

Write your name here

Surname

Other names

Centre Number

Candidate Number

**Edexcel GCE**

**Chemistry**

**Advanced**

**Unit 5: General Principles of Chemistry II – Transition  
Metals and Organic Nitrogen Chemistry  
(including synoptic assessment)**

Tuesday 22 January 2013 – Afternoon

**Time: 1 hour 40 minutes**

Paper Reference

**6CH05/01**

**You must have: Data Booklet**

Total Marks

**Candidates may use a calculator.**

### Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided  
– *there may be more space than you need.*

### Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets  
– *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (\*) are ones where the quality of your written communication will be assessed  
– *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

### Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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**PEARSON**

## SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box . If you change your mind, put a line through the box  and then mark your new answer with a cross .

- 1 The reaction between iron and nickel(II) sulfate may be represented by the ionic equation



- (a) This reaction is classified as a redox reaction because

(1)

- A the nickel(II) ions are oxidized and iron acts as an oxidizing agent.
- B the nickel(II) ions are oxidized and iron acts as a reducing agent.
- C the nickel(II) ions are reduced and iron acts as a reducing agent.
- D the nickel(II) ions are reduced and iron acts as an oxidizing agent.

- (b) This reaction proceeds spontaneously, therefore

(1)

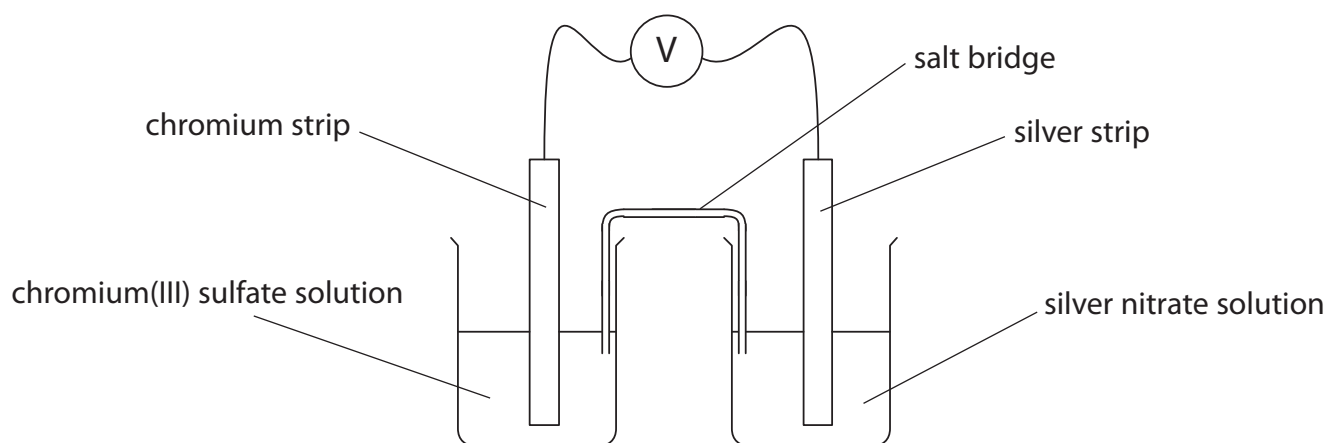
- A  $E_{\text{cell}}$  and  $\Delta S_{\text{total}}$  for this reaction must both be positive.
- B  $E_{\text{cell}}$  and  $\Delta S_{\text{total}}$  for this reaction must both be negative.
- C  $E_{\text{cell}}$  for this reaction must be positive and  $\Delta S_{\text{total}}$  negative.
- D  $E_{\text{cell}}$  for this reaction must be negative and  $\Delta S_{\text{total}}$  positive.

(Total for Question 1 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.



2 The diagram below shows an electrochemical cell.



(a) The salt bridge in this cell is **best** prepared by soaking filter paper in a (1)

- A 1 mol dm<sup>-3</sup> solution of potassium bromide.
- B 1 mol dm<sup>-3</sup> solution of potassium chloride.
- C saturated solution of potassium nitrate.
- D saturated solution of potassium iodide.

(b) The relevant standard electrode potentials for this cell are shown below.



