AS Level Chemistry A
H032/02 Depth in chemistry
Sample Question Paper

Date – Morning/Afternoon
Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry A

You may use:
- a scientific calculator

First name									
Last name									
Centre number						**Candidate number**				

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **20** pages.

Answer **all** the questions.

1 Bromine is a reactive element. It combines with other non-metals to form covalent compounds. Phosphorus tribromide, PBr_3, and iodine monobromide, IBr, are examples of covalent compounds used in organic synthesis.

(a) PBr_3 can be prepared by heating bromine with phosphorus, P_4.

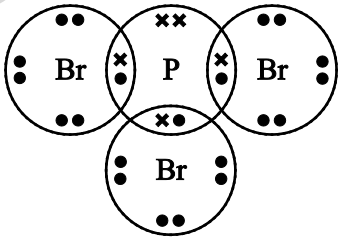
(i) Write an equation for this reaction.

…… **[1]**

(ii) How many molecules are present in 1.3535 g of PBr_3?

number of molecules = …… **[3]**

(iii) The '*dot-and-cross*' diagram of a molecule of PBr_3 is given below.



Name the shape of this molecule and explain why the molecule has this shape.

name: ……..

explanation: …….

…….

…….

[3]

(b) Bromine reacts with iodine to form iodine monobromide, IBr.

The table below lists some average bond enthalpies which are required in different parts of this question.

Bond	Average bond enthalpy / kJ mol^{-1}
Br–Br	+193
I–I	+151
I–Br	+175

(i) Average bond enthalpy is the enthalpy change for the breaking of 1 mole of bonds in gaseous molecules.

Why do Br_2 and I_2 **not** exist in the gaseous state under standard conditions?

……

…….. **[1]**

(ii) Calculate the enthalpy change of formation, $\Delta_f H$, for IBr.

$\Delta_f H$ = …… kJ mol^{-1} **[2]**

(c) Iodine monobromide, I–Br, is a polar molecule.

Heterolytic fission of the I–Br bond forms an electrophile.

State the meaning of the term *electrophile* and suggest the formula of the electrophile formed from IBr.

……

…….. **[2]**

(d) Bromine disproportionates when it reacts with potassium hydroxide solution.

Suggest an equation for this reaction.

…… **[1]**

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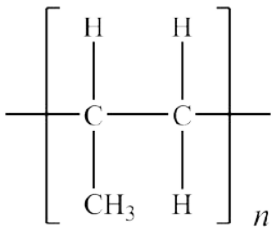
2 A large proportion of the world's output of organic chemicals is used to make addition polymers. These polymers have a variety of uses.

(a) Poly(propene) is used to make packaging, textiles and rope.

A repeat unit for poly(propene) is shown below.



(i) Explain why poly(propene) is a *saturated* hydrocarbon.

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…… **[1]**

(ii) State the bond angle around each carbon atom in poly(propene).

…… **[1]**

(iii) After polymers have been used for packaging, the waste polymers need to be processed to save resources, for example, by recycling.

Describe **two** other ways in which waste poly(propene) can be processed in a sustainable way.

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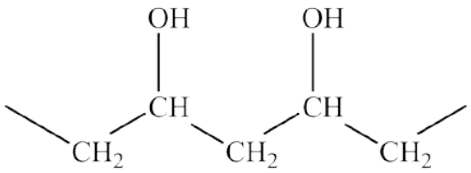
…… **[2]**

(b) Poly(ethenol) is used to make soluble laundry bags.

A section of the structure of poly(ethenol) is shown below.



(i) Draw a structure to represent one repeat unit of poly(ethenol).

