



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER



**CHEMISTRY**

**5070/02**

Paper 2 Theory

**October/November 2008**

**1 hour 30 minutes**

Candidates answer on the Question Paper.

Additional Materials: Answer Booklet/Paper

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.  
Write in dark blue or black pen.  
You may use a soft pencil for any diagrams, graphs or rough working.  
Do not use staples, paper clips, highlighters, glue or correction fluid.  
DO **NOT** WRITE IN ANY BARCODES.

**Section A**

Answer **all** questions.  
Write your answers in the spaces provided in the Question Paper.

**Section B**

Answer any **three** questions.  
Write your answers on any lined pages and/or separate answer paper.

A copy of the Periodic Table is printed on page 20.

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.

For Examiner's Use	
<b>Section A</b>	
<b>B7</b>	
<b>B8</b>	
<b>B9</b>	
<b>B10</b>	
<b>Total</b>	

This document consists of **20** printed pages.



## Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

For  
Examiner's  
Use

**A1** The diagram shows part of the Periodic Table.

											He
						B	C	N	O	F	Ne
						Al	Si	P	S	Cl	Ar
	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
										I	Xe

Answer these questions using **only** the elements shown in the diagram.

Each element can be used once, more than once or not at all.

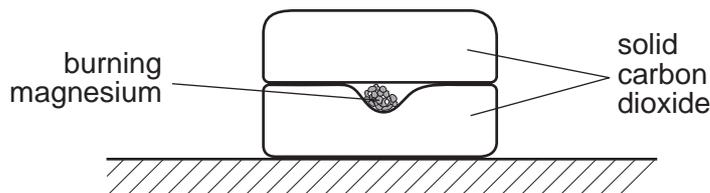
Write the symbol for

- (i) an element which is in Group 5 and Period 3,  [1]
- (ii) an element which is used as a gas in balloons,  [1]
- (iii) an element which forms ions in aqueous solution which give a white precipitate on reaction with aqueous silver nitrate,  [1]
- (iv) an element which forms an ion of type  $X^{3-}$ ,  [1]
- (v) an element which is a catalyst for the hydrogenation of alkenes,  [1]
- (vi) two elements which combine to form a compound which causes acid rain.  and  [1]

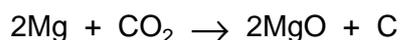
[Total: 6]

- A2** Several small pieces of magnesium are placed on a block of solid carbon dioxide. The solid carbon dioxide is at a temperature of  $-60^{\circ}\text{C}$ . The magnesium is ignited and another block of solid carbon dioxide is immediately placed on top.

For  
Examiner's  
Use



A vigorous reaction is observed.



- (a)** Suggest what could be seen as the reaction proceeds to completion.

.....  
 ..... [2]

- (b)** Why is another block of solid carbon dioxide placed above the burning magnesium?

..... [1]

- (c)** State **one** factor in the experiment which slows down the reaction.

..... [1]

- (d)** When 2 moles of magnesium react with one mole of carbon dioxide, 810 kJ of energy are released.  
 Calculate the energy released when 2.0 g of magnesium reacts completely with carbon dioxide.

[2]

- (e) In a second experiment 6.0 g of magnesium and 4.4 g of carbon dioxide are used. Which solid, magnesium or carbon dioxide is in excess?  
Show your working.

For  
Examiner's  
Use

[2]

- (f) Explain, in terms of the energy changes taking place in both bond-making and bond-breaking, why the reaction is exothermic.

.....  
.....  
..... [2]

[Total: 10]

**A3** Household waste can be disposed of by being dumped into landfill sites, recycled or burnt. In a landfill site, bacteria break down vegetable waste to produce a mixture of gases.

For  
Examiner's  
Use

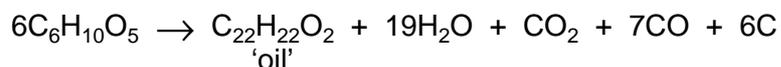
**(a)** Name **two** gases which are likely to be formed by this bacterial action.

..... and ..... [2]

**(b)** A small amount of butanoic acid is also formed by bacterial action in landfill sites. Draw the structure of butanoic acid.

[1]

**(c)** A type of 'oil' can be made from the cellulose in waste paper. The waste paper is heated at 350 °C under high pressure and in the presence of a nickel catalyst. The equation for this reaction is shown.



**(i)** State the function of a catalyst.

.....[1]

**(ii)** The 'oil',  $\text{C}_{22}\text{H}_{22}\text{O}_2$ , can be used for heating. Write an equation for the complete combustion of this 'oil'.

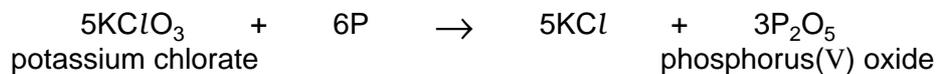
[2]

[Total: 6]

- A4** The head of a safety match contains potassium chlorate and antimony sulphide. The side of the matchbox contains red phosphorus. When a match is struck on the side of the box, the friction produces enough heat to light the match.