The emf of the cell shown in the diagram is (1)

- A +1.54 V
- B -1.54 V
- C +0.06 V
- D -0.06 V

(c) The mass of 1 mol of chromium(III) sulfate (Cr<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>) is 392 g. Hence, for the cell in the diagram to measure the **standard** electrode potential, 1 dm<sup>3</sup> of the chromium(III) sulfate solution used must contain (1)

- A 104 g of chromium(III) sulfate.
- B 196 g of chromium(III) sulfate.
- C 392 g of chromium(III) sulfate.
- D 784 g of chromium(III) sulfate.

(Total for Question 2 = 3 marks)



3 Vanadium is classified as a transition metal. This is because vanadium

- A is a d-block element.
- B has incompletely filled d orbitals.
- C forms stable ions with incompletely filled d orbitals.
- D forms stable ions in which it has different oxidation states.

(Total for Question 3 = 1 mark)

4 Copper(II) sulfate solution is blue. This is because

- A excited electrons emit light in the blue region of the spectrum as they drop back to the ground state.
- B excited electrons emit light in the red region of the spectrum as they drop back to the ground state.
- C electrons absorb light in the red region of the spectrum and the residual frequencies are observed.
- D electrons absorb light in the blue region of the spectrum and the residual frequencies are observed.

(Total for Question 4 = 1 mark)

5 One method of manufacturing hydrazine ( $\text{N}_2\text{H}_4$ ) involves the action of sodium chlorate(I) on excess ammonia at 443 K and 50 atm. The yield is normally around 80% but, if just 1 part per million of copper(II) ions is present, the yield drops to 30%.

The most likely explanation for this is the ability of copper(II) ions to

- A form complex ions with ammonia.
- B catalyse reactions producing other nitrogen compounds.
- C reduce the hydrazine as it is formed.
- D reduce the sodium chlorate(I).

(Total for Question 5 = 1 mark)

**Use this space for any rough working. Anything you write in this space will gain no credit.**



6 Platinum forms a complex with the formula  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$  and chromium forms a complex ion with the formula  $\text{CrCl}_4^-$ .

(a) Considering the shapes of these complexes,

(1)

- A both complexes are square planar.
- B both complexes are tetrahedral.
- C  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$  is tetrahedral and  $\text{CrCl}_4^-$  is square planar.
- D  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$  is square planar and  $\text{CrCl}_4^-$  is tetrahedral.

(b) Considering the structures of these complexes,

(1)

- A both complexes form stereoisomers.
- B neither complex forms a stereoisomer.
- C  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$  forms a stereoisomer but  $\text{CrCl}_4^-$  does not.
- D  $\text{CrCl}_4^-$  forms a stereoisomer but  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$  does not.

(c) Considering the bonding between the central atom and the ligands in these complexes,

(1)

- A the bonding in both complexes is dative covalent.
- B the bonding in both complexes is ionic.
- C the bonding in  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$  is dative covalent and in  $\text{CrCl}_4^-$  is ionic.
- D the bonding in  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$  is ionic and in  $\text{CrCl}_4^-$  is dative covalent.

**(Total for Question 6 = 3 marks)**

**Use this space for any rough working. Anything you write in this space will gain no credit.**



- 7 When concentrated ammonia solution is added to a green solution of chromium(III) sulfate, a green precipitate is formed which slowly dissolves in excess of the concentrated ammonia solution.

The chromium-containing species formed in these reactions are

	Green precipitate	Resulting solution
<input type="checkbox"/> A	$\text{Cr(OH)}_3$	$[\text{Cr(OH)}_6]^{3-}$
<input type="checkbox"/> B	$\text{Cr(OH)}_3$	$[\text{Cr(NH}_3)_6]^{3+}$
<input type="checkbox"/> C	$(\text{NH}_4)_2\text{CrO}_4$	$[\text{Cr(OH)}_6]^{3-}$
<input type="checkbox"/> D	$(\text{NH}_4)_2\text{CrO}_4$	$[\text{Cr(NH}_3)_6]^{3+}$

(Total for Question 7 = 1 mark)

- 8 Bromine reacts much faster with phenylamine than with benzene. This is because

- A N—H bonds are weaker than C—H bonds.
- B nitrogen is very electronegative.
- C the benzene ring has greater electron density in phenylamine than in benzene.
- D phenylamine reacts by addition whereas benzene reacts by substitution.

