Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Wednesday 16 January 2013 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

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 ▶

P41213A

7/6/5/4/5/

P 4 1 2 1 3 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 these bond angles is the **largest**?

☒ **A** Cl—B—Cl in BCl_3

☒ **B** H—N—H in NH_3

☒ **C** Cl—Be—Cl in $BeCl_2$

☒ **D** H—O—H in H_2O

(Total for Question 1 = 1 mark)

2 In propene, $CH_2{=}CH{-}CH_3$,

☒ **A** the C=C double bond is longer and stronger than the C—C single bond.

☒ **B** the C=C double bond is shorter and stronger than the C—C single bond.

☒ **C** the C=C double bond is shorter and weaker than the C—C single bond.

☒ **D** the C=C double bond is longer and weaker than the C—C single bond.

(Total for Question 2 = 1 mark)

3 Which of the following molecules is **not** polar?

☒ **A** HCl

☒ **B** CH_3Cl

☒ **C** $CHCl_3$

☒ **D** CCl_4

(Total for Question 3 = 1 mark)

4 The O—H bond in water is polar because, compared with the hydrogen atom, the oxygen atom has

☒ **A** more electrons.

☒ **B** more neutrons.

☒ **C** greater electronegativity.

☒ **D** a larger atomic radius.

(Total for Question 4 = 1 mark)

5 Which of the following compounds has the highest boiling temperature?

☒ **A** CH_4

☒ **B** CH_3Cl

☒ **C** HCHO

☒ **D** CH_3OH

(Total for Question 5 = 1 mark)

6 The oxidation number of sulfur in thiosulfate ions, $S_2O_3^{2-}$, is

☒ **A** +2

☒ **B** +3

☒ **C** +4

☒ **D** +6

(Total for Question 6 = 1 mark)

7 Which of the following is a redox reaction?

☒ **A** $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

☒ **B** $MgO + H_2O \rightarrow Mg(OH)_2$

☒ **C** $NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$

☒ **D** $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

(Total for Question 7 = 1 mark)

8 A solid gives a red colour in a flame test and reacts with concentrated sulfuric acid to produce steamy fumes, but no other gases. The solid could be

☒ **A** lithium bromide.

☒ **B** strontium chloride.

☒ **C** calcium bromide.

☒ **D** sodium chloride.

(Total for Question 8 = 1 mark)

9 Which of the following statements is correct?

☒ **A** Barium sulfate is less soluble in water than calcium sulfate.

☒ **B** Barium hydroxide is less soluble in water than calcium hydroxide.

☒ **C** Barium nitrate undergoes thermal decomposition more readily than calcium nitrate.

☒ **D** Barium shows more than one oxidation state in its compounds.

(Total for Question 9 = 1 mark)

10 Going down Group 7 from chlorine to iodine

☒ **A** the boiling temperature of the hydrogen halide decreases.

☒ **B** the polarity of the hydrogen halide bond increases.

☒ **C** the reducing power of the halide ion increases.

☒ **D** the oxidizing power of the halogen element increases.

(Total for Question 10 = 1 mark)

11 What colour is the vapour which forms when concentrated sulfuric acid is added to solid potassium iodide?

☒ **A** Green

☒ **B** Orange

☒ **C** Brown

☒ **D** Purple

(Total for Question 11 = 1 mark)

12 Calculate the volume of dilute hydrochloric acid, concentration 0.200 mol dm^{-3}, needed to neutralize 20 cm^3 of aqueous calcium hydroxide, concentration 0.100 mol dm^{-3}.

$$2HCl(aq) + Ca(OH)_2(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

☒ **A** 10 cm^3

☒ **B** 20 cm^3

☒ **C** 40 cm^3

☒ **D** 80 cm^3

(Total for Question 12 = 1 mark)

13 The reaction of heated magnesium with steam is faster than the reaction of magnesium with cold water. This is mainly because

☒ **A** in cold water, the water molecules do not collide as frequently with magnesium.

☒ **B** the coating of oxide on magnesium decomposes when it is heated.

☒ **C** the fraction of particles with energy greater than the activation energy is higher in the reaction with steam.

☒ **D** the reaction with steam goes by an alternative route with lower activation energy.

(Total for Question 13 = 1 mark)

14 Which of these compounds would **not** react when heated with a mixture of potassium dichromate(VI) and sulfuric acid?

