Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

8367336991

CHEMISTRY **9701/23**

Paper 2 AS Level Structured Questions **May/June 2017**

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 **12** printed pages.

IB17 06_9701_23/6RP

CAMBRIDGE International Examinations

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

1 Combustion data can be used to calculate the empirical formula, molecular formula and relative molecular mass of many organic compounds. Combustion data cannot distinguish between different structural isomers.

(a) Define the term *structural isomers*.

....

....

....

.... [2]

(b) **P** is a hydrocarbon, C_xH_y. A gaseous sample of **P** occupied a volume of 25 cm^3 at 37 °C and 100 kPa.

The sample was completely burned in 200 cm^3 of oxygen (an excess).
The final volume, measured under the same conditions as the gaseous sample (so that the water produced is liquid and its volume can be ignored), was 150 cm^3.

Treating the remaining gaseous mixture with concentrated alkali, to absorb carbon dioxide, decreased the volume to 50 cm^3.

The equation for the complete combustion of **P** can be represented as shown.

$$C_xH_y + (x + \frac{y}{4})O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

(i) Use the data given to calculate the value of *x*.

x = ... [1]

(ii) Use the data given to calculate the value of $(x + \frac{y}{4})$.

$(x + \frac{y}{4})$ = ... [1]

If you were unable to calculate values in **(b)(i)** and **(b)(ii)** then use the data in this box for the remaining parts of this question. These are **not** the correct values.

$$x = 6 \qquad (x + \frac{y}{4}) = 9$$

(iii) Give the molecular formula and the empirical formula of **P**.

molecular formula of **P** ....

empirical formula of **P** ....
[2]

(iv) **P** is unbranched.

Give the skeletal formulae for two possible structures of **P** that are positional isomers of each other.

[2]

(v) Use the general gas equation to calculate the mass of **P** present in the original 25 cm^3 gaseous sample, which was measured at 37 °C and 100 kPa.

Give your answer to **three** significant figures.

mass = ... g [3]

[Total: 11]

2 The halogens, chlorine, bromine and iodine, and their compounds, show a variety of similarities and trends in their physical and chemical properties.

(a) **(i)** Give the colours and states of chlorine, bromine and iodine at room temperature and pressure.

halogen	colour	state
chlorine		
bromine		
iodine		

[2]

(ii) The halogens become less volatile down the group.

Explain this trend in volatility.

....

....

.... [2]

(b) The halogens are oxidising agents.

State and explain the trend in oxidising power of the halogens.

....

....

....

.... [3]

(c) Concentrated sulfuric acid reacts with solid sodium halides.

(i) State any observations that would be made on addition of concentrated sulfuric acid to

- solid sodium chloride, ...

....

- solid sodium iodide. ....

....

[2]

(ii) Give reasons for the difference in the observations in **(i)**.

....

....

.... [2]

(iii) The addition of concentrated sulfuric acid to solid sodium bromide, NaBr, produces brown fumes and an acidic gas that decolourises acidified potassium manganate(VII) solution. This acidic gas is a significant contributor to acid rain.

Write the equation for the reaction of concentrated sulfuric acid with sodium bromide.

.... [2]

(d) An aqueous solution, **Z**, contains a mixture of sodium chloride and sodium iodide.

(i) Excess aqueous silver nitrate is added to **Z** in a test-tube. A yellow precipitate forms.

Explain the colour of this precipitate.

....

.... [1]

(ii) Aqueous ammonia is then added to the test-tube in **(i)**. The mass of precipitate decreases.

Explain this observation.

....

.... [1]

[Total: 15]

3 Sulfur trioxide, SO_3, is manufactured from sulfur dioxide and oxygen by the Contact process.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -196.0\,kJ\,mol^{-1}$$

(a) The enthalpy change of formation of SO_2, ΔH_f $SO_2(g)$, is $-296.8\,kJ\,mol^{-1}$.

(i) Define the term *enthalpy change of formation*.

....

....

