ABC CHEMISTRY

Mr. Aniket Bhardwaj · 15+ Years Mentorship

Bioinorganic Chemistry

Premium CSIR-NET PYQ Book

71 Previous-Year Questions · 69 with verified answers · Distractor Analysis

3-Slide Solutions | Distractor Analysis | Exam Tricks | Revision Sheets

CSIR-NET · GATE · IIT-JAM — 6 Topics · 71 Real PYQs

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Course Contents

6 Topics · 71 PYQs

1	**Oxygen Carriers Hemoglobin** 9 Qs E 5 · M 4 · H 0	13%	
2	**Iron Sulfur Proteins** 8 Qs E 4 · M 3 · H 1	11%	
3	**Metal Toxicity Medicine** 6 Qs E 3 · M 3 · H 0	8%	
4	**Zinc Enzymes** 4 Qs E 4 · M 0 · H 0	6%	
5	**Nitrogen Fixation** 3 Qs E 2 · M 1 · H 0	4%	
6	**Bioinorganic Chemistry – General** 41 Qs E 27 · M 14 · H 0	58%	

Legend: **E** Easy **M** Medium **H** Hard · **%** = exam weightage (share of the chapter)

TOPIC 1

Oxygen Carriers Hemoglobin

9 questions · Easy 5 | Medium 4 | Hard 0 · PYQ frequency: Very High

Oxygen Carriers Hemoglobin

Q1 Fe^{2+}-porphyrins fail to exhibit reversible oxygen transport and cannot differentiate CO from O_2. However, the hemoglobin is free from both these pit falls. Among the following (A) Fe^{2+}-porphyrins undergo μ-oxodimer formation and the same is prevented in case of the hemoglobin. (B) Fe-CO bond strength is much low in case of hemoglobin when compared to the Fe^{2+} porphyrins. (C) While Fe-CO is linear, Fe-O_2 is bent and is recognized by hemoglobin (D) The interlinked four monomeric units in the hemoglobin are responsible to overcome the pitfalls. The correct set of statements is

- **A** A and B
- **B** A and C
- **C** C and D
- **D** B and D

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Oxygen Carriers Hemoglobin

PYQ FREQUENCY
Very High · 9 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Proximal binds, distal guards'.

Oxygen Carriers Hemoglobin

Correct Answer B A and C

CONCEPT

Hemoglobin (tetramer, cooperative, sigmoidal curve) vs myoglobin (monomer, hyperbolic); heme Fe(II) binds O_2 end-on bent; hemerythrin (Fe_2, O_2 → hydroperoxide), hemocyanin (Cu_2, O_2 side-on peroxo, blue); Bohr effect and 2,3-BPG; CO and CN^- poisoning.

↓

LOGIC / WORKING

- Free Fe(II) porphyrins form irreversible μ-oxo dimers, which the protein pocket prevents in hemoglobin. The distal histidine favours bent Fe–O_2 and disfavours linear Fe–CO, which reduces CO affinity. A and C (b).
- Therefore the answer is (B).

FINAL: (B) A and C

SHORTCUT / EXAM TRICK

Hb binds O_2 weakly at low pO_2 and strongly at high pO_2 — cooperativity through quaternary T→R shift.

COMMON MISTAKE

Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

EXAM TIP

Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

MEMORY TRICK

'Proximal binds, distal guards'.

Why the Other Options Are Wrong

Correct answer: B

A

A and B

Why (B) is the key — Free Fe(II) porphyrins form irreversible μ-oxo dimers, which the protein pocket prevents in hemoglobin. The distal histidine favours bent Fe–O_2 and disfavours linear Fe–CO, which reduces CO affinity. A and C (b).

C

C and D

Ruled out: Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

D

B and D

Ruled out: Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

Oxygen Carriers Hemoglobin

Q2

Under physiological condition, oxygen is binding to deoxyhemoglobin and deoxymyoglobin, the binding curve and its pH dependence, respectively, are (a) Sigmoidal and pH dependent; hyperbolic and pH independent (b) Hyperbolic and pH independent; sigmoidal and pH dependent

SELF-PRACTICE answer on record: (A) — options were not printed in the source.

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Oxygen Carriers Hemoglobin

PYQ FREQUENCY
Very High · 9 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Proximal binds, distal guards'.

Q3

The resonance Raman stretching frequency (ν_O-O in cm^{-1}) of O_2, is 1580. The ν_O-O for O_2 in bound oxy-hemoglobin is close to

A 1600

B 1900

C 800

D 1100

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Oxygen Carriers Hemoglobin

PYQ FREQUENCY
Very High · 9 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Proximal binds, distal guards'.

Oxygen Carriers Hemoglobin

Correct Answer D 1100

CONCEPT

Hemoglobin (tetramer, cooperative, sigmoidal curve) vs myoglobin (monomer, hyperbolic); heme Fe(II) binds O_2 end-on bent; hemerythrin (Fe_2, O_2 → hydroperoxide), hemocyanin (Cu_2, O_2 side-on peroxo, blue); Bohr effect and 2,3-BPG; CO and CN^- poisoning.

↓

LOGIC / WORKING

- In oxyhaemoglobin O_2 binds as a superoxide-like Fe(III)–O_2^- unit; ν(O–O) drops from 1580 (free O_2) to ≈1105 cm^{-1}.
- Therefore the answer is (D).

FINAL: (D) 1100

SHORTCUT / EXAM TRICK

Hb binds O_2 weakly at low pO_2 and strongly at high pO_2 — cooperativity through quaternary T→R shift.

COMMON MISTAKE

Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

EXAM TIP

Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

MEMORY TRICK

'Proximal binds, distal guards'.

Why the Other Options Are Wrong

Correct answer: D

A — **1600**

Why (D) is the key — In oxyhaemoglobin O_2 binds as a superoxide-like Fe(III)–O_2^- unit; ν(O–O) drops from 1580 (free O_2) to ≈1105 cm^{-1}.

B — **1900**

Ruled out: Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

C — **800**

Ruled out: Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

Q4

The correct statement for cytochrome c is

A. It is a non-heme protein

B. The coordination number of iron in cytochrome c is five

C. It is a redox protein and an electron carrier

D. It can store or carry dioxygen

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Oxygen Carriers Hemoglobin

PYQ FREQUENCY
Very High · 9 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Proximal binds, distal guards'.

Oxygen Carriers Hemoglobin

Correct Answer C It is a redox protein and an electron carrier

CONCEPT

Hemoglobin (tetramer, cooperative, sigmoidal curve) vs myoglobin (monomer, hyperbolic); heme Fe(II) binds O_2 end-on bent; hemerythrin (Fe_2, O_2 → hydroperoxide), hemocyanin (Cu_2, O_2 side-on peroxo, blue); Bohr effect and 2,3-BPG; CO and CN^- poisoning.

↓

LOGIC / WORKING

- Cytochrome c is a haem protein with six-coordinate iron (His/Met axial ligands); it carries electrons (Fe^{2+}/Fe^{3+}) and cannot bind O_2.
- Therefore the answer is (C).

FINAL: (C) It is a redox protein and an electron carrier

SHORTCUT / EXAM TRICK

Hb binds O_2 weakly at low pO_2 and strongly at high pO_2 — cooperativity through quaternary T→R shift.

COMMON MISTAKE

Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

EXAM TIP

Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

MEMORY TRICK

'Proximal binds, distal guards'.

Why the Other Options Are Wrong

Correct answer: C

A **It is a non-heme protein**

Why (C) is the key — Cytochrome c is a haem protein with six-coordinate iron (His/Met axial ligands); it carries electrons (Fe^{2+}/Fe^{3+}) and cannot bind O_2.

B **The coordination number of iron in cytochrome c is five**

Ruled out: Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

D **It can store or carry dioxygen**

Ruled out: Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

Q5

The cooperative binding of O_2 in hemoglobin is due to

A. a decrease in size of iron followed by changes in the protein conformation

B. an increase in size of iron followed by changes in the protein conformation

C. a decrease in size of iron that is NOT accompanied by the protein conformational changes

D. an increase in size of iron that is NOT accompanied by the protein conformational changes

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Oxygen Carriers Hemoglobin

PYQ FREQUENCY
Very High · 9 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Proximal binds, distal guards'.

Oxygen Carriers Hemoglobin

Correct Answer A a decrease in size of iron followed by changes in the protein conformation

CONCEPT

Hemoglobin (tetramer, cooperative, sigmoidal curve) vs myoglobin (monomer, hyperbolic); heme Fe(II) binds O_2 end-on bent; hemerythrin (Fe_2, O_2 → hydroperoxide), hemocyanin (Cu_2, O_2 side-on peroxo, blue); Bohr effect and 2,3-BPG; CO and CN^- poisoning.

↓

LOGIC / WORKING

- On binding O_2 the iron becomes low-spin and smaller, drops into the porphyrin plane and pulls the proximal histidine with it; that movement propagates through the protein (T → R) and raises the affinity of the other subunits.
- Therefore the answer is (A).

FINAL: (A) a decrease in size of iron followed by changes in the protein conformation

SHORTCUT / EXAM TRICK

Hb binds O_2 weakly at low pO_2 and strongly at high pO_2 — cooperativity through quaternary T→R shift.

COMMON MISTAKE

Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

EXAM TIP

Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

MEMORY TRICK

'Proximal binds, distal guards'.

Why the Other Options Are Wrong

Correct answer: A

B **an increase in size of iron followed by changes in the protein conformation**

Why (A) is the key — On binding O_2 the iron becomes low-spin and smaller, drops into the porphyrin plane and pulls the proximal histidine with it; that movement propagates through the protein (T → R) and raises the affinity of the other subunits.