For  
Examiner's  
Use

- (a) The equation for this reaction is shown.



Which is the oxidant and which is the reductant in this reaction?

Explain your answer.

oxidant .....

reductant .....

explanation .....

.....[2]

- (b) Phosphorus(V) oxide,  $\text{P}_2\text{O}_5$ , absorbs water from the air to form meta-phosphoric acid,  $\text{HPO}_3$ .

- (i) Write an equation for this reaction.

[1]

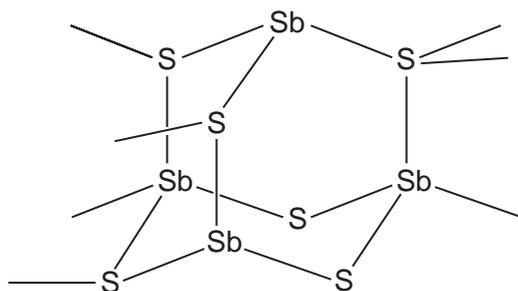
- (ii) On addition of more water, phosphoric acid is formed. Phosphoric acid has typical acidic properties. What would you observe when aqueous phosphoric acid is added to

aqueous sodium carbonate, .....

blue litmus paper? .....

[2]

(c) Part of the chain structure of antimony sulphide is shown below.



For  
Examiner's  
Use

Deduce the empirical formula of antimony sulphide.

..... [1]

[Total: 6]

**A5** Cement is made by heating clay with crushed calcium carbonate. During this process, the calcium carbonate is first converted to calcium oxide.

For  
Examiner's  
Use



(a) (i) What name is given to this type of chemical reaction?

.....[1]

(ii) Suggest why calcium oxide is used to neutralise acidic soils.

.....[1]

(b) Concrete is made from cement, sand and water. When set, concrete is slightly porous. When rain water soaks through concrete, some of the uncombined calcium oxide dissolves to form calcium hydroxide.

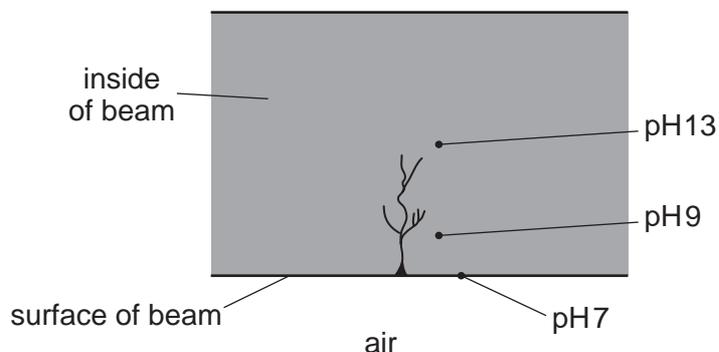
(i) Write an equation for this reaction.

[1]

(ii) The aqueous calcium hydroxide in wet concrete reacts with carbon dioxide in the air.



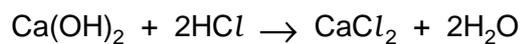
The diagram shows the pH at various points inside a cracked concrete beam.



Describe and explain the change in pH from the surface to the centre of the beam.

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

- (iii) 25.0 cm<sup>3</sup> of an aqueous solution of calcium hydroxide is exactly neutralised by 18.0 cm<sup>3</sup> of 0.040 mol/dm<sup>3</sup> hydrochloric acid.



Calculate the concentration, in mol/dm<sup>3</sup>, of the aqueous calcium hydroxide.

For  
Examiner's  
Use

concentration = .....mol/dm<sup>3</sup> [3]

[Total: 9]

**A6** Electrolysis is used to produce many important chemicals such as chlorine, sodium hydroxide and aluminium.

For  
Examiner's  
Use

**(a)** Chlorine is used in both water treatment and as a bleach.

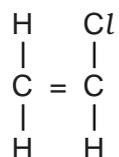
**(i)** Why is chlorine used in water treatment?

..... [1]

**(ii)** Name a substance, other than chlorine, that is used to bleach wood pulp.

..... [1]

**(b)** Chlorine is used to make chloroethene.



Chloroethene can be polymerised to form poly(chloroethene).

Draw a section of a poly(chloroethene) chain to show at least two repeating units.

[1]

**(c)** In the production of aluminium, sodium hydroxide is used to separate aluminium oxide from the impurities in the bauxite ore. The main impurity in the ore is iron(III) oxide. Aluminium oxide is an amphoteric oxide whilst iron(III) oxide is a basic oxide. Suggest how these two oxides can be separated by the addition of aqueous sodium hydroxide.

.....

.....

..... [2]

(d) Aluminium is extracted by the electrolysis of a mixture of molten aluminium oxide and cryolite. What is the function of the cryolite?

..... [1]

(e) Acidic foods can be safely packed in aluminium containers.  
Explain why the acid in the food does not attack the aluminium, despite the fact that aluminium is a reactive metal.

