Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Friday 10 June 2016 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
WCH02/01

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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6/6/6/6/5/

P 4 6 6 5 9 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 How many molecular ion peaks are in the mass spectrum of 1,2-dichloroethane?

Assume the only isotopes present are ^{1}H, ^{12}C, ^{35}Cl and ^{37}Cl.

☒ **A** 4

☒ **B** 3

☒ **C** 2

☒ **D** 1

(Total for Question 1 = 1 mark)

---

2 Four compounds that contribute to global warming are

A carbon dioxide

B methane

C dichlorodifluoromethane

D sulfur hexafluoride

(a) Which of these molecules is polar?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which of these compounds is emitted in the largest quantity by anthropogenic activity?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which of these compounds depletes the ozone layer?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) Which of these molecules has an octahedral structure?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 2 = 4 marks)

3 Which of the following is a tertiary alcohol?

☒ **A** 4-methylpentan-2-ol

☒ **B** 3-methylpentan-2-ol

☒ **C** 2-methylpentan-3-ol

☒ **D** 3-methylpentan-3-ol

(Total for Question 3 = 1 mark)

Use this space for rough working. Anything you write in this space will gain no credit.

4 This question is about two isomeric alcohols and two isomeric carbonyl compounds.

Propan-1-ol, $CH_3CH_2CH_2OH$

Propan-2-ol, $CH_3CH(OH)CH_3$

Propanal, CH_3CH_2CHO

Propanone, CH_3COCH_3

(a) Which of these compounds would **not** produce a colour change when heated with acidified sodium dichromate(VI) solution?

(1)

☒ **A** Propan-1-ol

☒ **B** Propan-2-ol

☒ **C** Propanal

☒ **D** Propanone

(b) Which pair of compounds would you expect to both have a singly charged peak at $m/e = 29$ in their mass spectra?

(1)

☒ **A** Propan-1-ol and propan-2-ol

☒ **B** Propan-2-ol and propanal

☒ **C** Propanal and propanone

☒ **D** Propan-1-ol and propanal

(c) Which compound would you expect to give a peak at $m/e = 31$ in its mass spectrum?

(1)