☒ **A** CH_3OH

☒ **B** $CH_3(CH_2)_2OH$

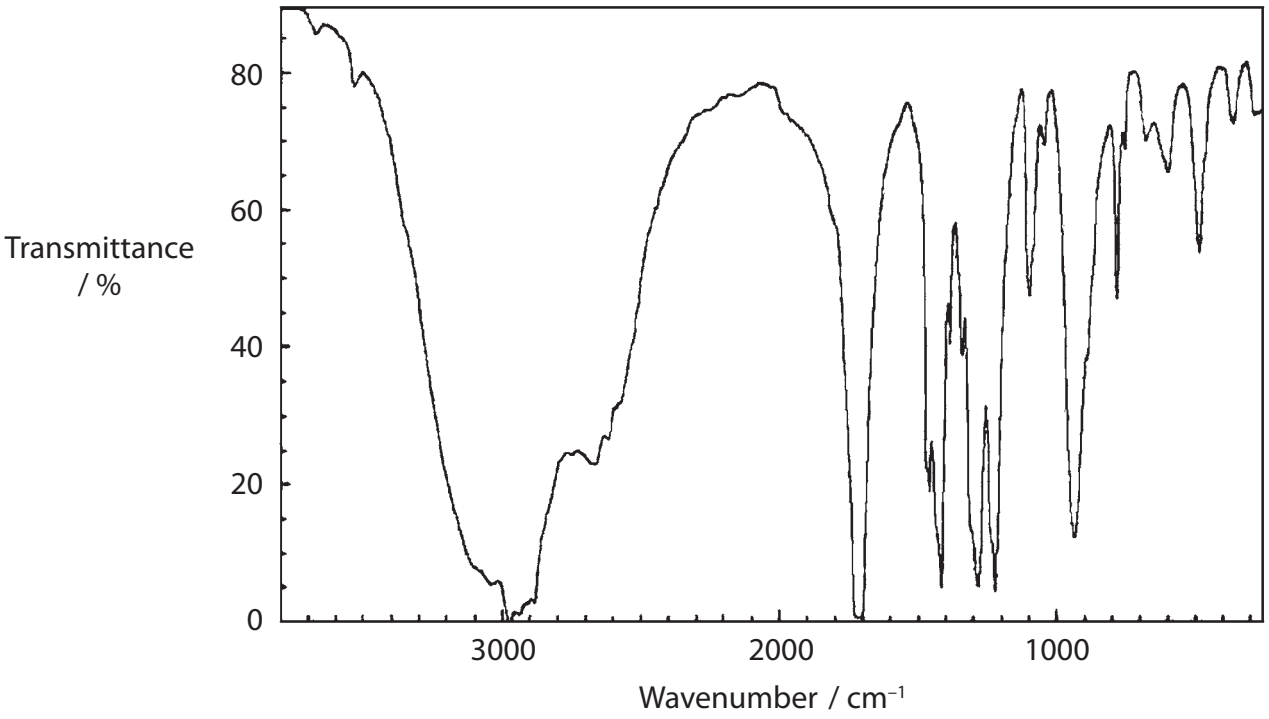
☒ **C** $(CH_3)_2CHOH$

☒ **D** $(CH_3)_3COH$

(Total for Question 14 = 1 mark)

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

15 Under certain conditions, butan-1-ol can be oxidized to the compound with infrared spectrum shown below.



O—H stretching vibrations alcohols	3750 – 3200 cm^{-1}
O—H stretching vibrations carboxylic acids	3300 – 2500 cm^{-1}
C═O stretching vibrations aldehydes and ketones	1740 – 1680 cm^{-1}
C═O stretching vibrations carboxylic acids	1725 – 1700 cm^{-1}

The compound is most likely to be

☒ **A** butan-2-ol.

☒ **B** butanal.

☒ **C** butanone.

☒ **D** butanoic acid.

(Total for Question 15 = 1 mark)

16 Which of the following is a **secondary** alcohol?

☒ **A** 2-methylpentan-3-ol

☒ **B** 2-methylpropan-2-ol

☒ **C** 2,2-dimethylpropan-1-ol

☒ **D** ethane-1,2-diol

(Total for Question 16 = 1 mark)

17 Propanal, CH_3CH_2CHO, and propanone, CH_3COCH_3, are isomers, but only propanal has a significant peak in its mass spectrum at mass/charge ratio

☒ **A** 15

☒ **B** 29

☒ **C** 43

☒ **D** 58

(Total for Question 17 = 1 mark)

18 The reaction of the halogenoalkane, C_2H_5Cl, with alcoholic ammonia is

☒ **A** nucleophilic substitution.

☒ **B** electrophilic substitution.

☒ **C** reduction.

☒ **D** elimination.

(Total for Question 18 = 1 mark)

19 The formation of a carbocation from a halogenoalkane is an example of

☒ **A** homolytic fission.

☒ **B** heterolytic fission.

☒ **C** an initiation reaction.

☒ **D** a propagation reaction.

(Total for Question 19 = 1 mark)

20 The equations below show some reactions which occur in the upper atmosphere.

$$O_3 \rightarrow O + O_2$$
$$NO + O_3 \rightarrow NO_2 + O_2$$
$$NO_2 + O \rightarrow NO + O_2$$

Which of the following statements is **not** correct?

☒ **A** Oxygen free radicals are formed by the action of ultraviolet light.

☒ **B** NO acts as a catalyst.

☒ **C** NO acts as an oxidizing agent.

☒ **D** NO is released by aircraft engines.

(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 Chlorine is used to prevent the growth of bacteria in swimming pool water. It reacts as shown below.

$$Cl_2(aq) + H_2O(l) \rightleftharpoons HCl(aq) + HClO(aq)$$

(a) (i) By giving appropriate oxidation numbers, explain why this is a disproportionation reaction.

(3)

(ii) State and explain the effect on the position of equilibrium if concentrated hydrochloric acid is added to a sample of chlorinated swimming pool water.

(2)

(b) In a similar reaction, chlorine reacts with sodium hydroxide to make household bleach.

$$Cl_2(aq) + 2NaOH(aq) \rightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$$

The concentration of NaClO in diluted bleach was measured by titration. A 25.0 cm^3 sample of bleach was pipetted into a conical flask. Approximately 1.5 g of solid potassium iodide and 10 cm^3 of hydrochloric acid with concentration 2.00 mol dm^{-3} were added. Each mole of ClO^-, from the NaClO in the solution of bleach, produced one mole of iodine, I_2, which was titrated with sodium thiosulfate solution.

(i) Complete the ionic half-equations below for the reaction of ClO^- with acidified potassium iodide by balancing them and **adding electrons** where required.

(2)

$$ClO^- + \text{.....}H^+ \rightarrow Cl^- + H_2O$$

$$\text{.....}I^- \rightarrow I_2$$

(ii) Use your answer to (a)(i) to write the overall ionic equation for the reaction between ClO^- and I^- ions in acidic conditions.

(1)

(iii) The iodine in the sample required a mean (average) titre of 24.20 cm^3 of 0.0500 mol dm^{-3} sodium thiosulfate solution. Thiosulfate ions react with iodine as shown below.

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

Calculate the number of moles of iodine in the solution.

(2)

(iv) What is the number of moles of ClO^- ions in the sample of diluted bleach?

(1)

(v) Hence calculate the concentration, in mol dm^{-3}, of ClO^- in the diluted bleach.

(1)

(vi) 1.5 g of potassium iodide, KI, contains 9.04×10^{-3} mol of I^-. Use your answers to (b)(ii) and (b)(iv) to show by calculation why this amount was suitable.

(2)

.....

.....

(vii) A student carrying out this titration measured the mean (average) titre as 24.50 cm^3.

What is the percentage difference in this student's titre, compared with the accurate value of 24.20 cm^3?

(1)

(viii) The difference between the student's mean titre and the accurate value was **not** due to the limitations in the accuracy of the measuring instruments.

Suggest one possible reason for this difference.

(1)

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.....

(c) Suggest **one** damaging effect to the upper atmosphere which could be caused by the presence of chlorine compounds.

(1)

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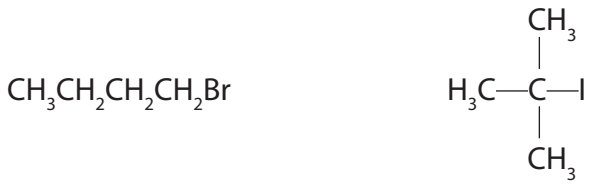
.....

(Total for Question 21 = 17 marks)

22 This question is about two halogenoalkanes, **X** and **Y**, which have the structures shown below.



X **Y**

(a) (i) Draw the skeletal formula of **X**.

(1)

(ii) Name **Y**.

(1)

.....

(iii) Write an equation for the reaction of **X** with an alcoholic solution of ammonia, and name the organic product.

(2)

Name of product .....

(iv) When **Y** is heated with an **aqueous** solution of potassium hydroxide, an alcohol is formed in a two-step reaction. Write the mechanism for this reaction using 'curly arrows' where appropriate and clearly showing the structure of the intermediate.

(3)

(v) When **Y** is heated with an **alcoholic** solution of potassium hydroxide, the alkene C_4H_8 is formed. What type of reaction occurs to produce the alkene?

(1)

.....

(b) Separate ethanolic solutions of **X** and **Y** were warmed with water containing dissolved silver nitrate. Describe what would be seen in each case, ignoring any differences in the rates of reaction.

(2)

Observation with **X**

.....

Observation with **Y**

.....

(c) The rates of hydrolysis of primary halogenoalkanes are affected by the strength of the bond between the carbon and the halogen atom.

Is the C—Br bond weaker or stronger than the C—I bond? Explain why the bond strength differs.

(2)

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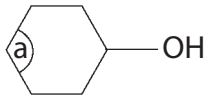
(Total for Question 22 = 12 marks)

23 The skeletal formula of cyclohexanol is shown below.



(a) (i) The actual bond angles differ from the angles in the two dimensional diagram shown.

What is the angle of the C—C—C bond labelled **a**?

(1)

Angle .....

*(ii) What is the angle of the C—O—H bond? Justify your answer, explaining why the size of the angle is different from the angle in (i).

(3)

Angle .....

Explanation .....

.....

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(b) (i) Suggest what you would expect to **see** when cyclohexanol reacts with sodium.

(2)

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(ii) Phosphorus(V) chloride (phosphorus pentachloride) is used to test for the presence of an —OH group. Write the equation for the reaction of cyclohexanol with phosphorus(V) chloride.

(2)

(iii) Give the chemical test you could use to identify the gas produced, and the observation you would make.

(1)

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(iv) Cyclohexanol reacts with hot acidified potassium dichromate(VI) solution.

Give the skeletal formula of the organic product of this reaction.

(1)

(v) What colour change would you observe as this reaction takes place?

(1)

From ..... to .....

(c) The mass spectrum of cyclohexanol has a prominent peak at mass / charge ratio 82. Suggest the molecular formula of the fragment which causes this peak.

(1)

.....

(Total for Question 23 = 12 marks)

TOTAL FOR SECTION B = 41 MARKS

SECTION C

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

24

Carbon capture is the name given to some processes used to prevent carbon dioxide entering the atmosphere. Carbon capture is carried out because carbon dioxide is a greenhouse gas.

Flue gases in chimneys contain carbon dioxide produced from burning fossil fuels. Various different compounds can be used to react with the carbon dioxide to capture it. Alternatively, carbon dioxide can be separated from other gases by a physical process.

Many sources of natural gas contain carbon dioxide, which can be removed by freezing.

Captured carbon dioxide must then be stored to prevent it entering the atmosphere. It can be injected into depleted oil and gas formations, or into porous rocks full of salt water. These are usually over 1 km below the Earth's surface and have non-porous rocks above them. Eventually the carbon dioxide dissolves, forming carbonate ions and then new minerals.

(a) Greenhouse gases can absorb infrared radiation. Explain why carbon dioxide absorbs infrared radiation but oxygen cannot.

(2)

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(b) A solution of the compound aminoethanol, $H_2NCH_2CH_2OH$, can be used to absorb carbon dioxide.

$$2H_2NCH_2CH_2OH + CO_2 + H_2O \rightleftharpoons (H_3NCH_2CH_2OH)_2CO_3$$

(i) Explain why aminoethanol is soluble in water.

(1)

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.....

(ii) The position of this equilibrium moves to the left on heating. This frees the captured carbon dioxide for storage. Use this information to decide whether the forward reaction is exothermic or endothermic. Explain your answer.

(2)

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(c) The composition of a sample of natural gas and the melting temperatures of four of its components are shown below.

	Percentage	Melting temperature / K
Methane	95.2	91.1
2-methylpropane	0.8	113.7
Butane	0.9	134.7
Other hydrocarbons	2.4	
Carbon dioxide	0.7	216.5

(i) Draw a dot and cross diagram for carbon dioxide.

(2)

(ii) The London forces between molecules of carbon dioxide are stronger than the London forces between molecules of methane. Suggest a reason for this.

(1)

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(iii) Use your knowledge of intermolecular forces to suggest why butane has a higher melting temperature than 2-methylpropane.

(2)

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(d) When carbon dioxide dissolves, it may eventually form minerals such as magnesium carbonate and calcium carbonate.

(i) State the results of flame tests carried out on these two minerals.

(2)

Magnesium carbonate .....

Calcium carbonate .....

*(ii) Magnesium carbonate and calcium carbonate both undergo thermal decomposition, but they have different stability to heat. The difference in stability to heat can be compared in an experiment.

Suggest how this experiment could be carried out. You should indicate

- how to detect when the thermal decomposition occurs
- the measurement you would make to compare the stability to heat
- how to make the comparison fair.

You may include a diagram if you wish but it is not essential.

(4)

*(iii) State and explain which of the two carbonates is more stable to heat.

(3)

(Total for Question 24 = 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)
							1.0 H hydrogen 1										(18) 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