C **a decrease in size of iron that is NOT accompanied by the protein conformational changes**

Ruled out: Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

D **an increase in size of iron that is NOT accompanied by the protein conformational changes**

Ruled out: Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

Q6

The Fe-Nporphyrin bond distances in the deoxy and oxy-hemoglobin, respectively, are

A. 2.1 and 2.0 AA

B. 2.0 and 2.0 AA

C. 2.2 and 2.3 AA

D. 2.3 and 2.5 AA

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Oxygen Carriers Hemoglobin

PYQ FREQUENCY
Very High · 9 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Proximal binds, distal guards'.

Oxygen Carriers Hemoglobin

Correct Answer A 2.1 and 2.0 AA

CONCEPT

Hemoglobin (tetramer, cooperative, sigmoidal curve) vs myoglobin (monomer, hyperbolic); heme Fe(II) binds O_2 end-on bent; hemerythrin (Fe_2, O_2 → hydroperoxide), hemocyanin (Cu_2, O_2 side-on peroxo, blue); Bohr effect and 2,3-BPG; CO and CN^- poisoning.

↓

LOGIC / WORKING

- Deoxy (high-spin Fe^+, out of plane) Fe–N ≈ 2.06–2.1 ; oxy (low-spin, in plane) ≈ 2.0 .
- Therefore the answer is (A).

FINAL: (A) 2.1 and 2.0 AA

SHORTCUT / EXAM TRICK

Hb binds O_2 weakly at low pO_2 and strongly at high pO_2 — cooperativity through quaternary T→R shift.

COMMON MISTAKE

Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

EXAM TIP

Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

MEMORY TRICK

'Proximal binds, distal guards'.

Why the Other Options Are Wrong

Correct answer: A

B **2.0 and 2.0 AA**

Why (A) is the key — Deoxy (high-spin Fe^{+}, out of plane) Fe–N ≈ 2.06–2.1 ; oxy (low-spin, in plane) ≈ 2.0 .

C **2.2 and 2.3 AA**

Ruled out: Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

D **2.3 and 2.5 AA**

Ruled out: Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

Q7 **The resonance Raman stretching frequencies (in cm^{-1}) of the bound O_2 species in oxyhemerthyrin and oxy-hemoglobin, respectively, are**

A. 850 and 1100

B. 750 and 850

C. 850 and 850

D. 1100 and 850

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Oxygen Carriers Hemoglobin

PYQ FREQUENCY
Very High · 9 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Proximal binds, distal guards'.

Oxygen Carriers Hemoglobin

Correct Answer A 850 and 1100

CONCEPT

Hemoglobin (tetramer, cooperative, sigmoidal curve) vs myoglobin (monomer, hyperbolic); heme Fe(II) binds O_2 end-on bent; hemerythrin (Fe_2, O_2 → hydroperoxide), hemocyanin (Cu_2, O_2 side-on peroxo, blue); Bohr effect and 2,3-BPG; CO and CN^- poisoning.

↓

LOGIC / WORKING

- Oxyhemerythrin binds O_2 as hydroperoxide (ν(O–O) ≈ 844 cm^{-1}); oxyhemoglobin binds it as a superoxide-like unit (≈1105 cm^{-1}).
- Therefore the answer is (A).

FINAL: (A) 850 and 1100

SHORTCUT / EXAM TRICK

Hb binds O_2 weakly at low pO_2 and strongly at high pO_2 — cooperativity through quaternary T→R shift.

COMMON MISTAKE

Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

EXAM TIP

Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

MEMORY TRICK

'Proximal binds, distal guards'.

Why the Other Options Are Wrong

Correct answer: A

B **750 and 850**

Why (A) is the key — Oxyhemerythrin binds O_2 as hydroperoxide (ν(O–O) ≈ 844 cm^{-1}); oxyhemoglobin binds it as a superoxide-like unit (≈1105 cm^{-1}).

C **850 and 850**

Ruled out: Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

D **1100 and 850**

Ruled out: Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

Q8

Consider the following statements for the oxygenation of hemocyanine: (A) Oxidation state of both copper atoms changes by two (B) It becomes intense blue from colorless (C) Dioxygen is reduced to O_2^{2-} (D) The μ-η^2:η^2 bond forms between each oxygen and copper atoms. The correct statements are:

A. (A) and (C)

B. (B) and (C)

C. (A), (B) and (C)

D. (B), (C) and (D)

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Oxygen Carriers Hemoglobin

PYQ FREQUENCY
Very High · 9 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Proximal binds, distal guards'.

Oxygen Carriers Hemoglobin

Correct Answer D (B), (C) and (D)

CONCEPT

Hemoglobin (tetramer, cooperative, sigmoidal curve) vs myoglobin (monomer, hyperbolic); heme Fe(II) binds O_2 end-on bent; hemerythrin (Fe_2, O_2 → hydroperoxide), hemocyanin (Cu_2, O_2 side-on peroxo, blue); Bohr effect and 2,3-BPG; CO and CN^- poisoning.

↓

LOGIC / WORKING

- Deoxyhemocyanin [$Cu(I)_2$] binds O_2 as μ-η^2:η^2-peroxide, giving $Cu(II)_2$ (each Cu changes by one). The colourless protein turns intense blue from an O_2^{2-}→Cu charge-transfer band. B, C and D (d).
- Therefore the answer is (D).

FINAL: (D) (B), (C) and (D)

SHORTCUT / EXAM TRICK

Hb binds O_2 weakly at low pO_2 and strongly at high pO_2 — cooperativity through quaternary T→R shift.

COMMON MISTAKE

Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

EXAM TIP

Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

MEMORY TRICK

'Proximal binds, distal guards'.

Why the Other Options Are Wrong

Correct answer: D

A **(A) and (C)**

Why (D) is the key — Deoxyhemocyanin [$Cu(I)_2$] binds O_2 as μ-η²:η²-peroxide, giving $Cu(II)_2$ (each Cu changes by one). The colourless protein turns intense blue from an $O_2^{2-} \rightarrow Cu$ charge-transfer band. B, C and D (d).

B **(B) and (C)**

Ruled out: Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

C **(A), (B) and (C)**

Ruled out: Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

Q9

The oxidation state of iron in met-hemoglobin is

A. Three

B. Two

C. Four

D. Zero

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Oxygen Carriers Hemoglobin

PYQ FREQUENCY
Very High · 9 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Proximal binds, distal guards'.

Oxygen Carriers Hemoglobin

Correct Answer A Three

CONCEPT

Hemoglobin (tetramer, cooperative, sigmoidal curve) vs myoglobin (monomer, hyperbolic); heme Fe(II) binds O_2 end-on bent; hemerythrin (Fe_2, O_2 → hydroperoxide), hemocyanin (Cu_2, O_2 side-on peroxo, blue); Bohr effect and 2,3-BPG; CO and CN^- poisoning.

↓

LOGIC / WORKING

- Hemoglobin met-hemoglobin Explanation as extracted from the printed page; notation may be imperfect.
- Therefore the answer is (A).

FINAL: (A) Three

SHORTCUT / EXAM TRICK

Hb binds O_2 weakly at low pO_2 and strongly at high pO_2 — cooperativity through quaternary T→R shift.

COMMON MISTAKE

Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

EXAM TIP

Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

MEMORY TRICK

'Proximal binds, distal guards'.

Why the Other Options Are Wrong

Correct answer: A

B **Two**

Why (A) is the key — Hemoglobin met-hemoglobin Explanation as extracted from the printed page; notation may be imperfect.

C **Four**

Ruled out: Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).

D **Zero**

Ruled out: Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

TOPIC REVISION

Oxygen Carriers Hemoglobin

9 PYQs · Last-minute revision

TOPIC SUMMARY

Hemoglobin (tetramer, cooperative, sigmoidal curve) vs myoglobin (monomer, hyperbolic); heme Fe(II) binds O_2 end-on bent; hemerythrin (Fe_2, O_2 → hydroperoxide), hemocyanin (Cu_2, O_2 side-on peroxo, blue); Bohr effect and 2,3-BPG; CO and CN^- poisoning.

IMPORTANT FORMULA SHEET

- Hill: $\log[Y/(1-Y)] = n \log pO_2 - \log P_{50}$
- O_2 binding: Fe–O–O angle ≈ 120°
- Mb: n = 1; Hb: n ≈ 2.8

FREQUENTLY ASKED CONCEPTS

- Why oxy-Hb is diamagnetic
- Role of proximal/distal His
- Colour of oxyhemocyanin (blue)
- BPG lowering affinity
- MetHb (Fe^{3+}) cannot bind O_2

COMMON MISTAKES & QUICK NOTES

Watch out:
Thinking the distal histidine binds Fe (it H-bonds to O_2; the proximal His binds Fe).
Picket-fence porphyrins model reversible O_2 binding by blocking μ-oxo dimer formation.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9

Expect 1 question(s) next session on Oxygen Carriers Hemoglobin.

TOPIC 2

Iron Sulfur Proteins

8 questions · Easy 4 | Medium 3 | Hard 1 · PYQ frequency: High

Q10

A metal ion that replace manganese (II) ion in mangano-proteins without changing its function, is

A. Fe (II)

B. Zn (II)

C. Mg (II)

D. Cu (II)

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Iron Sulfur Proteins

PYQ FREQUENCY
High · 7 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Cubane Fe_4S_4 — one electron per step'.

Correct Answer C Mg (II)

CONCEPT

Fe–S clusters ([2Fe–2S], [3Fe–4S], [4Fe–4S]) with cysteine ligation act as one-electron carriers; rubredoxin has a single Fe with four Cys; HiPIP uses the $[4Fe–4S]^{3+/2+}$ couple, ferredoxins the $^{2+/1+}$ couple; cubane geometry, antiferromagnetic coupling.

↓

LOGIC / WORKING

- Mg^{2+} and Mn^{2+} have similar size, charge and lack of redox activity, so Mg(II) can replace Mn(II) in many mangano-enzymes with retention of function.
- Therefore the answer is (C).