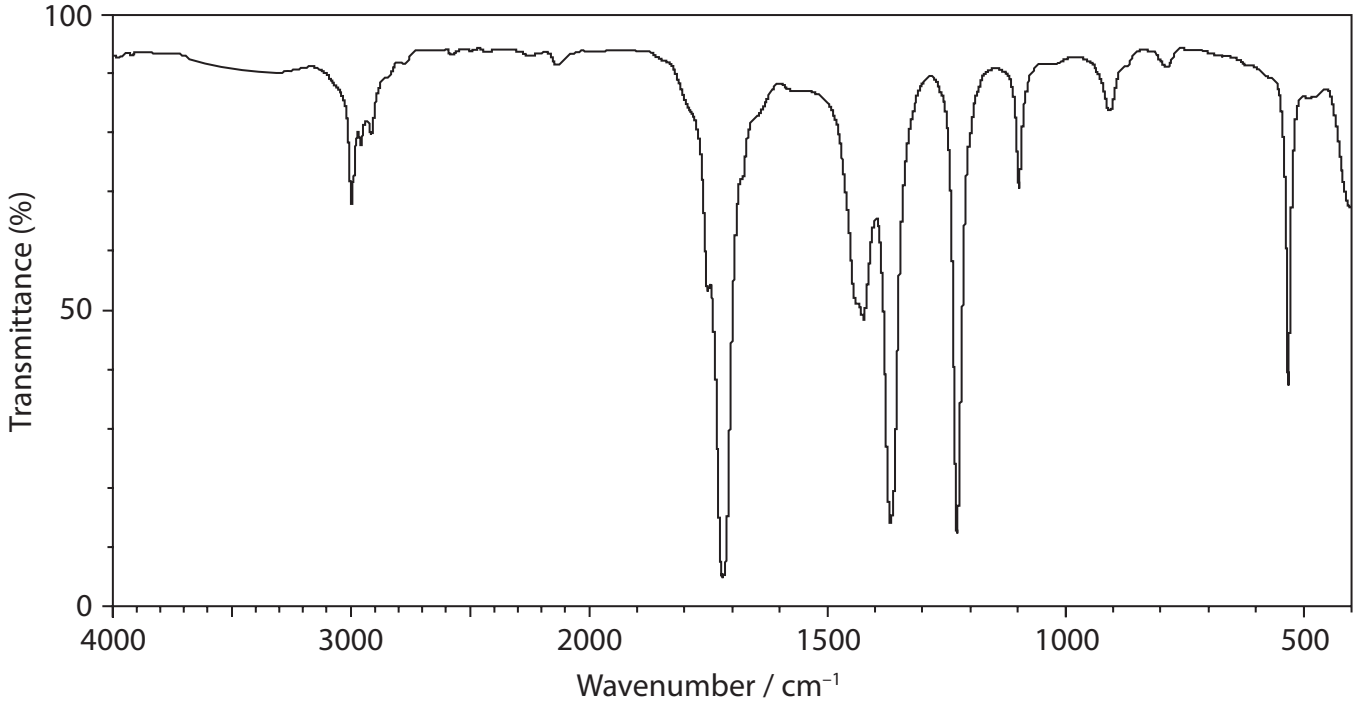
☒ **A** Propan-1-ol

☒ **B** Propan-2-ol

☒ **C** Propanal

☒ **D** Propanone

(d) The infrared spectrum of one of these compounds is given below.



Use the infrared absorptions, in wavenumbers, to identify the compound.

Bond	Wavenumber range / cm^{-1}
O—H (alcohol)	3750 – 3200
C—H (alkane)	2962 – 2853
C—H (aldehyde)	2900 – 2820 and 2775 – 2700
C═O (aldehyde or ketone)	1740 – 1680

The compound with this infrared spectrum is

(1)

☒ **A** propan-1-ol.

☒ **B** propan-2-ol.

☒ **C** propanal.

☒ **D** propanone.

(Total for Question 4 = 4 marks)

5 A Maxwell-Boltzmann curve shows the distribution of molecular energies in a reaction system. When the temperature in this system is **decreased**, the peak is

☒ **A** higher and further to the right.

☒ **B** higher and further to the left.

☒ **C** lower and further to the right.

☒ **D** lower and further to the left.

(Total for Question 5 = 1 mark)

Use this space for rough working. Anything you write in this space will gain no credit.

6 This question is about the equilibrium reaction between hydrogen and carbon dioxide.

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g) \qquad \Delta H^{\ominus} = +40 \text{ kJ mol}^{-1}$$

What effect would the following changes have on the rate of the reaction and the yield of carbon monoxide?

(a) **Decrease** in temperature from 700 K to 600 K.

(1)

	Rate	Yield of CO
☒ **A**	no change	decrease
☒ **B**	decrease	decrease
☒ **C**	decrease	increase
☒ **D**	no change	increase

(b) **Increase** in pressure.

(1)

	Rate	Yield of CO
☒ **A**	increase	increase
☒ **B**	increase	no change
☒ **C**	no change	increase
☒ **D**	no change	no change

(Total for Question 6 = 2 marks)

7 What is produced when magnesium burns in air?

☒ **A** Magnesium oxide only

☒ **B** Magnesium oxide and magnesium carbonate

☒ **C** Magnesium oxide and magnesium nitride

☒ **D** Magnesium oxide, magnesium nitride and magnesium carbonate

(Total for Question 7 = 1 mark)

8 What happens to the solubilities of hydroxides and sulfates as Group 2 is **ascended** from barium to magnesium?

	Solubility of hydroxides	Solubility of sulfates
☒ **A**	decreases	decreases
☒ **B**	decreases	increases
☒ **C**	increases	decreases
☒ **D**	increases	increases

(Total for Question 8 = 1 mark)

9 Which of the following substances does **not** form when a few drops of concentrated sulfuric acid are added to potassium bromide?

☒ **A** Br_2

☒ **B** H_2S

☒ **C** $KHSO_4$

☒ **D** SO_2

(Total for Question 9 = 1 mark)

10 10.00 cm^3 of 1.00 mol dm^{-3} sulfuric acid is fully neutralized by 20.00 cm^3 of 1.00 mol dm^{-3} of sodium hydroxide.

(a) What is the concentration, in mol dm^{-3}, of sodium sulfate solution produced by the reaction?

(1)

☒ **A** 0.33

☒ **B** 0.50

☒ **C** 0.67

☒ **D** 1.00

(b) The volumes are measured using burettes, with each burette reading having an uncertainty of ±0.05 cm^3.

The percentage uncertainty in measuring the 10.00 cm^3 of the acid is

(1)

☒ **A** ±0.05%

☒ **B** ±0.10%

☒ **C** ±0.50%

☒ **D** ±1.00%

(Total for Question 10 = 2 marks)

11 In water, hexan-1-ol is less soluble than ethanol. The best explanation for this is that

☒ **A** hexan-1-ol molecules cannot form hydrogen bonds with water molecules but ethanol molecules can.

☒ **B** carbon-carbon bonds are stronger in hexan-1-ol than in ethanol.

☒ **C** London forces between hexan-1-ol molecules are stronger than between ethanol molecules.

☒ **D** permanent dipole forces are stronger in hexan-1-ol than in ethanol.

(Total for Question 11 = 1 mark)

12 As Group 7 is **descended**, the boiling temperatures of the hydrogen halides, from HF to HI,

☒ **A** decrease then increase.

☒ **B** decrease.

☒ **C** increase then decrease.

☒ **D** increase.

(Total for Question 12 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

13 This question is about three chlorine compounds: BCl_3, NCl_3 and Cl_2O_7.

(a) For BCl_3, give the shape of the molecule and give the ClBCl bond angle.

(2)

Shape .....

Bond angle .....

*(b) For the NCl_3 molecule, draw the shape you would expect, and suggest the ClNCl bond angle. Explain why the molecule has this shape and bond angle.

(4)

Shape

Bond angle .....

Explanation .....

.....

.....

.....

.....

.....

(c) (i) What is the oxidation number of chlorine in Cl_2O_7?

(1)

.....

(ii) One oxygen atom bonds to both chlorine atoms in Cl_2O_7. Suggest a displayed formula for Cl_2O_7.

(1)

(iii) Water reacts with Cl_2O_7 to form a single product. Suggest the equation for this reaction. State symbols are not required.

(1)

(Total for Question 13 = 9 marks)

14 This question is about 1-chlorobutane, 1-bromobutane, and 1-iodobutane.

(a) 1-chlorobutane can be made by adding potassium chloride to a mixture of butan-1-ol and concentrated sulfuric acid.

(i) Explain why it is not possible to make 1-iodobutane from butan-1-ol using potassium iodide and concentrated sulfuric acid.

(2)

.....

.....

.....

.....

(ii) 1-iodobutane is prepared by adding iodine in small portions to a mixture of red phosphorus and butan-1-ol.

When all the iodine has been added, the mixture is refluxed.

In this reaction, iodine reacts with phosphorus to produce phosphorus triiodide, which then reacts with the butan-1-ol to form 1-iodobutane.

Write an equation for each reaction. State symbols are not required.

(2)

(b) The rates of reaction of three halogenoalkanes with water are compared.

2 cm^3 of ethanol is added to three test tubes, **A**, **B** and **C**.

Three drops of the halogenoalkane are added separately to each of these three test tubes.

1-chlorobutane is added to test tube **A**.

1-bromobutane is added to test tube **B**.

1-iodobutane is added to test tube **C**.

2 cm^3 portions of hot aqueous silver nitrate solution are added to each test tube.

(i) Explain why ethanol is added to each test tube.

(1)

.....

.....

(ii) Give the name of the organic product which forms in all of these reactions.

(1)

.....

(iii) The halide ion formed in each reaction reacts with the silver nitrate solution to give a precipitate.

Give the colour of the precipitate formed in test tube **C** and give the ionic equation for the formation of this precipitate.
Include state symbols in your equation.

(2)

Colour .....

Equation

(iv) Dilute and concentrated aqueous ammonia are added to separate samples of the precipitates formed in test tubes **A** and **C**.

Complete the table.

(2)

	Observation with dilute aqueous ammonia	Observation with concentrated aqueous ammonia
Precipitate from Tube **A**		
Precipitate from Tube **C**		

(v) Give the order in which the precipitates form, in the test tubes **A**, **B** and **C**, giving the fastest first.

(1)

.....

*(vi) State how the bond polarities of carbon-halogen bonds vary.

Explain why bond polarity does not determine the rate of this reaction.

(2)

.....

.....

.....

.....

.....

.....

(c) When these halogenoalkanes are heated separately with concentrated potassium hydroxide in ethanol, the same gaseous organic product forms.

(i) Give the structural formula for this organic product.

(1)

(ii) State the type of reaction which occurs.

(1)

.....

(iii) Give a chemical test for this organic product and state the colour change that occurs.

(2)

Test .....

Colour change .....

(d) All three halogenoalkanes undergo substitution reactions with ammonia.
The initial reaction forms butylamine, $CH_3CH_2CH_2CH_2NH_2$.

(i) Write the equation for the initial reaction of 1-iodobutane with ammonia.
State symbols are not required.

(1)

(ii) The butylamine formed also reacts with the 1-iodobutane in a further substitution reaction.

Suggest a structural formula for the product of this reaction.

(1)

(Total for Question 14 = 19 marks)

15 Hydrated barium nitrate, $Ba(NO_3)_2.4H_2O$, is strongly heated in a boiling tube and the following changes occur.

Stage 1 The white solid forms a clear colourless solution.

Stage 2 Condensation forms around the mouth of the boiling tube and a white solid starts to form at the bottom of the tube.

Stage 3 As the heating continues, the colourless solution disappears leaving another white solid.

Stage 4 This white solid melts.

Stage 5 Nitrogen dioxide and oxygen gases are given off, and barium oxide is left in the test tube.

(a) (i) Give the formula for the white solid formed in Stage 3.

(1)

.....

.....

(ii) What would you see when nitrogen dioxide is given off in Stage 5?

(1)

.....

(iii) Describe the test for oxygen and its positive result.

(1)

.....

.....

(iv) Write the equation for the complete thermal decomposition of hydrated barium nitrate, $Ba(NO_3)_2.4H_2O$.

State symbols are not required.

(2)

(b) Describe a simple test tube experiment that you can use to compare the thermal stabilities of **anhydrous** barium nitrate and **anhydrous** calcium nitrate.

State **two** essential conditions necessary to ensure a fair test.

You may wish to draw a diagram.

Detailed measurements are not required.

(3)

*(c) Explain why anhydrous calcium nitrate decomposes more readily than anhydrous barium nitrate.

(3)

(d) The chlorides of calcium and barium can be distinguished using flame tests.

State what you would see in each test.

(2)

Calcium chloride .....Barium chloride .....

(Total for Question 15 = 13 marks)

TOTAL FOR SECTION B = 41 MARKS

SECTION C

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

16 Sunflower oil is an important edible oil. It can be used as an alternative to butter in cooking.

A useful method of comparing fats and oils is by measuring their iodine values.
An iodine value is the amount of iodine in grams that reacts with 100 g of a fat or oil.
The iodine value is a measure of the degree of unsaturation of the fat or oil.

The iodine value of sunflower oil can be determined in the following way.

Add 0.200 g of sunflower oil to a 250 cm^3 conical flask.

Add 10 cm^3 of solvent to dissolve the oil.

Add 10.0 cm^3 of a solution of iodine monochloride, called Wijs solution.

Stopper the flask and allow to stand in the dark for half an hour.

Add 15 cm^3 (an excess) of 10% potassium iodide solution and 100 cm^3 of water, and shake the mixture.

Titrate the liberated iodine with 0.100 mol dm^{-3} sodium thiosulfate solution.
This gives the sample titre.

Carry out a blank titration with the same sodium thiosulfate solution, using 10 cm^3 of solvent, 10.0 cm^3 of Wijs solution, 15 cm^3 of 10% potassium iodide solution and 100 cm^3 of water.

(a) Trichloromethane and 1,1,1-trichloroethane are two possible solvents for this reaction.

(i) Give the **skeletal** formulae for trichloromethane and 1,1,1-trichloroethane .

(2)

Trichloromethane

1,1,1-trichloroethane

(ii) Explain why 1,1,1-trichloroethane has a higher boiling temperature than trichloromethane.

(2)

(iii) Suggest why solvents such as trichloromethane and 1,1,1-trichloroethane are no longer used.

(1)

(b) (i) Complete the formula of the product when iodine monochloride reacts with linoleic acid, $CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$, the most abundant unsaturated compound in sunflower oil.

(1)

$$CH_3(CH_2)_4—C—C—CH_2—C—C—(CH_2)_7COOH$$

(ii) Iodine monochloride solution is preferred to iodine solution for this reaction because it is more reactive.

Explain why this is so.

(1)

(iii) Suggest why Wijs solution is stored in a brown bottle.

(1)

(iv) The equation for the reaction between iodide ions and iodine monochloride is given below.

Show that this is a redox reaction by giving all the oxidation numbers and identifying the oxidizing agent.

(2)

$$ICl + I^- \rightarrow I_2 + Cl^-$$

Oxidation numbers ....

Oxidizing agent .....

(c) (i) Starch solution is usually added as an indicator towards the end of the titration.

Describe how the colour of the mixture would change during the titration, **before** starch is added.

(1)

.....

(ii) Explain why starch solution is not added at the start of the titration.

(1)

.....

.....

(d) In the blank titration, 40.0 cm^3 of 0.100 mol dm^{-3} sodium thiosulfate solution reacted with 10.0 cm^3 of Wijs solution.

(i) Calculate the number of moles of 0.100 mol dm^{-3} sodium thiosulfate that reacted in the **blank** titre.

(1)

(ii) Calculate the number of moles of iodine, I_2, which reacted with the thiosulfate solution in the blank titration.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

(1)

(iii) Using your answer to (d)(ii), and the equation in (b)(iv), deduce the corresponding number of moles of iodine monochloride solution in 10.0 cm^3 of Wijs solution.

(1)

(iv) The number of moles of iodine monochloride left after reacting the Wijs solution with the sample of the sunflower oil, calculated from the titre, is 1.10×10^{-3} mol.

Use this, and your answer to (d)(iii), to calculate the number of moles of iodine monochloride that reacted with the sample.

(1)

(v) Your answer to (d)(iv) is equal to the number of moles of iodine that would have reacted with 0.2 g of sunflower oil.

Calculate the number of moles of iodine that would have reacted with 100 g of sunflower oil.

(1)

(vi) Calculate the mass of iodine, I_2, which would have reacted with 100 g of sunflower oil, which is the iodine value for the sunflower oil.

(1)

(e) Butter contains a smaller percentage of unsaturated molecules than sunflower oil.

Would the titre value and iodine value for butter be higher, lower or about the same as the values for sunflower oil?

(1)

Titre value .....

Iodine value .....

(Total for Question 16 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
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	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(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