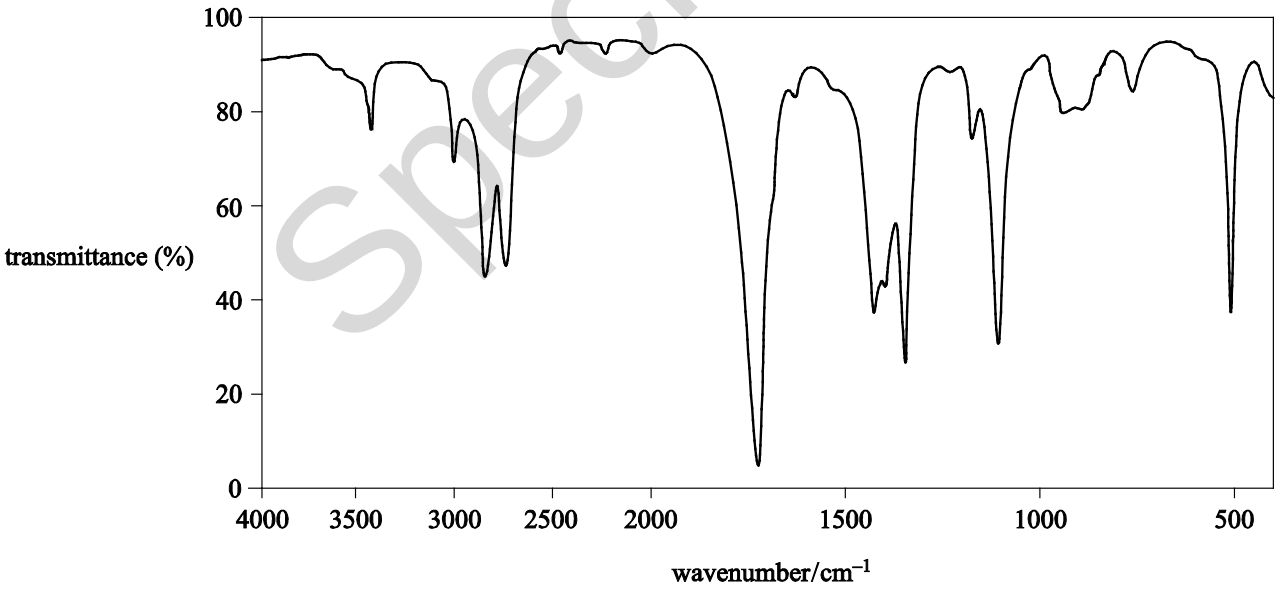
[1]

(ii) Poly(ethenol) is not manufactured from ethenol.

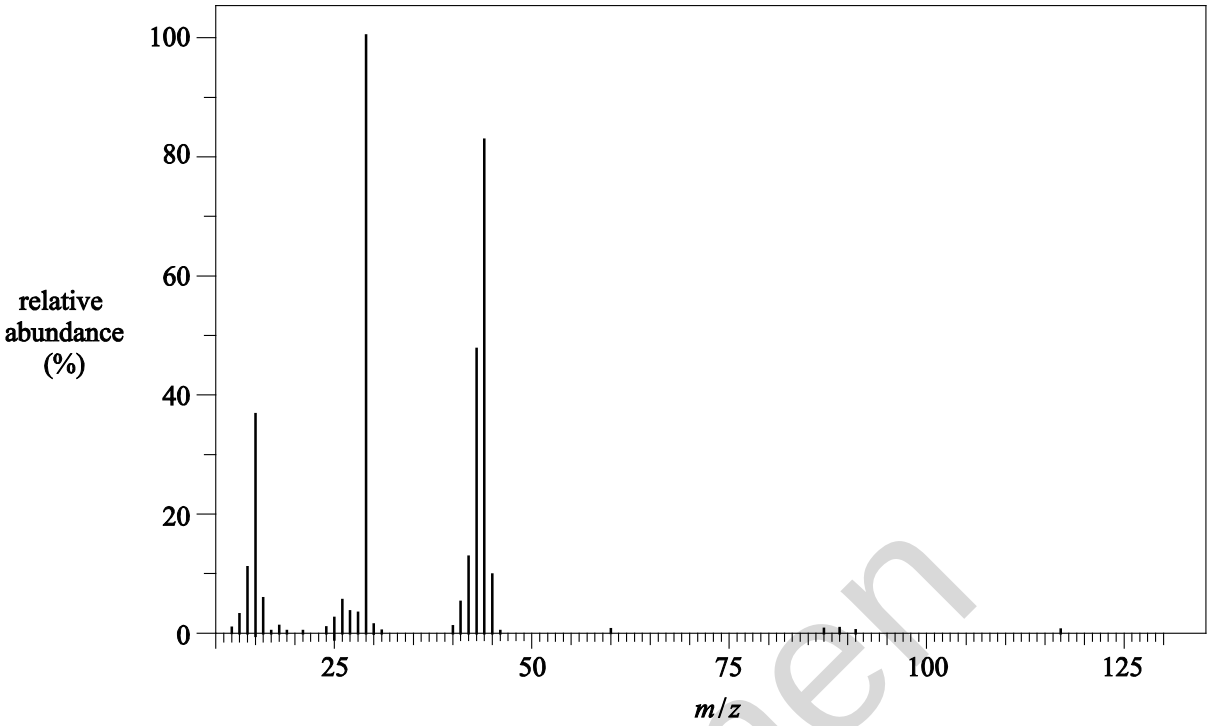
Ethenol is unstable and it forms a more stable structural isomer.