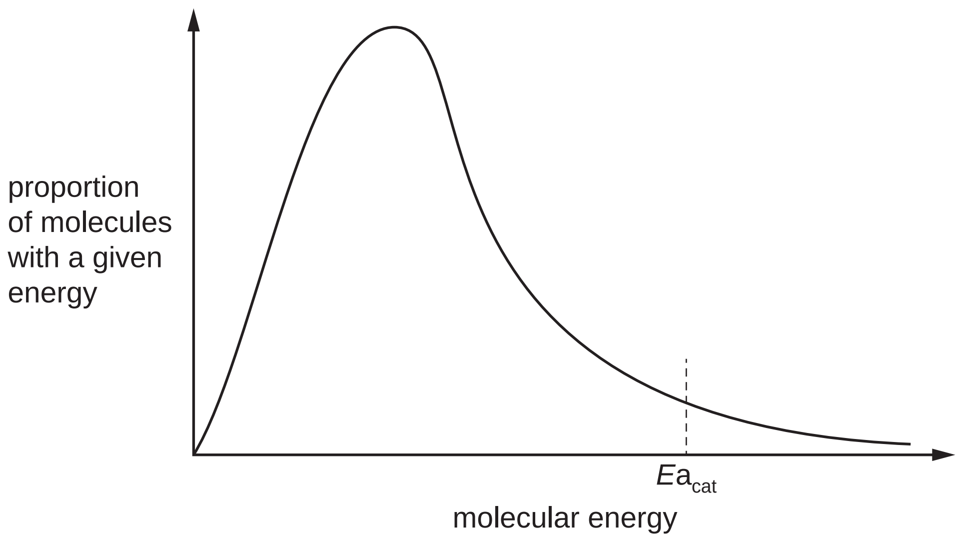
.... [2]

(ii) Use the data to calculate the enthalpy change of formation of $SO_3(g)$.

ΔH_f $SO_3(g)$ = ... $kJ\,mol^{-1}$ [2]

(b) The Contact process is usually carried out at a temperature of approximately 700 K, a pressure of approximately 150 kPa and in the presence of a vanadium(V) oxide catalyst, V_2O_5.

The Boltzmann distribution for a mixture of SO_2 and O_2 at 700 K is shown.
Ea_{cat} represents the activation energy for the reaction in the presence of the catalyst.



(i) Add a labelled mark, Ea_{uncat}, to the diagram to indicate the activation energy in the absence of the catalyst. [1]

(ii) State the benefit of using a catalyst in this reaction. Explain how it achieves this effect.

....

....

....

.... [2]

(iii) State and explain how an increase in pressure would affect both the rate of reaction and the yield of SO_3 in the Contact process.

rate ....

....

....

....

yield ....

....

....

....
[4]

(c) At a pressure of 1.50×10^5 Pa, 1.00 mol of sulfur dioxide gas, SO_2, was mixed with 1.00 mol of oxygen gas, O_2. The final equilibrium mixture formed was found to contain 0.505 mol of O_2.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(i) Calculate the amount, in mol, of SO_2 and SO_3 in the equilibrium mixture.

SO_2 = ... mol

SO_3 = ... mol
[1]

(ii) Calculate the partial pressure of oxygen gas, pO_2, in the equilibrium mixture.

pO_2 = ... Pa [2]

(d) In another equilibrium mixture formed from different starting amounts of SO_2 and O_2, the partial pressures of SO_2, O_2 and SO_3 were as shown.

$pSO_2 = 8.42 \times 10^2$ Pa

$pO_2 = 6.00 \times 10^4$ Pa

$pSO_3 = 9.10 \times 10^4$ Pa

(i) Write the expression for the equilibrium constant, K_p, for the production of SO_3 from SO_2 and O_2.

K_p =

[1]

(ii) Calculate the value of K_p for this reaction and state the units.

K_p = ...

units = ...
[2]

[Total: 17]

4 **A**, **B** and **C** all have the formula C_4H_8. They all decolourise bromine and are structural isomers of each other.

(a) State the name of the process by which **A**, **B** and **C** could be obtained from $C_{10}H_{22}$.

.... [1]

(b) Draw the structures of these three **structural** isomers.

[1]

(c) Only **A** shows geometrical isomerism.

(i) Explain the meaning of the term *geometrical isomerism*.

....

....

....

.... [2]

(ii) Draw the displayed formula of **A** and use it to show the mechanism of the reaction of **A** with HBr. Include all necessary charges, dipoles, lone pairs and curly arrows.

[4]

(d) **B** does **not** show geometrical isomerism.

B reacts with HBr to form a mixture of two structural isomers, **X** and **Y**.

B + HBr → **X** (has a chiral centre and is produced in higher yield than **Y**)

B + HBr → **Y** (does not have a chiral centre)

(i) State the meaning of the term *chiral centre*.

....

....

....

.... [1]

(ii) Name **B**.

.... [1]

(iii) **X** exists as a pair of optical isomers.

Draw these isomers using the conventional three-dimensional representation.

[2]

(iv) Explain why **X** is produced in higher yield than **Y**.

....

....

....

.... [2]

(e) **C** does **not** show geometrical isomerism.

C reacts with HBr to form a mixture of two structural isomers, neither of which has a chiral centre.

(i) Name **C**.

.... [1]

(ii) Draw the **displayed** formula of each of the structural isomers produced by the reaction of **C** with HBr.

[2]

[Total: 17]