Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 23 May 2014 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*****) are ones where the quality of your written communication will be assessed – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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6/6/6/6/

P 4 2 9 7 6 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following species has 50 neutrons?

☐ **A** $^{50}_{23}V$

☐ **B** $^{86}_{37}Rb^{-}$

☐ **C** $^{89}_{39}Y^{+}$

☐ **D** $^{91}_{40}Zr^{+}$

(Total for Question 1 = 1 mark)

2 Which of the following statements is correct about **all** isotopes of an element? They have

☐ **A** the same mass number.

☐ **B** the same number of neutrons.

☐ **C** more protons than neutrons.

☐ **D** the same electronic configuration.

(Total for Question 2 = 1 mark)

3 The element rhenium has two naturally-occurring isotopes, ^{185}Re and ^{187}Re. The relative atomic mass of rhenium is 186.2.

From this information, the percentage abundances of these two isotopes are

☐ **A** 12% ^{185}Re and 88% ^{187}Re

☐ **B** 40% ^{185}Re and 60% ^{187}Re

☐ **C** 60% ^{185}Re and 40% ^{187}Re

☐ **D** 88% ^{185}Re and 12% ^{187}Re

(Total for Question 3 = 1 mark)

4 In which of the following pairs does the second element have a **lower** 1st ionization energy than the first element?

	First element	Second element
☒ **A**	Si	C
☒ **B**	Na	Mg
☒ **C**	Be	B
☒ **D**	Ar	Ne

(Total for Question 4 = 1 mark)

5 An oxide of nitrogen contains 2.8 g of nitrogen and 8.0 g of oxygen.
What is the empirical formula of this oxide?

☒ **A** NO

☒ **B** NO_3

☒ **C** N_2O_3

☒ **D** N_2O_5

(Total for Question 5 = 1 mark)

6 Calculate the total number of **atoms** present in 1.8 g of water, H_2O.

DATA

- The molar mass of H_2O is 18 g mol^{-1}
- The Avogadro constant is 6.0×10^{23} mol^{-1}

☒ **A** 6.0×10^{22}

☒ **B** 6.0×10^{23}

☒ **C** 1.8×10^{23}

☒ **D** 1.8×10^{24}

(Total for Question 6 = 1 mark)

7 Calculate the mass of hydrated sodium thiosulfate, $Na_2S_2O_3.5H_2O$, required to prepare 200 cm^3 of a 0.100 mol dm^{-3} solution.

[Assume that the molar mass of $Na_2S_2O_3.5H_2O$ is 248 g mol^{-1}]

☒ **A** 0.124 g

☒ **B** 4.96 g

☒ **C** 24.8 g

☒ **D** 4960 g

(Total for Question 7 = 1 mark)

8 A 27.0 g sample of an unknown hydrocarbon, C_xH_y, was burned completely in excess oxygen to form 88.0 g of carbon dioxide and 27.0 g of water.

[Molar masses / g mol^{-1}: CO_2 = 44; H_2O = 18]

Which of the following is a possible formula of the unknown hydrocarbon?

☒ **A** CH_4

☒ **B** C_2H_6

☒ **C** C_4H_6

☒ **D** C_6H_6

(Total for Question 8 = 1 mark)

9 The Avogadro constant is equal to the number of

☒ **A** grams of any element which contains 6.0×10^{23} atoms of that element.

☒ **B** atoms contained in one mole of any element in its standard state.

☒ **C** particles (atoms, ions or molecules) required to make one gram of a substance.

☒ **D** atoms contained in one mole of any monatomic element.

(Total for Question 9 = 1 mark)

10 Nitrogen monoxide, NO, can be made by the catalytic oxidation of ammonia, NH_3.

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

In an experiment, 8.5 g of ammonia reacted to form 15.0 g of nitrogen monoxide. The percentage yield of nitrogen monoxide in this experiment is

☒ **A** 50%

☒ **B** 57%

☒ **C** 100%

☒ **D** 176%

(Total for Question 10 = 1 mark)

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11 Calculate the mass, in grams, of silver chloride, AgCl, formed when excess silver nitrate solution is added to 55.0 cm^3 of a 0.200 mol dm^{-3} solution of potassium chloride.

