Mock Exam 2

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

CHEMISTRY **9701**

Paper 2 AS Level Structured Questions **1 hour 25 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 72
- 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 This question is about atomic structure and the compounds of calcium, nitrogen and oxygen.

(a) Most elements contain different isotopes.

State **two** differences between isotopes of the same element.

.....

.....

..... **[1]**

(b) Complete the table for an atom and an ion of two different elements.

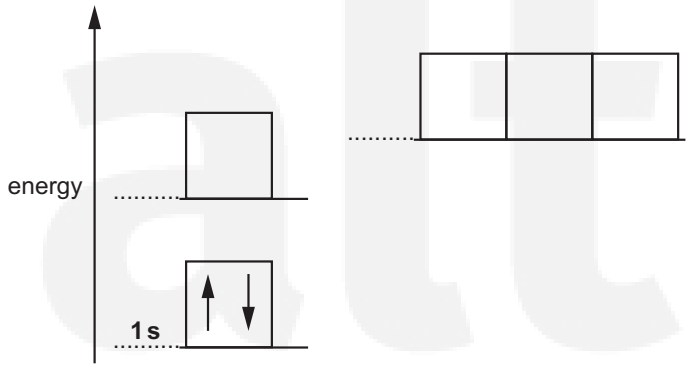
Element	Mass number	Protons	Neutrons	Electrons	Charge
.....	.....	26	28	.....	0
.....	80	.....	.....	36	2−

[2]

(c) Electrons occupy orbitals which are arranged in energy levels.

In the diagram below, each box represents an orbital and each electron is shown as an arrow.

Label the sub-shells and add arrows to show how electrons occupy orbitals in an atom of **oxygen**.



[2]

(d) Calcium reacts with nitrogen to form calcium nitride, Ca_3N_2, which is an ionic compound.

(i) Construct a 'dot-and-cross' diagram for Ca_3N_2.

Show outer electrons only and the charges on each ion.

[2]

(ii) Calcium nitride reacts with water to form a solution containing two alkaline compounds.

Write an equation for this reaction.

..... **[2]**

(e) Nitrogen forms an oxide with the formula N_2O. A molecule of N_2O is linear and has a nitrogen atom in the centre.

Draw a 'dot-and-cross' diagram for an N_2O molecule.

Show outer electrons only.

[2]

(f) A mixture of magnesium oxide and magnesium hydroxide has a mass of 3200 mg

This mixture is reacted with carbon dioxide to form magnesium carbonate and water.
The mass of water produced is 210 mg

$$Mg(OH)_2 + CO_2 \rightarrow MgCO_3 + H_2O$$

$$MgO + CO_2 \rightarrow MgCO_3$$

Calculate the percentage by mass of magnesium oxide in this mixture.

[4 marks]

% of magnesium oxide _____

[Total: 15]

2

The Contact process for the manufacture of sulfuric acid was originally patented in the 19th century and is still in use today.

The key step in the overall process is the reversible conversion of sulfur dioxide to sulfur trioxide in the presence of a vanadium(V) oxide catalyst.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -196\ kJ\ mol^{-1}$$

(a) **(a)** One way in which the sulfur dioxide for this reaction is produced is by heating the sulfide ore iron pyrites, FeS_2, in air. Iron(III) oxide is also produced. Write an equation for this reaction.

..... [2]

(b)

(i) Sulfur dioxide and sulfur trioxide both contain only S=O double bonds.

Draw labelled diagrams to show the shapes of these two molecules.

SO_2 SO_3

[2]

(ii) For your diagrams in **(i)**, name the shapes and suggest the bond angles.

SO_2 shape ..... SO_3 shape .....

SO_2 bond angle ..... SO_3 bond angle .....

[2]

(c) The conversion of sulfur dioxide into sulfur trioxide is carried out at a temperature of 400 °C.

(i) With reference to Le Chatelier's Principle and reaction kinetics, state and explain one advantage and one disadvantage of using a higher temperature.

.....

.....

.....

.....

.....

..... [4]

(ii) State the expression for the equilibrium constant, K_p, for the formation of sulfur trioxide from sulfur dioxide.