.....  
..... [2]

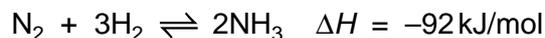
[Total: 8]

**Section B**

Answer **three** questions from this section.

The total mark for this section is 30.

**B7** Ammonia is made by the Haber process using an iron catalyst.



- (a) On the same axes draw energy profile diagrams to show both the catalysed and the uncatalysed reaction. Label the diagram to show
- the catalysed and uncatalysed reactions,
  - the reactants and products,
  - the enthalpy change for the reaction. [3]
- (b) The raw materials for the Haber process can be obtained from the air and from hydrocarbons produced by the distillation of petroleum.
- (i) Describe how pure nitrogen can be separated from other gases in the air. [1]
- (ii) Describe how hydrogen can be made from hydrocarbons. [2]
- (c) Explain how the position of equilibrium in the Haber process is altered by
- (i) an increase in pressure, [2]
- (ii) an increase in temperature. [2]

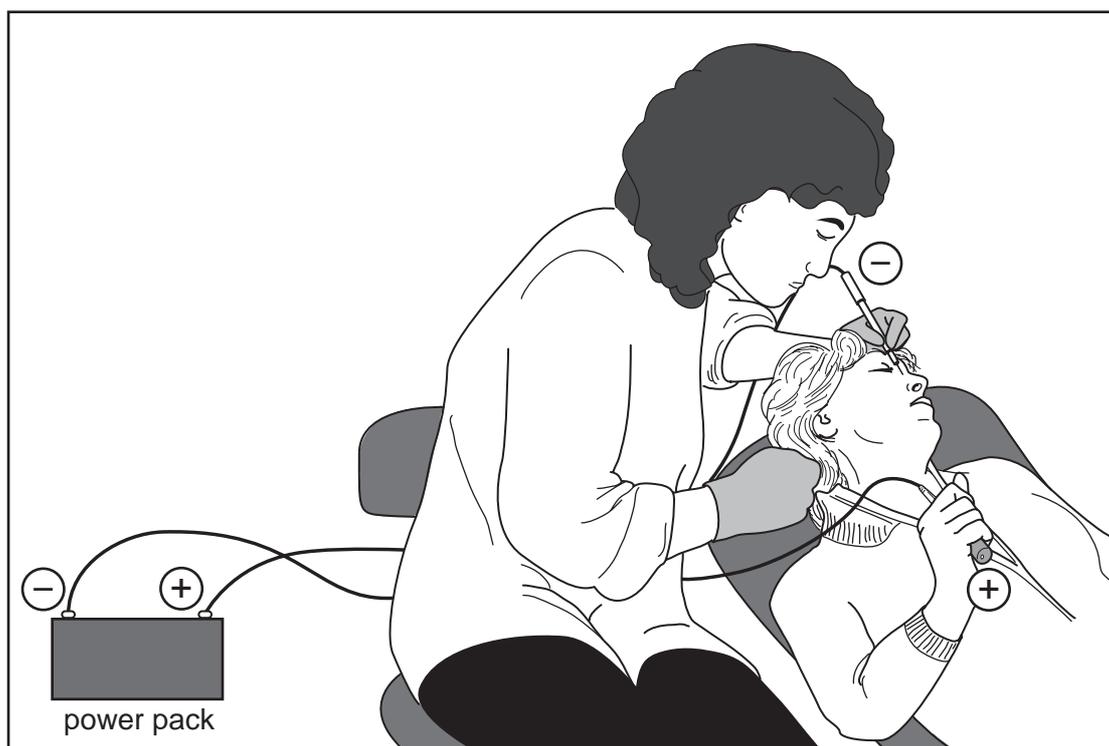
[Total: 10]