(Total for Question 8 = 1 mark)

- 9 X-ray diffraction provides evidence that benzene molecules have

- A delocalized  $\pi$  electrons.
- B carbon—carbon bonds that are all the same length.
- C lower thermodynamic stability than molecules of 1,3,5-cyclohexatriene.
- D greater thermodynamic stability than molecules of 1,3,5-cyclohexatriene.

(Total for Question 9 = 1 mark)

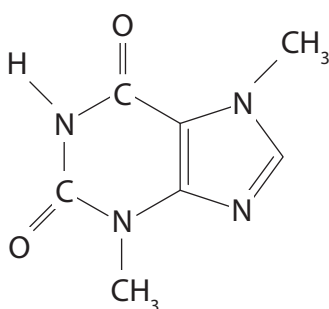


10 Benzene is nitrated using a mixture of concentrated nitric and sulfuric acids. The sulfuric acid

- A acts as a solvent for the benzene and the nitric acid.
- B protonates the benzene to speed up the reaction.
- C protonates the nitric acid which acts as a base.
- D reacts with the benzene to form a benzenesulfonic acid intermediate.

(Total for Question 10 = 1 mark)

11 The compound shown below is found in cocoa beans and in chocolate. Which of the groups listed is **not** present in its structure?



- A Alkyl
- B Amide
- C Amine
- D Ketone

(Total for Question 11 = 1 mark)

12 The **distinguishing** characteristic of combinatorial chemistry is that it involves the

- A simultaneous synthesis of many products.
- B interaction of starting materials to form a unique product.
- C use of catalysts.
- D use of polymer supports.

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.



13 Phenylamine (aniline),  $C_6H_5NH_2$ , may be prepared from nitrobenzene,  $C_6H_5NO_2$ .

(a) The reagent normally used for this reaction is

(1)

- A lithium tetrahydridoaluminate(III) (lithium aluminium hydride) in ether.
- B concentrated ammonia in ethanol.
- C potassium dichromate(VI) in sulfuric acid.
- D tin in concentrated hydrochloric acid.

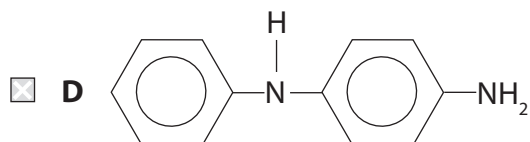
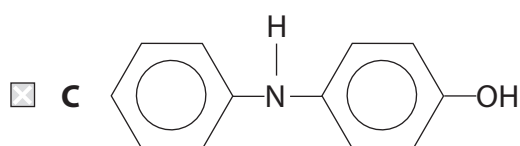
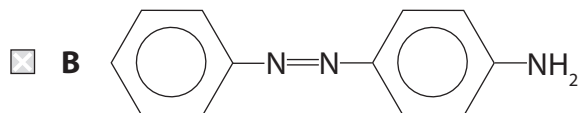
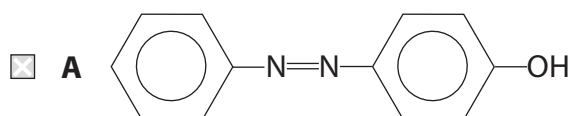
(b) The phenylamine is separated from the reaction mixture by

(1)

- A paper chromatography.
- B steam distillation.
- C filtration.
- D recrystallization.

(c) One test for phenylamine is to convert it into a diazonium ion which is then reacted with phenol to form an azo dye. The structure of this dye is

(1)



(Total for Question 13 = 3 marks)

