Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

8398966658

CHEMISTRY **9701/22**

Paper 2 AS Level Structured Questions **February/March 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 **13** printed pages and **3** blank pages.

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

1 This question is about Period 3 elements and their compounds.

(a) Give an explanation for each of the following statements.

(i) The atomic radius decreases across Period 3 (Na to Ar).

.....

.....

.....

..... [2]

(ii) The first ionisation energy of sulfur is lower than that of phosphorus.

.....

.....

.....

..... [2]

(iii) Sodium is a better electrical conductor than phosphorus.

.....

.....

.....

..... [2]

(iv) Magnesium is a better electrical conductor than sodium.

.....

..... [1]

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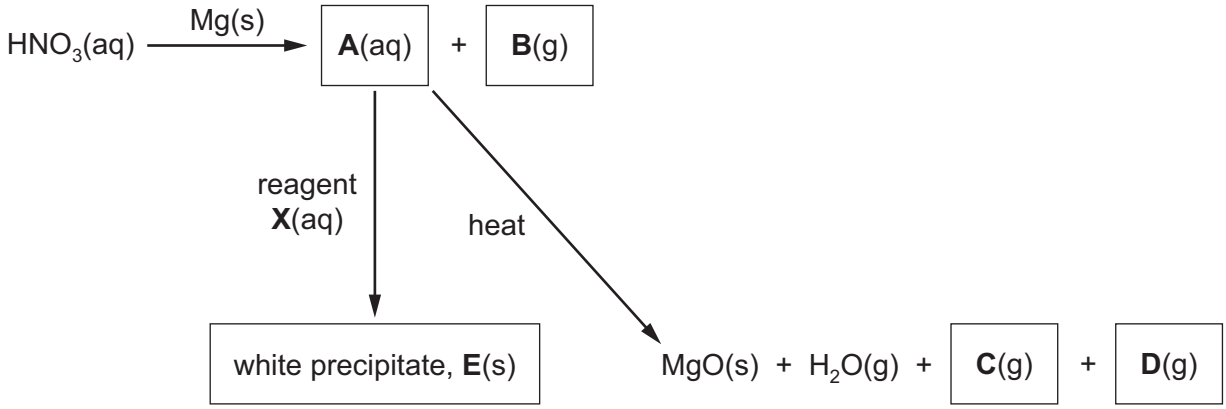
(b) The flow chart below shows a series of reactions.



(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]

[Total: 12]

2 Spathose is an iron ore that contains iron(II) carbonate, $FeCO_3$. The percentage of iron(II) carbonate in spathose can be determined by titration with acidified potassium dichromate(VI) solution using a suitable indicator.

The ionic equation is shown below.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$$

(a) A 5.00 g sample of spathose was reacted with excess concentrated hydrochloric acid and then filtered.
The filtrate was made up to 250 cm^3 in a volumetric flask with distilled water.

A 25.0 cm^3 sample of the standard solution required 27.30 cm^3 of 0.0200 mol dm^{-3} dichromate(VI) solution for complete reaction.

(i) Calculate the amount, in moles, of dichromate(VI) ions used in the titration.

amount = ... mol [1]

(ii) Use your answer to **(i)** to calculate the amount, in moles, of Fe^{2+} present in the 25.0 cm^3 sample.

amount = ... mol [1]

(iii) Use your answer to **(ii)** to calculate the amount, in moles, of Fe^{2+} present in the 250 cm^3 volumetric flask.

amount = ... mol [1]

(iv) Use your answer to **(iii)** to calculate the mass of iron(II) carbonate present in the sample of spathose.

mass = ... g [2]

(v) Calculate the percentage of iron(II) carbonate in the sample of spathose.

percentage of iron(II) carbonate = ... % [1]

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(b) Iron ores containing iron(III) compounds can be analysed using a similar method.

