Mock Exam 1

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

CHEMISTRY **9701**

Paper 2 AS Level Structured Questions **1 hour 35 minutes**

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

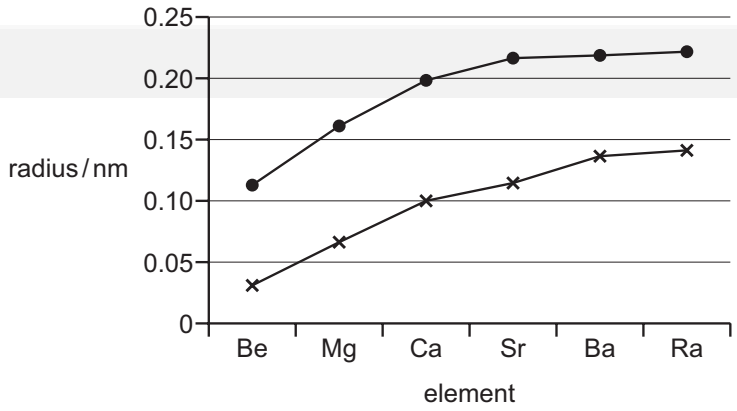
INFORMATION

- The total mark for this paper is 81
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

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

1 The elements in Group 2 and their compounds show various trends in their physical and chemical properties.

(a) The graph below shows the radius values of the atoms and 2+ ions of the elements in Group 2.



(i) Explain why both lines show a steady increase in the values of the radii down the group.

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..... [2]

(ii) State and explain which line represents the atomic radii and which represents the ionic radii.

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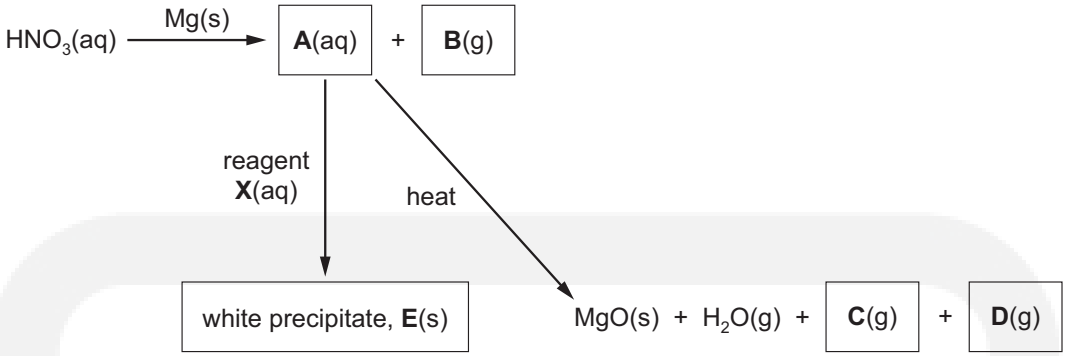
..... [2]

(b) The flow chart below shows a series of reactions.



(i) Give the **formula** of each of the compounds **A** to **D**.

A ..... **B** .....

C ..... **D** .....

[4]

(ii) **E** reacts with dilute aqueous acid to produce a gas that turns limewater cloudy.

Suggest the identity of reagent **X**.

..... [1]

Over one million tonnes of hydrogen cyanide, HCN, are produced each year using the Andrussow process. The overall equation for the reaction is shown.

$$CH_4(g) + NH_3(g) + 1\tfrac{1}{2}O_2(g) \rightleftharpoons HCN(g) + 3H_2O(g)$$

(c) The reaction exists as a dynamic equilibrium.

(i) Explain what is meant by the term *dynamic equilibrium*.

.....

..... [1]

(ii) State and explain how the amounts of the chemicals present in the equilibrium mixture will change when the pressure is increased.