TOTAL FOR SECTION A = 20 MARKS





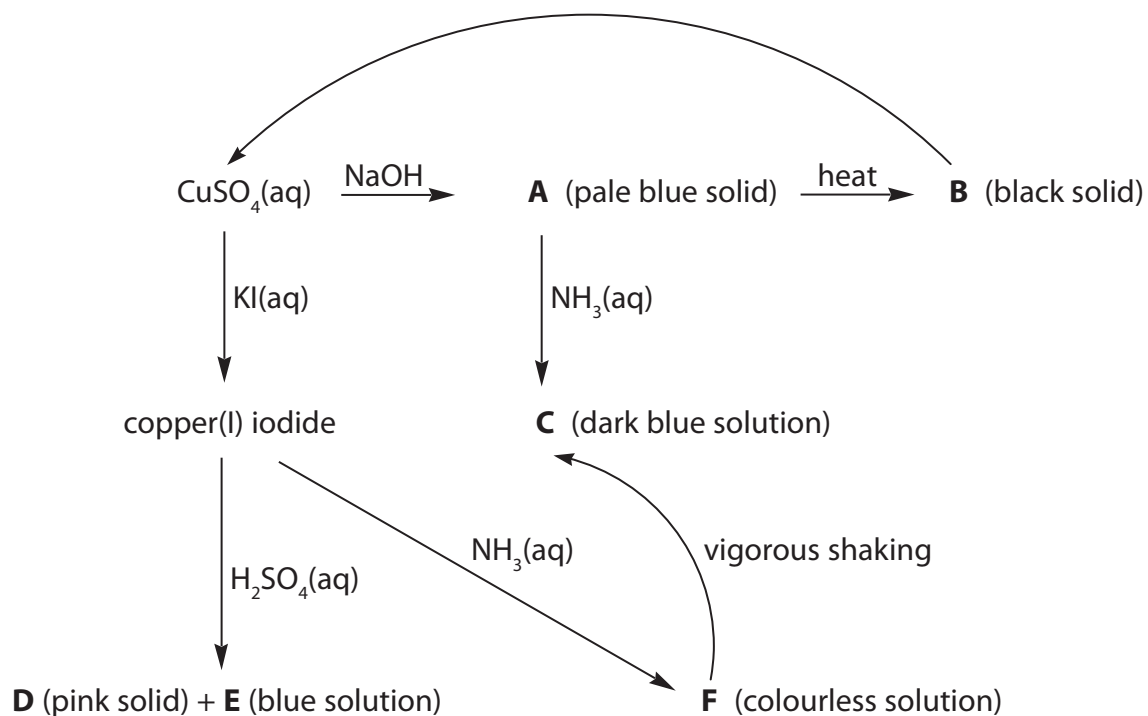
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## SECTION B

**Answer ALL the questions. Write your answers in the spaces provided.**

**14** This question concerns the chemistry of copper. In the sequence below, **A**, **B**, **C**, **D**, **E** and **F** all contain copper in various oxidation states.



(a) Identify, by name (including the oxidation state where appropriate) or formula, the copper-containing species in the sequence.

(6)

- A** .....
- B** .....
- C** .....
- D** .....
- E** .....
- F** .....



(b) Identify, by name or formula, the reagent that would be used to convert **B** into  $\text{CuSO}_4(\text{aq})$ .

(1)

(c) (i) **C** and **F** are the same type of chemical species. Name this type.

(1)

(ii) Explain why **C** is coloured but **F** is colourless.

(3)

\*(iii) Explain why **F** changes into **C** on shaking.

(2)



(d) The reaction of copper(I) iodide to form **D** and **E** is a disproportionation.

(i) Explain the term disproportionation.

(2)

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.....

(ii) Write an ionic equation for this reaction. State symbols are **not** required.

(1)

(iii) Use the relevant standard reduction (electrode) potentials, from the table on page 17 of your data booklet, to calculate the  $E_{\text{cell}}^{\ominus}$  value for this reaction, giving your answer with the appropriate sign.

(2)



\*(iv) If copper(I) iodide is treated with nitric acid, rather than sulfuric acid, a blue solution is still formed but no pink solid. Use the standard electrode potentials on page 15 of your data booklet to explain this. Quote any data that you use.

(4)

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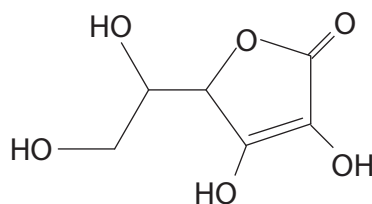
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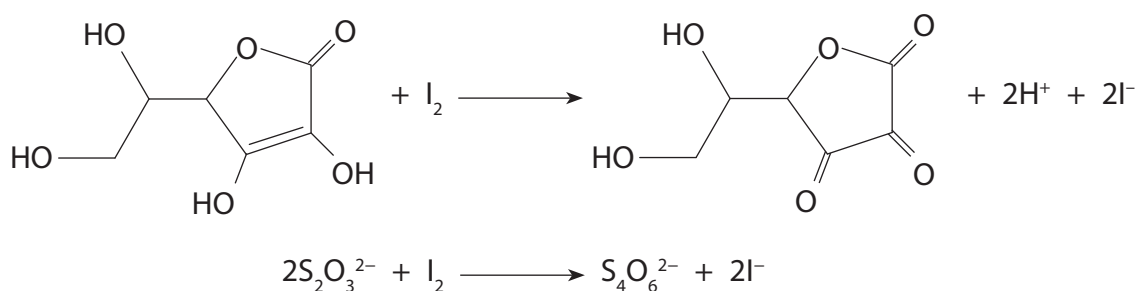
**(Total for Question 14 = 22 marks)**



