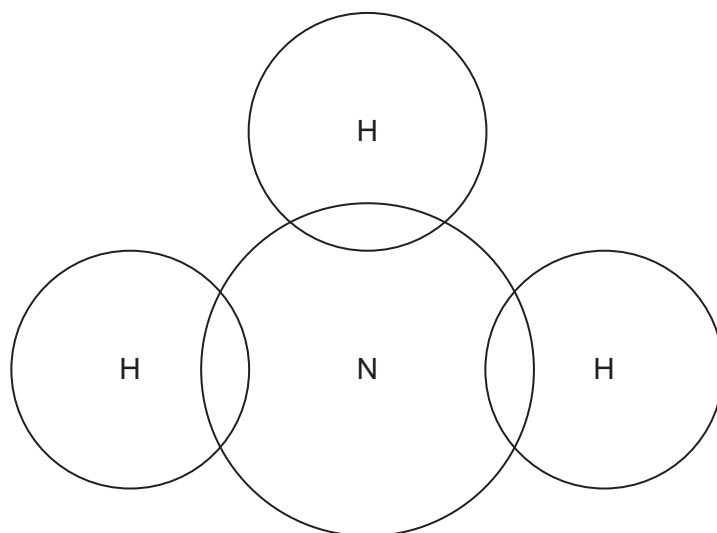


Fig. 3.1

[2]

(iv) Write a chemical equation for the reaction occurring in the Haber process and give the typical reaction conditions. Include units where appropriate.

chemical equation

reaction conditions:

temperature

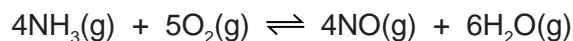
pressure

catalyst

[5]

(b) Ammonia is converted into nitric acid.

The first stage of this conversion uses a catalyst and occurs at a temperature of 900 °C and a pressure of 5 atmospheres.



The forward reaction is exothermic.

(i) Suggest which of the following elements is most likely to be used as a catalyst. Draw a circle around your answer.

calcium lead platinum sodium sulfur [1]

(ii) State the oxidation number of nitrogen in:

NH₃

NO

[2]

(iii) Use your answer to (ii) to explain whether the nitrogen in ammonia undergoes oxidation or reduction.

.....

..... [1]

(iv) Complete Table 3.1 using the words **increases**, **decreases** or **no change**.

Table 3.1

	effect on the equilibrium yield of NO(g)	effect on the rate of the forward reaction
decreasing the pressure		
decreasing the temperature		decreases
removing the catalyst		decreases

[4]

(v) Decreasing the temperature causes the rate of the forward reaction to decrease.

Explain, using collision theory, why the rate of the reaction is slower at the decreased temperature.

.....

.....

.....

..... [3]

6

(c) In the second stage, nitric acid is produced.

Balance the symbol equation for this reaction.

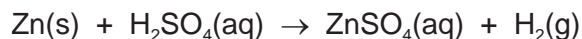


[Total: 21]

4 This question is about sulfuric acid and salts that are made from sulfuric acid.

(a) Zinc reacts with dilute sulfuric acid. Aqueous zinc sulfate is one of the products.

Powdered zinc is added to dilute sulfuric acid. The mixture is stirred. More zinc is added, with stirring, until the zinc is in excess.



The mixture is then filtered.

(i) Name the limiting reactant.

..... [1]

(ii) State two **observations** that indicate the zinc is in excess.

1

2 [2]

(iii) Name the filtrate.

..... [1]

(iv) Name **two** compounds which both react with dilute sulfuric acid to produce aqueous zinc sulfate.

1

2 [2]

(b) Zinc sulfate crystals are produced by heating aqueous zinc sulfate until a saturated solution is formed. When the saturated solution cools down, crystals of zinc sulfate start to form.

(i) State what is meant by the term saturated solution.

..... [2]

(ii) Explain why crystals form when the saturated solution cools down.

..... [1]

(c) Nickel(II) sulfate crystals contain water of crystallisation.

When nickel(II) sulfate crystals, $\text{NiSO}_4 \cdot x\text{H}_2\text{O}$, are heated, they give off water.



A student carries out an experiment to determine the value of x in $\text{NiSO}_4 \cdot x\text{H}_2\text{O}$.

step 1 Nickel(II) sulfate crystals are weighed.

step 2 Nickel(II) sulfate crystals are heated.

step 3 The remaining solid is allowed to cool and is then weighed.

step 4 The remaining solid is heated again, allowed to cool and is then weighed.

step 5 Step 4 is repeated until there is no change in mass.

(i) State the term used to describe crystals that contain water of crystallisation.

..... [1]

(ii) State why **step 4** is repeated until there is no change in mass.

..... [1]

(iii) In an experiment, 0.454 g of nickel(II) sulfate crystals, $\text{NiSO}_4 \cdot x\text{H}_2\text{O}$, is used. The mass of anhydrous nickel(II) sulfate, NiSO_4 , remaining is 0.310 g.

