



Cambridge International AS & A Level

CHEMISTRY

9701/12

Paper 1 Multiple Choice

October/November 2023

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A, B, C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has **16** pages.



1 Which particle contains 8 protons, 9 neutrons and 10 electrons?

- A $^{16}_8\text{O}^-$ B $^{16}_8\text{O}^{2-}$ C $^{17}_8\text{O}^-$ D $^{17}_8\text{O}^{2-}$

2 The second ionisation energy of oxygen is greater than the second ionisation energy of fluorine.

Which factor explains this difference?

- A The atomic radius of an oxygen atom is smaller than that of fluorine.
B The covalent bond in a fluorine molecule is weaker than the bond in an oxygen molecule.
C A spin-paired electron is removed from fluorine but **not** from oxygen.
D Fluorine has more electrons in total than oxygen. This causes a greater shielding of the nuclear attraction in fluorine.

3 Zinc reacts with concentrated nitric acid giving three products only: zinc nitrate, an oxide of nitrogen and water.

3.0 moles of zinc react with 8.0 moles of nitric acid. Zinc nitrate contains Zn^{2+} ions.

What could be the formula of the oxide of nitrogen?

- A N_2O B NO C N_2O_3 D NO_2

4 A 3.7 g sample of copper(II) carbonate is added to 25 cm^3 of 2.0 mol dm^{-3} hydrochloric acid.

Which volume of gas is produced at room conditions?

- A 0.60 dm^3 B 0.72 dm^3 C 1.20 dm^3 D 2.40 dm^3

5 Ammonium ions, NH_4^+ , are formed when ammonia gas reacts with hydrogen chloride gas.

Which statement about the changes that occur in this reaction is correct?

- A The dipole moment of an ammonium ion is greater than the dipole moment of an ammonia molecule.
B The H–N–H bond angle decreases when an ammonium ion is formed.
C The hybridisation of nitrogen does **not** change.
D There is electron transfer from nitrogen to chlorine.

6 Which feature is present in both ethene and poly(ethene)?

- A bond angles of 109.5°
- B π covalent bonds
- C σ covalent bonds
- D sp^3 orbitals

7 Two compounds of boron are sodium borohydride, $NaBH_4$, and boron trifluoride, BF_3 .

What are the shapes of the borohydride ion and the boron trifluoride molecule?

	borohydride ion	boron trifluoride
A	square planar	pyramidal
B	square planar	trigonal planar
C	tetrahedral	pyramidal
D	tetrahedral	trigonal planar

8 In an experiment, 0.100 mol of propan-1-ol is burnt completely in 12.0 dm^3 of oxygen, measured at room conditions.

What is the final volume of gas, measured at room conditions?

- A 7.20 dm^3 B 8.40 dm^3 C 16.80 dm^3 D 18.00 dm^3

9 At a temperature of 2500 K and a pressure of $1.00 \times 10^{-4} \text{ Pa}$, a sample of 0.321 g of sulfur vapour has a volume of $2.08 \times 10^6 \text{ m}^3$.

What is the molecular formula of sulfur under these conditions?

- A S B S_2 C S_4 D S_8

10 In the structure of solid SiO₂

each silicon atom is bonded to x oxygen atoms

each oxygen atom is bonded to y silicon atoms

each bond is a z type bond.

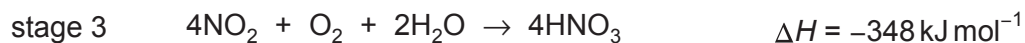
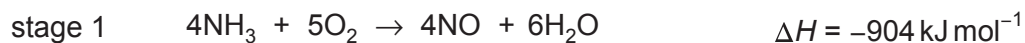
What is the correct combination of x, y and z in these statements?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

11 Nitric acid is made industrially by the oxidation of ammonia. The overall equation for the process is shown.



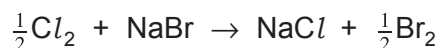
The process happens in three stages. The equations and enthalpy changes for these stages are given.



What is the enthalpy change of the process shown in equation 1?