K_p =

[1]

(iii) 2.00 moles of sulfur dioxide and 2.00 moles of oxygen were put in a flask and left to reach equilibrium.
At equilibrium, the pressure in the flask was 2.00×10^5 Pa and the mixture contained 1.80 moles of sulfur trioxide.

Calculate K_p. Include the units.

K_p = ...

units = ...
[5]

(d) Nitrogen monoxide reacts with chlorine to form nitrosyl chloride (NOCl).

$$2NO(g) + Cl_2(g) \rightleftharpoons 2NOCl(g)$$

1.50 mol of NO are mixed with 1.00 mol of Cl_2 and the mixture is left to reach equilibrium at a given temperature.
The equilibrium mixture contains 0.350 mol of NOCl

(i) Calculate the amount, in moles, of NO and of Cl_2 in the equilibrium mixture.

[2 marks]

Amount of NO _____ mol

Amount of Cl_2 _____ mol

(ii) Give the expression for the equilibrium constant, K_c, for the reaction between nitrogen monoxide and chlorine to form nitrosyl chloride.

[1 mark]

K_c =

(iii) A different equilibrium mixture is prepared in a flask of volume 800 cm^3 at a different temperature.
At equilibrium this mixture contains 0.850 mol of NO and 0.458 mol of Cl_2
For the reaction at this temperature $K_c = 1.32 \times 10^{-2}\ mol^{-1}\ dm^3$

Determine the amount, in moles, of NOCl in this equilibrium mixture.

[4 marks]

Amount of NOCl _____ mol

[Total: 24]

3 Ethanoic acid, CH_3COOH, is the main dissolved acid in vinegar.

(a) Ethanoic acid is a weak acid.

What is meant by *acid* and *weak acid*?

.....

.....

..... **[1]**

(b) Aluminium is reacted with ethanoic acid.

(i) The unbalanced equation for the reaction is shown below.

Balance the equation.

……. A*l*(s) + ……. CH_3COOH(aq) → ……. $(CH_3COO)_3Al$(aq) + …… H_2(g)

[1]

(ii) This reaction is a redox reaction.

Deduce which element has been oxidised and which element has been reduced, and state the changes in oxidation number.

Element oxidised: ..... oxidation number change: from ..... to .....

Element reduced: ..... oxidation number change: from ..... to .....

[2]

(c) A student plans to determine the concentration, in mol dm^{-3}, of CH_3COOH in a bottle of vinegar. The student will carry out a titration with aqueous barium hydroxide, $Ba(OH)_2(aq)$.

The student's method is outlined below.

- Dilute 10.0 cm^3 of vinegar from the bottle with distilled water and make the solution up to 250.0 cm^3.
- Add the diluted vinegar to the burette.
- Titrate 25.0 cm^3 volumes of 0.0450 mol dm^{-3} $Ba(OH)_2$ with the diluted vinegar.

The mean titre of the diluted vinegar is 25.45 cm^3.

The reaction in the student's titration is shown below.

$$2CH_3COOH(aq) + Ba(OH)_2(aq) \rightarrow (CH_3COO)_2Ba(aq) + 2H_2O(l)$$

(i) Calculate the concentration, in mol dm^{-3}, of CH_3COOH in the original bottle of vinegar.

Show your working.

concentration of CH_3COOH = ... mol dm^{-3} **[4]**

(ii) Suggest **one** assumption that the student has made that might mean that their calculated concentration of ethanoic acid in the vinegar is invalid.

Predict, with a reason, how the experimental result would differ from the actual concentration of CH_3COOH if the assumption were **not** correct.

.....

.....

.....

..... **[2]**

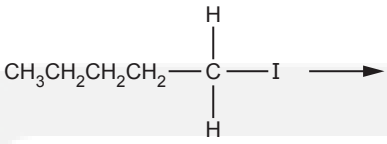
[Total: 10]

3 This question is about 1-iodopentane, $CH_3CH_2CH_2CH_2CH_2I$.

(a) 1-Iodopentane can be hydrolysed by aqueous sodium hydroxide.

