

NAME \_\_\_\_\_

CLASS **24S****JURONG PIONEER JUNIOR COLLEGE**  
**JC2 PRELIMINARY EXAMINATION 2025****CHEMISTRY**

Paper 2 Structured Questions

**9729/02****29 August 2025****2 hours**

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number in the spaces at the top of this page.

Write in dark blue or black pen.

You may use a HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.

A Data Booklet is provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	16
2	11
3	14
4	18
5	16
Penalty (delete accordingly)	
Lack <b>3sf</b> in final answer	-1 / NA
Missing/wrong <b>units</b> in final ans	-1 / NA
Bond linkages	-1 / NA
Total	75

This document consists of **20** printed pages.

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

- 1 Nitrogen is found in inorganic compounds such as the oxides of nitrogen, NO<sub>2</sub> and NO.

- (a) NO<sub>2</sub> can be produced from the thermal decomposition of gaseous N<sub>2</sub>O<sub>5</sub>.

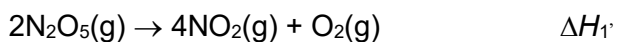


Table 1.1 gives some data relevant to this question.

**Table 1.1**

process	$\Delta H^\circ / \text{kJ mol}^{-1}$
standard enthalpy change of formation of N <sub>2</sub> O <sub>5</sub> (g)	+11.3
standard enthalpy change of formation of NO(g)	+89.0
$\text{NO}(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{NO}_2(\text{g})$	-58.1

- (i) Explain what is meant by standard enthalpy change of formation.

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 .....

[1]

- (ii) Use data from Table 1.1 to calculate  $\Delta H_1^\circ$ . You may find it helpful to draw an energy cycle.

[2]

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- (iii) In the solid state,  $\text{N}_2\text{O}_5$  has an ionic structure and consists of the ions,  $\text{NO}_2^+$  and  $\text{NO}_3^-$ .

Draw and name the shapes of  $\text{NO}_2^+$  and  $\text{NO}_3^-$ .

ion	$\text{NO}_2^+$	$\text{NO}_3^-$
diagram of shape		
name of shape		

[3]

- (b) Nitrogen dioxide,  $\text{NO}_2$ , and dinitrogen tetraoxide,  $\text{N}_2\text{O}_4$ , exist in dynamic equilibrium with each other.



At  $50^\circ\text{C}$  and a pressure of  $1.68 \times 10^5 \text{ Pa}$ , 4.60 g of the equilibrium gaseous mixture occupies  $1.00 \text{ dm}^3$ .

- (i) Assuming the gaseous mixture behaves ideally, calculate the average relative molecular mass,  $M_r$ , of the gaseous mixture.

[1]

- (ii) Using the following relationships, calculate the mole fraction of  $\text{N}_2\text{O}_4$ ,  $m$ , and the mole fraction of  $\text{NO}_2$ ,  $n$ , in the mixture.

$$m + n = 1$$

$$\text{Average } M_r = 92m + 46n$$

[1]

(iii) Hence calculate the partial pressures of  $\text{N}_2\text{O}_4$  and  $\text{NO}_2$  in the mixture.

[1]

(iv) Write an expression for equilibrium constant,  $K_p$ , for the reaction, and calculate its value. Include units in your answer.

[3]

(v) State and explain the effect of increasing the temperature on the average  $M_r$  of the equilibrium mixture.

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[2]

(c) With the aid of suitable equations, describe and explain the role of  $\text{NO}_2$  in the oxidation of atmospheric sulfur dioxide.

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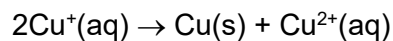
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[2]

[Total: 16]

- 2 Copper(I) salts in aqueous solution are unstable as shown by equation 1.

equation 1



- (a) (i) Using relevant data from the *Data Booklet*, calculate  $\Delta G^\circ$ , in  $\text{kJ mol}^{-1}$ , for the above reaction.

[2]

- (ii) Deduce the sign of  $\Delta S^\circ$  for the reaction and explain your answer.

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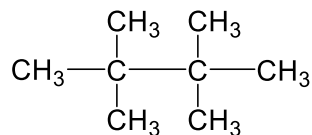
[1]

- (iii) Hence, determine if the reaction in equation 1 is exothermic or endothermic. Explain your answer.