FINAL: (C) Mg (II)

SHORTCUT / EXAM TRICK

HiPIP = high potential (+350 mV) = $^{3+/2+}$; ferredoxin = low potential (−400 mV) = $^{2+/1+}$.

COMMON MISTAKE

Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

EXAM TIP

Aconitase's unique Fe has no cysteine and binds citrate.

MEMORY TRICK

'Cubane Fe_4S_4 — one electron per step'.

Why the Other Options Are Wrong

Correct answer: C

A **Fe (II)**

Why (C) is the key — Mg^{2+} and Mn^{2+} have similar size, charge and lack of redox activity, so Mg(II) can replace Mn(II) in many mangano-enzymes with retention of function.

B **Zn (II)**

Ruled out: Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

D **Cu (II)**

Ruled out: Aconitase's unique Fe has no cysteine and binds citrate.

Q11

In the bacterial rubredoxin, the number of iron atoms, sulfur bridges and cysteine ligands are Fe atom & Sulfur bridge & Cysteine

A. 4, 4, 4

B. 2, 2, 4

C. 2, 2, 2

D. 1, 0, 4

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Iron Sulfur Proteins

PYQ FREQUENCY
High · 7 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Cubane Fe_4S_4 — one electron per step'.

Iron Sulfur Proteins

Correct Answer D 1, 0, 4

CONCEPT

Fe–S clusters ([2Fe–2S], [3Fe–4S], [4Fe–4S]) with cysteine ligation act as one-electron carriers; rubredoxin has a single Fe with four Cys; HiPIP uses the $[4Fe–4S]^{3+/2+}$ couple, ferredoxins the $^{2+/1+}$ couple; cubane geometry, antiferromagnetic coupling.

↓

LOGIC / WORKING

- Rubredoxin: one Fe, no sulfide bridges, four cysteine thiolates (d).
- Therefore the answer is (D).

FINAL: (D) 1, 0, 4

SHORTCUT / EXAM TRICK

HiPIP = high potential (+350 mV) = $^{3+/2+}$; ferredoxin = low potential (−400 mV) = $^{2+/1+}$.

COMMON MISTAKE

Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

EXAM TIP

Aconitase's unique Fe has no cysteine and binds citrate.

MEMORY TRICK

'Cubane Fe_4S_4 — one electron per step'.

Why the Other Options Are Wrong

Correct answer: D

A **4, 4, 4**

Why (D) is the key — Rubredoxin: one Fe, no sulfide bridges, four cysteine thiolates (d).

B **2, 2, 4**

Ruled out: Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

C **2, 2, 2**

Ruled out: Aconitase's unique Fe has no cysteine and binds citrate.

Q12

Oxidised form of enzyme catalase (structure A); prepared by the reaction of $[Fe(P)]^+$ (P = porphyrin) with H_2O_2 has green color because

A. Oxidation state of iron changed from Fe^III to Fe^IV

B. Porphyrin ring is oxidized by one electron

C. π - π^* transition appears in the visible region

D. Fe^IV is coordinated with anionic tyrosinate ligand in axial position

QUESTION INSIGHTS

ESTIMATED TIME
3–5 min

DIFFICULTY
Hard

CONCEPT TESTED
Iron Sulfur Proteins

PYQ FREQUENCY
High · 7 papers

REVISION PRIORITY
★★★★★

EXPECTED LEVEL
Part C (high merit)

MEMORY HOOK
'Cubane Fe_4S_4 — one electron per step'.

Correct Answer B Porphyrin ring is oxidized by one electron

CONCEPT

Fe–S clusters ([2Fe–2S], [3Fe–4S], [4Fe–4S]) with cysteine ligation act as one-electron carriers; rubredoxin has a single Fe with four Cys; HiPIP uses the $[4Fe–4S]^{3+/2+}$ couple, ferredoxins the $^{2+/1+}$ couple; cubane geometry, antiferromagnetic coupling.

↓

LOGIC / WORKING

- $[Fe(III)P]^{+}$ + H_2O_2 → Compound I: an oxo-Fe(IV) porphyrin π-cation radical. The green colour arises from the one-electron-oxidised porphyrin ring (π-cation radical absorbs across the visible), not from Fe(IV) alone. (Bank key (a) — verify; standard answer is the porphyrin radical.)
- Therefore the answer is (B).

FINAL: (B) Porphyrin ring is oxidized by one electron

SHORTCUT / EXAM TRICK

HiPIP = high potential (+350 mV) = $^{3+/2+}$; ferredoxin = low potential (−400 mV) = $^{2+/1+}$.

COMMON MISTAKE

Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

EXAM TIP

Aconitase's unique Fe has no cysteine and binds citrate.

MEMORY TRICK

'Cubane Fe_4S_4 — one electron per step'.

Why the Other Options Are Wrong

Correct answer: B

A — **Oxidation state of iron changed from Fe^III to Fe^IV**

Why (B) is the key — $[Fe(III)P]^{+}$ + H_2O_2 → Compound I: an oxo-Fe(IV) porphyrin π-cation radical. The green colour arises from the one-electron-oxidised porphyrin ring (π-cation radical absorbs across the visible), not from Fe(IV) alone. (Bank key (a) — verify; standard answer is the porphyrin radical.)

C — **π - π^* transition appears in the visible region**

Ruled out: Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

D — **Fe^IV is coordinated with anionic tyrosinate ligand in axial position**

Ruled out: Aconitase's unique Fe has no cysteine and binds citrate.

Q13 **Identify correct statements for mercury as an environment pollutant. A. Carbanionicbiomethylation converts it to $MeHg^+$ B. Thiol group of cysteine has strong affinity for mercury C. Mercury containing industrial catalyst release caused Minamata disaster The correct answer is:**

A. A and B

B. A and C

C. B and C

D. A, B and C

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Iron Sulfur Proteins

PYQ FREQUENCY
High · 7 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Cubane Fe_4S_4 — one electron per step'.

Correct Answer D A, B and C

CONCEPT

Fe–S clusters ([2Fe–2S], [3Fe–4S], [4Fe–4S]) with cysteine ligation act as one-electron carriers; rubredoxin has a single Fe with four Cys; HiPIP uses the $[4Fe–4S]^{3+/2+}$ couple, ferredoxins the $^{2+/1+}$ couple; cubane geometry, antiferromagnetic coupling.

↓

LOGIC / WORKING

- Bacteria methylate Hg^{2+} (via methylcobalamin, a carbanion transfer) to $MeHg^{+}$; cysteine thiols bind mercury very strongly; the Minamata disaster came from methylmercury discharged by a mercury-catalysed acetaldehyde plant. All three are correct.
- Therefore the answer is (D).

FINAL: (D) A, B and C

SHORTCUT / EXAM TRICK

HiPIP = high potential (+350 mV) = $^{3+/2+}$; ferredoxin = low potential (−400 mV) = $^{2+/1+}$.

COMMON MISTAKE

Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

EXAM TIP

Aconitase's unique Fe has no cysteine and binds citrate.

MEMORY TRICK

'Cubane Fe_4S_4 — one electron per step'.

Why the Other Options Are Wrong

Correct answer: D

A

A and B

Why (D) is the key — Bacteria methylate Hg^{2+} (via methylcobalamin, a carbanion transfer) to $MeHg^{+}$; cysteine thiols bind mercury very strongly; the Minamata disaster came from methylmercury discharged by a mercury-catalysed acetaldehyde plant. All three are correct.

B

A and C

Ruled out: Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

C

B and C

Ruled out: Aconitase's unique Fe has no cysteine and binds citrate.

Q14

Complex(es) which has/have unpaired electron(s) that is equal to that of iron center in oxymyoglobin is/are A. $[Fe(ox)_3]^{3-}$ B. $[Fe(CN)_6]^{3-}$ C. $[NiCl_4]^{2-}$ D. $[Cu(NH_3)_4]^{2+}$ (Given: ox = oxalato) Correct answer is

A. A and B

B. B and D

C. C only

D. C and D

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Iron Sulfur Proteins

PYQ FREQUENCY
High · 7 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Cubane Fe_4S_4 — one electron per step'.

Correct Answer B B and D

CONCEPT

Fe–S clusters ([2Fe–2S], [3Fe–4S], [4Fe–4S]) with cysteine ligation act as one-electron carriers; rubredoxin has a single Fe with four Cys; HiPIP uses the $[4Fe–4S]^{3+/2+}$ couple, ferredoxins the $^{2+/1+}$ couple; cubane geometry, antiferromagnetic coupling.

↓

LOGIC / WORKING

- Treating oxymyoglobin as Fe(III)–superoxide, the iron is low-spin d^5 with one unpaired electron. $[Fe(CN)_6]^{3-}$ (low-spin d^5) and $[Cu(NH_3)_4]^{2+}$ (d^9) also have one; $[Fe(ox)_3]^{3-}$ has five and $[NiCl_4]^{2-}$ two.
- Therefore the answer is (B).

FINAL: (B) B and D

SHORTCUT / EXAM TRICK

HiPIP = high potential (+350 mV) = $^{3+/2+}$; ferredoxin = low potential (−400 mV) = $^{2+/1+}$.

COMMON MISTAKE

Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

EXAM TIP

Aconitase's unique Fe has no cysteine and binds citrate.

MEMORY TRICK

'Cubane Fe_4S_4 — one electron per step'.

Why the Other Options Are Wrong

Correct answer: B

A

A and B

Why (B) is the key — Treating oxymyoglobin as Fe(III)–superoxide, the iron is low-spin d^5 with one unpaired electron. $[Fe(CN)_6]^{3-}$ (low-spin d^5) and $[Cu(NH_3)_4]^{2+}$ (d^9) also have one; $[Fe(ox)_3]^{3-}$ has five and $[NiCl_4]^{2-}$ two.

C

C only

Ruled out: Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

D

C and D

Ruled out: Aconitase's unique Fe has no cysteine and binds citrate.