- A** $-1480 \text{ kJ mol}^{-1}$
- B** -370 kJ mol^{-1}
- C** $-341.5 \text{ kJ mol}^{-1}$
- D** $+82 \text{ kJ mol}^{-1}$

- 12 Chlorine reacts with sodium bromide.

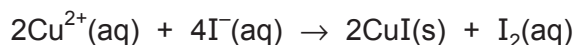


Which words correctly describe this reaction?

- 1 redox
- 2 displacement
- 3 disproportionation

- A 1, 2 and 3
- B 1 and 2 only
- C 1 only
- D 2 only

- 13 The equation for the reaction between aqueous copper ions and aqueous iodide ions is as follows.



What is the change in oxidation state of copper?

- A +2 to -1 B +2 to 0 C +2 to +1 D +4 to +2

- 14 A mixture of the three gases, oxygen, nitrogen and argon, is at a total pressure of 500 kPa. There is a total of 1.2 moles of gas in the mixture.

If the oxygen gas alone occupied the entire volume of the mixture, it would exert a pressure of 150 kPa.

At room conditions the amount of nitrogen gas in the mixture would occupy a volume of 5.76 dm³.

What is the partial pressure of the argon gas in the mixture?

- A 150 kPa
- B 200 kPa
- C 250 kPa
- D 300 kPa

- 15 0.200 mol of sulfur dioxide and 0.200 mol of oxygen are placed in a 1.00 dm^3 sealed container. The gases are allowed to react until equilibrium is reached.



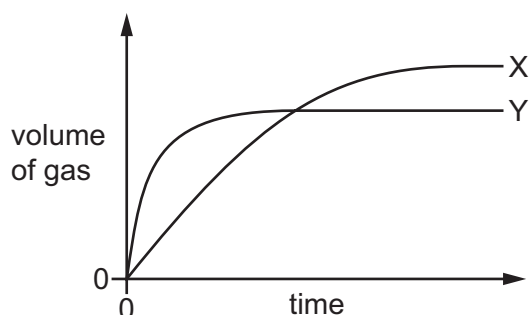
At equilibrium there is 0.100 mol of SO_3 in the container.

What is the value of K_c ?

- A $0.150 \text{ mol dm}^{-3}$
 B $0.800 \text{ mol dm}^{-3}$
 C $1.25 \text{ mol}^{-1} \text{ dm}^3$
 D $6.67 \text{ mol}^{-1} \text{ dm}^3$
- 16 The decomposition of hydrogen peroxide in the presence of MnO_2 produces water and oxygen gas.



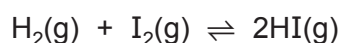
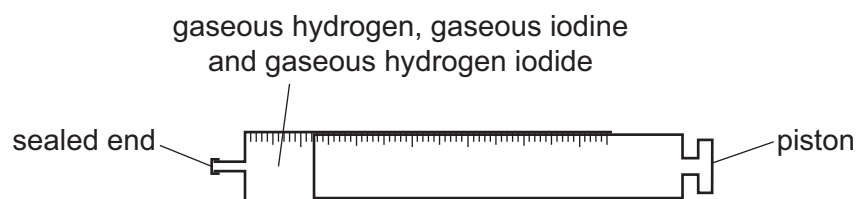
The volume of gas collected when 0.2 g of MnO_2 is added to two different hydrogen peroxide solutions at 20°C is shown on the graph as curves X and Y.



Which row shows the conditions that will result in curves X and Y?

	curve X			curve Y		
	volume of $\text{H}_2\text{O}_2 / \text{cm}^3$	concentration of $\text{H}_2\text{O}_2 / \text{mol dm}^{-3}$	form of MnO_2	volume of $\text{H}_2\text{O}_2 / \text{cm}^3$	concentration of $\text{H}_2\text{O}_2 / \text{mol dm}^{-3}$	form of MnO_2
A	50	0.1	lumps	50	0.2	powder
B	25	0.2	powder	25	0.1	lumps
C	50	0.1	lumps	20	0.2	powder
D	20	0.2	powder	40	0.1	lumps

- 17 The diagram shows a gas syringe with a free-moving piston. The syringe contains gaseous hydrogen, gaseous iodine and gaseous hydrogen iodide at equilibrium.



Three changes are listed.

