Cambridge International **A Level**

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

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5493011778

CHEMISTRY **9701/43**

Paper 4 Structured Questions **October/November 2014**

2 hours

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.

Section A
Answer **all** questions.

Section B
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.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total	

This document consists of **19** printed pages and **1** blank page.

CAMBRIDGE International Examinations

Section A

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

1 **(a)** Chlorine exists naturally as a mixture of two isotopes, ^{35}Cl and ^{37}Cl, in the abundance ratio of 3 : 1.

The mass spectrum of chlorine consists of five peaks.

(i) Suggest the mass numbers for these five peaks and the identities of the species responsible.

mass number	formula of species

(ii) Predict the ratios of the abundances of the three species with the highest mass numbers.

ratio of abundances = ...

[4]

(b) Strontium chloride, $SrCl_2$, can be used to produce a red colour in fireworks.

(i) Draw the 'dot-and-cross' diagram for strontium chloride. Show outer shell electrons only.

(ii) Use the following data, together with relevant data from the *Data Booklet*, to calculate a value for the lattice energy of strontium chloride. You may find it helpful to construct a Born-Haber cycle.

electron affinity per mole of chlorine atoms	–349 kJ mol^{-1}
standard enthalpy of atomisation of Sr(s)	+164 kJ mol^{-1}
standard enthalpy of formation of $SrCl_2$(s)	–830 kJ mol^{-1}

lattice energy = ... kJ mol^{-1}
[5]

(c) Strontium nitrate, $Sr(NO_3)_2$, can also be used to produce a red colour in fireworks.

(i) Strontium nitrate can easily be prepared from strontium carbonate, $SrCO_3$.

Suggest an equation for this preparation of strontium nitrate.

.....

(ii) Write an equation for the reaction that occurs when strontium nitrate is heated.

.....
[2]

(d) Describe and explain the trend in the thermal stabilities of the nitrates of the Group II elements.

.....

.....

.....

.....

..... [3]

[Total: 14]

[Turn over

2 **(a)** Bromate(V) ions, BrO_3^-, react with bromide ions in the presence of acid to produce bromine. Write an **ionic** equation for this reaction.

.....

..... [2]

(b) The initial rate of this reaction was measured, starting with different concentrations of the three reactants.

The following results were obtained.

experiment number	$[BrO_3^-]$ / mol dm^{-3}	$[Br^-]$ / mol dm^{-3}	$[H^+]$ / mol dm^{-3}	initial rate / mol dm^{-3} s^{-1}
1	0.040	0.020	0.50	2.64×10^{-4}
2	0.040	0.020	1.00	1.06×10^{-3}
3	0.040	0.080	0.50	1.06×10^{-3}
4	0.080	0.020	0.50	5.21×10^{-4}

(i) Use the data in the table to determine the order with respect to each reactant. Show your reasoning.

.....

.....

.....

.....

(ii) Write the rate equation for this reaction.

.....

(iii) Use the results of experiment 1 to calculate the rate constant, *k*, for this reaction. Include the units of *k*.

rate constant, *k* = ... units .....

[6]

[Total: 8]

3 Transition elements have characteristic properties due to their partially-filled d orbitals.

(a) (i) Which **two** elements in the first row of the d-block have only one electron in the 4s orbital of their neutral atoms?

.....

(ii) The d orbitals in an isolated transition metal atom or ion are described as being degenerate.