**B8** Sorrel is a small green plant.

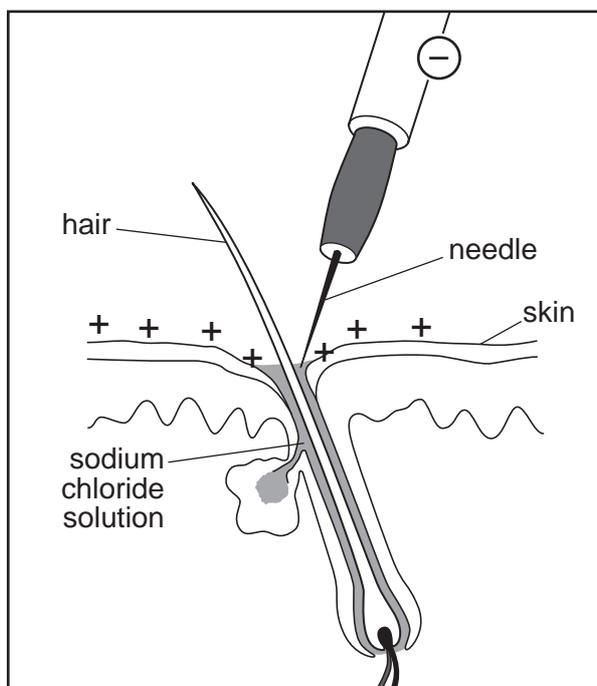
- (a) The pigments in the sorrel leaf can be separated by chromatography.
- (i) Describe how chromatography can be used to separate different pigments. [2]
  - (ii) Explain what is meant by  $R_f$  value. [1]
- (b) Sorrel plants contain a poisonous carboxylic acid **X**.  
What can be deduced about **X** from each of the following three pieces of information?
- (i) When **X** is warmed with acidified potassium manganate(VII), the solution changes from pink to colourless. [1]
  - (ii) Aqueous bromine is not decolourised when added to a solution of **X**. [1]
  - (iii) A  $0.1 \text{ mol/dm}^3$  solution of **X** has a pH of 3 whereas a  $0.1 \text{ mol/dm}^3$  solution of hydrochloric acid has a pH of 1. [1]
- (c) Analysis of 10.0 g of carboxylic acid **X** shows that it contains 2.67 g carbon, 0.220 g hydrogen and 7.11 g oxygen.
- (i) Deduce the empirical formula of **X**. [3]
  - (ii) The relative molecular mass of **X** is 90. Deduce the molecular formula of **X**. [1]

[Total: 10]

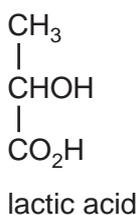
- B9** Electrolysis can be used to remove unwanted hair. The customer holds a metal bar which acts as a positive electrode. A needle, which acts as the negative electrode, is held by the operator.



- (a) What do you understand by the term *electrolysis*? [1]
- (b) The solution around the tip of the needle is mainly a dilute aqueous solution of sodium chloride.



- (i) Name all the ions present in the solution during this electrolysis. [1]
- (ii) During electrolysis a small amount of chlorine is formed at the surface of the skin. Write an ionic equation for this reaction. [1]
- (iii) During electrolysis, a gas forms at the tip of the needle and the solution changes from pH 7 to pH 10. Explain both these changes. [2]
- (c) Explain why aqueous sodium chloride solution conducts electricity but solid sodium chloride does not. [2]
- (d) The sweat glands in the skin produce small amounts of lactic acid.



Lactic acid reacts with ethanol to form an ester.

- (i) State the conditions needed to form an ester. [2]
- (ii) Draw the structure of the ester produced by the reaction of lactic acid with ethanol. [1]

[Total: 10]

**B10** Radioactive iodine is used to treat some cancerous tumours.

- (a) Two radioactive isotopes of iodine are  $^{125}_{53}\text{I}$  and  $^{131}_{53}\text{I}$ .

For each isotope state the type and number of subatomic particles present. [2]

- (b) Name a reagent that reacts with iodide ions to form iodine molecules.  
Describe the colour change that occurs in this reaction. [2]

- (c) Zinc can reduce iodine to iodide ions.  
Write an ionic equation for this reaction. [2]

- (d) In cancer treatment, the radioactive iodine can be injected into the tumour with a titanium needle.

(i) Titanium is a transition element. State **three** characteristic properties of transition elements. [2]

(ii) An oxide of titanium is formed from  $\text{Ti}^{3+}$  ions and oxide ions.  
Deduce the formula of this compound. [1]

(iii) Titanium(IV) chloride,  $\text{TiCl}_4$ , reacts with water to form titanium(IV) oxide,  $\text{TiO}_2$ , and hydrogen chloride. Write an equation for this reaction. [1]

[Total: 10]