[M_r : NiSO_4 , 155; H_2O , 18]

Determine the value of x in $\text{NiSO}_4 \cdot x\text{H}_2\text{O}$.

Use the following steps.

- Calculate the number of moles of NiSO_4 remaining.

moles of NiSO_4 =

- Calculate the mass of H_2O given off.

mass of H_2O = g

- Calculate the number of moles of H_2O given off.

moles of H_2O =

9

- Calculate the value of x .

$x = \dots\dots\dots$
[4]

[Total: 15]

5 This question is about iron.

(a) (i) Describe the bonding in a metallic element such as iron.

You may include a labelled diagram as part of your answer.

.....
.....
..... [3]

(ii) Explain why iron conducts electricity when it is solid.

..... [1]

(b) Iron is extracted from hematite in the blast furnace as shown in Fig. 5.1.

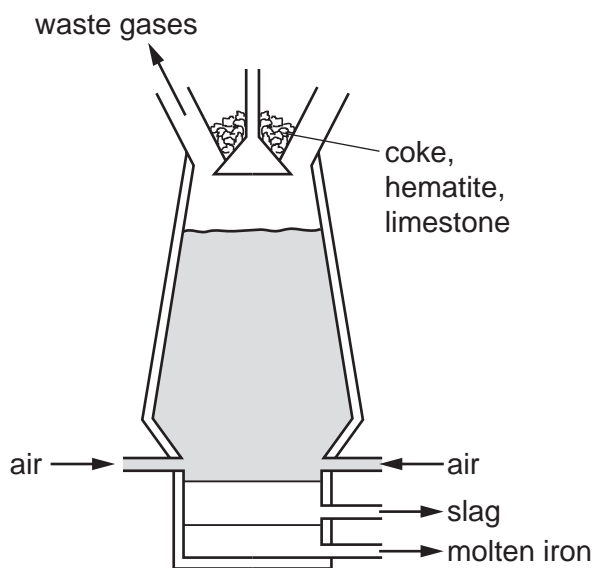


Fig. 5.1

(i) Give **two** reasons why coke is added to the blast furnace.

- 1
- 2 [2]

(ii) Explain how limestone removes the impurities in the hematite.

-
-
- [2]

(iii) Hematite contains iron(III) oxide.

Write a symbol equation for the conversion of iron(III) oxide to iron in the blast furnace.

- [2]

(iv) Suggest why the iron produced in the blast furnace is molten.

- [1]

(c) Most iron is converted into steel. Steel is an alloy.

Steel is more useful than pure iron because it is harder and stronger.

Explain why the structure of alloys causes them to be harder and stronger than pure metals.

You may include a diagram as part of your answer.

.....
 [2]

(d) Iron forms rust.

Rusting is prevented by coating iron with zinc.

(i) Name the substances that react with iron to form rust.

..... [1]

(ii) Name the process in which zinc is used to coat iron to prevent rusting.

..... [1]

(iii) Explain how the coating of zinc prevents rusting if the zinc is **not** scratched.

..... [1]

(iv) When zinc is scratched the iron becomes exposed.

Explain how the zinc continues to prevent rusting.

.....

 [2]

[Total: 18]

- 6 (a) Esters are members of a homologous series of organic compounds.

Give **two** characteristics that are the **same** for all members of a homologous series.

1

2

[2]

- (b) Ester **X** has the structure shown in Fig. 6.1.

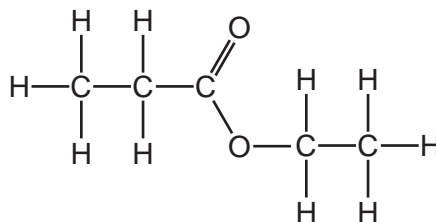


Fig. 6.1

Name ester **X**.

..... [1]

- (c) (i) Ester **Y** has the structural formula $\text{HCOOCH}_2\text{CH}_2\text{CH}_3$.

Name the alcohol and the carboxylic acid used to make ester **Y**.

alcohol

carboxylic acid

[2]

- (ii) State the molecular formula of ester **Y**.

..... [1]

- (d) Ester **Z** has the molecular formula $\text{C}_4\text{H}_8\text{O}_2$.

State the empirical formula of ester **Z**.

..... [1]

(e) Polymers containing ester linkages are known as polyesters.

Polyamides are another type of polymer. Nylon is a polyamide.

The structure of nylon is shown in Fig. 6.2.

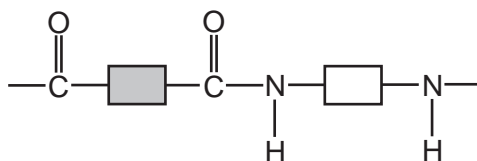


Fig. 6.2

(i) State the term used to describe the type of polymerisation used to produce polyesters and polyamides.

..... [1]

(ii) Complete Fig. 6.3 to show the structures of the monomers used to produce nylon. Show all of the atoms and all of the bonds.