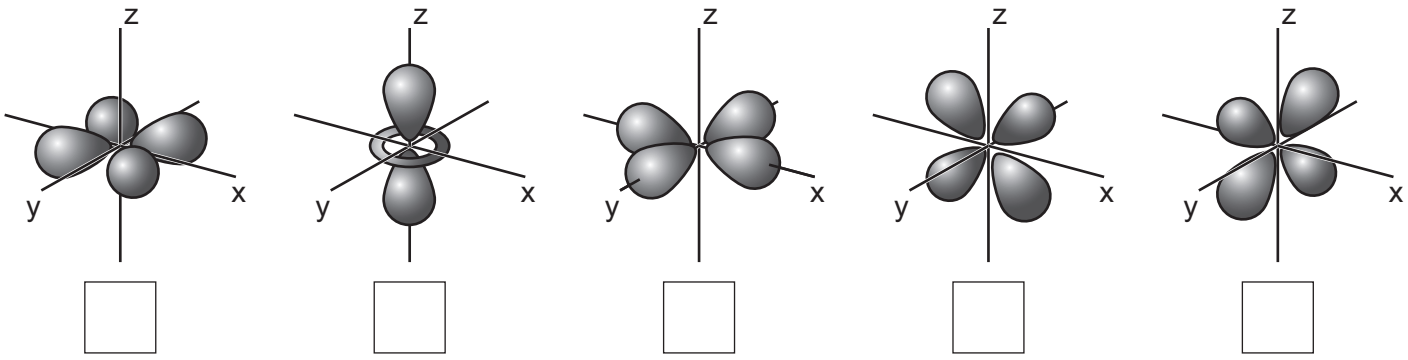
What is meant by the term *degenerate*?

.....

(iii) Sketches of the shapes of the atomic orbitals from the d subshell are shown.

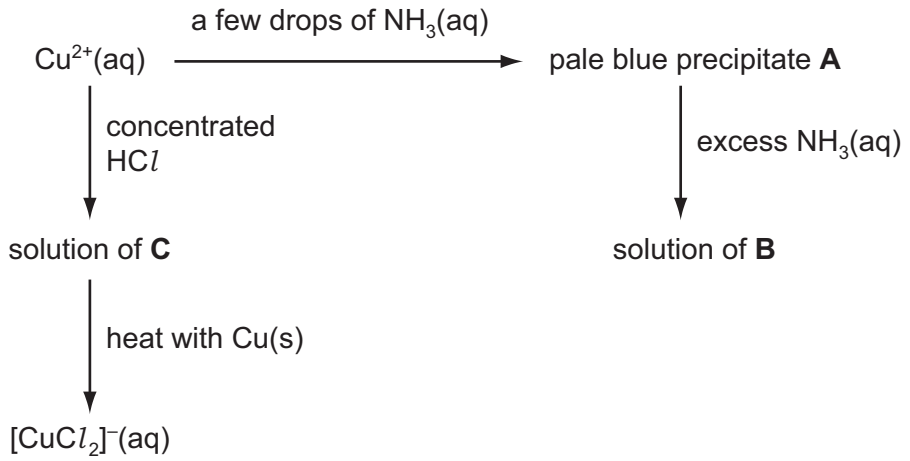
In an octahedral complex, the d orbitals are split into two groups at different energy levels.

On the diagram below, write an 'H' in the box under each of the orbitals at the higher energy level.



[4]

(b) The following scheme shows some reactions of $Cu^{2+}(aq)$.



(i) Suggest the formula of each of the following.

A .....

B .....

C .....

(ii) State the colour of the following solutions.

solution of **B** .....

solution of **C** .....

(iii) Name the type of reaction that occurs when **C** is heated with copper.

.....

Deduce the role of the copper metal in this reaction.

.....

[6]

(c) When the solution containing the complex $[CuCl_2]^-$ is poured into water, a precipitate of CuCl is formed. CuCl is white because it does not absorb visible light.

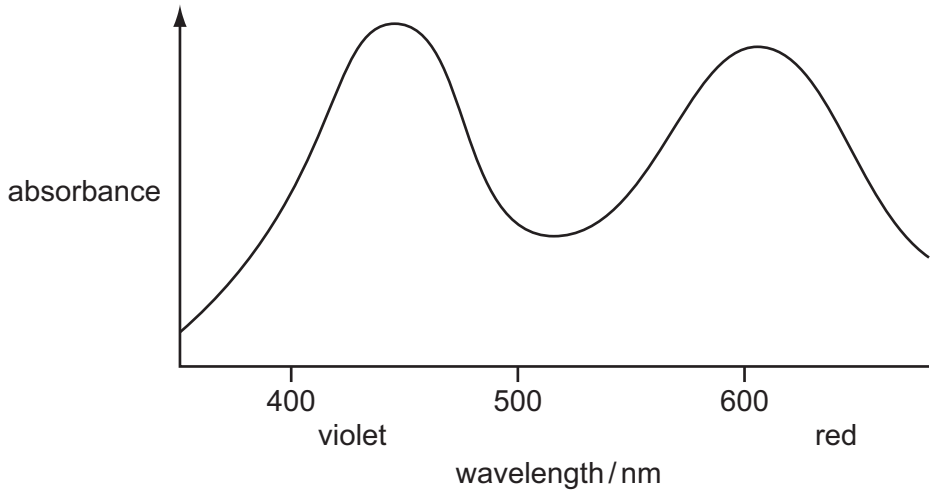
Explain why CuCl does **not** absorb visible light.