[The molar mass of AgCl = 143.4 g mol^{-1}]

$$AgNO_3(aq) + KCl(aq) \rightarrow AgCl(s) + KNO_3(aq)$$

☒ **A** 1.10 g

☒ **B** 1.58 g

☒ **C** 7.89 g

☒ **D** 11.0 g

(Total for Question 11 = 1 mark)

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12 Element X is in Group 3 and element Y is in Group 6 of the Periodic Table. Which of the following is the most likely formula of the compound formed when X and Y react together?

☒ **A** X_2Y_3

☒ **B** X_3Y_2

☒ **C** X_2Y

☒ **D** XY_2

(Total for Question 12 = 1 mark)

13 Metallic bonding is **best** described as the electrostatic attraction between

- ☒ **A** positive ions and delocalized electrons.
- ☒ **B** protons and electrons.
- ☒ **C** positive and negative ions.
- ☒ **D** nuclei and shared pairs of electrons.

(Total for Question 13 = 1 mark)

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14 Which of the following molecules contains a double bond?

- ☒ **A** F_2
- ☒ **B** F_2O
- ☒ **C** C_2F_4
- ☒ **D** C_2F_6

(Total for Question 14 = 1 mark)

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15 Which of the following statements is true?

- ☒ **A** Breaking covalent bonds requires energy and making ionic bonds requires energy.
- ☒ **B** Bond breaking is endothermic whereas bond making is exothermic.
- ☒ **C** Bond breaking is exothermic whereas bond making is endothermic.
- ☒ **D** Breaking ionic bonds releases energy whereas making covalent bonds requires energy.

(Total for Question 15 = 1 mark)

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16 Consider the two equations given below.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l) \qquad \Delta H = -572 \text{ kJ mol}^{-1}$$

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g) \qquad \Delta H = -484 \text{ kJ mol}^{-1}$$

From this information, calculate the enthalpy change for the following process

$$H_2O(g) \rightarrow H_2O(l)$$

☒ **A** -44 kJ mol^{-1}

☒ **B** $+44$ kJ mol^{-1}

☒ **C** -88 kJ mol^{-1}

☒ **D** $+88$ kJ mol^{-1}

(Total for Question 16 = 1 mark)

17 How many structural isomers have the molecular formula C_6H_{14}?

☒ **A** Four

☒ **B** Five

☒ **C** Six

☒ **D** Seven

(Total for Question 17 = 1 mark)

18 In addition to water, which of the following could be formed during the **incomplete** combustion of a hydrocarbon?

☒ **A** Carbon, carbon monoxide and hydrogen

☒ **B** Carbon and hydrogen

☒ **C** Carbon monoxide and hydrogen

☒ **D** Carbon and carbon monoxide

(Total for Question 18 = 1 mark)

19 Poly(ethene) is a plastic material made by polymerizing the hydrocarbon ethene. Which of the following is **not** true?

Pure poly(ethene) is

☒ **A** solidified ethene.

☒ **B** composed of carbon and hydrogen only.

☒ **C** a long-chain compound.

☒ **D** non-biodegradable.

(Total for Question 19 = 1 mark)

20 Which of the following statements correctly describes an environmental problem caused by the burning of hydrocarbon fuels?

☒ **A** The carbon dioxide produced is toxic and kills plants.

☒ **B** The smoke produced obscures sunlight and leads to global warming.

☒ **C** The water produced results in a damaging increase in rainfall.

☒ **D** The carbon dioxide produced traps heat radiated from the Earth and leads to global warming.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 Bromine, Br_2, can react with both alkanes and alkenes. The type of reaction that occurs depends on whether the Br—Br bond breaks by homolytic or heterolytic fission.

(a) (i) Write an equation to show the **homolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

(ii) Write an equation to show the **heterolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

(iii) Choosing from the products you have given in (a)(i) and (a)(ii), write the formula of a free radical and an electrophile.

(2)

Free radical ....

Electrophile ....

(b) The compound hexane, C_6H_{14}, can react with bromine, in the presence of UV light, according to the equation

$$C_6H_{14} + Br_2 \rightarrow C_6H_{13}Br + HBr$$

(i) Give the displayed formulae of the three structural isomers of $C_6H_{13}Br$ that could be formed in the above reaction.

(3)

First isomer

Second isomer

Third isomer

(ii) The bromoalkanes and the hydrogen bromide formed in this reaction are hazardous.

The bromoalkanes would be labelled as 'flammable'. Suggest a suitable hazard warning for the hydrogen bromide.