15 Vitamin C (L-ascorbic acid) is present in fresh fruit and vegetables although prolonged cooking destroys it. The structure of ascorbic acid,  $C_6H_8O_6$ , is shown below.



- (a) The amount of ascorbic acid present in a sample is determined by reacting it with a known amount of iodine. The excess iodine is then measured by titration with a solution of sodium thiosulfate, using a starch indicator. The equations for the reactions are given below.



Four 500 mg vitamin C tablets were dissolved in distilled water and the solution made up to  $250 \text{ cm}^3$  in a volumetric flask. A  $25.0 \text{ cm}^3$  portion of this solution was added to an iodine solution containing  $2.00 \times 10^{-3}$  moles of iodine. The resulting mixture was titrated with sodium thiosulfate solution of concentration  $0.0631 \text{ mol dm}^{-3}$ . The titration was repeated and the mean (average) titre was  $27.85 \text{ cm}^3$ .

- (i) State the type of chemical change undergone by ascorbic acid when it reacts with iodine.

(1)



(ii) State the colour of the solution in the flask just before the starch is added to the titration mixture and state the colour change at the end-point of the titration.

(2)

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(iii) Calculate the percentage by mass of ascorbic acid in the tablets. The molar mass of ascorbic acid is  $176 \text{ g mol}^{-1}$ .

(5)



(iv) Explain why using four tablets in 250 cm<sup>3</sup> of solution gives a more accurate result than two tablets in 250 cm<sup>3</sup>.

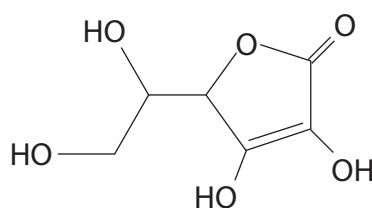
(1)

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(b) The structure of ascorbic acid is shown again below. Vitamin C is one of the optical isomers of this structure.



(i) Mark on this diagram the two chiral centres of this molecule.

(2)

(ii) How might you show that vitamin C is a single optical isomer and not a racemic mixture of the optical isomers of ascorbic acid?

(2)

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(iii) Despite its name, ascorbic acid is not a carboxylic acid but it does contain an ester group. Suggest what happens to destroy vitamin C on prolonged cooking.

(1)

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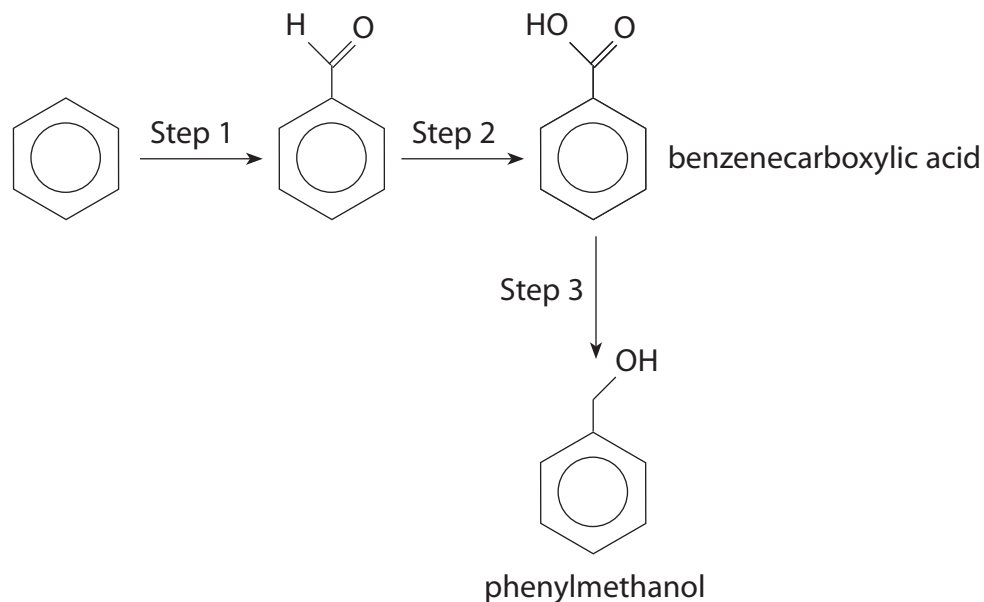
**(Total for Question 15 = 14 marks)**