Q15 The changes (from A-D given below) which occur when O_2 binds to hemerythrin are (A) One iron atoms is oxidized (B) Both the iron atoms are oxidized (C) O_2 binds to one iron atom and is also hydrogen bonded. (D) O_2 binds to both the iron atoms and is also hydrogen bonded.

A. B and C

B. B and D

C. A and D

D. A and C

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Iron Sulfur Proteins

PYQ FREQUENCY
High · 7 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Cubane Fe_4S_4 — one electron per step'.

Correct Answer A B and C

CONCEPT

Fe–S clusters ([2Fe–2S], [3Fe–4S], [4Fe–4S]) with cysteine ligation act as one-electron carriers; rubredoxin has a single Fe with four Cys; HiPIP uses the $[4Fe–4S]^{3+/2+}$ couple, ferredoxins the $^{2+/1+}$ couple; cubane geometry, antiferromagnetic coupling.

↓

LOGIC / WORKING

- O_2 binding converts the Fe(II)Fe(II) site to Fe(III)Fe(III), so both irons are oxidised. Hydroperoxide binds terminally to one Fe and hydrogen-bonds to the μ-oxo bridge. B and C (a).
- Therefore the answer is (A).

FINAL: (A) B and C

SHORTCUT / EXAM TRICK

HiPIP = high potential (+350 mV) = $^{3+/2+}$; ferredoxin = low potential (−400 mV) = $^{2+/1+}$.

COMMON MISTAKE

Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

EXAM TIP

Aconitase's unique Fe has no cysteine and binds citrate.

MEMORY TRICK

'Cubane Fe_4S_4 — one electron per step'.

Why the Other Options Are Wrong

Correct answer: A

B

B and D

Why (A) is the key — O_2 binding converts the Fe(II)Fe(II) site to Fe(III)Fe(III), so both irons are oxidised. Hydroperoxide binds terminally to one Fe and hydrogen-bonds to the μ-oxo bridge. B and C (a).

C

A and D

Ruled out: Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

D

A and C

Ruled out: Aconitase's unique Fe has no cysteine and binds citrate.

Q16

Consider the following statements for metallothioneins: A. the contain about 30% cysteine residues B. they prefer to bind soft metal ions such as Cd(II), Hg(II) and Zn(II) C. they are involved in electron transfer reactions D. they are low molecular weight proteins Correct statements are

A. A, B and C

B. A, B and D

C. A, C and D

D. B and C

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Iron Sulfur Proteins

PYQ FREQUENCY
High · 7 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Cubane Fe_4S_4 — one electron per step'.

Correct Answer B A, B and D

CONCEPT

Fe–S clusters ([2Fe–2S], [3Fe–4S], [4Fe–4S]) with cysteine ligation act as one-electron carriers; rubredoxin has a single Fe with four Cys; HiPIP uses the $[4Fe–4S]^{3+/2+}$ couple, ferredoxins the $^{2+/1+}$ couple; cubane geometry, antiferromagnetic coupling.

↓

LOGIC / WORKING

- Metallothioneins are small (6–7 kDa), about 30 % cysteine, and bind soft ions (Zn, Cd, Hg, Cu). They are storage/detoxification proteins, not electron carriers. A, B and D (b).
- Therefore the answer is (B).

FINAL: (B) A, B and D

SHORTCUT / EXAM TRICK

HiPIP = high potential (+350 mV) = $^{3+/2+}$; ferredoxin = low potential (−400 mV) = $^{2+/1+}$.

COMMON MISTAKE

Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

EXAM TIP

Aconitase's unique Fe has no cysteine and binds citrate.

MEMORY TRICK

'Cubane Fe_4S_4 — one electron per step'.

Why the Other Options Are Wrong

Correct answer: B

A **A, B and C**

Why (B) is the key — Metallothioneins are small (6–7 kDa), about 30 % cysteine, and bind soft ions (Zn, Cd, Hg, Cu). They are storage/detoxification proteins, not electron carriers. A, B and D (b).

C **A, C and D**

Ruled out: Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

D **B and C**

Ruled out: Aconitase's unique Fe has no cysteine and binds citrate.

Q17 **Which of the following statements for rubredoxin, A. F_2^+ center has a tetrahedral geometry. B. Reduced form of iron is diamagnetic. C. F_2^+ center undergoes Jahn-Teller distortion. D. It is a [2Fe-2S] cluster. are correct?**

A. A, B and C

B. A, C and D

C. C and D only

D. A and C only

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Iron Sulfur Proteins

PYQ FREQUENCY
High · 7 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Cubane Fe_4S_4 — one electron per step'.

Correct Answer D A and C only

CONCEPT

Fe–S clusters ([2Fe–2S], [3Fe–4S], [4Fe–4S]) with cysteine ligation act as one-electron carriers; rubredoxin has a single Fe with four Cys; HiPIP uses the $[4Fe–4S]^{3+/2+}$ couple, ferredoxins the $^{2+/1+}$ couple; cubane geometry, antiferromagnetic coupling.

↓

LOGIC / WORKING

- Rubredoxin has a single Fe in a tetrahedral Cys_4 site, not a 2Fe–2S cluster. Reduced high-spin Fe(II) is paramagnetic, and the tetrahedral d^6 $e^3t_2^3$ ion shows a Jahn–Teller distortion. A and C only (d).
- Therefore the answer is (D).

FINAL: (D) A and C only

SHORTCUT / EXAM TRICK

HiPIP = high potential (+350 mV) = $^{3+/2+}$; ferredoxin = low potential (−400 mV) = $^{2+/1+}$.

COMMON MISTAKE

Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

EXAM TIP

Aconitase's unique Fe has no cysteine and binds citrate.

MEMORY TRICK

'Cubane Fe_4S_4 — one electron per step'.

Why the Other Options Are Wrong

Correct answer: D

A **A, B and C**

Why (D) is the key — Rubredoxin has a single Fe in a tetrahedral Cys_4 site, not a 2Fe–2S cluster. Reduced high-spin Fe(II) is paramagnetic, and the tetrahedral d^6 $e^3t_2^3$ ion shows a Jahn–Teller distortion. A and C only (d).

B **A, C and D**

Ruled out: Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).

C **C and D only**

Ruled out: Aconitase's unique Fe has no cysteine and binds citrate.

TOPIC REVISION

Iron Sulfur Proteins

8 PYQs · Last-minute revision

TOPIC SUMMARY

Fe–S clusters ([2Fe–2S], [3Fe–4S], [4Fe–4S]) with cysteine ligation act as one-electron carriers; rubredoxin has a single Fe with four Cys; HiPIP uses the $[4Fe–4S]^{3+/2+}$ couple, ferredoxins the $^{2+/1+}$ couple; cubane geometry, antiferromagnetic coupling.

IMPORTANT FORMULA SHEET

- [4Fe–4S]: states 3+, 2+, 1+ (formal Fe oxidation 2.75 → 2.5 → 2.25)
- Rubredoxin: Fe(III)/Fe(II), tetrahedral S_4
- Rieske: [2Fe–2S] with 2 His + 2 Cys

FREQUENTLY ASKED CONCEPTS

- Which cluster in ferredoxin vs HiPIP
- Magnetic coupling in [2Fe–2S]
- Rieske centre ligation
- Aconitase substrate-binding Fe

COMMON MISTAKES & QUICK NOTES

Watch out:
Treating Fe–S clusters as multi-electron carriers (they move one electron at a time).
Aconitase's unique Fe has no cysteine and binds citrate.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17

Expect 1 question(s) next session on Iron Sulfur Proteins.

TOPIC 3

Metal Toxicity Medicine

6 questions · Easy 3 | Medium 3 | Hard 0 · PYQ frequency: High

Q18

Superoxide dismutase contains the metal ions

A. Zn (II) and Ni(II)

B. Cu(II) and Zn(II)

C. Ni (II) and Co(III)

D. Cu (II) and Fe (III)

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Metal Toxicity Medicine

PYQ FREQUENCY
High · 6 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Cis kills cancer, trans does not'.

Correct Answer B Cu(II) and Zn(II)

CONCEPT

Toxic metals (Hg, Pb, Cd, As, Tl) bind soft S donors; chelation therapy uses EDTA (Pb), BAL/dimercaprol (As, Hg), penicillamine (Cu, Wilson's disease), desferrioxamine (Fe overload); cisplatin binds N7 of guanine (cis geometry essential); Gd(III) MRI contrast, ^{99m}Tc imaging, Li_2CO_3, gold drugs (auranofin).

↓

LOGIC / WORKING

- Cu,Zn superoxide dismutase (b).
- Therefore the answer is (B).

FINAL: (B) Cu(II) and Zn(II)

SHORTCUT / EXAM TRICK

Soft toxic metals → soft (thiol) chelators; hard Fe^{3+} → hydroxamate (desferrioxamine).

COMMON MISTAKE

Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

EXAM TIP

Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

MEMORY TRICK

'Cis kills cancer, trans does not'.

Why the Other Options Are Wrong

Correct answer: B

A **Zn (II) and Ni(II)**
Why (B) is the key — Cu,Zn superoxide dismutase (b).

C **Ni (II) and Co(III)**
Ruled out: Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

D **Cu (II) and Fe (III)**
Ruled out: Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

Q19 **The number of inorganic Sulphur (or sulphide) atoms present in the metalloprotein active sites ofrubredoxin, 2-iron ferredoxin and 4-iron ferredoxin, respectively, are**

A. 0, 2 and 4

B. 2, 4 and 3

C. 0, 4 and 2

D. 0,2 and 3

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Metal Toxicity Medicine

PYQ FREQUENCY
High · 6 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Cis kills cancer, trans does not'.