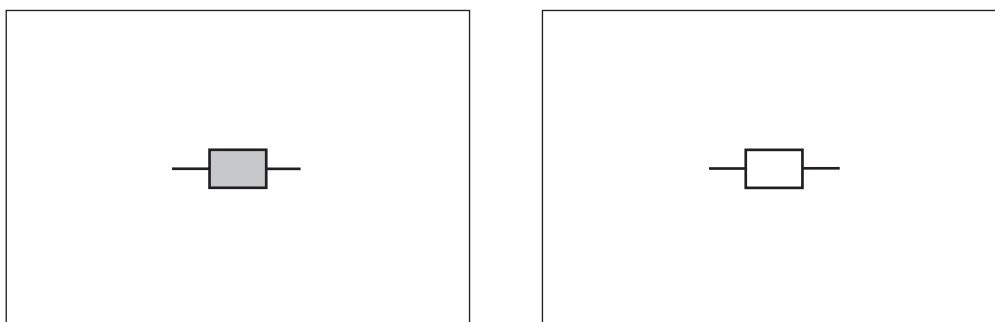


Fig. 6.3

[2]

(f) Naturally occurring polyamides are found in food.

(i) State the name given to naturally occurring polyamides.

..... [1]

(ii) Name the type of monomer which forms naturally occurring polyamides.

..... [1]

[Total: 12]

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The Periodic Table of Elements

Group									
I	II	III	IV	V	VI	VII	VIII		
1	2	3	4	5	6	7	8	9	10
H hydrogen 1	He helium 4	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20		
Key									
atomic number atomic symbol name relative atomic mass									
3	4	5	6	7	8	9	10	11	12
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20	Na sodium 23	Mg magnesium 24
11	12	13	14	15	16	17	18	19	20
Na sodium 23	Mg magnesium 24	Al aluminium 27	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	Ar argon 40	K potassium 39	Ca calcium 40
19	20	21	22	23	24	25	26	27	28
K potassium 39	Ca calcium 40	Sc scandium 45	Ti titanium 48	V vanadium 51	Cr chromium 52	Mn manganese 55	Fe iron 56	Co cobalt 59	Ni nickel 59
37	38	39	40	41	42	43	44	45	46
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 91	Nb niobium 93	Mo molybdenum 96	Tc technetium —	Ru ruthenium 101	Rh rhodium 103	Pd palladium 106
55	56	57–71	72	73	74	75	76	77	78
Cs caesium 133	Ba barium 137	lanthanoids	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195
87	88	89–103	104	105	106	107	108	109	110
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
81	82	83	84	85	86	87	88	89	90
Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —	Fr francium —	Ra radium —	Ac actinium —	Th thorium 232
113	114	115	116	117	118	119	120	121	122
Nh nihonium —	Fl flerovium —	Mc moscovium —	Lv livermorium —	Ts tennessine —	Og oganeson —	Uu unbinilium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
129	130	131	132	133	134	135	136	137	138
Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —
151	152	153	154	155	156	157	158	159	160
Uup unpentupium —	Uuq unquadrupium —	Uub unbibium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —
167	168	169	170	171	172	173	174	175	176
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
183	184	185	186	187	188	189	190	191	192
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
197	198	199	200	201	202	203	204	205	206
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
211	212	213	214	215	216	217	218	219	220
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
227	228	229	230	231	232	233	234	235	236
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
243	244	245	246	247	248	249	250	251	252
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
261	262	263	264	265	266	267	268	269	270
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
277	278	279	280	281	282	283	284	285	286
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
293	294	295	296	297	298	299	300	301	302
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
309	310	311	312	313	314	315	316	317	318
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
315	316	317	318	319	320	321	322	323	324
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
329	330	331	332	333	334	335	336	337	338
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
345	346	347	348	349	350	351	352	353	354
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
353	354	355	356	357	358	359	360	361	362
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
369	370	371	372	373	374	375	376	377	378
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
381	382	383	384	385	386	387	388	389	390
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
397	398	399	400	401	402	403	404	405	406
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
413	414	415	416	417	418	419	420	421	422
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
429	430	431	432	433	434	435	436	437	438
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
445	446	447	448	449	450	451	452	453	454
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
459	460	461	462	463	464	465	466	467	468
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
475	476	477	478	479	480	481	482	483	484
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
491	492	493	494	495	496	497	498	499	500
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
507	508	509	510	511	512	513	514	515	516
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
523	524	525	526	527	528	529	530	531	532
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
539	540	541	542	543	544	545	546	547	548
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
555	556	557	558	559	560	561	562	563	564
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
563	564	565	566	567	568	569	570	571	572
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
579	580	581	582	583	584	585	586	587	588
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
595	596	597	598	599	600	601	602	603	604
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
609	610	611	612	613	614	615	616	617	618
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
625	626	627	628	629	630	631	632	633	634
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
639	640	641	642	643	644	645	646	647	648
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —
655	656	657	658	659	660	661	662	663	664
Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —	Uut ununtrium —	Uuq unquadrupium —	Uub unbibium —</		