

Anglo-Chinese Junior College

JC2 Preliminary Examination

Higher 2



A Methodist Institution
(Founded 1866)

CHEMISTRY

Paper 1 Multiple Choice

9729/01

17 September 2025

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 **15** printed pages.

- 1 The most common oxidation state of americium, Am, in aqueous solution is +3.

Recently, Cu^{3+} has been shown to quantitatively oxidise $\text{Am}^{3+}(\text{aq})$ in dilute HNO_3 , while itself is reduced to Cu^{2+} .

In an experiment, 20.0 cm^3 of $0.0120 \text{ mol dm}^{-3} \text{ Am}^{3+}(\text{aq})$ was found to require 24.00 cm^3 of $0.0300 \text{ mol dm}^{-3} \text{ Cu}^{3+}$ for complete oxidation.

What is the formula of the americium-containing species formed?

- A $\text{Am}_2\text{O}_2^{2+}$
- B AmO_2^{2+}
- C AmO^{2+}
- D AmO^+

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

The table shows the fifth, sixth, seventh, eighth, ninth and tenth ionisation energies of an element ($Z \leq 20$) in the Periodic Table.

	5th	6th	7th	8th	9th	10th
ionisation energy / kJ mol^{-1}	7975	9590	11343	14944	16964	48610

What can be inferred about the element from the above data?

- A It is in the third period of the Periodic Table.
- B It is in Group 2 of the Periodic Table.
- C It is likely to form an ionic compound when reacted with oxygen.
- D Its 6th and 7th electrons are removed from different subshells.

- 3 Particle **R** has a proton number n and forms a stable monoatomic ion of charge -1 .

Particle **S** has a proton number of $(n+2)$ and it forms a stable monoatomic ion which is isoelectronic with the ion of **R**.

Which statement is correct?

- A Ion of **S** has a smaller ionic radius than ion of **R**.
- B **R** has a larger atomic radius than **S**.
- C Ion of **S** requires less energy than ion of **R** when an electron is removed from each particle.
- D Ion of **R** releases more energy than ion of **S** when an electron is added to each particle.

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

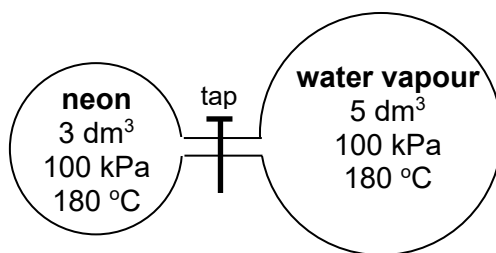
- A The electronegativity increases.
- B The volatility increases.
- C The enthalpy change of reaction with hydrogen becomes less exothermic.
- D The reactivity as reducing agents increases.

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

Which sequence is correct in terms of increasing radius?

- A $\text{Rb}^+ < \text{Sr}^{2+} < \text{As}^{3-} < \text{Se}^{2-}$
- B $\text{Sr}^{2+} < \text{Rb}^+ < \text{Se}^{2-} < \text{As}^{3-}$
- C $\text{As}^{3-} < \text{Se}^{2-} < \text{Sr}^{2+} < \text{Rb}^+$
- D $\text{Se}^{2-} < \text{Sr}^{2+} < \text{Rb}^+ < \text{As}^{3-}$

6 Two bulbs are connected as shown in the diagram below. The bulbs are connected by a narrow tube of negligible volume.



When the tap is opened, the two gases mix. The connected bulbs were then allowed to cool to room temperature.

What was the final pressure, in kPa, in the connected bulbs?

- A 13.9
- B 24.3
- C 37.5
- D 64.7

- 7 $(\text{CH}_3)_2\text{S} \cdot \text{BCl}_3$ is a solid that is commonly used in laboratories as a convenient source of BCl_3 . When heated, it reversibly decomposes to $(\text{CH}_3)_2\text{S}$ and BCl_3 .

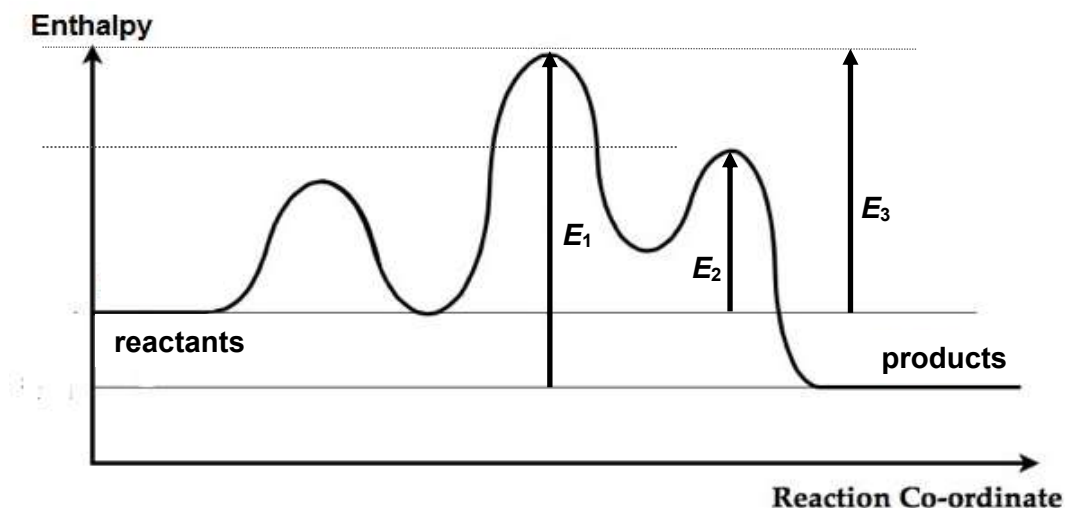
Which statement is true?

- A The dative bond is formed using the 2p orbitals of boron and sulfur.
 B $(\text{CH}_3)_2\text{S}$ and BCl_3 act as the Lewis acid and Lewis base respectively in the formation of $(\text{CH}_3)_2\text{S} \cdot \text{BCl}_3$.
 C The dative bond is from boron to sulfur.
 D The C-S-C bond angle decreases when the solid decomposes.
- 8 The compound $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$ is a superconductor.

In this compound, the oxidation number of bismuth is +3, strontium and calcium is +2 and oxygen is -2.

What are the possible oxidation numbers of the three copper atoms in $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$?

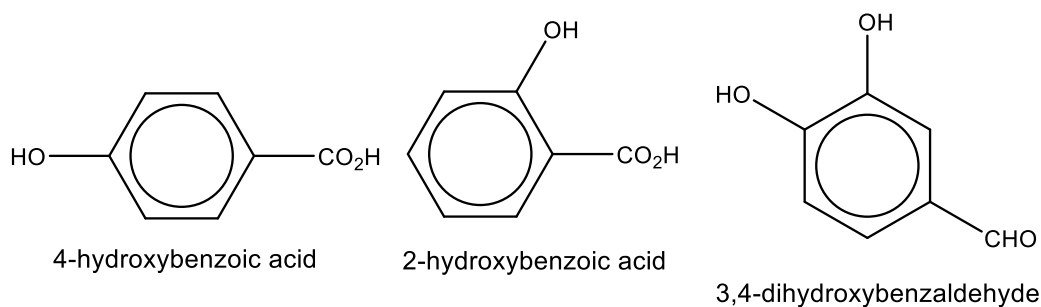
- A +1, +1, +2
 B +1, +2, +3
 C 0, +1, +3
 D 0, +2, +3
- 9 The energy profile diagram below represents a certain three-step reaction.



Which statements are correct about the above reaction?

- 1 E_3 is the activation energy of the second step.
 - 2 ΔH can be obtained by subtracting E_2 from E_1 .
 - 3 There are equal number of intermediates and transition states.
- A 1 only B 2 only C 1 and 3 D 2 and 3

- 10 4-hydroxybenzoic acid (A), 2-hydroxybenzoic acid (B) and 3,4-dihydroxybenzaldehyde (C) share the same molecular formula.



All three compounds combust exothermically. Their standard enthalpy changes of formation are tabulated below.

	standard enthalpy change of formation / kJ mol^{-1}
4-hydroxybenzoic acid	-481
2-hydroxybenzoic acid	-493
3,4-dihydroxybenzaldehyde	-392

Which statements are correct?

- 2-hydroxybenzoic acid and 3,4-dihydroxybenzaldehyde are chain isomers.
- The magnitude of the standard enthalpy change of combustion decreases in the order $C > A > B$.
- The thermodynamic stability decreases in the order $B > A > C$.

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

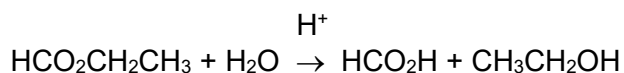
- 11 A 0.483 g sample of glycine ($M_r = 75.0$) was placed in a bomb calorimeter and then ignited in the presence of excess oxygen. The temperature rose by 0.54°C .

In a separate experiment using the same calorimeter, the combustion of 0.986 g of benzoic acid ($M_r = 122.0$) gave a temperature rise of 2.14°C . The enthalpy change of combustion of benzoic acid is $-3054 \text{ kJ mol}^{-1}$.

What is the enthalpy change of combustion, in kJ mol^{-1} , of glycine?

- A** -615 kJ mol^{-1}
B -967 kJ mol^{-1}
C $-2423 \text{ kJ mol}^{-1}$
D $-3812 \text{ kJ mol}^{-1}$

- 12 Ethyl formate undergoes a slow acid-catalysed hydrolysis in water.



The rate law is found to be

$$\text{rate} = k[\text{HCO}_2\text{CH}_2\text{CH}_3][\text{H}^+]$$

When 0.1 mol dm^{-3} of HCl is reacted with 0.4 mol dm^{-3} of ethyl formate, the half-life was found to be 62 min.

Another reaction was carried out with 0.3 mol dm^{-3} of HCl and 0.4 mol dm^{-3} of ethyl formate.

How long does it take for the concentration of ethyl formate to fall to $0.050 \text{ mol dm}^{-3}$?

- A** 31 min **B** 62 min **C** 93 min **D** 124 min

- 13 The decomposition of phosphorus pentachloride is reversible.

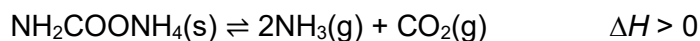


The rate constants of the forward and backward reactions are given as k_1 and k_{-1} respectively.

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 temperature and pressure?

	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

- 14 Ammonium carbamate, $\text{NH}_2\text{COONH}_4$, undergoes thermal decomposition.



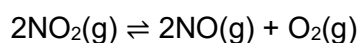
A vessel containing only $\text{NH}_2\text{COONH}_4$ is heated to 250°C . The reaction reached equilibrium at time t_1 . Subsequently both the temperature and volume of the vessel are decreased, and the reaction established a new equilibrium at time t_2 .

Which statements are correct?

- 1 At t_2 , $P_{\text{NH}_3} : P_{\text{CO}_2}$ is 2 : 1.
- 2 The rate of the forward reaction at t_1 is the same as that at t_2 .
- 3 The degree of decomposition of $\text{NH}_2\text{COONH}_4$ at t_1 is smaller than that at t_2 .
- 4 Decreasing the volume of the vessel at constant temperature has no effect on the equilibrium partial pressures of NH_3 and CO_2 .

- A** 1 and 4 **B** 2 only **C** 1 and 3 **D** 2 and 3

- 15 Nitrogen dioxide can decompose to form nitrogen monoxide and oxygen.

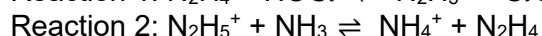


When 2.50 mol of nitrogen dioxide was allowed to undergo decomposition in a 0.8 dm^3 container, 0.528 mol of oxygen was present at equilibrium.

What is the numerical value of the equilibrium constant, K_c , for this reaction?

- A** 3.54 **B** 2.83 **C** 0.353 **D** 0.282

- 16 The position of equilibrium lies to the right in each of these reactions.



Which statement can be deduced from the information given above?

- A** The order of acid strength is $\text{HOC}l < \text{N}_2\text{H}_5^+ < \text{NH}_4^+$.
- B** N_2H_4 is the Bronsted–Lowry acid in Reaction 1.
- C** N_2H_5^+ and NH_3 are a conjugate acid–base pair in Reaction 2.
- D** N_2H_4 is a weaker base than NH_3 .

- 17 The value of $\text{p}K_w$ at 80°C is 13.94.

What is the pH of an aqueous solution of 0.05 mol dm^{-3} $\text{Ba}(\text{OH})_2$ at 80°C ?

- A** 12.64 **B** 12.94 **C** 13.44 **D** 13.94

- 18 The table below shows the numerical values of the solubility products (measured at 25 °C) for some salts.

Salt	CdCO_3	FeS	CoCO_3	CuS
K_{sp}	1.0×10^{-12}	6.0×10^{-19}	1.0×10^{-10}	8.0×10^{-37}

Which statement can be deduced from the information given above?

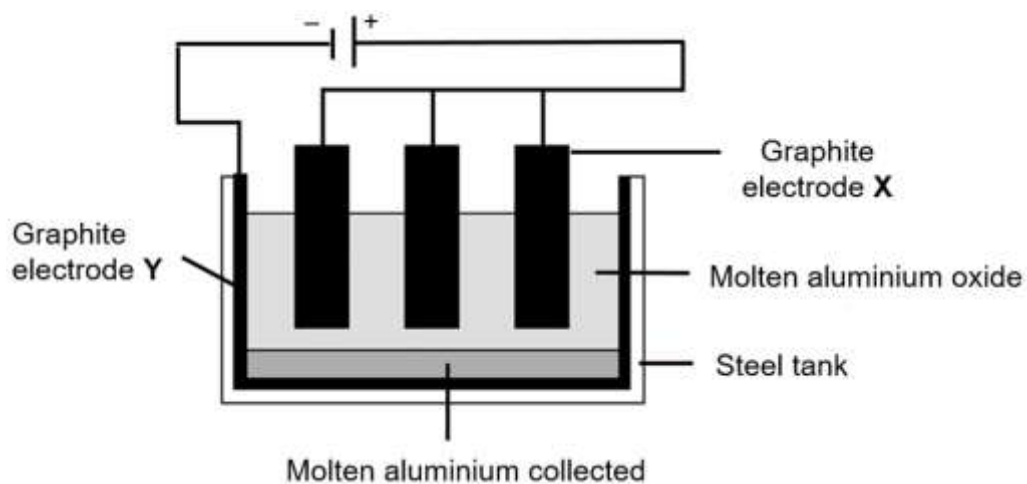
- A CuS is more soluble than FeS.
 B CdCO_3 is more soluble than CoCO_3 .
 C The solubility of these four salts will be increased at lower pH.
 D The K_{sp} value of CuS will decrease as less of it can dissolve when copper(II) nitrate is added to a saturated solution.
- 19 The solubilities of AgCl and AgI are x and y mol dm⁻³ respectively at 298 K.

Which statements are correct about a solution saturated with both AgCl and AgI?

- 1 $[\text{Ag}^+] = x + y$
 2 $[\text{Ag}^+] = [\text{I}^-] + [\text{Cl}^-]$
 3 $[\text{I}^-] < y$

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

20 Aluminium is extracted from its ore by electrolysis.

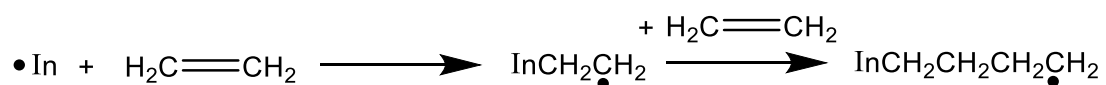


Which statements are correct?

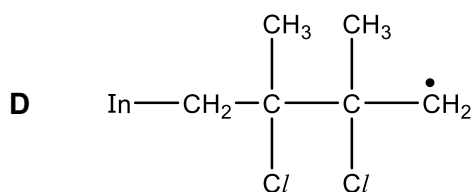
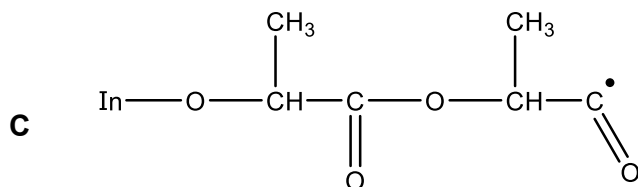
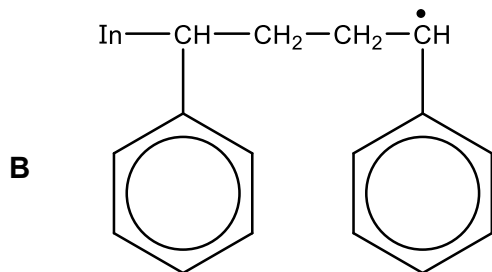
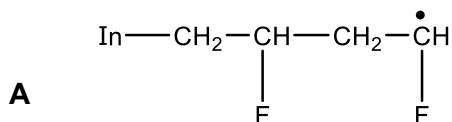
- 1 Aluminium ions migrate to electrode **X**.
- 2 Oxygen gas is produced.
- 3 Electrons move from electrode **X** to electrode **Y** via the external circuit.

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

- 21 Free radical addition is a mechanism used in the synthesis of some addition polymers. Alkene monomers will polymerise in the presence of a radical initiator (In^\bullet). For instance, the synthesis of polyethene begins as such.

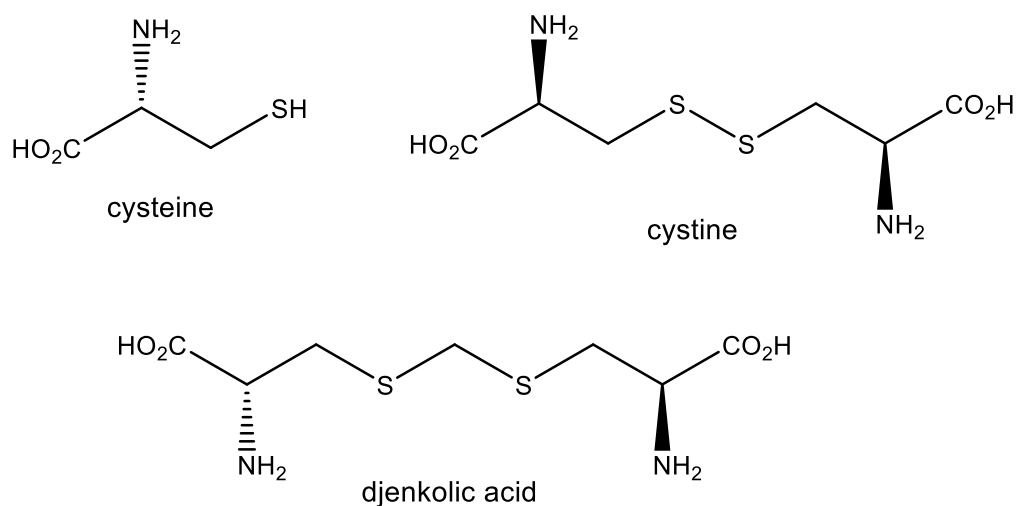


Which chain could **not** have arisen from free radical addition?



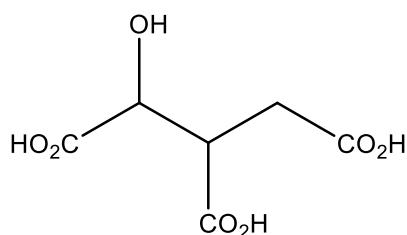
- 22** Cysteine and cystine are important biochemicals in which the former is biosynthesised from the latter. Cysteine is a naturally occurring α -amino acid, while djenkolic acid is a non-protein amino acid found in the djenkol beans of the Southeast Asian plant.

The three pK_a values of cysteine are 1.71, 8.33 (belonging to the thiol, $-SH$), and 10.78.



Which statement about cysteine, cystine and djenkolic acid is true?

- A** Cystine is a *meso* compound, hence it is non-chiral.
 - B** Cysteine exists solely in its zwitterionic form at pH 5.02.
 - C** Cystine and cysteine share the same empirical formula.
 - D** There are four stereoisomeric forms of djenkolic acid because there are two chiral atoms in djenkolic acid.
- 23** Isocitric acid is a naturally occurring compound found in fruit juices, vegetables, and other biological systems. It plays an important role in the citric acid cycle.



Which compound, on reaction with isocitric acid in the presence of concentrated sulfuric acid, will produce an organic product of molecular formula $C_9H_{12}O_8$?

- A** methanoic acid
- B** propan-2-ol
- C** methanol
- D** propanoic acid

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

A sample of an ester is hydrolysed by heating under reflux with aqueous sodium hydroxide. The two organic products of the hydrolysis are separated, purified and weighed.

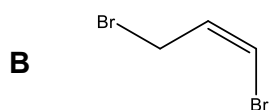
Which ester would produce a 3:1 mass ratio of the two products obtained?

- A** propyl methanoate
- B** ethyl ethanoate
- C** butyl methanoate
- D** methyl propanoate

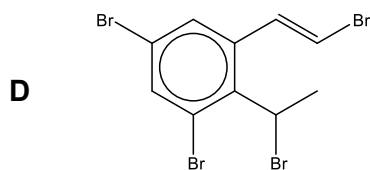
- 25** 0.04 mol of each of the following compounds was heated with KOH(aq), followed by addition of dilute HNO₃ and AgNO₃(aq).

Which compound will produce the highest mass of AgBr(s)?

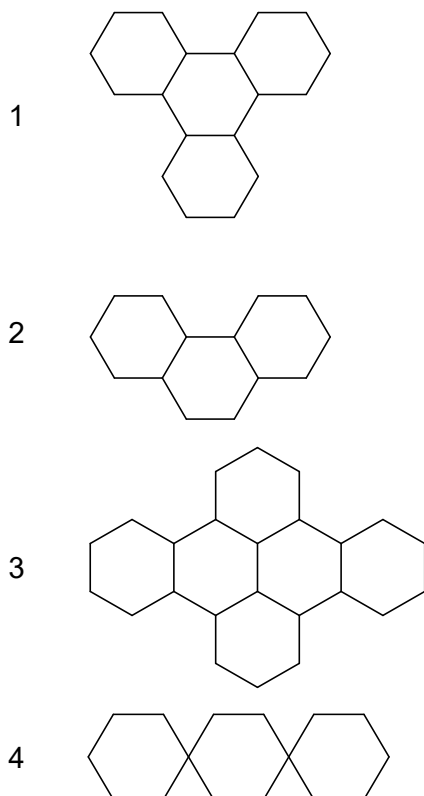
- A** BrCOCH₂COBr



- C** CH₃CH₂CH₂Br



- 26 Which pair of compounds will **not** form when cyclohexane is reacted with excess bromine gas in the presence of ultraviolet light?

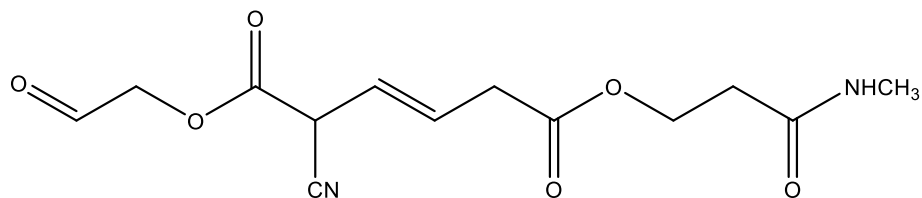


- A** 1 and 2 **B** 2 and 4 **C** 1 and 3 **D** 1 and 4

- 27 Esters can be reduced by LiAlH_4 in dry ether to give two alcohols as shown below.



Which product may be formed when the following compound is reacted with excess LiAlH_4 in dry ether?



- A** $\text{H}_2\text{NCH}_2\text{CH}(\text{CH}_2\text{OH})\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
B $\text{NCCH}(\text{CO}_2\text{H})\text{CH}=\text{CHCH}_2\text{CO}_2\text{H}$
C $\text{HOCH}_2\text{CH}_2\text{NHCH}_3$
D $\text{HOCH}_2\text{CH}_2\text{OH}$

- 28** Chymotrypsin is an enzyme that hydrolyses protein into smaller peptides and amino acids. It specifically hydrolyses the peptide bond on the carboxylic end of Phe.

The structure of tetrapeptide **X** and M_r of selected amino acids are given below.

tetrapeptide **X**: Val–Lys–Phe–Arg

amino acid	M_r
Val	117
Lys	146
Phe	165
Arg	174

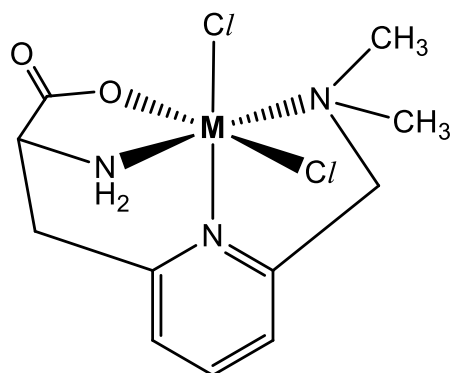
What are the M_r of the two fragments obtained when tetrapeptide **X** is hydrolysed by chymotrypsin?

- A** 174 and 392
B 174 and 428
C 245 and 321
D 263 and 339
- 29** *Use of the Data Booklet is relevant to this question.*

Which statement is true?

- A** CoF_3 is stable in water because $2\text{Co}^{3+} + 2\text{F}^- \rightarrow \text{F}_2 + 2\text{Co}^{2+}$ is a non-spontaneous reaction.
B It is possible to prepare aqueous iron(III) iodide.
C $\text{Cr}_2\text{O}_7^{2-}$ is the oxidised form of CrO_4^{2-} because it contains more oxygen atoms.
D The oxidation of iron(II) to iron(III) can be prevented at lower pH.

30 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 coordination number of the complex is 6.
- C** The complex contains a tetradentate ligand.
- D** The complex contains a ligand which is an α -amino acid.