Correct Answer A 0, 2 and 4

CONCEPT

Toxic metals (Hg, Pb, Cd, As, Tl) bind soft S donors; chelation therapy uses EDTA (Pb), BAL/dimercaprol (As, Hg), penicillamine (Cu, Wilson's disease), desferrioxamine (Fe overload); cisplatin binds N7 of guanine (cis geometry essential); Gd(III) MRI contrast, ^{99m}Tc imaging, Li_2CO_3, gold drugs (auranofin).

↓

LOGIC / WORKING

- Rubredoxin has a single Fe bound only by four cysteines (no inorganic S); 2Fe ferredoxin has an Fe_2S_2 core (2); 4Fe ferredoxin an Fe_4S_4 cubane (4).
- Therefore the answer is (A).

FINAL: (A) 0, 2 and 4

SHORTCUT / EXAM TRICK

Soft toxic metals → soft (thiol) chelators; hard Fe^{3+} → hydroxamate (desferrioxamine).

COMMON MISTAKE

Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

EXAM TIP

Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

MEMORY TRICK

'Cis kills cancer, trans does not'.

Why the Other Options Are Wrong

Correct answer: A

B **2, 4 and 3**

Why (A) is the key — Rubredoxin has a single Fe bound only by four cysteines (no inorganic S); 2Fe ferredoxin has an Fe_2S_2 core (2); 4Fe ferredoxin an Fe_4S_4 cubane (4).

C **0, 4 and 2**

Ruled out: Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

D **0,2 and 3**

Ruled out: Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

Q20 **Choose the correct statements for oxymyoglobin and cytochrome P_{450} (resting state) from the following: A. Both contain dianion of protoporphyrin-IX B. They have same fifth-ligand bonded to metal centre from the protein backbone C. They contain single active site D. They contain metal ion in +3 oxidation state**

(A) A, B and C

(B) A, C and D

(C) A, B and D

(D) B and C only

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Metal Toxicity Medicine

PYQ FREQUENCY
High · 6 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Cis kills cancer, trans does not'.

Correct Answer B A, C and D

CONCEPT

Toxic metals (Hg, Pb, Cd, As, Tl) bind soft S donors; chelation therapy uses EDTA (Pb), BAL/dimercaprol (As, Hg), penicillamine (Cu, Wilson's disease), desferrioxamine (Fe overload); cisplatin binds N7 of guanine (cis geometry essential); Gd(III) MRI contrast, ^{99m}Tc imaging, Li_2CO_3, gold drugs (auranofin).

↓

LOGIC / WORKING

- Both contain protoporphyrin-IX^{2-} and a single heme site. Iron is formally Fe(III) in both: Fe(III)–O_2^- in oxymyoglobin and resting Fe(III) in P450. The fifth ligands differ: His in myoglobin, Cys thiolate in P450. A, C and D (b).
- Therefore the answer is (B).

FINAL: (B) A, C and D

SHORTCUT / EXAM TRICK

Soft toxic metals → soft (thiol) chelators; hard Fe^{3+} → hydroxamate (desferrioxamine).

COMMON MISTAKE

Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

EXAM TIP

Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

MEMORY TRICK

'Cis kills cancer, trans does not'.

Why the Other Options Are Wrong

Correct answer: B

A

A, B and C

Why (B) is the key — Both contain protoporphyrin-IX^{2-} and a single heme site. Iron is formally Fe(III) in both: Fe(III)–O_2^- in oxymyoglobin and resting Fe(III) in P450. The fifth ligands differ: His in myoglobin, Cys thiolate in P450. A, C and D (b).

C

A, B and D

Ruled out: Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

D

B and C only

Ruled out: Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

Q21

Correct combination of number and size of rings present in a metal ion-porphine complex (including metal ion bearing chelate rings) is

A. four 5-membered and four 6-membered

B. two 5-membered and six 6-membered

C. six 5-membered and two 6-membered

D. five 5-membered and three 6-membered

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Metal Toxicity Medicine

PYQ FREQUENCY
High · 6 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Cis kills cancer, trans does not'.

Correct Answer A four 5-membered and four 6-membered

CONCEPT

Toxic metals (Hg, Pb, Cd, As, Tl) bind soft S donors; chelation therapy uses EDTA (Pb), BAL/dimercaprol (As, Hg), penicillamine (Cu, Wilson's disease), desferrioxamine (Fe overload); cisplatin binds N7 of guanine (cis geometry essential); Gd(III) MRI contrast, ^{99m}Tc imaging, Li_2CO_3, gold drugs (auranofin).

↓

LOGIC / WORKING

- Porphine has four five-membered pyrrole rings; chelation of the metal by the four pyrrole N atoms creates four six-membered chelate rings (M–N–C–C$_m$eso–C–N).
- Therefore the answer is (A).

FINAL: (A) four 5-membered and four 6-membered

SHORTCUT / EXAM TRICK

Soft toxic metals → soft (thiol) chelators; hard Fe^{3+} → hydroxamate (desferrioxamine).

COMMON MISTAKE

Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

EXAM TIP

Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

MEMORY TRICK

'Cis kills cancer, trans does not'.

Why the Other Options Are Wrong

Correct answer: A

B — **two 5-membered and six 6-membered**

Why (A) is the key — Porphine has four five-membered pyrrole rings; chelation of the metal by the four pyrrole N atoms creates four six-membered chelate rings (M–N–C–$C_m$eso–C–N).

C — **six 5-membered and two 6-membered**

Ruled out: Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

D — **five 5-membered and three 6-membered**

Ruled out: Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

Q22 **Consider the following statements for deoxy-hemerythrin and deoxy-hemocyanin: A. they are involved in O_2 transport in biological systems B. they contain two metal ions in their active site C. active site metal centres are bridged by amino acid residues D. they prefer to bind only one O_2 per active site The correct statements are**

A. A, B and D

B. A, C and D

C. B, C and D

D. A and C

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Metal Toxicity Medicine

PYQ FREQUENCY
High · 6 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Cis kills cancer, trans does not'.

Correct Answer A A, B and D

CONCEPT

Toxic metals (Hg, Pb, Cd, As, Tl) bind soft S donors; chelation therapy uses EDTA (Pb), BAL/dimercaprol (As, Hg), penicillamine (Cu, Wilson's disease), desferrioxamine (Fe overload); cisplatin binds N7 of guanine (cis geometry essential); Gd(III) MRI contrast, ^{99m}Tc imaging, Li_2CO_3, gold drugs (auranofin).

↓

LOGIC / WORKING

- Both transport O_2, both have two metal ions at the active site, and both bind one O_2 per site. Only hemerythrin's irons are bridged by amino-acid carboxylates; the two coppers of hemocyanin have no bridging residue. A, B and D (a).
- Therefore the answer is (A).

FINAL: (A) A, B and D

SHORTCUT / EXAM TRICK

Soft toxic metals → soft (thiol) chelators; hard Fe^{3+} → hydroxamate (desferrioxamine).

COMMON MISTAKE

Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

EXAM TIP

Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

MEMORY TRICK

'Cis kills cancer, trans does not'.

Why the Other Options Are Wrong

Correct answer: A

B **A, C and D**

Why (A) is the key — Both transport O_2, both have two metal ions at the active site, and both bind one O_2 per site. Only hemerythrin's irons are bridged by amino-acid carboxylates; the two coppers of hemocyanin have no bridging residue. A, B and D (a).

C **B, C and D**

Ruled out: Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

D **A and C**

Ruled out: Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

Q23

The metal transferred by bacteria and fungi using siderophores/siderochromes is

A. Mo

B. Cu

C. Fe

D. Zn

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Metal Toxicity Medicine

PYQ FREQUENCY
High · 6 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Cis kills cancer, trans does not'.

Correct Answer C Fe

CONCEPT

Toxic metals (Hg, Pb, Cd, As, Tl) bind soft S donors; chelation therapy uses EDTA (Pb), BAL/dimercaprol (As, Hg), penicillamine (Cu, Wilson's disease), desferrioxamine (Fe overload); cisplatin binds N7 of guanine (cis geometry essential); Gd(III) MRI contrast, ^{99m}Tc imaging, Li_2CO_3, gold drugs (auranofin).

↓

LOGIC / WORKING

- Siderophores are the high-affinity Fe(III) chelators that bacteria and fungi secrete to scavenge iron.
- Therefore the answer is (C).

FINAL: (C) Fe

SHORTCUT / EXAM TRICK

Soft toxic metals → soft (thiol) chelators; hard Fe^{3+} → hydroxamate (desferrioxamine).

COMMON MISTAKE

Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

EXAM TIP

Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

MEMORY TRICK

'Cis kills cancer, trans does not'.

Why the Other Options Are Wrong

Correct answer: C

A **Mo**

Why (C) is the key — Siderophores are the high-affinity Fe(III) chelators that bacteria and fungi secrete to scavenge iron.

B **Cu**

Ruled out: Using EDTA for mercury (BAL/DMSA are the thiol antidotes).

D **Zn**

Ruled out: Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order $Cl^- > NH_3$).

TOPIC REVISION

Metal Toxicity Medicine

6 PYQs · Last-minute revision

TOPIC SUMMARY

Toxic metals (Hg, Pb, Cd, As, Tl) bind soft S donors; chelation therapy uses EDTA (Pb), BAL/dimercaprol (As, Hg), penicillamine (Cu, Wilson's disease), desferrioxamine (Fe overload); cisplatin binds N7 of guanine (cis geometry essential); Gd(III) MRI contrast, ^{99m}Tc imaging, Li_2CO_3, gold drugs (auranofin).

IMPORTANT FORMULA SHEET

- Cisplatin: cis-$[PtCl_2(NH_3)_2]$; hydrolysis inside cell (low Cl^-)
- HSAB: Hg^{2+}, Pb^{2+}, Cd^{2+} soft → S-rich proteins
- Gd^{3+}: 7 unpaired electrons → relaxivity

FREQUENTLY ASKED CONCEPTS

- Why transplatin is inactive
- Chelating agent per metal
- Minamata/itai-itai causes
- Radiopharmaceutical nuclides

COMMON MISTAKES & QUICK NOTES

Watch out:
Using EDTA for mercury (BAL/DMSA are the thiol antidotes).
Cisplatin's leaving groups are Cl^-; the NH_3 ligands stay (trans effect order Cl^- > NH_3).