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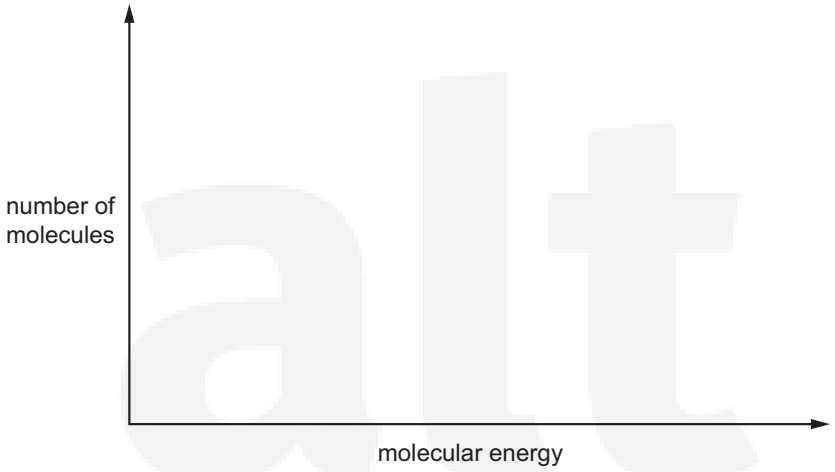
..... [2]

(d) The process uses a platinum catalyst, which increases the rate of reaction.

Sketch a Boltzmann distribution on the axes given below and use your diagram to explain how the platinum catalyst increases the rate of the reaction.



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..... [3]

(e) **(d)** The reaction of hydrogen cyanide with propanone is an important first step in many organic syntheses.

(i) Give the full name of the mechanism of this reaction.

..... [1]

(ii) Complete the diagram to show the mechanism of the reaction of hydrogen cyanide with propanone.
Draw the structure of the intermediate and the product of the reaction.
Include all relevant charges, partial charges, curly arrows and lone pairs.

[5]

[Total: 21]

2 For many compounds the enthalpy change of formation cannot be calculated directly. An indirect method based on enthalpy changes of combustion can be used.

The enthalpy change of combustion can be found by a calorimetry experiment in which the heat energy given off during combustion is used to heat a known mass of water and the temperature change recorded.

(a) (i) Explain the meaning of the term *standard enthalpy change of combustion*.

.....

.....

..... [3]

(ii) Write the equation for the complete combustion of ethanol, C_2H_5OH.

..... [1]

(b) In an experiment to determine the enthalpy change of combustion of ethanol, 0.23 g of ethanol was burned and the heat given off raised the temperature of 100 g of water by 16.3 °C.

(i) Calculate the heat energy change, q, during the combustion of 0.23 g of ethanol.

q = ... J [1]

(ii) Calculate the enthalpy change on burning 1 mole of ethanol. Include a sign in your answer.

ΔH = ... $kJ\,mol^{-1}$ [1]

(iii) Suggest **two** reasons why the value for the enthalpy change of combustion of ethanol determined by a simple laboratory calorimetry experiment is likely to be lower than the true value.

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..... [2]

(c) The table gives some enthalpy change of combustion values.

substance	enthalpy change of combustion / kJ mol^{-1}
C(s)	–393.5
$H_2(g)$	–285.8
$C_3H_7OH(l)$	–2021.0

(i) Construct a labelled energy cycle to show how these values could be used to calculate the enthalpy change of formation of $C_3H_7OH(l)$, ΔH_f.

$$3C(s) + 4H_2(g) + \frac{1}{2}O_2(g) \xrightarrow{\Delta H_f} C_3H_7OH(l)$$

[3]

(ii) Calculate the enthalpy change of formation, ΔH_f, of $C_3H_7OH(l)$.

ΔH_f = ... kJ mol^{-1} [2]

[Total: 13]

3 The elements in Group 17, the halogens, and their compounds, show many similarities and trends in their properties. Some data are given for the elements fluorine to iodine.

element	bond energy / kJ mol^{-1}	standard enthalpy change of atomisation, $\Delta H_{at}^{\ominus}$ / kJ mol^{-1}	boiling point of element / K	boiling point of **hydrogen halide** / K
fluorine, F–F	158	79	85	293
chlorine, Cl–Cl	242	121	238	188
bromine, Br–Br	193	112	332	206
iodine, I–I	151	107	457	238

(a) (i) Explain the meaning of the term *standard enthalpy change of atomisation*.