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 .....  
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 .....

[1]

- (b) Some copper(I) compounds are used as reagents in organic reactions where new carbon-carbon bonds are formed. Larger alkanes can also be formed through the reaction of alkanes with some halogens. However, the yield of the larger alkanes obtained through such a reaction is low.
- (i) Trace amount of alkane **A** is obtained when 2-methylpropane reacts with bromine in the presence of ultraviolet light.

**A**

Outline the mechanism of this reaction, clearly showing how **A** is formed in the above reaction.

[3]

- (ii) Chloroalkanes can be formed by the above mechanism but not iodoalkanes. Use relevant data from the *Data Booklet* to explain why iodoalkanes cannot be formed.

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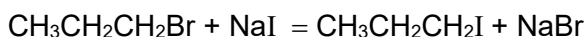
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[1]

- (iii) Iodoalkanes can be made by warming a bromoalkane with a solution of sodium iodide in dry propanone, in which sodium bromide is almost insoluble.



Suggest why the above reaction produces a high yield of  $\text{CH}_3\text{CH}_2\text{CH}_2\text{I}$  despite the C–I bond being weaker than the C–Br bond.

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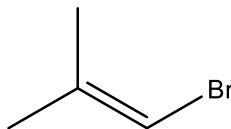
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[1]

- (iv) A student wanted to distinguish 2-bromo-2-methylpropane,  $(\text{CH}_3)_3\text{CBr}$ , from compound **B** shown below.



compound **B**

The student suggested the following method:

Step 1: To 2 cm<sup>3</sup> of each compound, add an equal volume of NaOH(aq).

Step 2: Then add 1 cm<sup>3</sup> of AgNO<sub>3</sub>(aq).

Step 3: Then add excess of dilute HCl(aq).

Identify and explain two improvements to the student's proposed method.

Improvement 1:

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Improvement 2:

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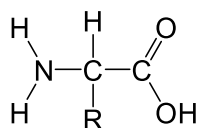
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[2]

[Total: 11]

- 3 Amino acids are the fundamental building blocks of proteins and play crucial roles in various biological processes. Amino acids are crystalline solids with high melting points, are water-soluble, and exist as zwitterions. The general structure of an  $\alpha$ -amino acid is given below.



where R represents the side-chain on the  $\alpha$ -carbon of amino acid.

- (a) Explain why amino acids exist as crystalline solids at room temperature.

.....  
 .....  
 .....

[1]

- (b) The Strecker synthesis is one method to prepare  $\alpha$ -amino acids in the laboratory by reacting readily available aldehydes or ketones in the presence of  $\text{NH}_4\text{Cl}$  and  $\text{KCN}$ .

However, the Strecker synthesis lacks chirality control, producing racemic mixtures. This poses serious issues in pharmaceuticals, where specific enantiomers are crucial for safety and biological compatibility.

Alanine (2-aminopropanoic acid) can be prepared from the Strecker synthesis as shown in Fig. 3.1.