.....

.....

..... [2]

(d) The complex ion $[Cr(H_2O)_6]^{3+}$ is coloured because it **absorbs** visible light. The absorption spectrum for $[Cr(H_2O)_6]^{3+}$ is shown below.



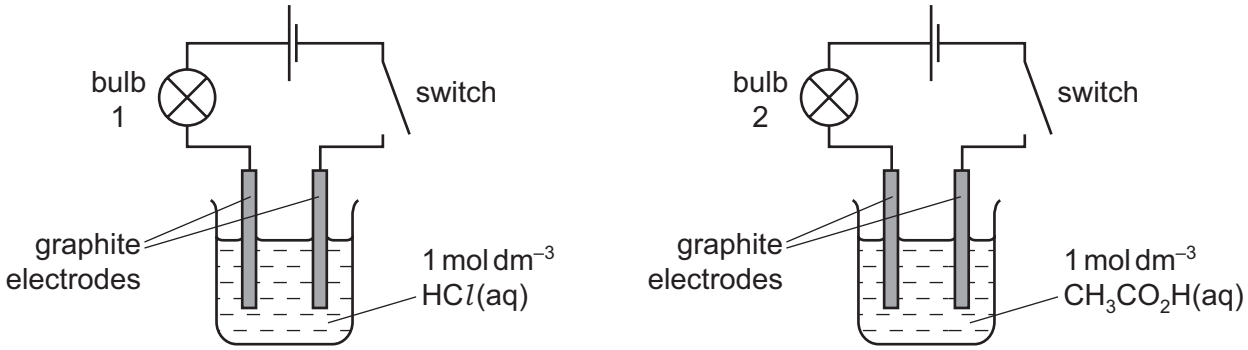
Suggest the colour of this complex ion. Explain your answer.

.....

..... [2]

[Total: 14]

4 **(a)** The following circuits were set up using aqueous hydrochloric and aqueous ethanoic acids as electrolytes. Assume that the two circuits were identical apart from the electrolyte.



When the switches were closed, bulb 1 was brighter than bulb 2. Explain why.

.....

.....

.....

..... [2]

(b) **(i)** State what is meant by a *buffer solution*.

.....

.....

(ii) Outline how a buffer solution can be prepared from ethanoic acid and a named base.

.....

.....

[4]

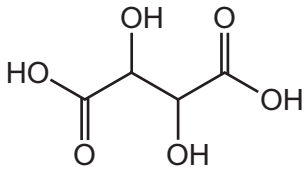
(c) Amino acids such as alanine, $CH_3CH(NH_2)CO_2H$, can act as a buffer solution.
Construct **two** equations to illustrate this.

equation 1

equation 2

[2]

(d) Tartaric acid is present in many plants.



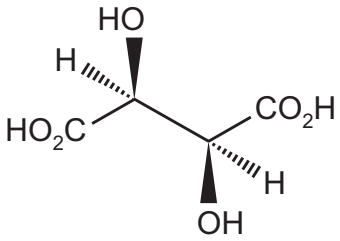
tartaric acid

(i) Tartaric acid has two dissociation constants, K_1 and K_2, for which the pK_a values are 2.99 and 4.40.
Suggest equations showing the two dissociations that give rise to these pK_a values.

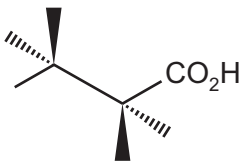
pK_a 2.99

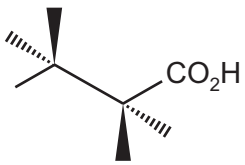
pK_a 4.40

(ii) One stereoisomer of tartaric acid is shown.