Analysis of the structural isomer gave the following data.

Infrared spectrum



Mass spectrum



Use **all** the data to show that the isomer is **not** ethenol.

Identify the structural isomer of ethenol.

In your answer you should make clear how your explanation is linked to the evidence.

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…….. **[4]**

3 Nitrogen can be reacted with hydrogen in the presence of a catalyst to make ammonia in the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92 \text{ kJ mol}^{-1}$$

(a) Describe and explain the effect of increasing the pressure on the rate of this reaction.

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……

…… **[2]**

(b) A mixture of N_2 and H_2 was left to react until it reached equilibrium. The equilibrium mixture had the following composition:

N_2	1.20 mol dm^{-3}
H_2	2.00 mol dm^{-3}
NH_3	0.877 mol dm^{-3}

(i) Calculate a value for K_c for this equilibrium.

K_c = …… dm^6 mol^{-2} **[3]**

(ii) Explain how the following changes would affect the amount of NH_3 present in the equilibrium mixture.

Use of a catalyst:

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……

A higher temperature:

……

……

[3]

(c) 1.00 tonne of ammonia from the Haber process is reacted with carbon dioxide to prepare the fertiliser urea, NH_2CONH_2.

$$2NH_3(g) + CO_2(g) \rightarrow NH_2CONH_2(s) + H_2O(l)$$

1.35 tonnes of urea are formed.

Calculate the percentage yield of urea.

Show **all** your working.

yield = **……** % **[3]**

4 Students work together in groups to identify four different solutions.

Each solution contains one of the following compounds:

- ammonium sulfate, $(NH_4)_2SO_4$
- sodium sulfate, Na_2SO_4
- sodium chloride, NaCl
- potassium bromide, KBr.

Your group has been provided with universal indicator paper and the following test reagents:

- barium chloride solution
- silver nitrate solution
- dilute ammonia solution
- sodium hydroxide solution.

(a)* A student in your group suggests the following plan:

- Add about 1 cm depth of each solution into separate test-tubes.
- Add a few drops of barium chloride solution to each test-tube.
- A white precipitate will show which solutions contain sulfate ions.
- Two of the solutions will form a white precipitate.

Describe how you would expand this plan so that all four solutions could be identified using a positive test result.

You should provide observations and conclusions that would enable your group to identify all four solutions.

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…… **[6]**

(b) Solid barium chloride has a high melting point. Barium chloride dissolves in water to form a solution that can be used to test for sulfate ions.

(i) Draw a '*dot-and-cross*' diagram to show the bonding in solid barium chloride.
Show outer electrons only.

[2]

(ii) A solution of barium chloride can be made in the laboratory using dilute hydrochloric acid.

Suggest a compound that can be reacted with hydrochloric acid to make barium chloride.