**DATA SHEET**  
**The Periodic Table of the Elements**

		Group																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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3	4	7 <b>Li</b> Lithium 3	9 <b>Be</b> Beryllium 4	11 <b>B</b> Boron 5	12 <b>C</b> Carbon 6	13 <b>Al</b> Aluminium 13	14 <b>N</b> Nitrogen 7	15 <b>O</b> Oxygen 8	16 <b>F</b> Fluorine 9	17 <b>Ne</b> Neon 10	18 <b>Ar</b> Argon 18	19 <b>K</b> Potassium 19	20 <b>Ca</b> Calcium 20	21 <b>Sc</b> Scandium 21	22 <b>Ti</b> Titanium 22	23 <b>V</b> Vanadium 23	24 <b>Cr</b> Chromium 24	25 <b>Mn</b> Manganese 25	26 <b>Fe</b> Iron 26	27 <b>Co</b> Cobalt 27	28 <b>Ni</b> Nickel 28	29 <b>Cu</b> Copper 29	30 <b>Zn</b> Zinc 30	31 <b>Ga</b> Gallium 31	32 <b>Ge</b> Germanium 32	33 <b>As</b> Arsenic 33	34 <b>Se</b> Selenium 34	35 <b>Br</b> Bromine 35	36 <b>Kr</b> Krypton 36	37 <b>Rb</b> Rubidium 37	38 <b>Sr</b> Strontium 38	39 <b>Y</b> Yttrium 39	40 <b>Zr</b> Zirconium 40	41 <b>Nb</b> Niobium 41	42 <b>Mo</b> Molybdenum 42	43 <b>Tc</b> Technetium 43	44 <b>Ru</b> Ruthenium 44	45 <b>Rh</b> Rhodium 45	46 <b>Pd</b> Palladium 46	47 <b>Ag</b> Silver 47	48 <b>Cd</b> Cadmium 48	49 <b>In</b> Indium 49	50 <b>Sn</b> Tin 50	51 <b>Sb</b> Antimony 51	52 <b>Te</b> Tellurium 52	53 <b>I</b> Iodine 53	54 <b>Xe</b> Xenon 54	55 <b>Cs</b> Caesium 55	56 <b>Ba</b> Barium 56	57 <b>La</b> Lanthanum 57	58 <b>Ce</b> Cerium 58	59 <b>Pr</b> Praseodymium 59	60 <b>Nd</b> Neodymium 60	61 <b>Pm</b> Promethium 61	62 <b>Sm</b> Samarium 62	63 <b>Eu</b> Europium 63	64 <b>Gd</b> Gadolinium 64	65 <b>Tb</b> Terbium 65	66 <b>Dy</b> Dysprosium 66	67 <b>Ho</b> Holmium 67	68 <b>Er</b> Erbium 68	69 <b>Tm</b> Thulium 69	70 <b>Yb</b> Ytterbium 70	71 <b>Lu</b> Lutetium 71	72 <b>Fr</b> Francium 87	73 <b>Ra</b> Radium 88	74 <b>Ac</b> Actinium 89	75 <b>Th</b> Thorium 90	76 <b>Pa</b> Protactinium 91	77 <b>U</b> Uranium 92	78 <b>Np</b> Neptunium 93	79 <b>Pu</b> Plutonium 94	80 <b>Am</b> Americium 95	81 <b>Cm</b> Curium 96	82 <b>Bk</b> Berkelium 97	83 <b>Cf</b> Californium 98	84 <b>Es</b> Einsteinium 99	85 <b>Fm</b> Fermium 100	86 <b>Md</b> Mendelevium 101	87 <b>No</b> Nobelium 102	88 <b>Lr</b> Lawrencium 103	89 <b>Fr</b> Francium 87	90 <b>Ra</b> Radium 88	91 <b>Ac</b> Actinium 89	92 <b>Th</b> Thorium 90	93 <b>Pa</b> Protactinium 91	94 <b>U</b> Uranium 92	95 <b>Np</b> Neptunium 93	96 <b>Pu</b> Plutonium 94	97 <b>Am</b> Americium 95	98 <b>Cm</b> Curium 96	99 <b>Bk</b> Berkelium 97	100 <b>Cf</b> Californium 98	101 <b>Es</b> Einsteinium 99	102 <b>Fm</b> Fermium 100	103 <b>Md</b> Mendelevium 101	104 <b>No</b> Nobelium 102	105 <b>Lr</b> Lawrencium 103	106 <b>Lu</b> Lutetium 71	107 <b>Yb</b> Ytterbium 70	108 <b>Tm</b> Thulium 69	109 <b>Er</b> Erbium 68	110 <b>Ho</b> Holmium 67	111 <b>Dy</b> Dysprosium 66	112 <b>Tb</b> Terbium 65	113 <b>Gd</b> Gadolinium 64	114 <b>Eu</b> Europium 63	115 <b>Pm</b> Promethium 61	116 <b>Sm</b> Samarium 62	117 <b>Pr</b> Praseodymium 59	118 <b>Nd</b> Neodymium 60	119 <b>Pm</b> Promethium 61	120 <b>Sm</b> Samarium 62	121 <b>Eu</b> Europium 63	122 <b>Gd</b> Gadolinium 