(1)

....

(iii) Calculate the percentage atom economy by mass for the formation of $C_6H_{13}Br$.

Give your answer to **three** significant figures.

Use the expression

$$\text{atom economy} = \frac{\text{molar mass of the desired product}}{\text{sum of the molar masses of all products}} \times 100\%$$

(2)

(c) Fluorine, F_2, and chlorine, Cl_2, react with **methane**, CH_4, by a similar mechanism, although the rates of reaction are very different.

(i) Write an equation for the reaction between **methane** and fluorine, assuming they react in a 1:1 mole ratio. State symbols are not required.

(1)

*(ii) On the basis of comparing the relative sizes of the fluorine and chlorine atoms, it might be predicted that the F—F bond energy would be greater than the Cl—Cl bond energy.
Suggest an explanation for this prediction.

(2)

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(iii) Draw a dot and cross diagram to show the arrangement of the outermost electrons in a fluorine molecule, F_2.

(2)

(iv) The actual bond energies are shown below.

Bond	Bond energy / kJ mol^{-1}
F—F	158
Cl—Cl	243

By referring to your dot and cross diagram in your answer to (c)(iii), suggest an explanation for the fact that the F—F bond energy is **less** than that of the Cl—Cl bond energy.

(2)

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....

(v) Suggest why a mixture of methane and chlorine requires exposure to UV light, or heat, before a reaction occurs, whereas methane reacts rapidly with fluorine at room temperature in the absence of UV light or heat.

(1)

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....

(d) The alkene hex-3-ene reacts with bromine to produce 3,4-dibromohexane. Complete the mechanism below by adding curly arrows to show the movement of electron pairs in both steps and by giving the structural formula of the intermediate carbocation.

(3)

3,4-dibromohexane

(e) The mechanism shown in (d) shows *Z*-hex-3-ene reacting with bromine. *E*-hex-3-ene also reacts with bromine to form 3,4-dibromohexane.

(i) Draw the structure of *E*-hex-3-ene.

(1)

(ii) Explain why both *Z*-hex-3-ene and *E*-hex-3-ene react with bromine to produce the **same** structural isomer.

(1)

....

....

(Total for Question 21 = 23 marks)

22 Lattice energy can be used as a measure of ionic bond strength. Born-Haber cycles can be used to determine experimental values of lattice energies.

The table below shows the energy changes that are needed to determine the lattice energy of lithium fluoride, LiF.

Energy change	ΔH / kJ mol^{-1}
Enthalpy change of atomization of lithium	+159
First ionization energy of lithium	+520
Enthalpy change of atomization of fluorine, $\frac{1}{2}F_2$	+79
First electron affinity of fluorine	−328
Enthalpy change of formation of lithium fluoride	−616

(a) Define the term **lattice energy**.

(2)

....

....

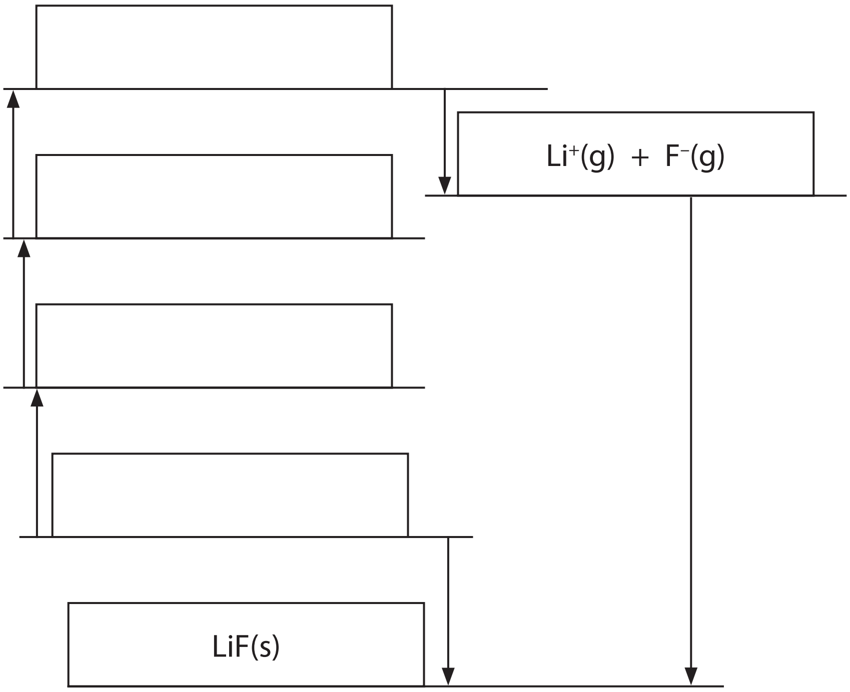
....