.....

.....

..... [3]

(ii) For fluorine and chlorine, the enthalpy changes of atomisation are half the value of the bond energies.

For bromine and iodine, the enthalpy changes of atomisation are much more than half the value of the bond energies.

Suggest a reason for this difference.

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.....

..... [1]

(iii) The standard enthalpy of formation of iodine monochloride, ICl, is –24.0 kJ mol^{-1}.

Use this information and the bond energies of iodine and chlorine to calculate the I–Cl bond energy.

I–Cl bond energy = ... kJ mol^{-1} [2]

(b) **(i)** Explain the trend in the boiling points of the hydrogen halides, HC*l*, HBr and HI.

.....

.....

..... [2]

(ii) Suggest why the hydrogen halide HF does not follow the trend in boiling points shown by HC*l*, HBr and HI.

.....

.....

..... [2]

(c) In an experiment, two of the halogens are represented as $\mathbf{P}_2$ and $\mathbf{Q}_2$.

$\mathbf{P}_2$ combines with hydrogen on heating to form H**P**, which can be easily broken down into its elements. A solution of H**P** in water reacts with aqueous silver ions to form a yellow precipitate that is insoluble in dilute aqueous ammonia.

$\mathbf{Q}_2$ combines explosively with hydrogen in sunlight to form H**Q**, which is stable to heat. A solution of H**Q** in water reacts with aqueous silver ions to form a white precipitate that is soluble in dilute aqueous ammonia.

(i) Identify the halogens $\mathbf{P}_2$ and $\mathbf{Q}_2$.

$\mathbf{P}_2$ = ... $\mathbf{Q}_2$ = ...
[1]

(ii) H**P** readily decomposes into its elements when heated but H**Q** is stable to heat.
Explain this with reference to bond energies.

.....

.....

..... [2]

(iii) Write an equation for the thermal decomposition of H**P**.

..... [1]

(iv) Write ionic equations, including state symbols, for

1. the formation of the white precipitate on addition of aqueous silver ions to aqueous H**Q**,

   .....

2. the subsequent dissolving of this precipitate in dilute aqueous ammonia.

   .....

[2]

(d) The Group 17 elements can oxidise many metals to form halides.

(i) Describe the relative reactivity of the elements in Group 17 as oxidising agents.

.....

..... [1]

(ii) Chlorine reacts with hot tin metal to form tin(IV) chloride, $SnCl_4$.

$SnCl_4$ is a colourless liquid at room temperature that reacts vigorously with water to form an acidic solution.

Suggest the type of structure and bonding shown by $SnCl_4$. Explain your answer.

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..... [2]

(e) (c) The Group 17 elements form soluble halides with sodium.

(i) Describe what is seen when dilute $AgNO_3(aq)$ is added to NaBr(aq) followed by aqueous ammonia.

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..... [2]

(ii) NaCl reacts with concentrated H_2SO_4 to form HCl and $NaHSO_4$.

Explain the difference between the reactions of concentrated H_2SO_4 with NaCl and with NaI. Your answer should refer to the role of the sulfuric acid in each reaction.