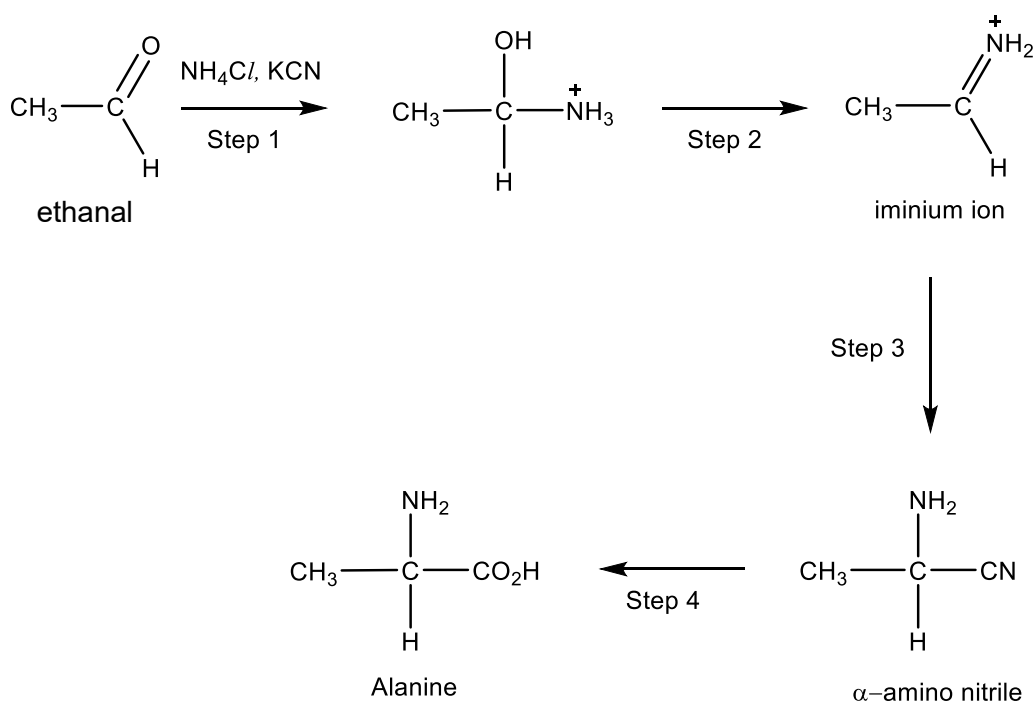


Fig. 3.1

- (i) State the type of reaction that occurred in steps 2 and 4.

step 2: .....

step 4: .....

[2]



- (ii) Step 3 in the Strecker synthesis involves the reaction of the iminium ion and  $\text{CN}^-$  to form the  $\alpha$ -amino nitrile. This reaction is similar to the reaction between  $\text{CN}^-$  and carbonyl compounds.

State and describe the mechanism for step 3. In your answer, show relevant lone pairs of electrons and show the movement of electrons by curly arrows.

Type of mechanism: .....

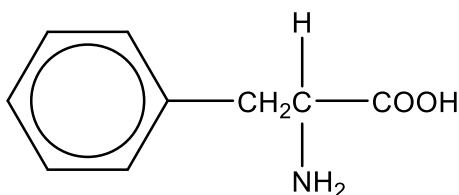
[2]

- (iii) Using your answer in (b)(ii), explain why alanine formed by the Strecker Synthesis method exists as a racemic mixture.

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[1]

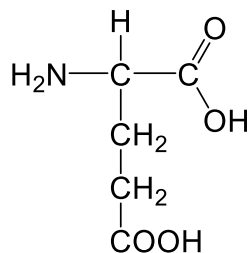
- (iv) Phenylalanine can also be formed via the Strecker synthesis. Suggest the structure of the starting compound necessary for step 1 of the Strecker synthesis to obtain phenylalanine.



phenylalanine

[1]

- (c) Glutamic acid is a non-essential  $\alpha$ -amino acid vital for protein synthesis and is the main excitatory neurotransmitter in vertebrates.



**Glutamic acid**

Glutamic acid has  $pK_a$  values of 2.1, 4.1 and 9.5.

- (i) Explain the difference in the  $pK_a$  values of the two carboxylic acid groups on glutamic acid.

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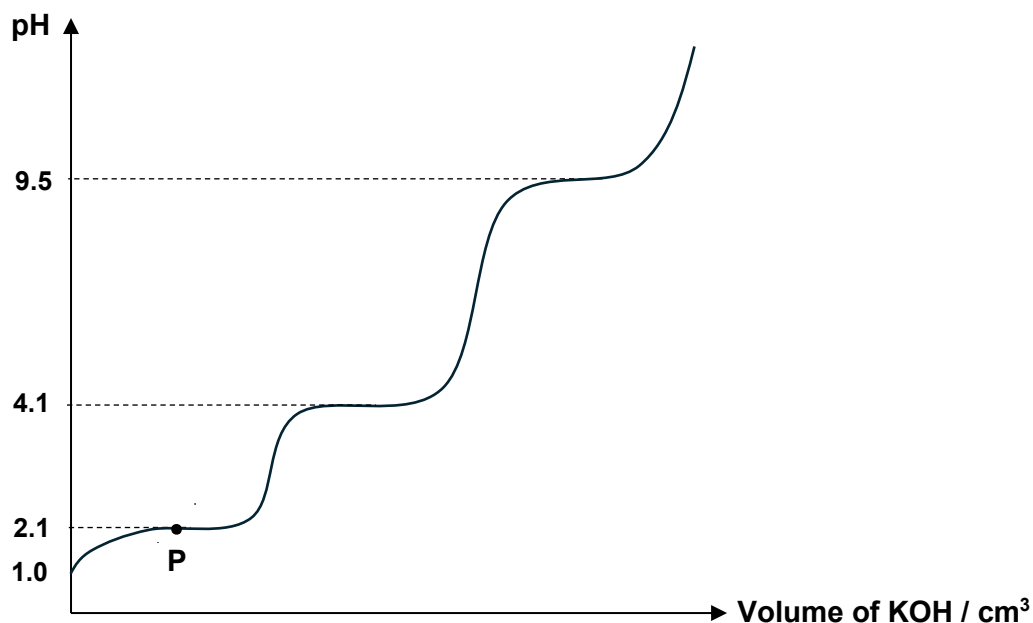
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[2]