- 1 increasing the total pressure by adding an inert gas and keeping the volume constant
- 2 increasing the pressure by adding more gaseous hydrogen iodide and keeping the volume constant
- 3 decreasing the volume by pushing the piston to the left

Which changes will result in an equilibrium position at which the rate of the forward reaction has increased?

- A** 2 only **B** 1 and 2 **C** 1 and 3 **D** 2 and 3

- 18 Which row gives the best description of the variations in the melting points and the first ionisation energies of the elements in Period 3 from sodium to argon?

	melting points	first ionisation energies
A	increase up to a peak at aluminium then decrease	generally decrease
B	increase up to a peak at aluminium then decrease	generally increase
C	increase up to a peak at silicon then decrease	generally decrease
D	increase up to a peak at silicon then decrease	generally increase

- 19** X and Y are atoms of different elements in Period 3 of the Periodic Table. Neither X nor Y is argon.

X is a non-metal.

X has a greater atomic radius than Y.

Which statement is correct?

- A** X has more occupied electron shells than Y.
 - B** X has more protons in each atom than Y.
 - C** X has the same number of outer electrons in each atom as Y.
 - D** Y is a non-metal.
- 20** Four mixtures are added to four separate 50 cm³ samples of water and stirred.
- Which mixture results in a solution with the highest pH?
- A** 1.0 g of aluminium oxide and 1.0 g of aluminium chloride
 - B** 1.0 g of magnesium oxide and 1.0 g of magnesium chloride
 - C** 1.0 g of phosphorus oxide and 1.0 g of phosphorus chloride
 - D** 1.0 g of silicon dioxide and 1.0 g of silicon chloride
- 21** What happens when a piece of magnesium ribbon is placed in cold water?
- A** A vigorous effervescence occurs.
 - B** Bubbles of gas form slowly on the magnesium.
 - C** The magnesium floats on the surface of the water and reacts quickly.
 - D** The magnesium glows and a white solid is produced.

- 22** The table gives some data for compounds of two elements from Group 2 of the Periodic Table.

element	decomposition temperature of carbonate / °C	solubility of sulfate in mol / 100 g of water	solubility of hydroxide in mol / 100 g of water
calcium	840	4.66×10^{-3}	1.53×10^{-3}
Z	?	?	2.00×10^{-5}

What is the missing data for element Z?

	decomposition temperature of carbonate / °C	solubility of sulfate in mol / 100 g of water
A	350	1.83×10^{-1}
B	350	7.11×10^{-5}
C	1100	1.83×10^{-1}
D	1100	7.11×10^{-5}

- 23** Q is a mixture of two compounds of Group 2 elements.

Q undergoes thermal decomposition to produce a white solid and only two gaseous products. One of the gaseous products relights a glowing splint.

What could be the components of mixture Q?

- A** MgCl_2 and CaCO_3
- B** MgCO_3 and $\text{Ca}(\text{NO}_3)_2$
- C** $\text{Mg}(\text{NO}_3)_2$ and $\text{Ca}(\text{NO}_3)_2$
- D** MgO and CaO

- 24** Iodine has a higher melting point than chlorine.

What is the reason for this?

- A** Iodine has stronger covalent bonds than chlorine.
- B** Iodine molecules have stronger permanent dipoles than chlorine molecules.
- C** Iodine is more volatile than chlorine.
- D** Iodine has stronger instantaneous dipole–induced dipole forces than chlorine.

- 25** When concentrated sulfuric acid is added to solid sodium chloride, HCl is formed but **not** Cl_2 .

When concentrated sulfuric acid is added to solid sodium iodide, I_2 is formed.

Which statement explains these observations?

- A** Sulfuric acid is an oxidising agent and chloride ions are more easily oxidised than iodide ions.
- B** Sulfuric acid is an oxidising agent and iodide ions are more easily oxidised than chloride ions.
- C** Sulfuric acid is a reducing agent and chloride ions are more easily reduced than iodide ions.
- D** Sulfuric acid is a reducing agent and iodide ions are more easily reduced than chloride ions.
- 26** NaOH(aq) is added to $\text{NH}_4\text{Cl(aq)}$. The mixture is warmed.