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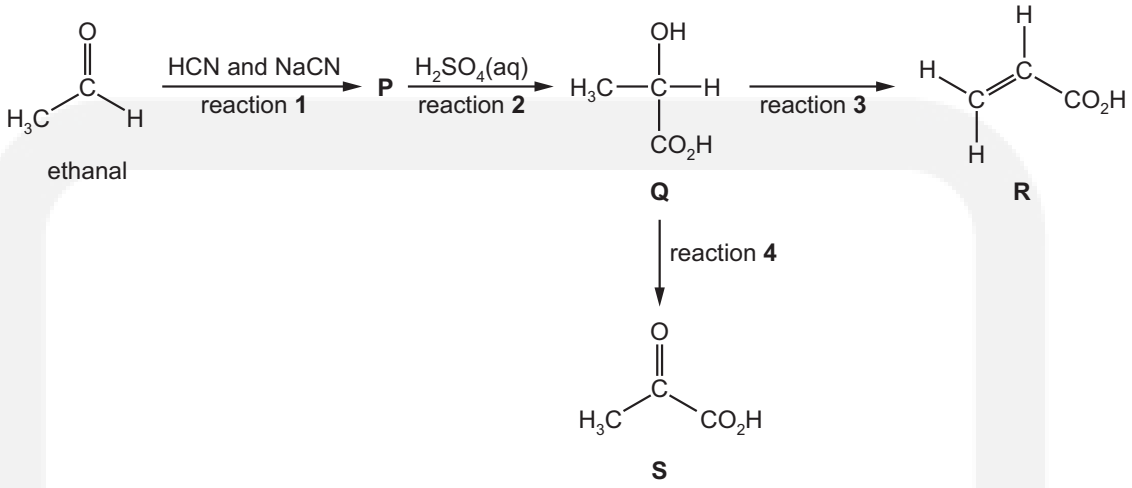
..... [3]

[Total: 24]

4 The diagram shows a reaction sequence starting from ethanal.



(a) (i) Draw the **displayed** formula of **P**.

[1]

(ii) Name the type of chemical reaction that occurs in reaction **3**.

..... [1]

(iii) Write an equation to represent reaction **4**.

Use [O] to represent the oxidising agent.

..... [1]

(iv) State the reagents and conditions for reaction **4**.

..... [1]

(b) Compound **Q** is formed as a mixture of two optical isomers.

(i) Explain what is meant by the term *optical isomers*.

.....

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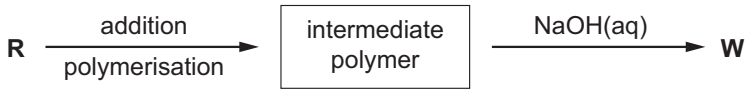
..... [1]

(ii) Draw the **two** optical isomers of **Q**, showing clearly their three-dimensional structures.

[2]

(c) **R** can be used to make a polymer, **W**, in two steps.



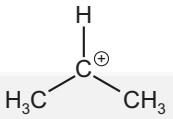
Draw one repeat unit of **W**.

[3]

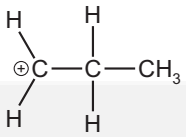
(d) Compound **Z**, $H_2C{=}CHCH_3$, is produced from **R**.

Z can be used in a two-step process to produce 2-aminopropane.

(i) In the first step, **Z** reacts with HBr to form two products. The structure of the product depends on which intermediate is formed, intermediate **I** or intermediate **II**.



intermediate **I**



intermediate **II**

Explain why intermediate **I** is more likely to form than intermediate **II**.

.....

.....

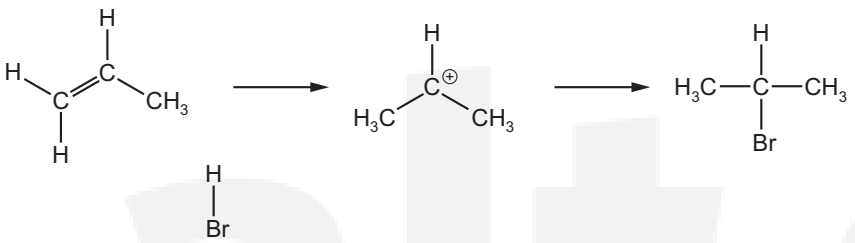
.....

..... [2]

(ii) When intermediate **I** forms, the product of the first step is **T**.

Complete the diagram to show the mechanism for the conversion of **Z** to **T**.
Include all relevant charges, partial charges, curly arrows and lone pairs.