....

(b) The diagram below shows an incomplete Born-Haber cycle for the formation of lithium fluoride from lithium and fluorine.

(i) Complete the diagram by writing the formulae of the correct species, including state symbols, in the four empty boxes.

(4)



(ii) Calculate the lattice energy of lithium fluoride, in kJ mol^{-1}.

(2)

lattice energy = ... kJ mol^{-1}

*(c) The lattice energies of sodium fluoride, sodium chloride and magnesium fluoride are shown in the table below.

Compound	Lattice energy / kJ mol^{-1}
Sodium fluoride, NaF	−918
Sodium chloride, NaCl	−780
Magnesium fluoride, MgF_2	−2957

Explain, in terms of the sizes and charges of the ions involved, the differences between the lattice energy values of

(i) NaF and NaCl

(2)

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(ii) NaF and MgF_2

(2)

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(Total for Question 22 = 12 marks)

23 Alkanes are used as fuels in homes and in industry. It is, therefore, important that the enthalpy changes involving alkanes are known.

(a) Define the term **standard enthalpy change of formation** of a compound.

Give the conditions of temperature and pressure that are used when measuring a **standard** enthalpy change.

(3)

Definition ....

....

....

....

Standard temperature is ....

Standard pressure is ....

(b) Write the equation, with state symbols, that accompanies the enthalpy change of formation of hexane, C_6H_{14}(l).

(2)

(c) Enthalpy changes can be calculated using enthalpy changes of combustion. Values for some standard enthalpy changes of combustion are shown in the table below.

Substance	$\Delta H_c^\ominus$ / kJ mol^{-1}
$C(s)$	−394
$H_2(g)$	−286
$CH_4(g)$	−890

Use these data to complete the Hess cycle below for the reaction and then calculate the standard enthalpy change for the reaction, in kJ mol^{-1}.

$$C(s) \quad + \quad 2H_2(g) \quad \rightarrow \quad CH_4(g)$$

(3)

Space for working

standard enthalpy change for the reaction = ... kJ mol^{-1}

(d) The equations for the combination of gaseous carbon atoms and gaseous hydrogen atoms to form methane, CH_4, and ethane, C_2H_6, are shown below.

$$C(g) + 4H(g) \rightarrow CH_4(g) \qquad \Delta H = -1652 \text{ kJ mol}^{-1}$$

$$2C(g) + 6H(g) \rightarrow C_2H_6(g) \qquad \Delta H = -2825 \text{ kJ mol}^{-1}$$

Use these data to calculate

(i) the mean bond enthalpy of a C—H bond in methane, in kJ mol^{-1}.

(1)

(ii) the bond enthalpy of a C—C bond, in kJ mol^{-1}, clearly showing your working.

(2)

(Total for Question 23 = 11 marks)

24 This question is about atomic structure.

(a) Draw diagrams to show the shape of an s-orbital and of a p-orbital.

(2)

s-orbital	p-orbital

(b) Complete the table to show the number of electrons that **completely** fill the following regions.

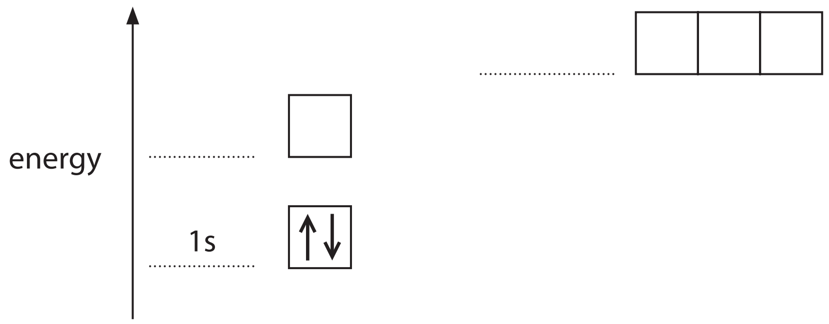
(3)

Region	Number of electrons present when completely filled
a d-orbital	
a p sub-shell	
the third shell (n = 3)	

(c) The energy diagram below is for the eight electrons present in an oxygen atom. Complete the diagram for an oxygen atom by adding

- labels to identify the other occupied sub-shells
- arrows to show how the remaining six electrons are arranged in the orbitals.