The following graph in Fig. 3.2 was obtained when protonated glutamic acid was titrated with aqueous potassium hydroxide.



**Fig 3.2**

- Identify the 2 major species present at point **P** and write an equation to illustrate how glutamic acid can maintain the pH of a solution at 2.1 when a small amount of  $\text{OH}^-$  is added.

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[2]

- .....
- .....

[1]

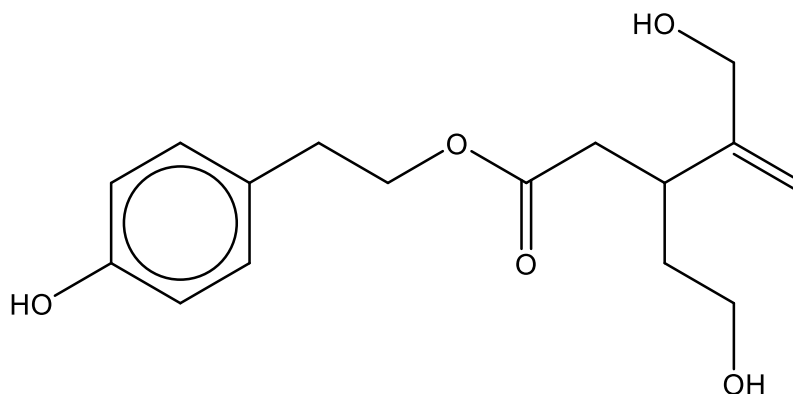
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[2]

[Total: 14]

- 4 Oleocanthal,  $C_{17}H_{20}O_5$ , is a naturally occurring compound found in olive oil, known for its anti-inflammatory and antioxidant properties. When oleocanthal is reacted with  $NaBH_4$ , compound **C** is formed.

Fig. 4.1 shows the structural formula of a molecule of compound **C**.



Compound **C**

Fig. 4.1

- (a) (i) The molecule of compound **C** contains  $sp^2$  hybridised carbon atoms. Describe how  $sp^2$  hybridised orbitals are formed.
- .....
- .....
- ..... [1]
- (ii) State the number of  $sp^2$  hybridised carbon atoms in a molecule of compound **C**.
- ..... [1]
- (iii) Deduce the number of stereoisomers of compound **C**.
- ..... [1]
- (iv) Write the equation for the reduction of oleocanthal by  $NaBH_4$  to give compound **C**.
- Use  $[H]$  to represent the reducing agent and use the molecular formula of oleocanthal and compound **C** in the equation.
- ..... [1]
- (v) State the number of moles of  $H_2(g)$  that will be evolved when 1 mol of compound **C** reacts with an excess of sodium metal.
- ..... [1]

(b) Draw structures of the organic compounds formed when compound **C** is

(i) heated with excess dilute NaOH(aq)

[2]

(ii) reacted with excess Br<sub>2</sub>(aq).

[2]

- (c) Hexan-1-ol,  $\text{C}_6\text{H}_{13}\text{OH}$ , is one of the compounds that contribute to the aroma of olive oil.

A student used the apparatus shown in Fig. 4.2 to carry out an experiment to determine the enthalpy change of combustion of hexan-1-ol.