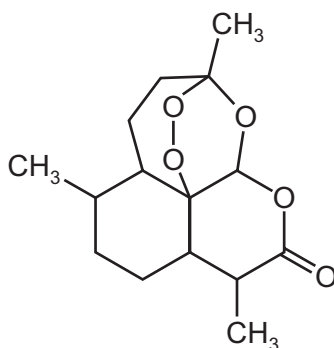
The gas that is produced turns damp red litmus paper blue.

Which row is correct?

	behaviour of the ammonium ion in NH_4Cl	behaviour of the water present on the litmus paper
A	Brønsted–Lowry acid	Brønsted–Lowry base
B	Brønsted–Lowry acid	Brønsted–Lowry acid
C	Brønsted–Lowry base	Brønsted–Lowry acid
D	Brønsted–Lowry base	Brønsted–Lowry base

- 27** Artemisinin is a powerful anti-malarial drug.

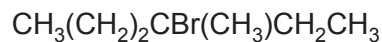
artemisinin



How many chiral centres are there in each molecule of artemisinin?

- A** 4 **B** 6 **C** 7 **D** 8

28 Which row shows the correct name and classification of the halogenoalkane shown?



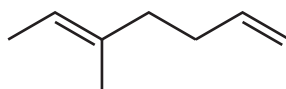
	name	classification of halogenoalkane
A	3-bromo-3-methylhexane	secondary
B	3-bromo-3-methylhexane	tertiary
C	3-bromo-4-methylhexane	tertiary
D	4-bromo-5-methylhexane	secondary

29 How many geometrical (cis/trans) isomers are there of hex-2,4-diene, $\text{CH}_3\text{CH}=\text{CHCH}=\text{CHCH}_3$?

- A** none; hex-2,4-diene does **not** show geometric isomerism
B 2
C 3
D 4

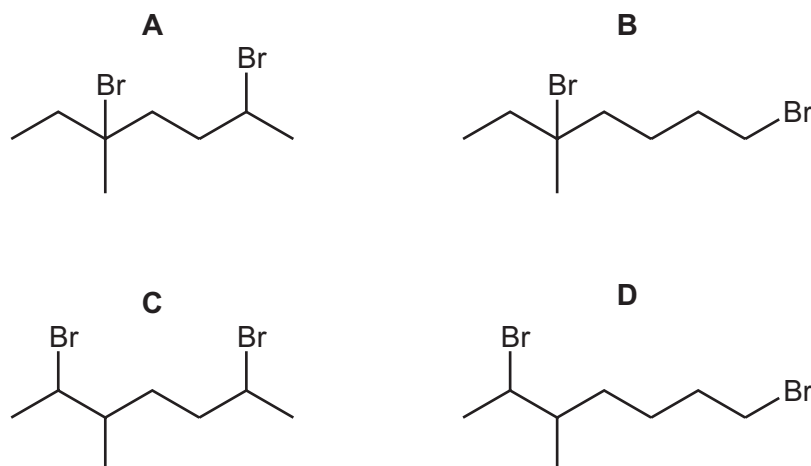
30 The structure of compound X is shown.

compound X

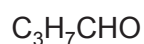


One mole of compound X reacts completely with two moles of hydrogen bromide.

What is the structure of the major product of this reaction?



31 The formulae of three compounds are shown.

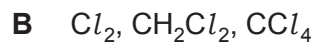
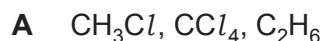


Only one of these compounds will decolourise bromine water. Only one of these compounds will produce a silver mirror with Tollens' reagent.

Which row shows the correct results?

	decolourises bromine water	forms a silver mirror with Tollens' reagent
A	$\text{C}_3\text{H}_7\text{CHO}$	$\text{C}_2\text{H}_5\text{COCH}_3$
B	$\text{C}_2\text{H}_5\text{COCH}_3$	$\text{C}_3\text{H}_7\text{CHO}$
C	$\text{CH}_2\text{CHCH}_2\text{CH}_2\text{OH}$	$\text{C}_2\text{H}_5\text{COCH}_3$
D	$\text{CH}_2\text{CHCH}_2\text{CH}_2\text{OH}$	$\text{C}_3\text{H}_7\text{CHO}$

32 Which list contains a compound that is **not** made during the free radical substitution of methane with chlorine?



33 Propanoic acid can be used to make propene by a two-stage synthesis.

Which row shows suitable reagents for this synthesis?

	reagent for first stage	reagent for second stage
A	LiAlH_4	conc. H_2SO_4
B	LiAlH_4	NaOH in ethanol
C	NaBH_4	conc. H_2SO_4
D	NaBH_4	NaOH in ethanol

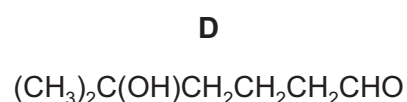
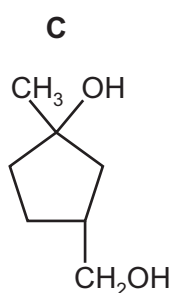
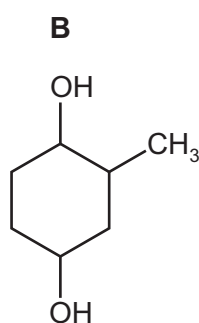
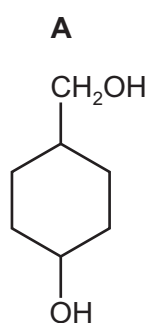
34 Which alcohol reacts with alkaline $I_2(aq)$ to produce ethanoate ions?

- A ethanol
- B methylpropan-2-ol
- C propan-2-ol
- D butan-2-ol

35 Heating compound X, $C_7H_{14}O_2$, under reflux with an excess of acidified potassium dichromate(VI) produces compound Y.

Compound Y produces hydrogen gas with sodium metal and forms orange crystals with 2,4-DNPH reagent.

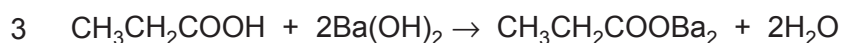
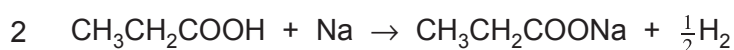
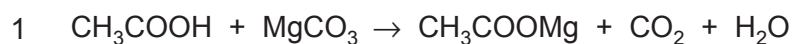
What could X be?



36 Which reaction takes place by a nucleophilic addition mechanism?

- A propene reacting with hydrogen bromide
- B 2-bromopropane reacting with sodium hydroxide in ethanol
- C propanone reacting with hydrogen cyanide
- D methane reacting with chlorine

37 Three equations are shown.



Which of the equations are correct?

- A 1, 2 and 3
- B 1 and 2 only
- C 2 only
- D 3 only

38 How many esters with the molecular formula $C_5H_{10}O_2$ can be made by reacting a primary alcohol with a carboxylic acid?

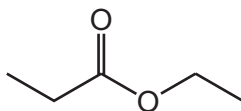
A 4

B 5

C 6

D 8

39 The diagram shows an ester. It is heated under reflux with an excess of $NaOH(aq)$.



Which row shows the 2 products of the reaction?

	product 1	product 2
A		
B		
C		
D		

40 Oxygen has three stable isotopes, ^{16}O , ^{17}O and ^{18}O . All three isotopes are present in a sample of oxygen gas, O_2 , which was analysed using a mass spectrometer.

How many peaks associated with the O_2^+ ion would be expected?

A 3

B 5

C 6

D 9

Important values, constants and standards

molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23} \text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ (4.18 $\text{J g}^{-1} \text{ K}^{-1}$)

The Periodic Table of Elements

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19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57–71 lanthanoids	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89–103 actinoids	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000
lanthanoids		La lanthanum 138.9	Ce cerium 140.1	Pr praseodymium 140.9	Nd neodymium 144.4	Pm promethium —	Sm samarium 150.4	Eu europium 152.0	Gd gadolinium 157.3	Tb terbium 158.9	Dy dysprosium 162.5	Ho holmium 164.9	Er erbium 167.3	Tm thulium 168.9	Yb ytterbium 173.1	Lu lutetium 175.0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
actinoids		Ac actinium —	Th thorium 232.0	Pa protactinium 231.0	U uranium 238.0	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									