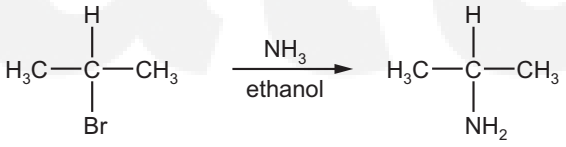
Z **T**



[3]

(iii) **T** can then be converted to 2-aminopropane.

T



2-aminopropane

Name the mechanism for this conversion.

..... [1]

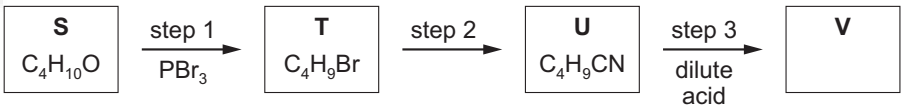
[Total: 16]

5 **S** is a secondary alcohol with molecular formula $C_4H_{10}O$.

(a) Draw the displayed formula of **S**.

[1]

(b) **S** is converted to **V** in a three-step reaction sequence.



In step 1, the secondary alcohol **S** reacts with PBr_3 to produce **T**, which has molecular formula C_4H_9Br.

(i) Give the systematic name of **T**.

..... [1]

(ii) Name the type of reaction that occurs in step 1.

..... [1]

(iii) State the reagent(s) and conditions for step 2.

.....

..... [2]

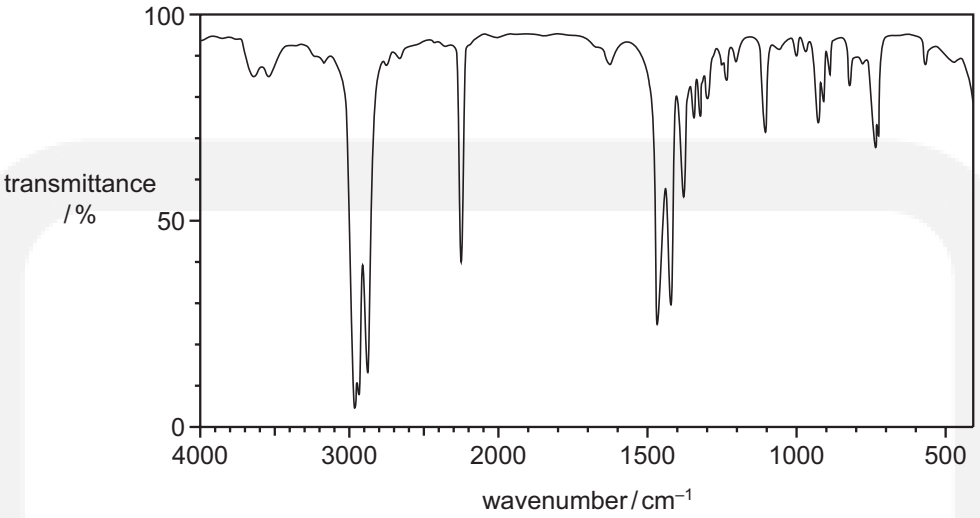
(iv) Step 3 involves heating C_4H_9CN with dilute acid to form **V**.

Complete the equation for this reaction.

$$.....C_4H_9CN + ...H^+ + ...H_2O \rightarrow .....$$ [2]

(v) An unlabelled sample contains either **S**, **T** or **U**.

The sample produces the infrared spectrum shown.



Explain how this spectrum confirms that the unknown sample contains **U**.

In your answer identify **one** relevant absorption in the infrared spectrum and the bond that corresponds to this absorption in the region above 1500 cm^{-1}.

.....

..... [1]

[Total: 8]

Important values, constants and standards

molar gas constant	$R = 8.31\,J\,K^{-1}\,mol^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\,C\,mol^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23}\,mol^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,C$
molar volume of gas	$V_m = 22.4\,dm^3\,mol^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,dm^3\,mol^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,mol^2\,dm^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,kJ\,kg^{-1}\,K^{-1}$ ($4.18\,J\,g^{-1}\,K^{-1}$)

The Periodic Table of Elements

Group 1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –