Cambridge International AS & A Level

**Cambridge International Examinations**
Cambridge International Advanced Subsidiary and Advanced Level

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| CANDIDATE NAME | | | | | | | | | |
| CENTRE NUMBER | | | | | | CANDIDATE NUMBER | | | |

*8468970221*

**CHEMISTRY** **9701/22**

Paper 2 AS Level Structured Questions **October/November 2016**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **10** printed pages and **2** blank pages.


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

**1** A 0.50 g sample of a Group 2 metal, **M**, was added to 40.0 $cm^3$ of 1.00 mol $dm^{-3}$ hydrochloric acid (an excess).

equation 1 $\quad\quad$ **M**(s) + 2HC$l$(aq) $\rightarrow$ **M**C$l_2$(aq) + $H_2$(g)

**(a)** Calculate the amount, in moles, of hydrochloric acid present in 40.0 $cm^3$ of 1.00 mol $dm^{-3}$ HC$l$.

amount = ..... mol [1]

**(b)** When the reaction had finished, the resulting solution was made up to 100 $cm^3$ in a volumetric flask.

A 10.0 $cm^3$ sample of the solution from the volumetric flask required 15.0 $cm^3$ of 0.050 mol $dm^{-3}$ sodium carbonate solution, $Na_2CO_3$, for complete neutralisation of the remaining hydrochloric acid.

**(i)** Write the equation for the complete reaction of sodium carbonate with hydrochloric acid.

..... [1]

**(ii)** Calculate the amount, in moles, of sodium carbonate needed to react with the hydrochloric acid in the 10.0 $cm^3$ sample from the volumetric flask.

amount = ..... mol [1]

**(iii)** Calculate the amount, in moles, of hydrochloric acid in the 10.0 $cm^3$ sample.

amount = ..... mol [1]

**(iv)** Calculate the total amount, in moles, of hydrochloric acid remaining after the reaction shown in equation 1.

amount = ..... mol [1]

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**(v)** Use your answers to **(a)** and **(b)(iv)** to calculate the amount, in moles, of hydrochloric acid that reacted with the 0.50 g sample of **M**.

amount = ..... mol [1]

**(vi)** Use your answer to **(v)** and equation 1 to calculate the amount, in moles, of **M** in the 0.50 g sample.

amount = ..... mol [1]

**(vii)** Calculate the relative atomic mass, $A_r$, of **M** and identify **M**.

$A_r$ of **M** = .....

identity of **M** = .....
[2]

[Total: 9]

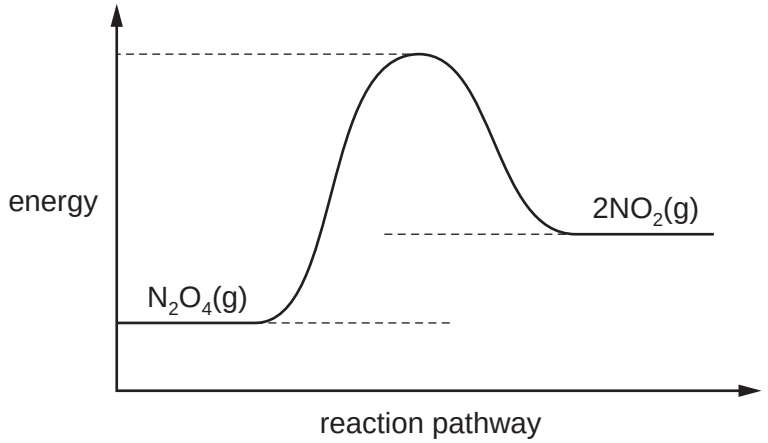
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**[Turn over**

**2** Dinitrogen tetraoxide, $N_2O_4$, and nitrogen dioxide, $NO_2$, exist in dynamic equilibrium with each other.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = +54\,kJ\,mol^{-1}$$

The energy profile for this reaction is shown.




**(a)** Add labelled arrows to the energy profile to indicate

- the enthalpy change of the reaction, $\Delta H$,
- the activation energy of the forward reaction, $E_a$.

[2]

**(b)** 0.0500 mol of $N_2O_4$ was placed in a sealed vessel of volume 1.00 $dm^3$, at a temperature of 50 °C and a pressure of $1.68 \times 10^5$ Pa. The mass of the resulting equilibrium mixture was 4.606 g.

**(i)** Calculate the average molecular mass, $M_r$, of the resulting equilibrium mixture. Give your answer to **three** significant figures.

$M_r$ = ..... [2]

**(ii)** The number of moles of $N_2O_4$ that dissociated can be represented by $n$.

State, in terms of $n$, the amount, in moles, of $NO_2$ in the equilibrium mixture.

moles of $NO_2$ = ..... [1]

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The number of moles of $N_2O_4$ remaining at equilibrium is (0.05 – *n*).

**(iii)** State, in terms of *n*, the total amount, in moles, of gas in the equilibrium mixture.

[1]

**(iv)** State, in terms of *n*, the mole fraction of $NO_2$ in the equilibrium mixture.

[1]

In this equilibrium mixture, the mole fraction of $NO_2$ is 0.400.

**(v)** Use your answers to **(ii)** and **(iv)** to calculate the amount in moles of each gas in the equilibrium mixture. Give your answers to **three** significant figures.

amount of $N_2O_4$ = ..... mol

amount of $NO_2$ = ..... mol
[2]

**(vi)** Write the expression for the equilibrium constant, $K_p$, for this equilibrium.

$K_p$ =

[1]

**(vii)** Use the total pressure of the mixture, $1.68 \times 10^5$ Pa, to calculate the value of the equilibrium constant, $K_p$, and give its units.

$K_p$ = .....

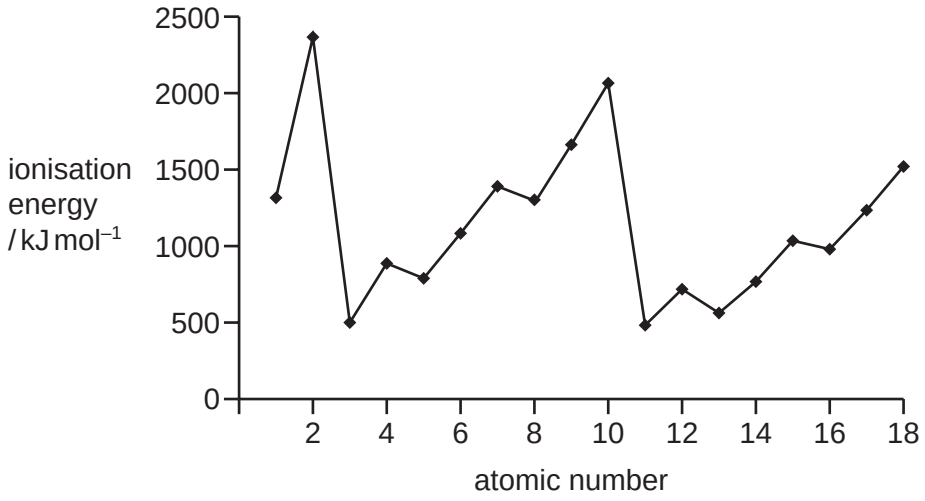
units = .....
[3]

[Total: 13]

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**3** The Periodic Table is arranged such that the properties of the elements show a number of trends.

**(a)** A plot of the first ionisation energies for the first 18 elements is shown.




**(i)** Explain why the values show a general increase from atomic number 11 to 18.

.....

.....

..... [2]

**(ii)** Explain the decreases in first ionisation energies between

- atomic numbers 12 and 13,

.....

.....

.....

- atomic numbers 15 and 16.

.....

.....

.....

[4]

**(iii)** Suggest an explanation for the trend in the first ionisation energies of the elements with atomic numbers 2, 10 and 18.

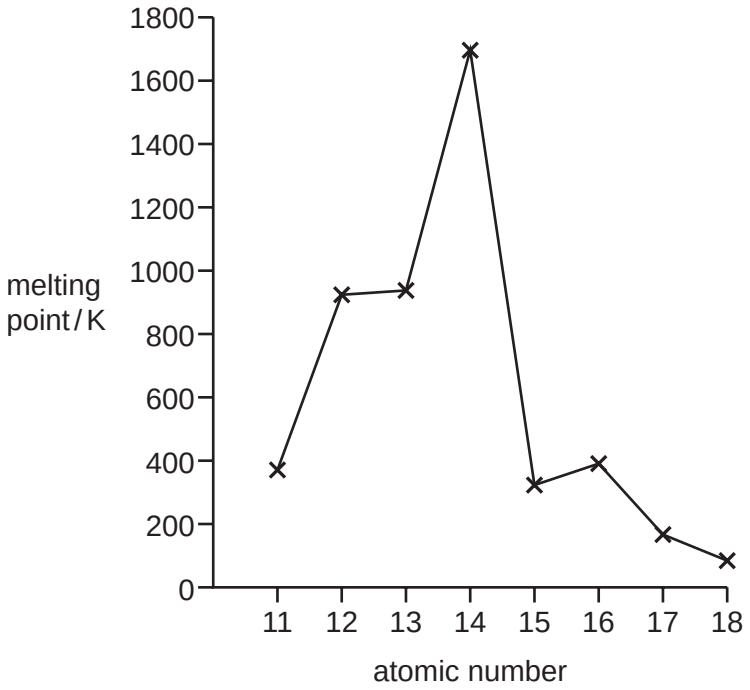
.....

.....

..... [2]

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**(b)** A plot of the melting points of the elements across the third period is shown.




**(i)** Explain the increase in melting point from atomic number 11 to 12.

.....

.....

..... [2]

**(ii)** Suggest a reason why the increase from atomic number 12 to 13 is much smaller than the increase from atomic number 11 to 12.

.....

..... [1]

**(iii)** State and explain the pattern of the melting points from atomic number 15 to 18.

.....

.....

.....

..... [3]

**(iv)** Explain why the element with atomic number 14 has a melting point so much higher than the rest of the elements in the third period.

.....

..... [1]

[Total: 15]

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**[Turn over**

**4** In each section of this question the structural formula of an organic compound is shown. For each compound answer the questions about it.

**(a)** $CH_3CH_2CHBrCH_3$

**(i)** Name this compound.

..... [1]

**(ii)** This compound shows stereoisomerism.

Draw the **two** stereoisomers in the conventional way.

[2]

**(iii)** Give the structures of **three** other structural isomers of $C_4H_9Br$.

[3]

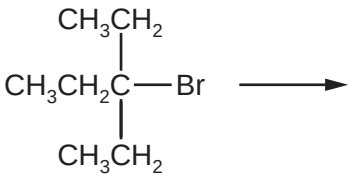
**(b)** $(C_2H_5)_3CBr$

**(i)** Name this compound.

..... [1]

**(ii)** $(C_2H_5)_3CBr$ reacts with aqueous $OH^-$.

Complete the mechanism for this reaction including all necessary curly arrows, charges, partial charges and lone pairs.




[3]

**(iii)** What *type of mechanism* occurs in **(ii)**?

..... [1]

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**(c)** $CH_3CH_2CH_2CHBrCH_3$

**(i)** Give the reagents and conditions necessary for the conversion of this compound into a mixture of alkenes.

.....

..... [2]

**(ii)** Give the name of the mechanism for the conversion in **(i)**.

..... [1]

**(iii)** Draw the skeletal formulae of the three alkenes produced by the conversion in **(i)**.

[3]

[Total: 17]

**5** In each section of this question choose the answer or answers from the options listed.

**(a)** Six particles are listed.

$H\bullet$ $H^+$ $Cl\bullet$ $Cl^-$ $\bullet CH_3$ $^+CH_3$

**(i)** Identify **two** particles produced during the reaction of methane and chlorine in the presence of UV light.

..... [1]

**(ii)** Identify the **two** particles produced by the heterolytic fission of a bond in chloromethane.

..... [1]

**(b)** Seven reaction types are listed.

addition substitution oxidation elimination

hydrolysis condensation reduction

**(i)** Name the type of reaction involved when Tollens' reagent is used to identify an aldehyde.

..... [1]

**(ii)** Name the type of reaction involved in the test for a carbonyl group using 2,4-DNPH.

..... [1]

**(iii)** Name the type of reaction involved in the reaction of a ketone with $NaBH_4$.

..... [1]

**(iv)** Name the type of reaction involved in the reaction of an aldehyde with HCN.

..... [1]

[Total: 6]

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