Surname		Centre Number	Candidate Number
Other Names			2

GCE AS/A level

1091/01

CHEMISTRY CH1

P.M. TUESDAY, 15 May 2012

1½ hours

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-5	
B	6	
	7	
	8	
	9	
	10	
TOTAL MARK		

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- copy of the **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions in the spaces provided.
Section B Answer **all** questions in the spaces provided.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The *QWC* label alongside particular part-questions indicates those where the Quality of Written Communication is assessed.

If you run out of space, use the continuation page at the back of the booklet, taking care to number the question(s) correctly.

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SECTION A

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

1. Sketch a diagram to show the shape of a *p* orbital. [1]

2. Complete the following definition of *relative atomic mass*: [1]

The relative atomic mass of an element is the average mass of one atom of the element relative to

....

....

3. State which **one** of the following contains the greatest number of molecules. [1]

A 3 g of hydrogen

B 32 g of oxygen

C 36 g of water

D 66 g of carbon dioxide ....

4. Phosgene is a compound of carbon, oxygen and chlorine. It is used to make polyurethanes and polycarbonates. Its percentage composition, by mass, is as follows.

C 12.1% O 16.2% Cl 71.7%

(a) Calculate the **empirical** formula of this compound. [2]

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(b) What other information would you need to know to be able to deduce the **molecular** formula of this compound? [1]

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5. *(a)* The electronic structures of five atoms, **A** to **E**, are listed below. Arrange these atoms in order of increasing molar first ionisation energy. [2]

Atom	**A**	**B**	**C**	**D**	**E**
Electronic structure	$1s^2$	$1s^2\,2s^2$	$1s^2\,2s^2\,2p^1$	$1s^2\,2s^2\,2p^3$	$1s^2\,2s^2\,2p^6$

lowest .... *highest*

(b) State, giving a reason for your choice, which **one** of the following gives the first four ionisation energies for silicon, Si. [2]

	Ionisation energy / kJ mol^{-1}			
	1st	2nd	3rd	4th
W	496	4563	6913	9544
X	578	1817	2745	11578
Y	738	1451	7733	10541
Z	789	1577	3232	4356

Letter ....

Reason ....

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Section A Total [10]

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0 3

Turn over.

Examiner only

SECTION B

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

6. Magnesium is best known for burning with a characteristic brilliant white light, however in industry it is the third most commonly used structural metal. The metal itself was first produced by Sir Humphry Davy in 1808 by the electrolysis of a mixture of magnesia and mercury oxide.

(a) Magnesium has three stable isotopes ^{24}Mg, ^{25}Mg and ^{26}Mg.

(i) State the number of protons present in an atom of ^{24}Mg. [1]

....

(ii) Deduce the number of neutrons present in an atom of ^{26}Mg. [1]

....

(iii) In order to calculate the relative atomic mass of magnesium, what would you need to know in addition to the relative mass of each isotope? [1]

....

(b) Magnesium also has a radioactive isotope ^{28}Mg which has a half-life of 21 hours.

(i) If you started with 2.0 g of ^{28}Mg, calculate the mass of this isotope remaining after 84 hours. [1]

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....

(ii) Name **one** useful radioactive isotope and briefly describe how it is used in medicine, industry or analysis. [2]

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Examiner only

(c) In order to obtain a mass spectrum of a gaseous sample of magnesium, the sample must be ionised.

(i) State how the magnesium atoms are ionised in the sample. [1]

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....

(ii) Give a reason why it is necessary to ionise the magnesium atoms in the sample. [1]

....

....

(iii) State how the ions of magnesium are separated. [1]

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(d) Magnesium reacts with nitrogen forming magnesium nitride, which is an ionic compound.

By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of a nitride ion, N^{3-}. [1]

1s	2s	2p	3s	3p
□	□	□□□	□	□□□

(e) Magnesium nitride reacts with water to form magnesium hydroxide and ammonia.

$$\square\ Mg_3N_2 + \square\ H_2O \longrightarrow \square\ Mg(OH)_2 + \square\ NH_3$$

(i) Balance the equation above. [1]

(ii) Calculate the minimum mass of magnesium nitride required to form 1.75 g of magnesium hydroxide, giving your answer to **three** significant figures. [3]

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0 5

Total [14]

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7. Judith carried out three experiments to study the reaction between powdered magnesium and hydrochloric acid.
She used a gas syringe to measure the volume of hydrogen evolved, at room temperature and pressure, at set intervals. In each case, the amount of acid used was sufficient to react with all the magnesium.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

The details of each experiment are shown in Table 1 below.

Experiment	Mass of magnesium / g	Volume of HCl / cm^3	Concentration of HCl / mol dm^{-3}
A	0.061	40.0	0.50
B	0.101	40.0	1.00
C	0.101	20.0	2.00

Table 1

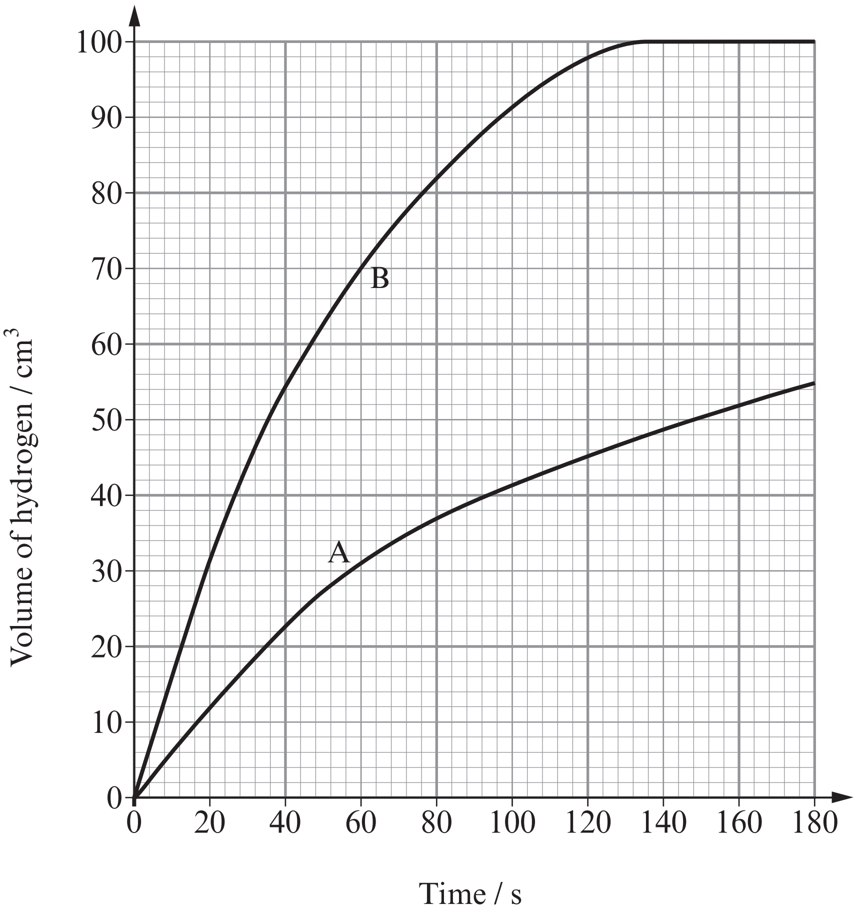
The results obtained in experiment **C** are shown in Table 2 below.

Time / s	Volume of hydrogen / cm^3
0	0
20	50
40	75
60	88
80	92
100	100
120	100

Table 2

(a) The results for experiments **A** and **B** have already been plotted on the grid below.

On the same grid, plot the results for experiment **C** and draw a line of best fit. [3]



(b) (i) State in which experiment the reaction begins most rapidly and **use the graph** to explain your choice. [2]

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....

(ii) By referring to Table 1 give an explanation of your answer in part (i). [1]

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....

(c) State the volume of hydrogen evolved after 30 seconds in experiment **B**. [1]

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(d) Using **only** the values in Table 1, show that the acid is in excess in experiment **C**. [2]

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(e) (i) In experiment **A**, 0.061 g of magnesium produces 60 cm^3 of hydrogen. If 0.122 g of magnesium were used, under the same conditions, then 120 cm^3 would be produced. Explain why using 0.610 g would not produce 600 cm^3 of hydrogen. [1]

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(ii) Calculate the volume of hydrogen produced using 0.610 g of magnesium. [2]

(1 mole of gas molecules occupies 24 dm^3 at 25 °C)

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(f) State one method of slowing down the reaction in experiment **C** and use collision theory to explain your choice. Assume that the quantities of magnesium and hydrochloric acid are the same as those in Table 1. [3]
QWC [1]

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Total [16]

Examiner only

8. *(a)* The vast majority of motor vehicles worldwide are powered by petrol or diesel which come from crude oil. Give **two** reasons why we cannot rely indefinitely on oil as a source of transport fuel. [2]

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(b) Many vehicle manufacturers around the world have made the development of alternative fuels a priority. One such fuel being studied is hydrogen.

Its main advantage is that the only waste product is water, however hydrogen does not occur naturally on Earth. It is produced by passing an electric current through water.

(i) A leading car manufacturer said,
"Cars powered by hydrogen will be pollution-free".
Give **two** reasons why this is not necessarily true. [2]
QWC [1]

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(ii) A spokesperson for a safety group said,
"Hydrogen can burn explosively. It must not be used in cars unless it is 100% safe".
State, giving a reason, whether you agree with this. [1]

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Examiner only

(c) The first line in the visible atomic emission spectrum for hydrogen has a wavelength of 656 nm, while that for helium has a wavelength of 707 nm.
State, giving a reason, which line has

(i) the higher frequency, [1]

....

....

(ii) the higher energy. [1]

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(d) The first ionisation energy of helium is 2370 kJ mol^{-1} while that of neon is 2080 kJ mol^{-1}.
Explain why neon has a lower first ionisation energy than helium. [2]

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(e) Another noble gas is radon. Its more stable isotope ^{222}Rn has a half-life of 3.8 days, decays by α-emission and is responsible for the majority of the public exposure to ionising radiation.

(i) Give the symbol and mass number of the atom formed by the loss of one α-particle from an atom of ^{222}Rn. [1]

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(ii) Explain why doctors are concerned that an over-exposure to radon may cause lung cancer. [1]

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Total [12]

Examiner only

9. Ethanol is an important industrial chemical and can be made by the direct hydration of ethene using a phosphoric acid catalyst.

$$CH_2{=}CH_2(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g) \quad \Delta H = -46\,kJ\,mol^{-1}$$

(a) State, giving your reasons, the general conditions of temperature and pressure required to give a high equilibrium yield of ethanol in this process. [4]
QWC [1]

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(b) Using the standard enthalpy change for the reaction above and the standard enthalpy changes of formation ($\Delta H_f^\ominus$) given in the table below, calculate the standard enthalpy change of formation of gaseous ethanol. [3]

Compound	$\Delta H_f^\ominus$ / kJ mol^{-1}
$CH_2{=}CH_2(g)$	52.3
$H_2O(g)$	–242

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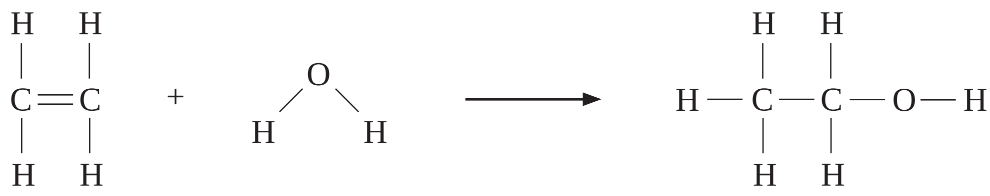
(c) Another way of calculating the enthalpy change of a reaction is by using average bond enthalpies. Use the values in the table below to calculate the enthalpy change for the direct hydration of ethene. [3]



Bond	Average bond enthalpy / kJ mol^{-1}
C—C	348
C═C	612
C—H	412
C—O	360
O—H	463

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(d) (i) Give a reason why the calculated value in *(c)* is different to the actual value, –46 kJ mol^{-1}. [1]

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(ii) Explain whether your answer to part (i) supports the use of average bond enthalpies to calculate the energy change for a reaction. [1]

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Examiner only

(e) Phosphoric acid is an example of a heterogeneous catalyst.
Explain the term *heterogeneous* in this context. [1]

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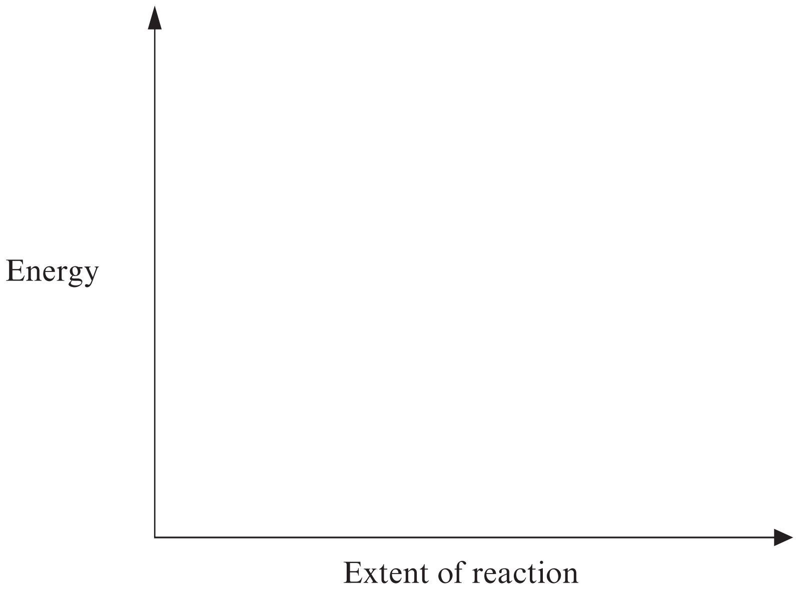
(f) (i) Sketch on the axes below the energy profile for an exothermic reaction. [1]



(ii) On the same axes, sketch and label the energy profile if the same reaction is carried out using a catalyst. [1]

Total [16]

Examiner only

10. Berian was asked to find the identity of a Group 1 metal hydroxide by titration.

He was told to use the following method.

- Fill a burette with hydrochloric acid solution.
- Accurately weigh about 1.14 g of the metal hydroxide.
- Dissolve all the metal hydroxide in water, transfer the solution to a volumetric flask then add more water to make exactly 250 cm^3 of solution.
- Accurately transfer 25.0 cm^3 of this solution into a conical flask.
- Add 2-3 drops of a suitable indicator to this solution.
- Carry out a rough titration of this solution with the hydrochloric acid.
- Accurately repeat the titration several times and calculate a mean titre.

Berian's results are shown below:

Mass of metal hydroxide = 1.14 g

Concentration of acid solution = 0.730 g HCl in 100 cm^3 of water

Mean titre = 23.80 cm^3

(a) Give a reason why Berian does not simply add 1.14 g of metal hydroxide to 250 cm^3 of water. [1]

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(b) Name a suitable piece of apparatus for transferring 25.0 cm^3 of the metal hydroxide solution to a conical flask. [1]

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(c) State why he adds an indicator to this solution. [1]

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(d) Suggest why Berian was told to carry out a rough titration first. [1]

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Examiner only

(e) Explain why he carried out several titrations and calculated a mean value. [1]

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(f) The equation for the reaction between the metal hydroxide and hydrochloric acid is given below. M represents the symbol of the Group 1 metal.

$$MOH + HCl \longrightarrow MCl + H_2O$$

(i) Calculate the concentration, in mol dm^{-3}, of the HCl in the burette. [2]

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(ii) Calculate the number of moles of HCl used in the titration. [1]

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(iii) Deduce the number of moles of MOH in 25.0 cm^3 of the solution. [1]

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(iv) Calculate the total number of moles of MOH in the original solution. [1]

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(v) Calculate the relative molecular mass of MOH. [1]

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(vi) Deduce the Group 1 metal in the hydroxide. [1]

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Total [12]

Section B Total [70]

Question number	Write the question numbers in the left-hand margin

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WJEC
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GCE AS/A level

1091/01-A

CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1

P.M. TUESDAY, 15 May 2012

SJJ*(S12-1091-01A)

THE PERIODIC TABLE

Group

s Block · d Block · p Block

Period	1	2											3	4	5	6	7	0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 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
3	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	40.0 Ar Argon 18
4	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
5	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	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
6	133 Cs Caesium 55	137 Ba Barium 56	139 La ▸ Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) ▸▸ Ac Actinium 89															

Key

A_r — relative atomic mass Symbol Name Z — atomic number

f Block

▸ Lanthanoid elements	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) 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
▸▸ Actinoid elements	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