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q18 Q19 Q20 Q21 Q22 Q23

Expect 1 question(s) next session on Metal Toxicity Medicine.

TOPIC 4

Zinc Enzymes

4 questions · Easy 4 | Medium 0 | Hard 0 · PYQ frequency: Occasional

Q24 Based on the behaviour of the metalloenzymes, consider the following statements (A) In the enzymes, the zinc activates O_2, to form peroxide species. (B) In the enzymes, the zinc activates H_2O and provides a zinc boud hydroxide. (C) In the oxidases, the iron activates O_2, to break the bonding between the two oxygens (D) Zinc ion acts as a nucleophile and attacks at the peptide carbonyl The set of correct statements is,

A. A and B

B. B and C

C. C and D

D. A and D

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Zinc Enzymes

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Zinc: Lewis acid, no redox, no colour'.

Correct Answer B B and C

CONCEPT

Zn^{2+} (d^{10}, redox-inert, flexible coordination, strong Lewis acid) activates water or substrates: carbonic anhydrase (His_3–Zn–OH^-, CO_2 hydration), carboxypeptidase (peptide hydrolysis), alcohol dehydrogenase (with NAD^+), zinc fingers (structural, Cys_2His_2).

↓

LOGIC / WORKING

- Zn^{2+} is redox-inactive; it lowers the pKa of bound water, giving the nucleophilic Zn–OH. Iron oxidases activate O_2 and cleave the O–O bond. Zn^{2+} is a Lewis acid, not a nucleophile. B and C (b).
- Therefore the answer is (B).

FINAL: (B) B and C

SHORTCUT / EXAM TRICK

Zn lowers the pKa of bound water to ~7, generating a nucleophilic hydroxide at physiological pH.

COMMON MISTAKE

Assigning Zn a role in electron transfer.

EXAM TIP

Co(II)-substituted CA is active and coloured — used to study the spectroscopically silent Zn site.

MEMORY TRICK

'Zinc: Lewis acid, no redox, no colour'.

Why the Other Options Are Wrong

Correct answer: B

A

A and B

Why (B) is the key — Zn^{2+} is redox-inactive; it lowers the pKa of bound water, giving the nucleophilic Zn–OH. Iron oxidases activate O_2 and cleave the O–O bond. Zn^{2+} is a Lewis acid, not a nucleophile. B and C (b).

C

C and D

Ruled out: Assigning Zn a role in electron transfer.

D

A and D

Ruled out: Co(II)-substituted CA is active and coloured — used to study the spectroscopically silent Zn site.

Q25

In the catalytic hydration of CO_2 by carbonic anhydrase, CO_2 first interacts with

A. OH group of the active site of the enzyme and then with zinc

B. H_2O of the active site of the enzyme and then with zinc

C. zinc of the active site of the enzyme and then with OH group

D. zinc of the active site of the enzyme and then with H_2O

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Zinc Enzymes

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Zinc: Lewis acid, no redox, no colour'.

Correct Answer A OH group of the active site of the enzyme and then with zinc

CONCEPT

Zn^{2+} (d^{10}, redox-inert, flexible coordination, strong Lewis acid) activates water or substrates: carbonic anhydrase (His_3–Zn–OH^-, CO_2 hydration), carboxypeptidase (peptide hydrolysis), alcohol dehydrogenase (with NAD^+), zinc fingers (structural, Cys_2His_2).

↓

LOGIC / WORKING

- The zinc-bound hydroxide attacks CO_2 (nucleophilic attack on carbon); the resulting bicarbonate then coordinates to zinc before being displaced by water.
- Therefore the answer is (A).

FINAL: (A) OH group of the active site of the enzyme and then with zinc

SHORTCUT / EXAM TRICK

Zn lowers the pKa of bound water to ~7, generating a nucleophilic hydroxide at physiological pH.

COMMON MISTAKE

Assigning Zn a role in electron transfer.

EXAM TIP

Co(II)-substituted CA is active and coloured — used to study the spectroscopically silent Zn site.

MEMORY TRICK

'Zinc: Lewis acid, no redox, no colour'.

Why the Other Options Are Wrong

Correct answer: A

B

H_2O of the active site of the enzyme and then with zinc

Why (A) is the key — The zinc-bound hydroxide attacks CO_2 (nucleophilic attack on carbon); the resulting bicarbonate then coordinates to zinc before being displaced by water.

C

zinc of the active site of the enzyme and then with OH group

Ruled out: Assigning Zn a role in electron transfer.

D

zinc of the active site of the enzyme and then with H_2O

Ruled out: Co(II)-substituted CA is active and coloured — used to study the spectroscopically silent Zn site.

Q26

Molybdoenzymes can both oxidize as well as reduce the substrates, because

A. Mo(VI) is more stable than Mo(IV)

B. Mo(IV) can transfer oxygen atom to the substrate and Mo(VI) can abstract oxygen atom from the substrate

C. Conversion of Mo(VI) to Mo(IV) is not favoured

D. Mo(VI) can transfer oxygen atom to the substrate and Mo(IV) can abstract oxygen atom from the substrate

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Zinc Enzymes

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Zinc: Lewis acid, no redox, no colour'.

Correct Answer D Mo(VI) can transfer oxygen atom to the substrate and Mo(IV) can abstract oxygen atom from the substrate

CONCEPT

Zn^{2+} (d^{10}, redox-inert, flexible coordination, strong Lewis acid) activates water or substrates: carbonic anhydrase (His_3–Zn–OH^-, CO_2 hydration), carboxypeptidase (peptide hydrolysis), alcohol dehydrogenase (with NAD^+), zinc fingers (structural, Cys_2His_2).

↓

LOGIC / WORKING

- Oxo-transfer: Mo(VI)=O delivers an O atom to a substrate (reduction of Mo to IV), and Mo(IV) takes an O atom from a substrate (oxidation back to VI).
- Therefore the answer is (D).

FINAL: (D) Mo(VI) can transfer oxygen atom to the substrate and Mo(IV) can abstract oxygen atom from the substrate

SHORTCUT / EXAM TRICK

Zn lowers the pKa of bound water to ~7, generating a nucleophilic hydroxide at physiological pH.

COMMON MISTAKE

Assigning Zn a role in electron transfer.

EXAM TIP

Co(II)-substituted CA is active and coloured — used to study the spectroscopically silent Zn site.

MEMORY TRICK

'Zinc: Lewis acid, no redox, no colour'.

Why the Other Options Are Wrong

Correct answer: D

A **Mo(VI) is more stable than Mo(IV)**

Why (D) is the key — Oxo-transfer: Mo(VI)=O delivers an O atom to a substrate (reduction of Mo to IV), and Mo(IV) takes an O atom from a substrate (oxidation back to VI).

B **Mo(IV) can transfer oxygen atom to the substrate and Mo(VI) can abstract oxygen atom from the substrate**

Ruled out: Assigning Zn a role in electron transfer.

C **Conversion of Mo(VI) to Mo(IV) is not favoured**

Ruled out: Co(II)-substituted CA is active and coloured — used to study the spectroscopically silent Zn site.

Q27

Consider the following statements with respect to Cytochrome P-450 (A) It has histidine coordinated to iron centre (B) It is a membrane bound metalloenzymes (C) It has Fe(III) ion in the resting state of the enzyme The correct statement(s) is/are

A. A, B

B. A, C

C. B, C

D. A only

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Zinc Enzymes

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Zinc: Lewis acid, no redox, no colour'.

Zinc Enzymes

Correct Answer C B, C

CONCEPT

Zn^{2+} (d^{10}, redox-inert, flexible coordination, strong Lewis acid) activates water or substrates: carbonic anhydrase (His_3–Zn–OH^-, CO_2 hydration), carboxypeptidase (peptide hydrolysis), alcohol dehydrogenase (with NAD^+), zinc fingers (structural, Cys_2His_2).

↓

LOGIC / WORKING

- Cytochrome P-450 is a membrane-bound haem enzyme with a cysteine thiolate (not histidine) as the axial ligand and Fe(III) in the resting state: statements B and C.
- Therefore the answer is (C).

FINAL: (C) B, C

SHORTCUT / EXAM TRICK

Zn lowers the pKa of bound water to ~7, generating a nucleophilic hydroxide at physiological pH.

COMMON MISTAKE

Assigning Zn a role in electron transfer.

EXAM TIP

Co(II)-substituted CA is active and coloured — used to study the spectroscopically silent Zn site.

MEMORY TRICK

'Zinc: Lewis acid, no redox, no colour'.

Why the Other Options Are Wrong

Correct answer: C

A — **A, B**

Why (C) is the key — Cytochrome P-450 is a membrane-bound haem enzyme with a cysteine thiolate (not histidine) as the axial ligand and Fe(III) in the resting state: statements B and C.

B — **A, C**

Ruled out: Assigning Zn a role in electron transfer.

D — **A only**

Ruled out: Co(II)-substituted CA is active and coloured — used to study the spectroscopically silent Zn site.

TOPIC REVISION

Zinc Enzymes

4 PYQs · Last-minute revision

TOPIC SUMMARY

Zn^{2+} (d^{10}, redox-inert, flexible coordination, strong Lewis acid) activates water or substrates: carbonic anhydrase (His_3–Zn–OH^-, CO_2 hydration), carboxypeptidase (peptide hydrolysis), alcohol dehydrogenase (with NAD^+), zinc fingers (structural, Cys_2His_2).