(2)



(d) Successive ionization energies provide evidence for the arrangement of electrons in atoms. The eight successive ionization energies of oxygen are shown in the table below.

Ionization number	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionization energy / kJ mol^{-1}	1314	3388	5301	7469	10989	13327	71337	84080

(i) Define the term **first ionization energy**.

(3)

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....

(ii) Write an equation, with state symbols, to show the **third** ionization energy of oxygen.

(2)

*(iii) Explain how the data in the table provide evidence that there are two occupied electron shells in an oxygen atom.

(2)

(Total for Question 24 = 14 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
6.9 **Li** lithium 3	9.0 **Be** beryllium 4											10.8 **B** boron 5	12.0 **C** carbon 6	14.0 **N** nitrogen 7	16.0 **O** oxygen 8	19.0 **F** fluorine 9	20.2 **Ne** neon 10
23.0 **Na** sodium 11	24.3 **Mg** magnesium 12											27.0 **Al** aluminium 13	28.1 **Si** silicon 14	31.0 **P** phosphorus 15	32.1 **S** sulfur 16	35.5 **Cl** chlorine 17	39.9 **Ar** argon 18
39.1 **K** potassium 19	40.1 **Ca** calcium 20	45.0 **Sc** scandium 21	47.9 **Ti** titanium 22	50.9 **V** vanadium 23	52.0 **Cr** chromium 24	54.9 **Mn** manganese 25	55.8 **Fe** iron 26	58.9 **Co** cobalt 27	58.7 **Ni** nickel 28	63.5 **Cu** copper 29	65.4 **Zn** zinc 30	69.7 **Ga** gallium 31	72.6 **Ge** germanium 32	74.9 **As** arsenic 33	79.0 **Se** selenium 34	79.9 **Br** bromine 35	83.8 **Kr** krypton 36
85.5 **Rb** rubidium 37	87.6 **Sr** strontium 38	88.9 **Y** yttrium 39	91.2 **Zr** zirconium 40	92.9 **Nb** niobium 41	95.9 **Mo** molybdenum 42	[98] **Tc** technetium 43	101.1 **Ru** ruthenium 44	102.9 **Rh** rhodium 45	106.4 **Pd** palladium 46	107.9 **Ag** silver 47	112.4 **Cd** cadmium 48	114.8 **In** indium 49	118.7 **Sn** tin 50	121.8 **Sb** antimony 51	127.6 **Te** tellurium 52	126.9 **I** iodine 53	131.3 **Xe** xenon 54
132.9 **Cs** caesium 55	137.3 **Ba** barium 56	138.9 **La*** lanthanum 57	178.5 **Hf** hafnium 72	180.9 **Ta** tantalum 73	183.8 **W** tungsten 74	186.2 **Re** rhenium 75	190.2 **Os** osmium 76	192.2 **Ir** iridium 77	195.1 **Pt** platinum 78	197.0 **Au** gold 79	200.6 **Hg** mercury 80	204.4 **Tl** thallium 81	207.2 **Pb** lead 82	209.0 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 **Ce** cerium 58	141 **Pr** praseodymium 59	144 **Nd** neodymium 60	[147] **Pm** promethium 61	150 **Sm** samarium 62	152 **Eu** europium 63	157 **Gd** gadolinium 64	159 **Tb** terbium 65	163 **Dy** dysprosium 66	165 **Ho** holmium 67	167 **Er** erbium 68	169 **Tm** thulium 69	173 **Yb** ytterbium 70	175 **Lu** lutetium 71
* Actinide series	232 **Th** thorium 90	[231] **Pa** protactinium 91	238 **U** uranium 92	[237] **Np** neptunium 93	[242] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[245] **Bk** berkelium 97	[251] **Cf** californium 98	[254] **Es** einsteinium 99	[253] **Fm** fermium 100	[256] **Md** mendelevium 101	[254] **No** nobelium 102	[257] **Lr** lawrencium 103