A standard solution of an aqueous iron(III) compound is reacted with aqueous tin(II) chloride. Aqueous tin(IV) chloride and aqueous iron(II) chloride are the products of this reaction.

(i) Write an **ionic** equation for this reaction. Do not include state symbols.

..... [2]

(ii) Any excess tin(II) chloride can be removed by reaction with $HgCl_2$(aq). A white precipitate of Hg_2Cl_2 is produced.

Complete the equation for this reaction.

.....(.....) + ...$HgCl_2$(aq) → $SnCl_4$(.....) + Hg_2Cl_2(.....)

[2]

[Total: 10]

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

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

(a) (i) Draw a dot-and-cross diagram to represent the bonding in a molecule of ammonia, NH_3, and state the shape of the molecule.

shape of molecule .....

[3]

(ii) A molecule of hydrogen cyanide, HCN, is shown.

$$H—C\equiv N$$

The bonding between the carbon and nitrogen atoms consists of one sigma (σ) bond and two pi (π) bonds.

Sketch the shape of the sigma bond and one of the pi bonds in the space below.
Show clearly the position of the atomic nuclei in each diagram.

sigma (σ)

pi (π)

[2]

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(b) 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.

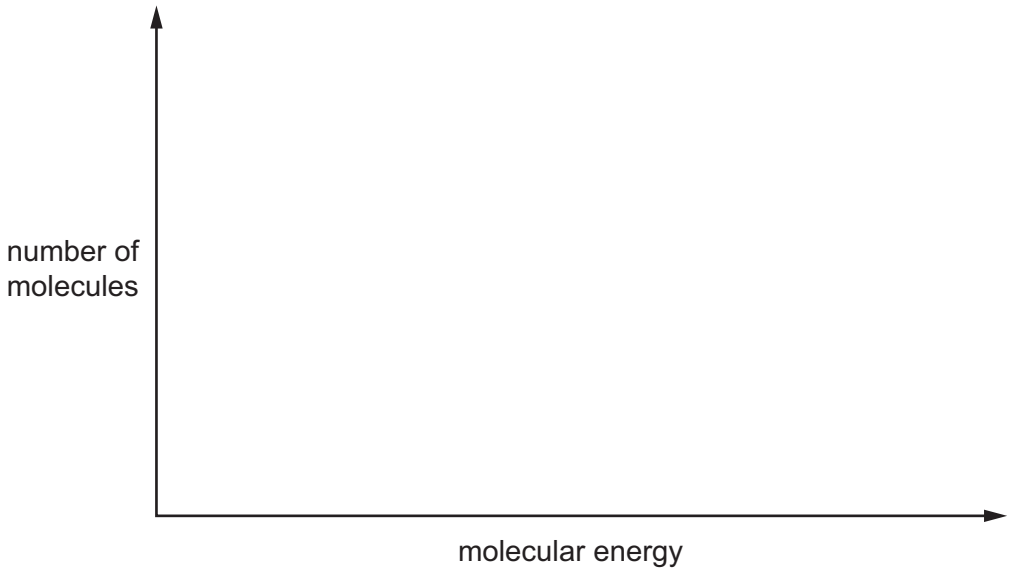
.....

.....

..... [2]

(c) 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.



.....

.....

.....

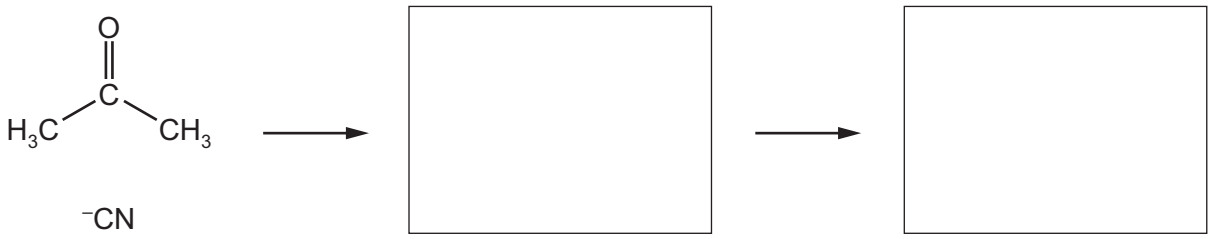
..... [3]

(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: 17]

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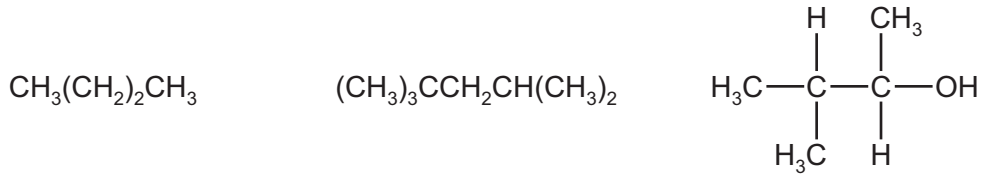
Question 4 starts on the next page.

4 The following compounds were all found to be components of a sample of petrol.



G **H** **J**

(a) (i) Give the **molecular** formula of compound **G**.

..... [1]

(ii) Give the **empirical** formula of compound **H**.

..... [1]

(iii) Draw the **skeletal** formula of compound **J**.

[1]

(b) Write an equation to represent the complete combustion of compound **H**.

..... [1]

(c) Fossil fuels are often contaminated with sulfur.

State and explain why supplies of fossil fuels that contain sulfur pose a problem to the environment.

.....

.....

..... [2]

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(d) The boiling points of compounds **G**, **H** and **J** are shown below.

compound	**G**	**H**	**J**
boiling point / °C	0	99	112

Explain the differences in the boiling points of the three compounds.

.....

.....

.....

.....

.....

.....

..... [4]

(e) Compound **J** can be produced from 2-chloro-3-methylbutane, $C_5H_{11}Cl$.

Give the reagent(s) and conditions for this reaction.

..... [1]

[Total: 11]

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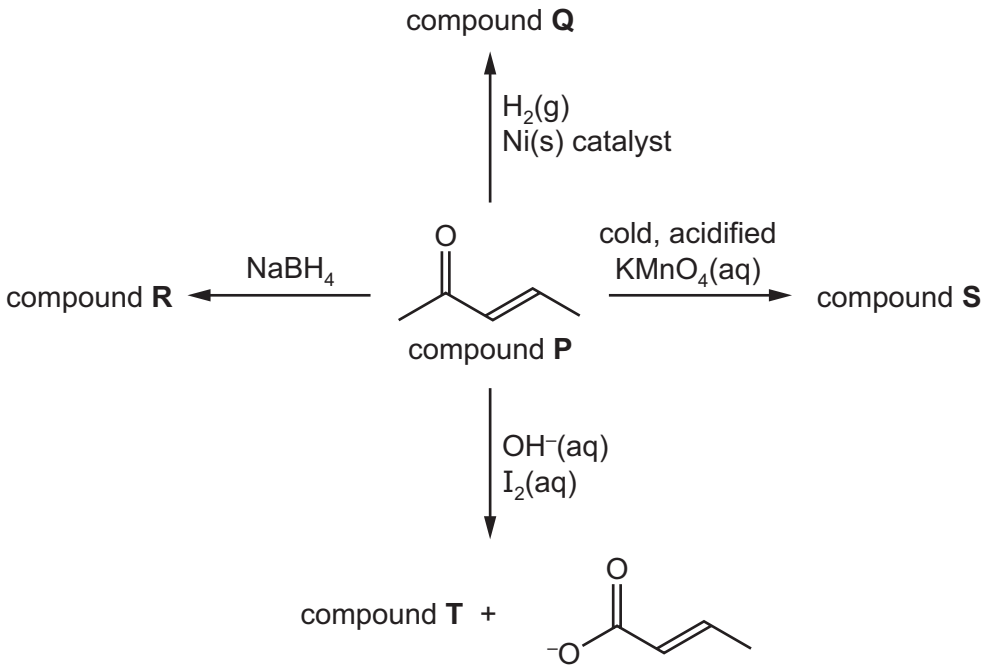
[Turn over

5 Some reactions of compound **P**, C_5H_8O, are shown.



(a) (i) Give the structures for organic compounds **Q**, **R**, **S** and **T**.

Q

R

S

T

[4]

(ii) Give the systematic name of compound **P**.

..... [1]

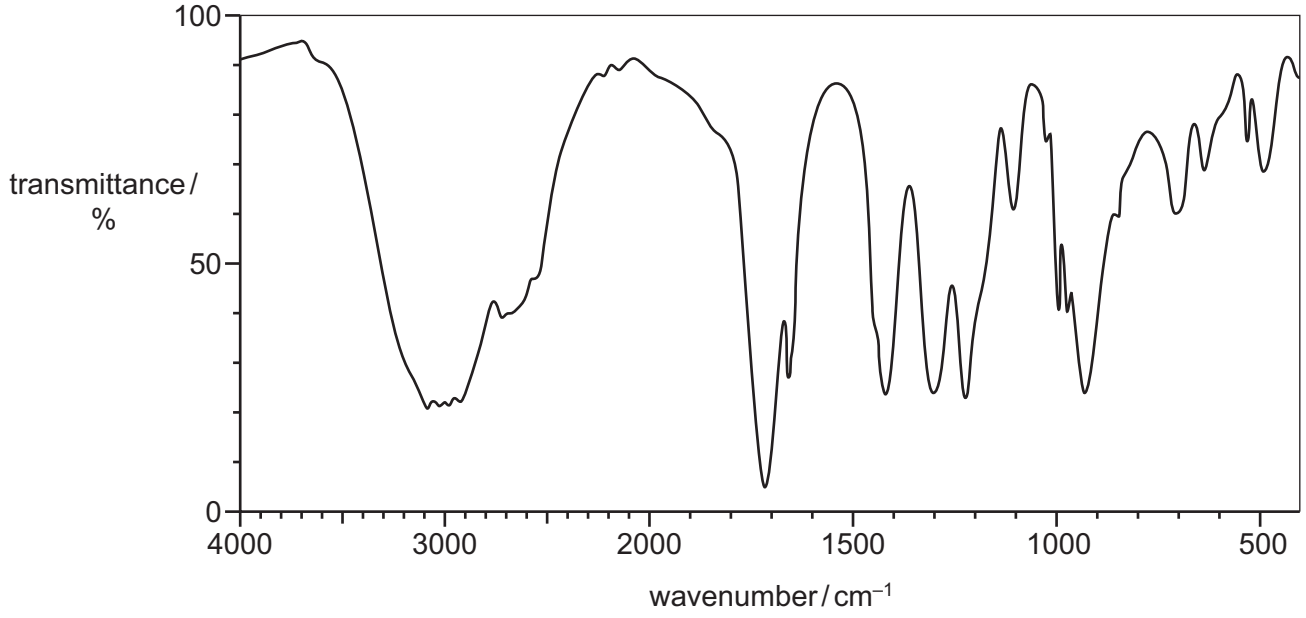
(iii) What would you observe when compound **P** is reacted with 2,4-dinitrophenylhydrazine (2,4-DNPH)?

..... [1]

(b) Compound **U** contains a chiral centre and has the same molecular formula as compound **P**, C_5H_8O.

- Compound **U** readily decolourises a sample of bromine water.
- Compound **U** does not show cis-trans isomerism.
- When compound **U** is heated under reflux in the presence of excess acidified potassium dichromate(VI), the organic product gives the infra-red spectrum shown.

infra-red spectrum of **product**



Use the information given to suggest a structure for compound **U**.
Explain your answer.

[4]

[Total: 10]

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