IMPORTANT FORMULA SHEET

- CA: Zn–OH^- + CO_2 → Zn–HCO_3^-; $k_{cat} \approx 10^6\ s^{-1}$
- pKa of Zn-bound water ≈ 7 (vs 15.7 free)
- Zn finger: Cys_2His_2 tetrahedral

FREQUENTLY ASKED CONCEPTS

- Why Zn (not Cu/Fe) for hydrolases
- Mechanism of carbonic anhydrase
- Co^{2+} substitution as spectroscopic probe
- Zinc finger motif

COMMON MISTAKES & QUICK NOTES

Watch out:
Assigning Zn a role in electron transfer.
Co(II)-substituted CA is active and coloured — used to study the spectroscopically silent Zn site.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q24 Q25 Q26 Q27

Expect 1 question(s) next session on Zinc Enzymes.

TOPIC 5

Nitrogen Fixation

3 questions · Easy 2 | Medium 1 | Hard 0 · PYQ frequency: Occasional

Q28

The reduction of nitrogen to ammonia, carried out by the enzyme nitrogenase, needs,

A. 2 electrons

B. 4 electrons

C. 6 electrons

D. 8 elecrons

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nitrogen Fixation

PYQ FREQUENCY
Occasional · 3 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'8 electrons, 16 ATP, 1 H_2'.

Correct Answer D 8 elecrons

CONCEPT

Nitrogenase (Fe protein + MoFe protein with P-cluster and FeMo-cofactor Fe_7MoS_9C-homocitrate) reduces N_2 to $2NH_3$ with 8 e^-/8 H^+ and 16 ATP, evolving H_2; alternative V- and Fe-only nitrogenases; Haber–Bosch comparison; dinitrogen complexes (end-on, side-on).

↓

LOGIC / WORKING

- $N_2 + 8H^+ + 8e^- + 16ATP \rightarrow 2NH_3 + H_2$: nitrogenase uses eight electrons (six for N_2, two for the obligatory H_2).
- Therefore the answer is (D).

FINAL: (D) 8 elecrons

SHORTCUT / EXAM TRICK

Acetylene reduction to ethylene is the standard nitrogenase activity assay.

COMMON MISTAKE

Writing the stoichiometry with 6 electrons (biological reaction uses 8, one H_2 per N_2).

EXAM TIP

The central carbide (C^{4-}) in FeMo-co was confirmed by X-ray/ESEEM in 2011.

MEMORY TRICK

'8 electrons, 16 ATP, 1 H_2'.

Why the Other Options Are Wrong

Correct answer: D

A **2 electrons**

Why (D) is the key — $N_2 + 8H^+ + 8e^- + 16ATP \rightarrow 2NH_3 + H_2$: nitrogenase uses eight electrons (six for N_2, two for the obligatory H_2).

B **4 electrons**

Ruled out: Writing the stoichiometry with 6 electrons (biological reaction uses 8, one H_2 per N_2).

C **6 electrons**

Ruled out: The central carbide (C^{4-}) in FeMo-co was confirmed by X-ray/ESEEM in 2011.

Q29 The number of histidine amino acid nitrogen atoms coordinated to bimetallic active site of oxyhemocyanin, and oxyhemerythrin, respectively, are

A. 2, 3 and 3, 3

B. 3, 3 and 2, 3

C. 3, 3 and 2, 2

D. 2, 4 and 3,2

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Nitrogen Fixation

PYQ FREQUENCY
Occasional · 3 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'8 electrons, 16 ATP, 1 H_2'.

Correct Answer B 3, 3 and 2, 3

CONCEPT

Nitrogenase (Fe protein + MoFe protein with P-cluster and FeMo-cofactor Fe_7MoS_9C-homocitrate) reduces N_2 to $2NH_3$ with 8 e^-/8 H^+ and 16 ATP, evolving H_2; alternative V- and Fe-only nitrogenases; Haber–Bosch comparison; dinitrogen complexes (end-on, side-on).

↓

LOGIC / WORKING

- Oxyhemocyanin: each of the two Cu atoms is bound by three histidines (3, 3). Oxyhemerythrin: one Fe has three histidines and the other two (3, 2) — written as '3,3 and 2,3'.
- Therefore the answer is (B).

FINAL: (B) 3, 3 and 2, 3

SHORTCUT / EXAM TRICK

Acetylene reduction to ethylene is the standard nitrogenase activity assay.

COMMON MISTAKE

Writing the stoichiometry with 6 electrons (biological reaction uses 8, one H_2 per N_2).

EXAM TIP

The central carbide (C^{4-}) in FeMo-co was confirmed by X-ray/ESEEM in 2011.

MEMORY TRICK

'8 electrons, 16 ATP, 1 H_2'.

Why the Other Options Are Wrong

Correct answer: B

A **2, 3 and 3, 3**

Why (B) is the key — Oxyhemocyanin: each of the two Cu atoms is bound by three histidines (3, 3). Oxyhemerythrin: one Fe has three histidines and the other two (3, 2) — written as '3,3 and 2,3'.

C **3, 3 and 2, 2**

Ruled out: Writing the stoichiometry with 6 electrons (biological reaction uses 8, one H_2 per N_2).

D **2, 4 and 3,2**

Ruled out: The central carbide (C^{4-}) in FeMo-co was confirmed by X-ray/ESEEM in 2011.

Q30

The metal ions present in the active site of nitrogenase enzyme co-factor are

A. Fe, Mo

B. Fe, W

C. Fe, Cu

D. Fe, Ni

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nitrogen Fixation

PYQ FREQUENCY
Occasional · 3 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'8 electrons, 16 ATP, 1 H_2'.

Correct Answer A Fe, Mo

CONCEPT

Nitrogenase (Fe protein + MoFe protein with P-cluster and FeMo-cofactor Fe_7MoS_9C-homocitrate) reduces N_2 to $2NH_3$ with 8 e^-/8 H^+ and 16 ATP, evolving H_2; alternative V- and Fe-only nitrogenases; Haber–Bosch comparison; dinitrogen complexes (end-on, side-on).

↓

LOGIC / WORKING

- The FeMo-cofactor of nitrogenase contains 7 Fe, 1 Mo, 9 S, a central carbide and homocitrate.
- Therefore the answer is (A).

FINAL: (A) Fe, Mo

SHORTCUT / EXAM TRICK

Acetylene reduction to ethylene is the standard nitrogenase activity assay.

COMMON MISTAKE

Writing the stoichiometry with 6 electrons (biological reaction uses 8, one H_2 per N_2).

EXAM TIP

The central carbide (C^{4-}) in FeMo-co was confirmed by X-ray/ESEEM in 2011.

MEMORY TRICK

'8 electrons, 16 ATP, 1 H_2'.

Why the Other Options Are Wrong

Correct answer: A

B **Fe, W**

Why (A) is the key — The FeMo-cofactor of nitrogenase contains 7 Fe, 1 Mo, 9 S, a central carbide and homocitrate.

C **Fe, Cu**

Ruled out: Writing the stoichiometry with 6 electrons (biological reaction uses 8, one H_2 per N_2).

D **Fe, Ni**

Ruled out: The central carbide (C^{4-}) in FeMo-co was confirmed by X-ray/ESEEM in 2011.

TOPIC REVISION

Nitrogen Fixation

3 PYQs · Last-minute revision

TOPIC SUMMARY

Nitrogenase (Fe protein + MoFe protein with P-cluster and FeMo-cofactor Fe_7MoS_9C-homocitrate) reduces N_2 to $2NH_3$ with 8 e^-/8 H^+ and 16 ATP, evolving H_2; alternative V- and Fe-only nitrogenases; Haber–Bosch comparison; dinitrogen complexes (end-on, side-on).

IMPORTANT FORMULA SHEET

- $N_2 + 8H^+ + 8e^- + 16ATP \rightarrow 2NH_3 + H_2 + 16ADP + 16P_i$
- FeMo-co: Fe_7MoS_9C(homocitrate)
- $\nu(N\equiv N)$ 2331 cm^{-1} free; lower when bound

FREQUENTLY ASKED CONCEPTS

- Composition of FeMo-cofactor
- Why H_2 is always evolved
- Role of ATP
- Inhibitors (CO, C_2H_2 reduced to C_2H_4 assay)

COMMON MISTAKES & QUICK NOTES

Watch out:
Writing the stoichiometry with 6 electrons (biological reaction uses 8, one H_2 per N_2).
The central carbide (C^{4-}) in FeMo-co was confirmed by X-ray/ESEEM in 2011.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q28 Q29 Q30

Expect 1 question(s) next session on Nitrogen Fixation.

TOPIC 6

Bioinorganic Chemistry – General

41 questions · Easy 27 | Medium 14 | Hard 0 · PYQ frequency: Very High

Q31

Among the following drugs, the anticancer agents is:

A captopril

B chloroquine

C camptothecin

D ranitidine

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer C camptothecin

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Camptothecin is a topoisomerase-I inhibitor used against cancer; captopril is an ACE inhibitor, chloroquine an antimalarial, ranitidine an H_2 antagonist.
- Therefore the answer is (C).

FINAL: (C) camptothecin

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: C

A **captopril**

Why (C) is the key — Camptothecin is a topoisomerase-I inhibitor used against cancer; captopril is an ACE inhibitor, chloroquine an antimalarial, ranitidine an H_2 antagonist.

B **chloroquine**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **ranitidine**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q32

The correct set of the biologically essential elements is,

A. Fe, Mo, Cu, Zn

B. Fe, Cu, Co, Ru

C. Cu, Mn, Zn, Ag

D. Fe, Ru, Zn, Mg

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A Fe, Mo, Cu, Zn

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Fe, Mo, Cu and Zn are all essential trace elements; Ru and Ag have no biological role.
- Therefore the answer is (A).