Complete the diagrams showing two other stereoisomers of tartaric acid.

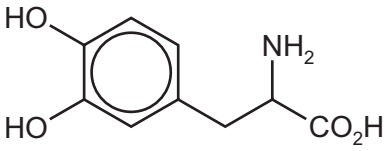




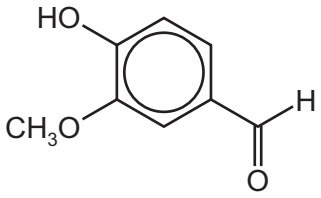
[4]

[Total: 12]

5 L-DOPA is used in the treatment of Parkinson's disease. It can be prepared from vanillin.



L-DOPA



vanillin

(a) L-DOPA and vanillin each contain an aromatic benzene ring.
Describe, with the aid of a diagram, the bonding and shape of a molecule of benzene, C_6H_6.

.....

.....

.....

.....

.....

..... [5]

(b) A student carried out some reactions with samples of L-DOPA and vanillin using reagents **X**, **Y** and **Z**.

- Reagent **X** reacted with L-DOPA **and** with vanillin.
- Reagent **Y** reacted with L-DOPA but **not** with vanillin.
- Reagent **Z** reacted with vanillin but **not** with L-DOPA.

Assume that the CH_3O– group in vanillin does not react.
Suggest possible identities of reagents **X**, **Y** and **Z** and give the structures of the organic products that were formed.

Reagent **X** .....

product with L-DOPA

product with vanillin

Reagent **Y** .....

product with L-DOPA

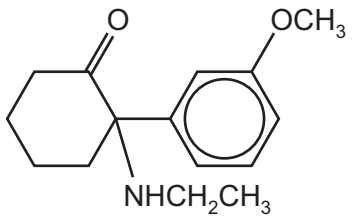
Reagent **Z** .....

product with vanillin

[7]

[Total: 12]

6 Methoxetamine is a derivative of the pharmaceutical drug, ketamine.



methoxetamine

(a) (i) What is the molecular formula of methoxetamine?

.....

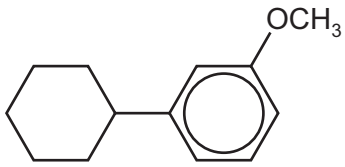
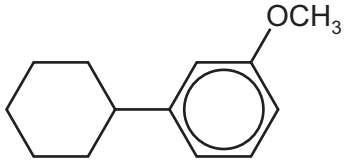
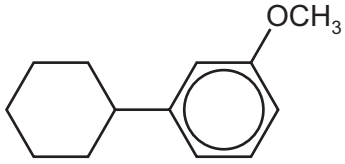
(ii) On the diagram above, **circle** any chiral centres that are present in methoxetamine.

(iii) Name **two** functional groups in methoxetamine, in addition to the aryl group.

.....

[4]

(b) In the table, complete the structure of each of the compounds formed when methoxetamine is reacted with the following reagents.
State the type of reaction in each case.

reagent	structure of product	type of reaction
(i) LiAlH$_4$		
(ii) HCl(aq)		
(iii) CH$_3$COCl		

[6]

[Total: 10]

Section B

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

7 **(a)** Explain what is meant by the term *partition coefficient*.

.....

..... [2]

(b) When 20 cm^3 of ethoxyethane were shaken with 75 cm^3 of an aqueous solution containing 5.00 g of an organic compound, **J**, in 75 cm^3 of water, it was found that 2.14 g of **J** were extracted into the ethoxyethane.

Calculate the partition coefficient, $K_{partition}$, of **J** between ethoxyethane and water.

$K_{partition}$ = ... [2]

(c) In a new experiment

- 10 cm^3 of ethoxyethane were shaken with 75 cm^3 of an aqueous solution containing 5.00 g of **J** and the layers were separated.
- The aqueous layer was shaken with a second 10 cm^3 portion of ethoxyethane and the layers were separated.
- The two organic layers were combined.