64	123 <b>Tb</b> Terbium 65	124 <b>Dy</b> Dysprosium 66	125 <b>Ho</b> Holmium 67	126 <b>Er</b> Erbium 68	127 <b>Tm</b> Thulium 69	128 <b>Yb</b> Ytterbium 70	129 <b>Lu</b> Lutetium 71	130 <b>Fr</b> Francium 87	131 <b>Ra</b> Radium 88	132 <b>Ac</b> Actinium 89	133 <b>Th</b> Thorium 90	134 <b>Pa</b> Protactinium 91	135 <b>U</b> Uranium 92	136 <b>Np</b> Neptunium 93	137 <b>Pu</b> Plutonium 94	138 <b>Am</b> Americium 95	139 <b>Cm</b> Curium 96	140 <b>Bk</b> Berkelium 97	141 <b>Cf</b> Californium 98	142 <b>Es</b> Einsteinium 99	143 <b>Fm</b> Fermium 100	144 <b>Md</b> Mendelevium 101	145 <b>No</b> Nobelium 102	146 <b>Lr</b> Lawrencium 103	147 <b>Lu</b> Lutetium 71	148 <b>Yb</b> Ytterbium 70	149 <b>Tm</b> Thulium 69	150 <b>Er</b> Erbium 68	151 <b>Ho</b> Holmium 67	152 <b>Dy</b> Dysprosium 66	153 <b>Tb</b> Terbium 65	154 <b>Gd</b> Gadolinium 64	155 <b>Eu</b> Europium 63	156 <b>Pm</b> Promethium 61	157 <b>Sm</b> Samarium 62	158 <b>Pr</b> Praseodymium 59	159 <b>Nd</b> Neodymium 60	160 <b>Pm</b> Promethium 61	161 <b>Sm</b> Samarium 62	162 <b>Eu</b> Europium 63	163 <b>Gd</b> Gadolinium 64	164 <b>Tb</b> Terbium 65	165 <b>Dy</b> Dysprosium 66	166 <b>Ho</b> Holmium 67	167 <b>Er</b> Erbium 68	168 <b>Tm</b> Thulium 69	169 <b>Yb</b> Ytterbium 70	170 <b>Lu</b> Lutetium 71	171 <b>Lu</b> Lutetium 71	172 <b>Yb</b> Ytterbium 70	173 <b>Tm</b> Thulium 69	174 <b>Er</b> Erbium 68	175 <b>Ho</b> Holmium 67	176 <b>Dy</b> Dysprosium 66	177 <b>Tb</b> Terbium 65	178 <b>Gd</b> Gadolinium 64	179 <b>Eu</b> Europium 63	180 <b>Pm</b> Promethium 61	181 <b>Sm</b> Samarium 62	182 <b>Pr</b> Praseodymium 59	183 <b>Nd</b> Neodymium 60	184 <b>Pm</b> Promethium 61	185 <b>Sm</b> Samarium 62	186 <b>Eu</b> Europium 63	187 <b>Gd</b> Gadolinium 64	188 <b>Tb</b> Terbium 65	189 <b>Dy</b> Dysprosium 66	190 <b>Ho</b> Holmium 67	191 <b>Er</b> Erbium 68	192 <b>Tm</b> Thulium 69	193 <b>Yb</b> Ytterbium 70	194 <b>Lu</b> Lutetium 71	195 <b>Lu</b> Lutetium 71	196 <b>Yb</b> Ytterbium 70	197 <b>Tm</b> Thulium 69	198 <b>Er</b> Erbium 68	199 <b>Ho</b> Holmium 67	200 <b>Dy</b> Dysprosium 66	201 <b>Tb</b> Terbium 65	202 <b>Gd</b> Gadolinium 64	203 <b>Eu</b> Europium 63	204 <b>Pm</b> Promethium 61	205 <b>Sm</b> Samarium 62	206 <b>Pr</b> Praseodymium 59	207 <b>Nd</b> Neodymium 60	208 <b>Pm</b> Promethium 61	209 <b>Sm</b> Samarium 62	210 <b>Eu</b> Europium 63	211 <b>Gd</b> Gadolinium 64	212 <b>Tb</b> Terbium 65	213 <b>Dy</b> Dysprosium 66	214 <b>Ho</b> Holmium 67	215 <b>Er</b> Erbium 68	216 <b>Tm</b> Thulium 69	217 <b>Yb</b> Ytterbium 70	218 <b>Lu</b> Lutetium 71	219 <b>Lu</b> Lutetium 71	220 <b>Yb</b> Ytterbium 70	221 <b>Tm</b> Thulium 69	222 <b>Er</b> Erbium 68	223 <b>Ho</b> Holmium 67	224 <b>Dy</b> Dysprosium 66	225 <b>Tb</b> Terbium 65	226 <b>Gd</b> Gadolinium 64	227 <b>Eu</b> Europium 63	228 <b>Pm</b> Promethium 61	229 <b>Sm</b> Samarium 62	230 <b>Pr</b> Praseodymium 59	231 <b>Nd</b> Neodymium 60	232 <b>Pm</b> Promethium 61	233 <b>Sm</b> Samarium 62	234 <b>Pr</b> Praseodymium 59	235 <b>Nd</b> Neodymium 60	236 <b>Pm</b> Promethium 61	237 <b>Sm</b> Samarium 