(i) Outline the mechanism for this reaction.

Include curly arrows, relevant dipoles and the final product(s).



[3]

(ii) 1-Iodopentane can also be hydrolysed by water using aqueous silver nitrate, with ethanol as the solvent.

A student uses this method to compare the rates of hydrolysis of 1-iodopentane and 1-bromopentane.

What measurement and observation would allow the student to compare the rates of hydrolysis?

.....

..... **[1]**

(iii) 1-Iodopentane was found to react faster than 1-bromopentane.

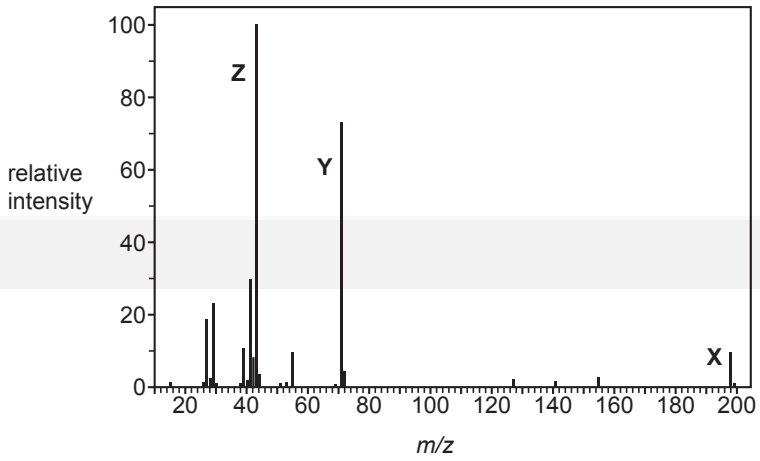
Explain why.

.....

.....

..... **[2]**

(b) The mass spectrum of 1-iodopentane is shown below.



(i) What information is given by the peak labelled **X** (*m*/*z* = 198)?

..... **[1]**

(ii) Write the structural formulae of the ions responsible for the peaks labelled **Y** and **Z**.

Y (*m*/*z* = 71) .....

Z (*m*/*z* = 43) ..... **[2]**

(c) 2-Iodo-2-methylbutane is an isomer of 1-iodopentane.

(i) Draw the structure of 2-iodo-2-methylbutane.

[1]

(ii) Suggest **one** similarity and **one** difference between the mass spectra of 1-iodopentane and 2-iodo-2-methylbutane.

Similarity .....

.....

Difference .....

..... **[2]**

[Total: 12]

5

5 A student reacted together an alcohol and a carboxylic acid under appropriate conditions to produce an ester.
A sweet smelling organic liquid, **Q**, with the empirical formula C_2H_4O was produced.
The M_r of **Q** was found by experiment to be 87.5.

(a) What is the molecular formula of **Q**?

..... [1]

(b) In the boxes below, draw the structural formulae of **four** isomers with this formula that are esters.

W	**X**
Y	**Z**

[4]

A sample of **Q** was hydrolysed by heating with aqueous sulfuric acid.
The resulting mixture was heated under reflux with acidified potassium dichromate(VI) to give a **single** organic product, **R**.
The product, **R**, was collected and subjected to the following tests.

A sample of **R** gave no reaction with Tollens' reagent.

A second sample of **R** gave no reaction with 2,4-dinitrophenylhydrazine reagent.

A third sample of **R** gave an effervescence with sodium carbonate.

(c) (i) What does the result of the test with Tollens' reagent show about **R**?

.....

(ii) What does the result of the test with 2,4-dinitrophenylhydrazine reagent show about **R**?

.....

(iii) What functional group does the result of the test with sodium carbonate show to be present in **R**?

.....

[3]

(d) (i) What is the identity of the single organic compound, **R**?

.....

(ii) Which of your structures, **W**, **X**, **Y** or **Z**, represents the ester, **Q**?

.....

[2]

(e) Which, if any, of your esters, **W**, **X**, **Y** or **Z**, is chiral?

.....

..... [1]

[Total: 11]

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 –