Use the value of $K_{partition}$ you calculated in **(b)** to calculate the total mass of **J** extracted by this procedure.

total mass of **J** = ... [2]

(d) Paper chromatography and gas / liquid chromatography both rely on the partition of compounds between mobile and stationary phases.

(i) Identify the mobile phase in paper chromatography.

.....

(ii) Suggest what type of liquid is used for the stationary phase in gas / liquid chromatography.

.....

(iii) Both these techniques can be used to separate mixtures.

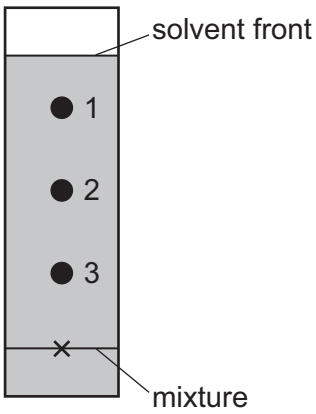
State what you would measure in order to distinguish between the components in the mixture in

1. paper chromatography, ...

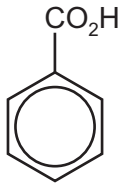
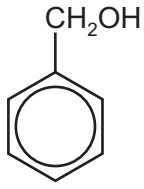
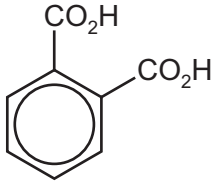
2. gas / liquid chromatography. .....

[4]

(e) A mixture of three compounds was analysed by paper chromatography using a non-polar solvent. The resulting chromatogram is shown.



Identify which compound is responsible for each spot.

compound	spot
	
	
	

[1]

[Total: 11]

8 **(a)** Analysis of a sample of DNA showed that 33% of the nitrogenous bases present was guanine. Calculate the percentages of the **other** bases in this sample of DNA.

adenine .....% cytosine .....% thymine .....% [2]

(b) Many drug molecules are chiral, but are often produced as a mixture of optical isomers.

(i) Suggest why a larger mass of the mixture is required than of a single optical isomer.

.....

.....

(ii) Suggest a problem that might arise as a result of taking a mixture of optical isomers.

.....

.....
[2]

(c) There are four structural isomers with the molecular formula $C_5H_{10}O$ that are aldehydes.

(i) Draw the structures of these aldehydes.

P

Q

R

S

(ii) The NMR spectrum of **one** of these isomers contains **four** absorptions.
Which isomer **P**, **Q**, **R** or **S** gives this spectrum?

isomer .....

(iii) Predict the number of absorptions that would be given by each of the other three isomers.

isomer letter (**P**, **Q**, **R** or **S**)	number of absorptions

[6]

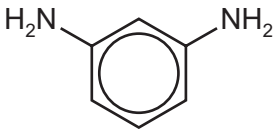
[Total: 10]

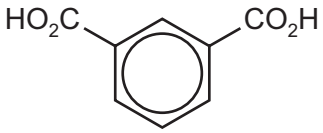
9 **(a)** Polymers can be formed by addition or condensation polymerisation.
Complete the table.

polymer	method of polymerisation
nylon	
PVC (polychloroethene)	
Terylene	

[1]

(b) *Nomex* is a polymeric material with excellent flame-resistant properties.
It contains a polymer made from the two monomers shown below.





Draw the structure of the polymer showing **two** repeat units. The linkages between monomer units should be shown fully displayed.

[2]

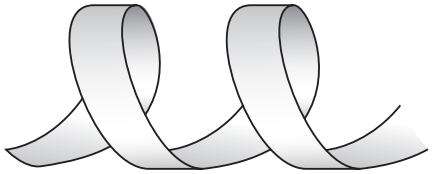
(c) Proteins are natural polymers. Explain what is meant by the *primary structure* of a protein.

.....

.....

..... [1]

(d) Use the diagram to show an example of how the **α-helix** secondary structure in proteins is stabilised.



.....

..... [2]

(e) The tertiary structure of a protein is destroyed during the process of denaturation. Explain how this can occur by

(i) the addition of alkali,

.....

.....

(ii) the addition of Hg^{2+} ions,

.....

.....

(iii) heating to 70 °C.

.....

.....

[3]

[Total: 9]

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