…… **[1]**

5 Alcohols are used in organic synthesis.

(a) Pentan-2-ol can be prepared by the alkaline hydrolysis of 2-iodopentane.

$$CH_3CH(I)CH_2CH_2CH_3 + NaOH \rightarrow CH_3CH(OH)CH_2CH_2CH_3 + NaI$$

The reaction mixture is boiled for 20 minutes.

(i) State the most appropriate technique that could be used to boil the reaction mixture for 20 minutes.

…… [1]

(ii) Describe the mechanism for the alkaline hydrolysis of 2-iodopentane.

In your answer, include the name of the mechanism, curly arrows and relevant dipoles.

name of mechanism: **…….**

[4]

(b) Alcohols can be converted into haloalkanes in a substitution reaction.

Plan an experiment to prepare approximately 0.1 mol of 2-bromopentane, $CH_3CHBrCH_2CH_2CH_3$, from pentan-2-ol, $CH_3CH(OH)CH_2CH_2CH_3$.

Your plan should include a calculation of the mass of alcohol required and details of the chemicals to be used in the reaction.

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…… **[2]**

(c)* Alcohols can be converted into alkenes in an elimination reaction.

The elimination of H_2O from pentan-2-ol forms a mixture of organic products.

Give the names and structures of all the organic products in the mixture.

Your answer should explain how the reaction leads to the different isomers.

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…… **[6]**

6 A student carries out an experiment to identify an unknown carbonate.

- The student weighs a sample of the solid carbonate in a weighing bottle.
- The student tips the carbonate into a beaker and weighs the empty weighing bottle.
- The student prepares a 250.0 cm^3 solution of the carbonate.
- The student carries out a titration using 25.0 cm^3 of this solution measured using a pipette with 0.100 mol dm^{-3} hydrochloric acid in the burette.

(a) The sample of carbonate is dissolved in approximately 100 cm^3 of distilled water in a beaker and the solution transferred to a volumetric flask. The volume of the solution is made up to 250.0 cm^3 with distilled water.

Another student suggests two possible sources of error:

- A small amount of solid remained in the weighing bottle.
- A small amount of solution remained in the beaker.

State whether the other student's statements are correct.

How could the procedure be improved?

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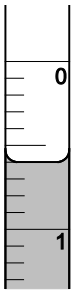
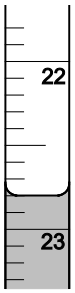
…….. **[2]**

(b) The student carries out the final part of the experiment by adding 0.100 mol dm^{-3} hydrochloric acid to a burette and performing a titration using a 25.0 cm^3 sample of the aqueous carbonate.

The student reads the burette to the nearest 0.05 cm^3.

The diagrams below show the initial burette reading and the final burette reading.

initial reading		final reading	

(i) Record the student's readings and the titre.

[1]

(ii) Describe what the student should do next to obtain reliable results for the titration.

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……

…….. **[1]**

(c) The equation below represents the reaction between the carbonate and hydrochloric acid.

$$M_2CO_3(aq) + 2HCl(aq) \rightarrow 2MCl(aq) + CO_2(g) + H_2O(l)$$

(i) Calculate the amount, in mol, of M_2CO_3 used in the titration.

$n(M_2CO_3)$ = ... mol **[2]**

(ii) The student's mass readings are recorded below.

Mass of weighing bottle + carbonate / g	14.92
Mass of weighing bottle / g	13.34

Use the student's results to identify the carbonate, M_2CO_3.

Show **all** your working.

[4]

7 An alcohol **A** contains carbon, hydrogen and oxygen only. The alcohol is a liquid at room temperature and pressure but can easily be vaporised.

1.15 g of **A** produces 761 cm^3 of gas when vaporised, measured at 100 kPa and 366 K.

Determine the molar mass of compound **A** and draw a possible structure for **A**.

Show **all** your working.

molar mass = ... g mol^{-1}

Structure of **A**

[5]

END OF QUESTION PAPER

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