**16** Benzenecarboxylic acid (benzoic acid) and phenylmethanol (benzyl alcohol) are compounds which occur naturally and have a wide range of uses. For example, benzenecarboxylic acid is used as a food preservative and phenylmethanol is used as a solvent.

A laboratory sequence for the preparation of these two compounds is shown below.



(a) In the first step of the synthesis, benzene reacts with hydrogen chloride and carbon monoxide in the presence of aluminium chloride in an electrophilic substitution called the Gattermann-Koch reaction. The hydrogen chloride and carbon monoxide together behave as if they form the unstable species methanoyl chloride ( $\text{HCOCl}$ ).

(i) Explain why benzene undergoes substitution rather than addition reactions. A detailed description of the bonding in benzene is **not** required.

(2)

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(ii) Give the mechanism for step 1, including the formation of the electrophile.

(4)

(iii) Identify the reagents and essential conditions used in the remaining steps of the sequence. You may assume that the correct reaction temperatures are being used.

(4)

Step 2 .....

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Step 3 .....

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\*(b) Phenol reacts faster than phenylmethanol in electrophilic substitution reactions.  
Suggest why this is so.

(4)

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**(Total for Question 16 =14 marks)**

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**TOTAL FOR SECTION B = 50 MARKS**

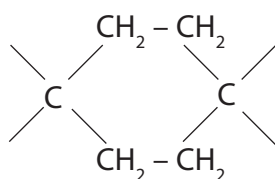
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(iii) Complete the diagram to show the structure of the *cis* isomer.

(1)



(iv) Explain why tranexamic acid melts at 300 °C while the alkane, undecane (C<sub>11</sub>H<sub>24</sub>) which has almost the same number of electrons, melts at -26 °C. A detailed description of the forces involved is **not** required.

(3)

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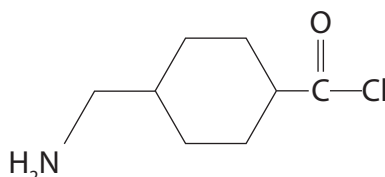
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(b) The diagram below shows a compound, **K**, which is a derivative of tranexamic acid.



(i) Identify by name or formula a compound that might react with tranexamic acid to form **K**.

(1)

.....



(ii) Under suitable conditions, molecules of **K** react together forming a polymer, **L**.  
Draw the structure of **L**, showing two repeat units.

(2)

(iii) Name the type of polymerization that results in the formation of **L**.

.....  
(1)

(iv) State the type of naturally occurring substance which contains the same type  
of linkage as in the polymer **L**.

(1)  
.....



- (c) If the sequence of reactions, that produces polymer **L** from tranexamic acid, is carried out starting with the *cis* isomer of tranexamic acid, an organic compound, **M**, is formed.

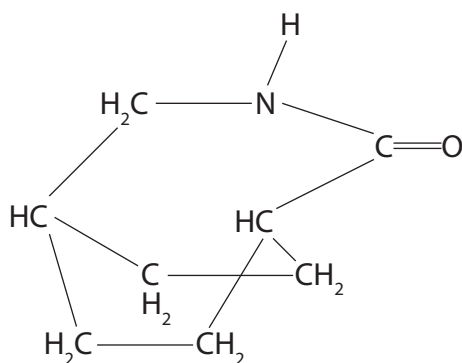
The low resolution nuclear magnetic resonance (nmr) spectrum of **M** has six peaks with relative heights 4:4:2:1:1:1.

The infrared (IR) spectrum of **M** has peaks in the region 1700–1630  $\text{cm}^{-1}$  and 3500–3140  $\text{cm}^{-1}$ .

- (i) The structure of **M** is shown below.