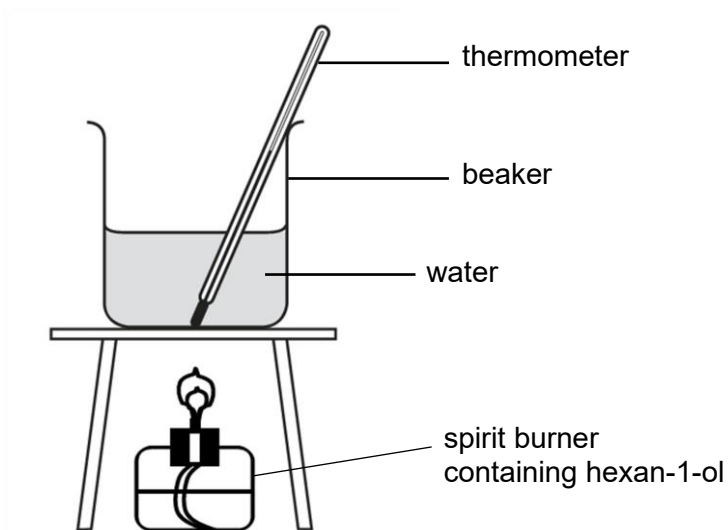


Fig. 4.2

The experimental results obtained are shown in Table 4.1.

Table 4.1

mass of water in beaker / g	250
initial temperature of water / °C	31.0
final temperature of water / °C	44.5
initial mass of spirit burner and hexan-1-ol / g	50.91
final mass of spirit burner and hexan-1-ol / g	50.34

- (i) Using data from Table 4.1, calculate the heat, in kJ, gained by the water in this experiment. The specific heat capacity of water is  $4.18 \text{ J g}^{-1} \text{ K}^{-1}$ .

- (ii) The enthalpy change of combustion of hexan-1-ol is  $-3980 \text{ kJ mol}^{-1}$ . Calculate the percentage efficiency of heat transfer in this experiment.

[2]

- (d) Olive oil primarily contains triesters, which do not vapourise easily. Hence, raw olive oil is unsuitable as a direct fuel for diesel engine as the triesters present will accumulate and clog the engine components. Olive oil can be converted into biodiesel through a chemical process called transesterification. The resulting esters from this process are more suitable for use as fuel in diesel engines.

One transesterification reaction is shown in Fig. 4.3.

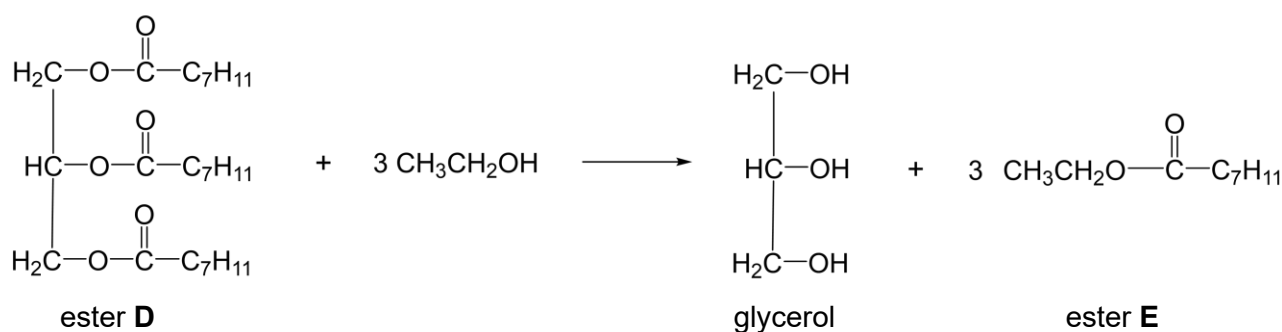


Fig. 4.3

- (i) Explain why ester **E** is more suitable than ester **D** to be used as a fuel in diesel engines.

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.....

[2]

A large amount of glycerol is generated as a by-product in the production of biodiesel from natural oils. Efforts are being made to convert glycerol into more useful organic products.

- (ii) Give the systematic name of glycerol.

.....

[1]

- (iii) The properties of glycerol are affected by the intermolecular forces present between glycerol molecules.

Draw a labelled diagram to name and show the strongest intermolecular force present between two molecules of glycerol.

[1]

- (iv) Glycerol can react with hydrogen chloride to form dichlorinated products. Draw the structures of all possible dichlorinated products from this reaction. **Ignore any stereoisomers.**

[2]

[Total: 18]



- 5** Silver is known for forming a range of sparingly soluble salts, such as silver carbonate and the silver halides. Their low solubility in water makes them useful in qualitative analysis and photographic processes.