62	238 <b>Eu</b> Europium 63	239 <b>Gd</b> Gadolinium 64	240 <b>Tb</b> Terbium 65	241 <b>Dy</b> Dysprosium 66	242 <b>Ho</b> Holmium 67	243 <b>Er</b> Erbium 68	244 <b>Tm</b> Thulium 69	245 <b>Yb</b> Ytterbium 70	246 <b>Lu</b> Lutetium 71	247 <b>Lu</b> Lutetium 71	248 <b>Yb</b> Ytterbium 70	249 <b>Tm</b> Thulium 69	250 <b>Er</b> Erbium 68	251 <b>Ho</b> Holmium 67	252 <b>Dy</b> Dysprosium 66	253 <b>Tb</b> Terbium 65	254 <b>Gd</b> Gadolinium 64	255 <b>Eu</b> Europium 63	256 <b>Pm</b> Promethium 61	257 <b>Sm</b> Samarium 62	258 <b>Pr</b> Praseodymium 59	259 <b>Nd</b> Neodymium 60	260 <b>Pm</b> Promethium 61	261 <b>Sm</b> Samarium 62	262 <b>Pr</b> Praseodymium 59	263 <b>Nd</b> Neodymium 60	264 <b>Pm</b> Promethium 61	265 <b>Sm</b> Samarium 62	266 <b>Eu</b> Europium 63	267 <b>Gd</b> Gadolinium 64	268 <b>Tb</b> Terbium 65	269 <b>Dy</b> Dysprosium 66	270 <b>Ho</b> Holmium 67	271 <b>Er</b> Erbium 68	272 <b>Tm</b> Thulium 69	273 <b>Yb</b> Ytterbium 70	274 <b>Lu</b> Lutetium 71	275 <b>Lu</b> Lutetium 71	276 <b>Yb</b> Ytterbium 70	277 <b>Tm</b> Thulium 69	278 <b>Er</b> Erbium 68	279 <b>Ho</b> Holmium 67	280 <b>Dy</b> Dysprosium 66	281 <b>Tb</b> Terbium 65	282 <b>Gd</b> Gadolinium 64	283 <b>Eu</b> Europium 63	284 <b>Pm</b> Promethium 61	285 <b>Sm</b> Samarium 62	286 <b>Pr</b> Praseodymium 59	287 <b>Nd</b> Neodymium 60	288 <b>Pm</b> Promethium 61	289 <b>Sm</b> Samarium 62	290 <b>Pr</b> Praseodymium 59	291 <b>Nd</b> Neodymium 60	292 <b>Pm</b> Promethium 61	293 <b>Sm</b> Samarium 62	294 <b>Eu</b> Europium 63	295 <b>Gd</b> Gadolinium 64	296 <b>Tb</b> Terbium 65	297 <b>Dy</b> Dysprosium 66	298 <b>Ho</b> Holmium 67	299 <b>Er</b> Erbium 68	300 <b>Tm</b> Thulium 69	301 <b>Yb</b> Ytterbium 70	302 <b>Lu</b> Lutetium 71	303 <b>Lu</b> Lutetium 71	304 <b>Yb</b> Ytterbium 70	305 <b>Tm</b> Thulium 69	306 <b>Er</b> Erbium 68	307 <b>Ho</b> Holmium 67	308 <b>Dy</b> Dysprosium 66	309 <b>Tb</b> Terbium 65	310 <b>Gd</b> Gadolinium 64	311 <b>Eu</b> Europium 63	312 <b>Pm</b> Promethium 61	313 <b>Sm</b> Samarium 62	314 <b>Pr</b> Praseodymium 59	315 <b>Nd</b> Neodymium 60	316 <b>Pm</b> Promethium 61	317 <b>Sm</b> Samarium 62	318 <b>Pr</b> Praseodymium 59	319 <b>Nd</b> Neodymium 60	320 <b>Pm</b> Promethium 61	321 <b>Sm</b> Samarium 62	322 <b>Eu</b> Europium 63	323 <b>Gd</b> Gadolinium 64	324 <b>Tb</b> Terbium 65	325 <b>Dy</b> Dysprosium 66	326 <b>Ho</b> Holmium 67	327 <b>Er</b> Erbium 68	328 <b>Tm</b> Thulium 69	329 <b>Yb</b> Ytterbium 70	330 <b>Lu</b> Lutetium 71	331 <b>Lu</b> Lutetium 71	332 <b>Yb</b> Ytterbium 70	333 <b>Tm</b> Thulium 69	334 <b>Er</b> Erbium 68	335 <b>Ho</b> Holmium 67	336 <b>Dy</b> Dysprosium 66	337 <b>Tb</b> Terbium 65	338 <b>Gd</b> Gadolinium 64	339 <b>Eu</b> Europium 63	340 <b>Pm</b> Promethium 61	341 <b>Sm</b> Samarium 62	342 <b>Pr</b> Praseodymium 59	343 <b>Nd</b> Neodymium 60	344 <b>Pm</b> Promethium 61	345 <b>Sm</b> Samarium 62	346 <b>Pr</b> Praseodymium 59	347 <b>Nd</b> Neodymium 60	348 <b>Pm</b> Promethium 61	349 <b>Sm</b> Samarium 62	350 <b>Eu</b> Europium 63	351 <b>Gd</b> Gadolinium 64	352 <b>Tb</b> Terbium 65	353 <b>Dy</b> Dysprosium 66	354 <b>Ho</b> Holmium 67	355 <b>Er</b> Erbium 68	356 <b>Tm</b> Thulium 69	357 <b>Yb</b> Ytterbium 70	358 <b>Lu</b> Lutetium 71	359 <b>Lu</b> Lutetium 71	360 <b>Yb</b> Ytterbium 70	361 <b>Tm</b> Thulium 69	362 <b>Er</b> Erbium 68	363 <b>Ho</b> Holmium 67	364 <b>Dy</b> Dysprosium 66	365 <b>Tb</b> Terbium 65	366 <b>Gd</b> Gadolinium 64	367 <b>Eu</b> Europium 63	368 <b>Pm</b> Promethium 61	369 <b>Sm</b> Samarium 62	370 <b>Pr</b> Praseodymium 59	371 <b>Nd</b> Neodymium 60	372 <b>Pm</b> Promethium 61	373 <b>Sm</b> Samarium 62	374 <b>Pr</b> Praseodymium 59	375 <b>Nd</b> Neodymium 60	376 <b>Pm</b> Promethium 61	377 <b>Sm</b> Samarium 62	378 <b>Eu</b> Europium 63	379 <b>Gd</b> Gadolinium 64	380 <b>Tb</b> Terbium 65	381 <b>Dy</b> Dysprosium 66	382 <b>Ho</b> Holmium 67	383 <b>Er</b> Erbium 68	384 <b>Tm</b> Thulium 69	385 <b>Yb</b> Ytterbium 70	386 <b>Lu</b> Lutetium 71	387 <b>Lu</b> Lutetium 71	388 <b>Yb</b> Ytterbium 70	389 <b>Tm</b> Thulium 69	390 <b>Er</b> Erbium 68	391 <b>Ho</b> Holmium 67	392 <b>Dy</b> Dysprosium 66	393 <b>Tb</b> Terbium 65	394 <b>Gd</b> Gadolinium 64	395 <b>Eu</b> Europium 63	396 <b>Pm</b> Promethium 61	397 <b>Sm</b> Samarium 62	398 <b>Pr</b> Praseodymium 59	399 <b>Nd</b> Neodymium 60	400 <b>Pm</b> Promethium 61	401 <b>Sm</b> Samarium 62	402 <b>Pr</b> Praseodymium 59	403 <b>Nd</b> Neodymium 60	404 <b>Pm</b> Promethium 61	405 <b>Sm</b> Samarium 62	406 <b>Eu</b> Europium 63	407 <b>Gd</b> Gadolinium 64	408 <b>Tb</b> Terbium 65	409 <b>Dy</b> Dysprosium 66	410 <b>Ho</b> Holmium 67	411 <b>Er</b> Erbium 68	412 <b>Tm</b> Thulium 69	413 <b>Yb</b> Ytterbium 70	414 <b>Lu</b> Lutetium 71	415 <b>Lu</b> Lutetium 71	416 <b>Yb</b> Ytterbium 70	417 <b>Tm</b> Thulium 69	418 <b>Er</b> Erbium 68	419 <b>Ho</b> Holmium 67	420 <b>Dy</b> Dysprosium 66	421 <b>Tb</b> Terbium 65	422 <b>Gd</b> Gadolinium 64	423 <b>Eu</b> Europium 63	424 <b>Pm</b> Promethium 61	425 <b>Sm</b> Samarium 62	426 <b>Pr</b> Praseodymium 59	427 <b>Nd</b> Neodymium 60	428 <b>Pm</b> Promethium 61	429 <b>Sm</b> Samarium 62	430 <b>Pr</b> Praseodymium 59	431 <b>Nd</b> Neodymium 60	432 <b>Pm</b> Promethium 61	433 <b>Sm</b> Samarium 62	434 <b>Eu</b> Europium 63	435 <b>Gd</b> Gadolinium 64	436 <b>Tb</b> Terbium 65	437 <b>Dy</b> Dysprosium 66	438 <b>Ho</b> Holmium 67	439 <b>Er</b> Erbium 68	440 <b>Tm</b> Thulium 69	441 <b>Yb</b> Ytterbium 70	442 <b>Lu</b> Lutetium 71	443 <b>Lu</b> Lutetium 71	444 <b>Yb</b> Ytterbium 70	445 <b>Tm</b> Thulium 69	446 <b>Er</b> Erbium 68	447 <b>Ho</b> Holmium 67	448 <b>Dy</b> Dysprosium 66	449 <b>Tb</b> Terbium 65	450 <b>Gd</b> Gadolinium 64	451 <b>Eu</b> Europium 63	452 <b>Pm</b> Promethium 61	453 <b>Sm</b> Samarium 62	454 <b>Pr</b> Praseodymium 59	455 <b>Nd</b> Neodymium 60	456 <b>Pm</b> Promethium 61	457 <b>Sm</b> Samarium 62	458 <b>Pr</b> Praseodymium 59	459 <b>Nd</b> Neodymium 60	460 <b>Pm</b> Promethium 61	461 <b>Sm</b> Samarium 62	462 <b>Eu</b> Europium 63	463 <b>Gd</b> Gadolinium 64	464 <b>Tb</b> Terbium 65	465 <b>Dy</b> Dysprosium 66	466 <b>Ho</b> Holmium 67