The nmr spectrum shows that the molecule, **M**, has six different hydrogen environments. Use the letters **a** to **f** to label the H atoms of **M** showing the six hydrogen environments. All thirteen hydrogen atoms should be labelled.

(4)



- (ii) Explain how the IR data are consistent with the structure of **M**.

(2)

- (iii) Suggest why **M** is formed from the *cis* isomer but not from the *trans* isomer.

(2)

(Total for Question 17 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS  
TOTAL FOR PAPER = 90 MARKS



# The Periodic Table of Elements

	1	2	Key										0 (8)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)		
	relative atomic mass		atomic symbol																atomic (proton) number	
	atomic symbol		name																atomic (proton) number	
1.0	1.0		H																1	
hydrogen																				
1	6.9	9.0	45.0	47.9	50.9	52.0	54.9	55.8	58.9	58.7	63.5	65.4	69.7	72.6	74.9	79.0	79.9	83.8	4.0	
Li	Be	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	He	2	
lithium	beryllium	scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton	helium	10	
3	4	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	18		
23.0	24.3	88.9	91.2	92.9	95.9	[98]	101.1	102.9	106.4	107.9	112.4	114.8	118.7	121.8	127.6	126.9	131.3	39.9		
Na	Mg	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	Ar	9	
sodium	magnesium	yttrium	zirconium	niobium	molybdenum	technetium	ruthenium	rhodium	palladium	silver	cadmium	indium	tin	antimony	tellurium	iodine	xenon	argon	17	
11	12	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	18		
39.1	40.1	88.9	91.2	92.9	95.9	186.2	190.2	192.2	195.1	197.0	200.6	204.4	207.2	209.0	[209]	[210]	[222]	20.2		
K	Ca	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	Ne	10	
potassium	calcium	lanthanum	hafnium	tantalum	tungsten	rhenium	osmium	iridium	platinum	gold	mercury	thallium	lead	bismuth	polonium	astatine	radon	neon	10	
19	20	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	20		
85.5	87.6	137.3	178.5	180.9	183.8	186.2	190.2	192.2	195.1	197.0	200.6	204.4	207.2	209.0	[209]	[210]	[222]	20.2		
Rb	Sr	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Ne	10	
rubidium	strontium	barium	lanthanum	hafnium	tungsten	rhenium	osmium	iridium	platinum	gold	mercury	thallium	lead	bismuth	polonium	astatine	radon	neon	10	
37	38	56	57	72	73	74	76	77	78	79	80	81	82	83	84	85	86	20		
132.9	137.3	178.5	178.5	180.9	183.8	186.2	190.2	192.2	195.1	197.0	200.6	204.4	207.2	209.0	[209]	[210]	[222]	20.2		
Cs	Ba	Ra	Ac*	Rf	Db	Sg	Hs	Mt	Ds	Rg								Ne	10	
caesium	barium	radium	actinium	rutherfordium	dubnium	seaborgium	hassium	meitnerium	darmstadtium	roentgenium									Ne	10
55	56	88	89	104	105	106	108	109	110	111								20		
[223]	[226]	[226]	[227]	[261]	[262]	[266]	[277]	[268]	[271]	[272]								20		
Fr	Ra		Ac*	Rf	Db	Sg	Hs	Mt	Ds	Rg								20		
francium	radium		actinium	rutherfordium	dubnium	seaborgium	hassium	meitnerium	darmstadtium	roentgenium								20		
87	88		89	104	105	106	108	109	110	111								20		
* Lanthanide series			Elements with atomic numbers 112-116 have been reported but not fully authenticated																	
* Actinide series			140	141	144	[147]	150	152	157	159	163	165	167	169	173	175	175	175	175	
			Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Lu	Lu	Lu	
			cerium	praseodymium	neodymium	promethium	samarium	europium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium	lutetium	lutetium	lutetium	lutetium	
			58	59	60	61	62	63	64	65	66	67	68	69	70	71	71	71	71	
			232	[231]	238	[237]	[242]	[243]	[247]	[245]	[251]	[254]	[253]	[256]	[254]	[257]	[254]	[257]	[257]	
			Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	No	Lr	Lr	
			thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendeleevium	nobelium	lawrencium	nobelium	lawrencium	lawrencium	
			90	91	92	93	94	95	96	97	98	99	100	101	102	103	102	103	103	