- (a)** The values of the solubility products of some silver salts at 298 K are given in Table 5.1.

**Table 5.1**

salt	$K_{sp}$ value
AgBr	$5.0 \times 10^{-13}$
$\text{Ag}_2\text{CO}_3$	$6.3 \times 10^{-12}$

- (i)** Write an expression for the solubility product,  $K_{sp}$ , of  $\text{Ag}_2\text{CO}_3$ .

..... [1]

- (ii)**  $\text{Ag}_2\text{CO}_3$  solid was stirred in  $100 \text{ cm}^3$  of water until no more  $\text{Ag}_2\text{CO}_3$  solid can dissolve.

Calculate the mass of  $\text{Ag}_2\text{CO}_3$  that was dissolved in this sample of water.

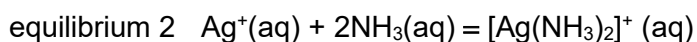
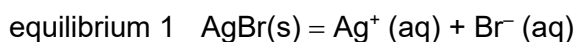
[3]

- (iii) A solution contains  $0.10 \text{ mol dm}^{-3}$  each of  $\text{Br}^-$  and  $\text{CO}_3^{2-}$ .  $\text{AgBr}$  and  $\text{Ag}_2\text{CO}_3$  can be precipitated by adding  $\text{AgNO}_3(\text{aq})$  dropwise to the solution. Which salt will precipitate out first,  $\text{AgBr}$  or  $\text{Ag}_2\text{CO}_3$ ? Explain your answer with appropriate calculations.

[2]

- (b)  $\text{AgBr}$  is soluble in concentrated  $\text{NH}_3(\text{aq})$  but sparingly soluble in dilute  $\text{NH}_3(\text{aq})$ .

Consider the following two equilibria at 298K.



Use the concepts of Le Chatelier's principle **and** solubility product, as applied to equilibria 1 and 2, explain why  $\text{AgBr}$  is soluble in concentrated  $\text{NH}_3(\text{aq})$  but sparingly soluble in dilute  $\text{NH}_3(\text{aq})$ .

Calculations are **not** required.

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[3]

- [1]

- Predict whether it would require more energy or less energy to initiate this process in AgCl compared to AgBr. Explain your answer as fully as you can.

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[2]


Nc1ccc(O)cc1.[Ag]Br.[Ag]Br.[OH-].[OH-]>>O=C1C=CC(=O)C=C1.N.O.[Ag].[Ag].[Br-].[Br-]

rodinal

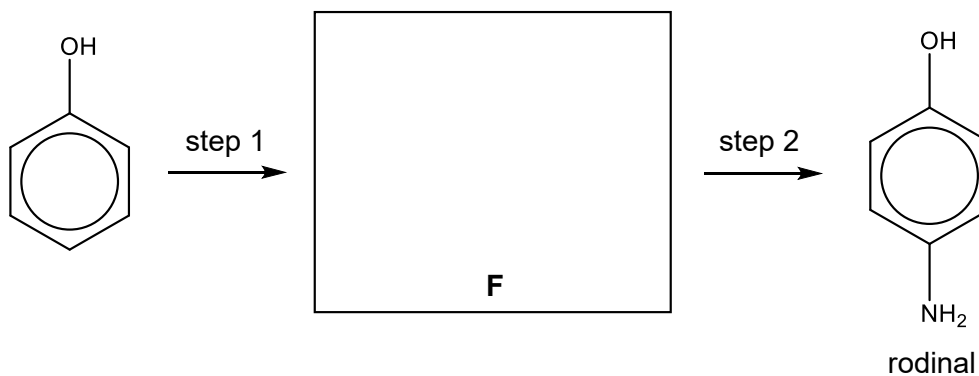
1,4-benzoquinone

- (iii) Write a half-equation for the oxidation of rodinal to 1,4-benzoquinone under the conditions described for the development of latent photographic image.

..... [1]

(iv) Rodinal can be synthesised from phenol.

State the reagents and conditions for steps 1 and 2 and draw the structure of compound **F** in the box provided.



step 1: .....

step 2: .....

[3]

[Total: 16]