Anglo-Chinese Junior College

JC2 Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

CHEMISTRY **9729/01**

Paper 1 Multiple Choice 13 September 2023
1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and index number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions in this section. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **16** printed pages.

1 Which types of chemical bonds listed below are present in solid ammonium nitrate?

1 ionic bonds
2 dative bonds
3 hydrogen bonds

A 1 only
B 1 and 2 only
C 1 and 3 only
D 1, 2 and 3

2 1.00 mol of gaseous molecules **A** take up a volume of 50 dm^3 at a pressure of 2 bar and a temperature of 50 ^oC.

Which statements explain the above observation?

1 Gaseous molecules of **A** are in constant rapid random motion.
2 Gaseous molecules of **A** have significant molecular volume.
3 Gaseous molecules of **A** experience strong intermolecular forces of attraction.

A 1 only
B 1 and 2 only
C 2 and 3 only
D 1, 2 and 3

3 Two properties relating to silicon and sulfur which are non–metallic elements and their atoms are as follows.

- property 1 – the oxide forms a strong acid in water
- property 2 – no paired 3p electrons

Which properties do silicon and sulfur have?

	silicon	sulfur
A	1 and 2	1 only
B	1 and 2	1 and 2
C	2 only	1 only
D	2 only	1 and 2

4 The Group 2 metals have higher melting points than the Group 1 metals.

Which factors could contribute towards the higher melting points?

1 There are smaller interatomic distances in the metallic lattices of the Group 2 metals.

2 Two valence electrons from each Group 2 metal atom are available for bonding in the metallic lattice.

3 Group 2 metals have the higher first ionisation energy.

A 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 1 only

5 Which statement about the trend in the property of the halogens down the group is correct?

A The electronegativity increases.

B The reactivity as oxidising agents increases.

C The enthalpy change of reaction with hydrogen becomes more endothermic.

D The volatility increases.

6 Group 1 and Group 2 ionic hydrides react with water.

$$H^- + H_2O \rightarrow OH^- + H_2$$

In an experiment, 1.01 g of a sample of an ionic hydride is dissolved in excess H_2O. The resulting solution required 24.0 cm^3 of a 2.0 mol dm^{-3} HC*l* solution for complete neutralisation.

What is the formula of the hydride?

A LiH

B NaH

C MgH_2

D CaH_2

7 Two identical iron(II) sulfate solutions were separately titrated with acidified $K_2Cr_2O_7$ and acidified $KMnO_4$ solutions of equal concentrations.

Which statement describes the required volumes of $K_2Cr_2O_7$ and $KMnO_4$ solutions needed to completely oxidise the iron(II)?

A The volume of $KMnO_4$ solution is 0.83 times that of the volume of $K_2Cr_2O_7$.

B The volume of $KMnO_4$ solution is 1.20 times that of the volume of $K_2Cr_2O_7$.

C The volume of $KMnO_4$ solution is 1.82 times that of the volume of $K_2Cr_2O_7$.

D The volume of $KMnO_4$ solution is 2.22 times that of the volume of $K_2Cr_2O_7$.

8 Which reaction represents a standard enthalpy change at 298 K?

A $\frac{1}{2}F_2(g) \longrightarrow F(g)$

B $C(g) + O_2(g) \longrightarrow CO_2(g)$

C $C(s) + 4F(g) \longrightarrow CF_4(g)$

D $C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(g)$

9 Ethane undergoes combustion as shown.

$$C_2H_6(g) + \frac{7}{2}O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l) \qquad \Delta H_c^{\ominus} = -1561 \text{ kJ mol}^{-1}$$

Some relevant data are given below.

$\Delta H_c^{\ominus}$ of C(s) = –394 kJ mol^{-1}
$\Delta H_f^{\ominus}$ of $C_2H_6(g)$ = –85 kJ mol^{-1}
$\Delta H_f^{\ominus}$ of $H_2O(g)$ = –243 kJ mol^{-1}

What is the standard enthalpy change of vaporisation of $H_2O(l)$?

A +43 kJ mol^{-1}

B –43 kJ mol^{-1}

C +129 kJ mol^{-1}

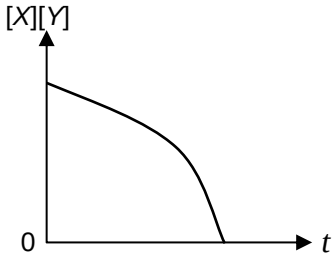
D –129 kJ mol^{-1}

10 The product [*X*][*Y*] of the concentrations of *X* and *Y* is plotted against time, *t*, for the following second-order reaction.

$$X + Y \longrightarrow Z$$

Which graph would be obtained?

A



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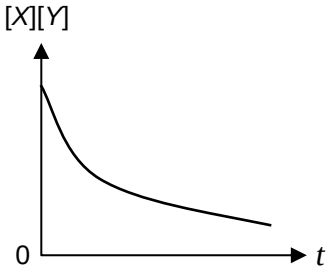

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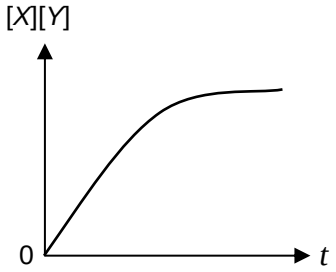
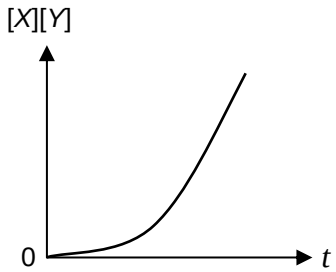


D



11 Two first order reactions were started at the same time. Reaction **I** had an initial concentration of 1 mol dm^{-3} and a half-life of 20 minutes. Reaction **II** had an initial concentration of 4 mol dm^{-3} and a half-life of 10 minutes.

At what time would the concentrations in the two reactions become equal?

A 15 min

B 35 min

C 40 min

D 50 min

12 The reaction between sulfur dioxide and oxygen is reversible.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The rate constants of the forward and backward reactions are given as k_1 and k_{-1} respectively.

What happens to the values of k_1, k_{-1}, K_c and the equilibrium position if an inert gas is introduced into the reaction vessel at constant volume?

	k_1	k_{-1}	K_c	equilibrium position
A	unchanged	unchanged	unchanged	unchanged
B	increases	decreases	increases	shifts to right
C	decreases	increases	decreases	shifts to left
D	unchanged	unchanged	unchanged	shifts to right

13 Malic acid is a dibasic acid which is used in skincare products.

The pK_a values of malic acid are 3.40 and 5.20.

What volume of 0.200 mol dm^{-3} KOH needs to be added to 20.00 cm^3 of 0.240 mol dm^{-3} of malic acid to form a buffer solution of pH 5.22?

A 35.70 cm^3

B 35.90 cm^3

C 36.10 cm^3

D 36.30 cm^3

14 The indicator bromophenol blue, HIn, changes colour from yellow to blue over a pH range of 3.0 to 4.6.

Which statement is correct?

A When bromophenol blue is added to pure water at 25 ^{o}C, [HIn] > [In^-].

B Bromophenol blue would be a suitable indicator for the titration of a strong base and a weak acid.

C The In^- ions are yellow.

D The pK_a of bromophenol blue is around 3.8.

15 The numerical values of the solubility products of zinc carbonate and silver carbonate are 1.46×10^{-10} and 8.46×10^{-12} respectively.

Which statement can be deduced from the information given above?

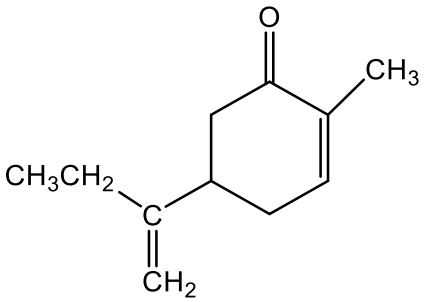
A The units of solubility product for both salts are the same.

B In an aqueous solution containing 0.01 mol dm^{-3} zinc ions and 0.01 mol dm^{-3} silver ions, silver carbonate will be precipitated first.

C In saturated solutions of each salt, the concentrations of carbonate ions are the same.

D Zinc carbonate is a less soluble salt than silver carbonate in water.

16 A compound derived from plant essential oil has the following structure.



When the compound is reacted with HBr in CCl_4, how many new chiral centres are formed in the major product in this reaction?

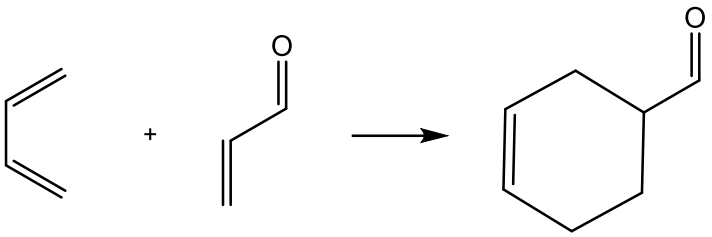
A 1

B 2

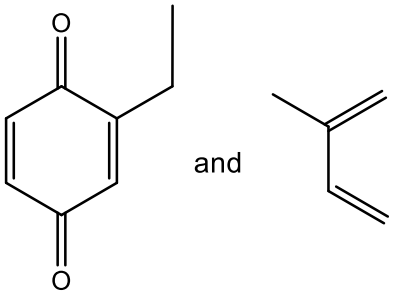
C 3

D 4

17 Unsaturated carbonyl compounds can undergo a useful reaction known as the Diels-Alder reaction with a diene. An example is shown below.

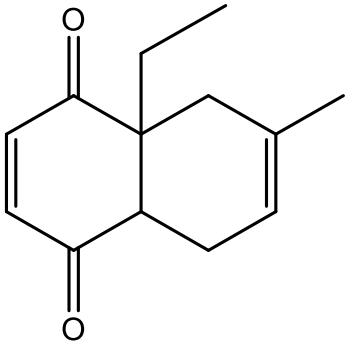


A student reacted the following diene and carbonyl compound together in a Diels-Alder reaction.

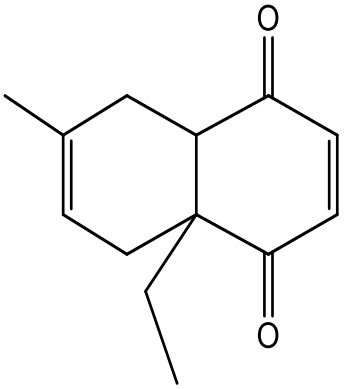


Which compound would **not** be formed as a product?

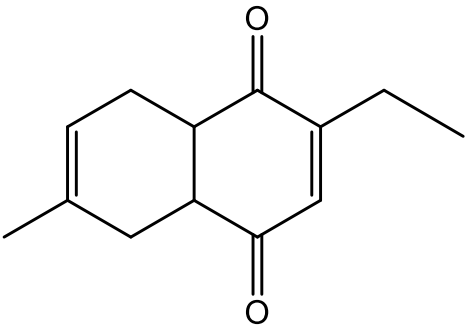
A



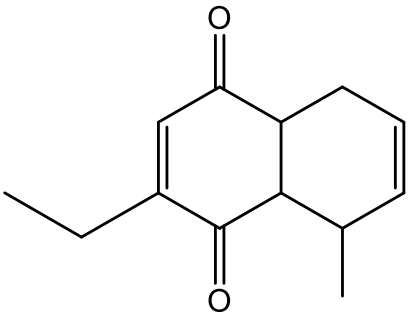
C



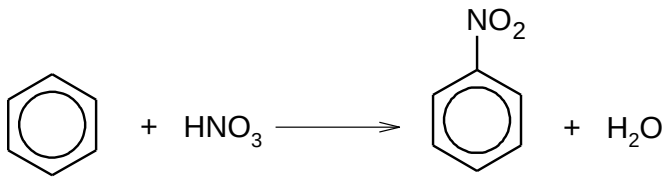
B



D



18 Nitrobenzene is a yellow liquid with the smell of almonds. It may be prepared by heating a mixture of benzene, concentrated nitric acid and concentrated sulfuric acid under reflux.



Why is concentrated sulfuric acid used?

A It acts as a Lewis acid catalyst.

B It removes protons from nitric acid, thus forming NO_2^- ions.

C It donates protons to nitric acid, thus forming NO_2^+ ions.

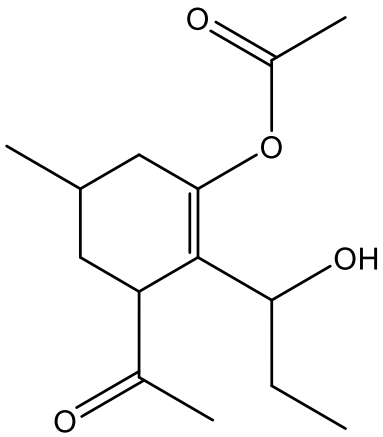
D It acts a dehydrating agent to remove water from benzene and nitric acid.

19 The same mass of each of the four organic compounds was heated up to 50 ^{o}C with excess alkaline aqueous iodine.

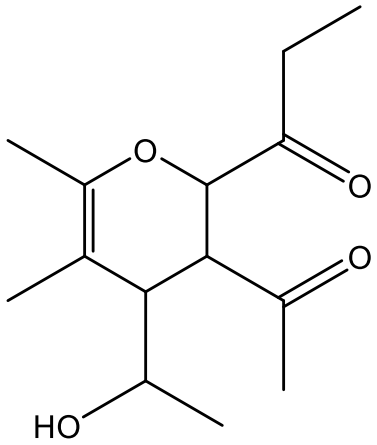
The mixture was then filtered, and the filtrate was washed with tetrachloromethane to remove unreacted iodine. The aqueous layer was treated with a dilute acid, followed by aqueous silver nitrate, and the precipitate, if formed, was collected.

Which structure gives the greatest mass of precipitate?

A



C



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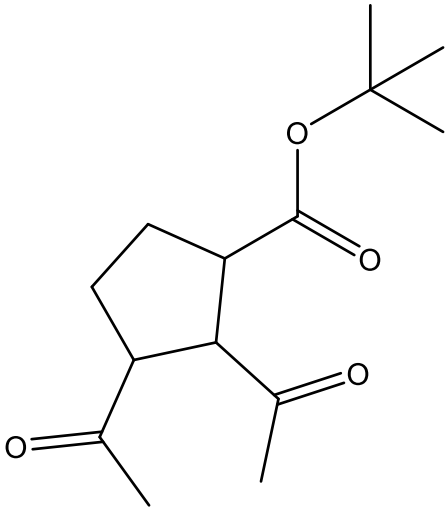

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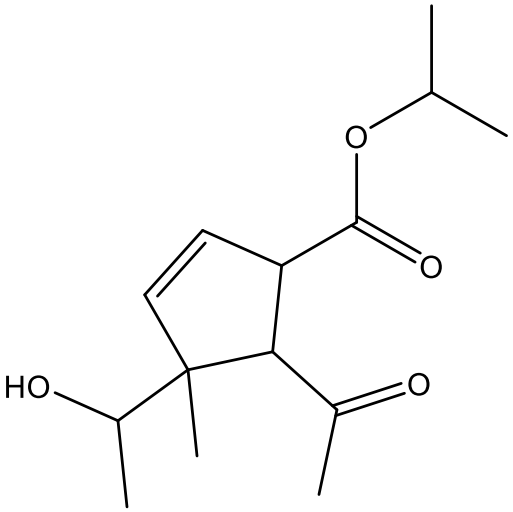
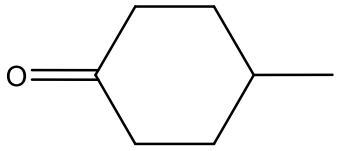


20 The structure of compound **Z** is shown below:



Z

Which statement about compound **Z** is true?

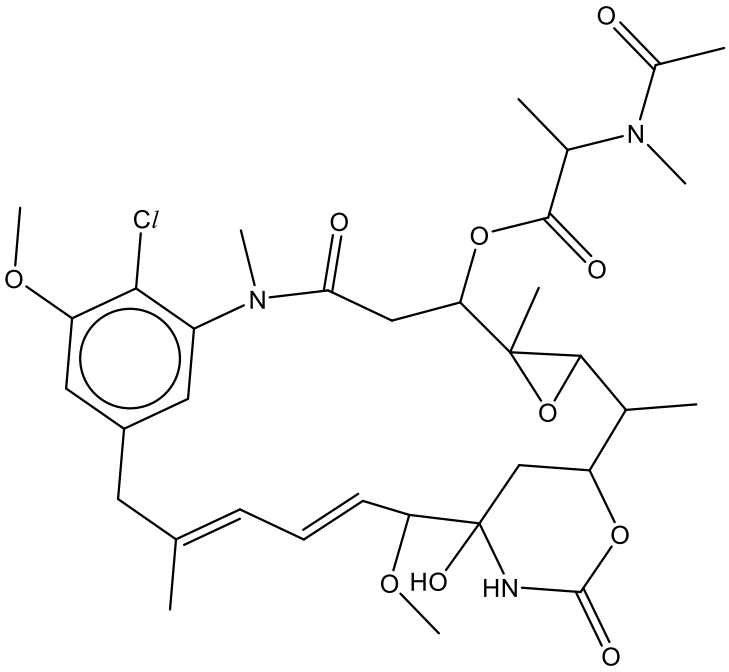
A All six carbon atoms in the 6-membered ring in **Z** lie in the same plane.

B It reacts with cold HCN in the presence of NaCN to produce a racemic mixture, due to the trigonal planar geometry about the carbonyl carbon.

C It changes warm acidified aqueous potassium manganate(VII) from purple to colourless.

D There are two sp^2 hybridised atoms in **Z**.

21 Maytansine is a potent antitumour agent. It has 34 carbons.



Which statement about maytansine is **false**?

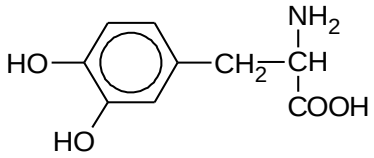
A Its molecular formula is $C_{34}H_{46}ClN_3O_{10}$.

B 3 moles of CO_2 are formed when 1 mole of maytansine is oxidised by hot acidified $KMnO_4$.

C It does not react with 2,4-dinitrophenylhydrazine.

D 1 mole of H_2 is formed when 1 mole of maytansine is reacted with excess sodium.

22 The molecule shown is used in the treatment of Parkinson's disease.



Which statements about the molecule are correct?

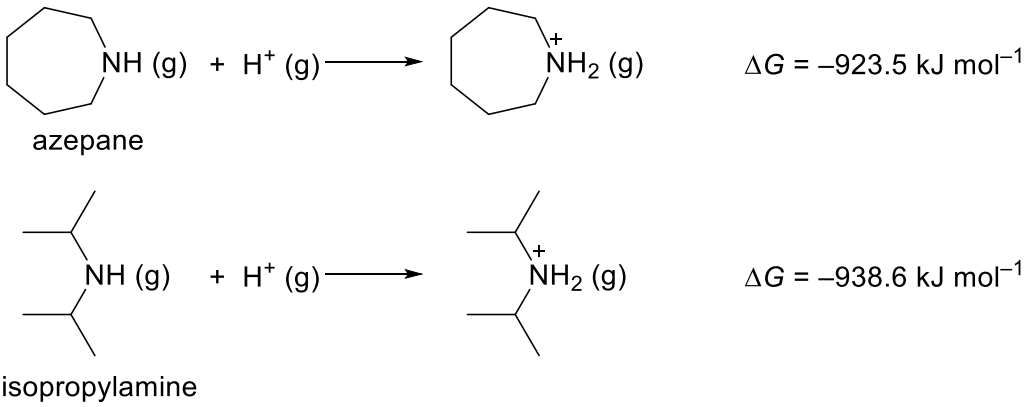
1 It is likely to be soluble in water due to zwitterion formation.

2 Two Br atoms will be incorporated when aqueous bromine is added.

3 One mole of molecule reacts with three moles of sodium hydrogen carbonate solution to form a salt.

A 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 1 only

23 The basicity of gaseous azepane and diisopropylamine is measured by the Gibbs free energy change, ΔG, for the protonation of the two amines in gaseous phase:



The pK_b of azepane and diisopropylamine are 2.93 and 3.43, respectively.

Which statement correctly explains the differences in basicity of the two amines shown?

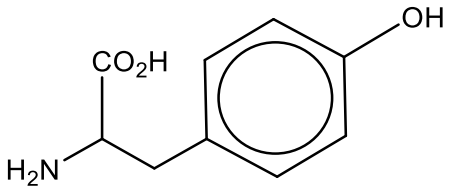
A Diisopropylamine is a stronger base in gaseous phase as it has a smaller electron cloud size than azepane.

B Diisopropylamine is a weaker base in water as the conjugate acid is less readily hydrated due to steric hindrance from the two bulky $(CH_3)_2CH–$ groups.

C Azepane is a stronger base in water as it has fewer hydrogen atoms compared to diisopropylamine.

D Azepane is a weaker base in gaseous phase as it is a primary amine, while diisopropylamine is a secondary amine.

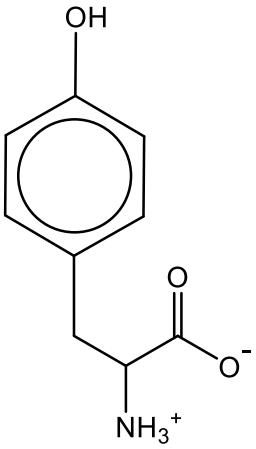
24 Tyrosine was first discovered in 1846 by German chemist Justus von Liebig in the protein casein from cheese. It is found in animal sources such as meats.



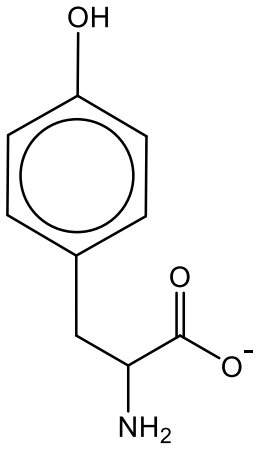
There are three pK_a values associated with tyrosine: 2.20, 9.22, 10.46.

What is the major species present in a solution of tyrosine at pH 5.71?

A



C



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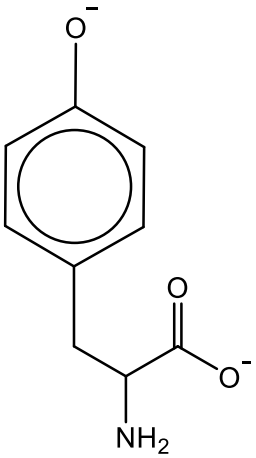

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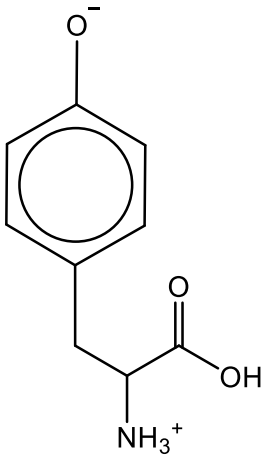


25 J is a synthetic nonapeptide that is found in honeybee venom.

To investigate the sequence of amino acids in J, the nonapeptide was first hydrolysed by two enzymes. The protein fragments were then separated and their sequence determined.

The first enzyme, which hydrolysed the polypeptide chain at the carboxylic end of the amino acid lysine, Lys, yielded the following fragments.

Trp-Ile-Lys
Leu-Arg
Arg-Ile-Ser-Lys

The following protein fragments were obtained from the second enzyme which hydrolysed the polypeptide chain at the carboxylic end of the amino acid isoleucine, Ile.

Ser-Lys-Trp-Ile
Arg-Ile
Lys-Leu-Arg

Which is the correct primary structure of the nonapeptide J?

A Lys-Leu-Arg-Ile-Ser-Lys-Trp-Ile-Lys

B Arg-Ile-Ser-Lys-Trp-Ile-Lys-Leu-Arg

C Ser-Lys-Trp-Ile-Lys-Leu-Arg-Ile-Ser

D Trp-Ile-Lys-Leu-Arg-Ile-Ser-Lys-Trp

26 *Use of the Data Booklet is relevant to this question*.

Vanadium forms a number of aqueous ions.

Which statements are correct?

1 Excess zinc can reduce VO_2^+(aq) to V^{2+}(aq) in acidic conditions.

2 Excess Fe^{3+}(aq) can oxidise V^{2+}(aq) to VO_2^+ (aq) in acidic conditions.

3 Excess Zn^{2+}(aq) ions can oxidise V^{2+}(aq) ions to V^{3+}(aq) ions.

A 1 only

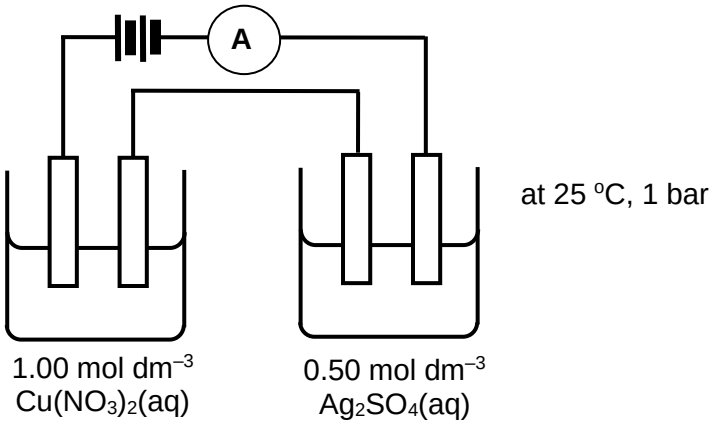
B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

27 *Use of the Data Booklet is relevant to this question.*

Using inert electrodes, a current was passed through two beakers containing aqueous silver(I) sulfate and aqueous copper(II) nitrate, connected in series under standard conditions.



What is the ratio of the mass of copper to silver deposited when current flows?

A 0.29 **B** 0.59 **C** 1.70 **D** 3.40

28 Hexaaquatitanium(III) ion hydrolyses as shown.

$$Ti(H_2O)_6^{3+}(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + Ti(H_2O)_5OH^{2+}(aq)$$

Which statements are correct?

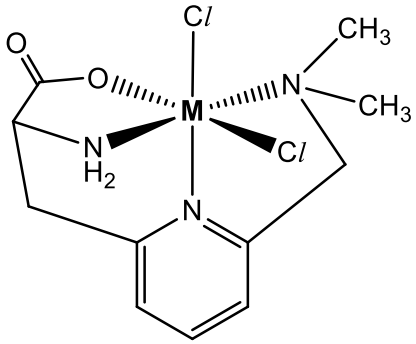
1 The corresponding hexaaquatitanium(II) ion, $Ti(H_2O)_6^{2+}$, is less likely to undergo hydrolysis.

2 This hydrolysis is favoured by low pH conditions.

3 Titanium undergoes a change in oxidation state.

A 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 1 only

29 Which statement regarding the neutral metal complex below is **false**?



A The oxidation number of **M** in the complex is +2 because the complex is neutral and there are two chloride ligands.

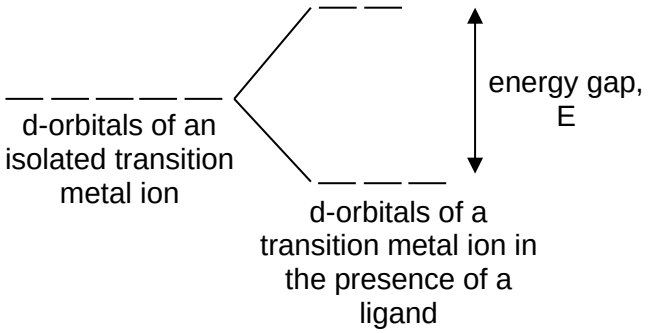
B The complex contains a ligand which possesses a primary and tertiary amine.

C The complex contains a ligand which is an α-amino acid.

D The complex is octahedral with respect to **M**.

30 *Use of Data Booklet is relevant to this question.*

The following diagram shows how the d–orbitals are split in an octahedral environment.



Some transition metal ions exhibit the ability to change their electronic configuration from a ‘high spin’ state to a ‘low spin’ state.

In a ‘high spin’ state, the electrons occupy all the d–orbitals singly first, before starting to pair up in the lower energy d–orbitals.

In a ‘low spin’ state, the lower energy d–orbitals are first filled, by pairing up if necessary, before the higher energy d–orbitals are used.

Which transition metal ion is likely to be able to exhibit both spin states?

A Cu^{2+} **B** Cr^{3+} **C** Fe^{3+} **D** Ni^{2+}