FINAL: (A) Fe, Mo, Cu, Zn

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **Fe, Cu, Co, Ru**

Why (A) is the key — Fe, Mo, Cu and Zn are all essential trace elements; Ru and Ag have no biological role.

C **Cu, Mn, Zn, Ag**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **Fe, Ru, Zn, Mg**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q33

Patients suffering from Wilson's disease have

A. Low level of Cu-Zn superoxide dismutase

B. High level of Cu-Zn superoxide dismutase

C. Low level of copper-storage protein, ceruloplasmin

D. High level of copper-storage protein, ceruloplasmin

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer C Low level of copper-storage protein, ceruloplasmin

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Wilson's disease is a copper-handling defect with low serum ceruloplasmin and copper accumulation in liver and brain.
- Therefore the answer is (C).

FINAL: (C) Low level of copper-storage protein, ceruloplasmin

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: C

A **Low level of Cu-Zn superoxide dismutase**

Why (C) is the key — Wilson's disease is a copper-handling defect with low serum ceruloplasmin and copper accumulation in liver and brain.

B **High level of Cu-Zn superoxide dismutase**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **High level of copper-storage protein, ceruloplasmin**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q34

L-DOPA is used for treatment of

A. tuberculosis

B. Parkinson's disease

C. diabetes

D. cancer

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer B Parkinson's disease

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- L-DOPA crosses the blood–brain barrier and is decarboxylated to dopamine, replacing the dopamine deficit in Parkinson's disease.
- Therefore the answer is (B).

FINAL: (B) Parkinson's disease

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: B

A **tuberculosis**

Why (B) is the key — L-DOPA crosses the blood–brain barrier and is decarboxylated to dopamine, replacing the dopamine deficit in Parkinson's disease.

C **diabetes**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **cancer**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q35

The extent of π-electron conjugation in macrocyclic rings of (1) heme, (2) coenzyme B_{12} and (3) chlorophyll follows the order

A. (1)>(3)>(2)

B. (1)>(2)>(3)

C. (3)>(1)>(2)

D. (2)>(1)>(3)

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A (1)>(3)>(2)

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Heme (porphyrin) is fully conjugated; chlorophyll (chlorin) has one reduced pyrrole ring; the corrin of B_{12} is the least conjugated. Order 1 > 3 > 2.
- Therefore the answer is (A).

FINAL: (A) (1)>(3)>(2)

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **(1)>(2)>(3)**

Why (A) is the key — Heme (porphyrin) is fully conjugated; chlorophyll (chlorin) has one reduced pyrrole ring; the corrin of B_{12} is the least conjugated. Order 1 > 3 > 2.

C **(3)>(1)>(2)**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **(2)>(1)>(3)**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q36

The biological functions of cytochrome P_{450} and myoglobin are, respectively

A. oxidation of alkene and O_2 storage

B. O_4 transport and O_2 storage

C. O_2 storage and electron carrier

D. electron carrier and O_2 transport

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A oxidation of alkene and O_2 storage

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- P450 oxidises alkenes (mono-oxygenase); myoglobin stores O_2 (a).
- Therefore the answer is (A).

FINAL: (A) oxidation of alkene and O_2 storage

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A‖ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **O_4 transport and O_2 storage**
Why (A) is the key — P450 oxidises alkenes (mono-oxygenase); myoglobin stores O_2 (a).

C **O_2 storage and electron carrier**
Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **electron carrier and O_2 transport**
Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q37

Deoxy-hemocyanin is

A. heme protein and paramagnetic

B. colourless and diamagnetic

C. O_2 transporter and paramagnetic

D. blue colored and diamagnetic

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer B colourless and diamagnetic

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Deoxyhemocyanin contains two Cu(I) (d^{10}) centres: colourless and diamagnetic; only on binding O_2 does it become blue (Cu(II)–peroxo).
- Therefore the answer is (B).

FINAL: (B) colourless and diamagnetic

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: B

A **heme protein and paramagnetic**

Why (B) is the key — Deoxyhemocyanin contains two Cu(I) (d^{10}) centres: colourless and diamagnetic; only on binding O_2 does it become blue (Cu(II)–peroxo).

C **O_2 transporter and paramagnetic**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **blue colored and diamagnetic**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q38 From the following transformations, A. Epoxidation of alkene B. Dioldehydrase reaction C. Conversion of ribonucleotide-to-deoxyribonucleotide D. 1, 2-carbon shift in organic substrates those promoted by coenzyme B_{12} are

(A) A and B

(B) B, C and D

(C) A, B and D

(D) A, B and C

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer B B, C and D

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Coenzyme B_{12} (adenosylcobalamin) drives radical 1,2-rearrangements: diol dehydrase, ribonucleotide reductase (class II) and carbon-skeleton mutases; alkene epoxidation is not a B_{12} reaction. B, C and D.
- Therefore the answer is (B).

FINAL: (B) B, C and D

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: B

A

A and B

Why (B) is the key — Coenzyme B_{12} (adenosylcobalamin) drives radical 1,2-rearrangements: diol dehydrase, ribonucleotide reductase (class II) and carbon-skeleton mutases; alkene epoxidation is not a B_{12} reaction. B, C and D.

C

A, B and D

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D

A, B and C

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q39

The number of inorganic sulfides in cubane like ferredoxin and their removal method, respectively, are

A. eight and washing with an acid

B. four and washing with a base

C. eight and washing with a base

D. four and washing with an acid

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer D four and washing with an acid

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- The Fe_4S_4 cubane holds four inorganic sulfides, released as H_2S on acid treatment (acid-labile sulfide).
- Therefore the answer is (D).

FINAL: (D) four and washing with an acid

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: D

A **eight and washing with an acid**

Why (D) is the key — The Fe_4S_4 cubane holds four inorganic sulfides, released as H_2S on acid treatment (acid-labile sulfide).

B **four and washing with a base**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

C **eight and washing with a base**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q40

The chelate rings made by macrocyclic ligand in vitamin B_{12} are

A. One five-membered and three six-membered

B. Two five-membered and two six-membered

C. Three five-membered and one six-membered

D. Four six-membered

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A One five-membered and three six-membered

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- In the corrin ring one pair of pyrrole units is joined directly (a five-membered chelate ring with Co) and the other three are bridged by methine carbons (three six-membered chelate rings).
- Therefore the answer is (A).

FINAL: (A) One five-membered and three six-membered

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B — **Two five-membered and two six-membered**

Why (A) is the key — In the corrin ring one pair of pyrrole units is joined directly (a five-membered chelate ring with Co) and the other three are bridged by methine carbons (three six-membered chelate rings).

C — **Three five-membered and one six-membered**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D — **Four six-membered**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q41

In the catalytic cycle of Cytochrome P_{450}, the generation of [(porphyrin)+Fe^IV(O)] from [(porphyrin)Fe^III(OOH)] involves

A. One electron oxidation of [(porphyrin)Fe^III(OOH)]

B. Formation of the intermediate [(porphyrin)Fe^IV(OH)]

C. Homolytic O-O cleavage of [(porphyrin)Fe^IV(OOH)]

D. Heterolytic O-O cleavage of [(porphyrin)Fe^III(OOH)]

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer D Heterolytic O-O cleavage of [(porphyrin)Fe^III(OOH)]

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Heterolytic O–O cleavage of protonated Fe(III)–OOH forms compound I (d).
- Therefore the answer is (D).

FINAL: (D) Heterolytic O-O cleavage of [(porphyrin)Fe^III(OOH)]

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A‖ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: D

A **One electron oxidation of [(porphyrin)Fe^III(OOH)]**
Why (D) is the key — Heterolytic O–O cleavage of protonated Fe(III)–OOH forms compound I (d).

B **Formation of the intermediate [(porphyrin)Fe^IV(OH)]**
Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

C **Homolytic O-O cleavage of [(porphyrin)Fe^IV(OOH)]**
Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q42

The ligand system present in vitamin B_{12} is:

A. Porphyrin

B. Corrin

C. Phthalocyanine

D. Crown ether

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer B Corrin

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Cobalt in vitamin B_{12} sits in a corrin ring (one fewer meso carbon than porphyrin, partly saturated).
- Therefore the answer is (B).

FINAL: (B) Corrin

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: B

A **Porphyrin**

Why (B) is the key — Cobalt in vitamin B_{12} sits in a corrin ring (one fewer meso carbon than porphyrin, partly saturated).

C **Phthalocyanine**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **Crown ether**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q43

The coordination geometry of copper (II) in the type I copper protein plastocyanin is:

A. square planar

B. tetrahedral

C. octahedral

D. distorted tetrahedral

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer D distorted tetrahedral

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- The type-1 (blue) copper site of plastocyanin is a distorted tetrahedron of two His, one Cys and one Met — the entatic geometry between Cu(II) and Cu(I) preferences.
- Therefore the answer is (D).

FINAL: (D) distorted tetrahedral

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: D

A **square planar**

Why (D) is the key — The type-1 (blue) copper site of plastocyanin is a distorted tetrahedron of two His, one Cys and one Met — the entatic geometry between Cu(II) and Cu(I) preferences.

B **tetrahedral**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

C **octahedral**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q44

If an enzyme fixes N_2, in plants by evolving H_2, the number of electrons and protons associated with that, respectively are

A. 6 and 6

B. 8 and 8

C. 6 and 8

D. 8 and 6

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer B 8 and 8

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- $N_2 + 8H^+ + 8e^- \rightarrow 2NH_3 + H_2$: eight electrons and eight protons per N_2 when one H_2 is evolved.
- Therefore the answer is (B).

FINAL: (B) 8 and 8

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: B

A **6 and 6**

Why (B) is the key — $N_2 + 8H^+ + 8e^- \rightarrow 2NH_3 + H_2$: eight electrons and eight protons per N_2 when one H_2 is evolved.

C **6 and 8**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **8 and 6**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_\parallel$ in EPR.

Q45

Ozone present in upper atmosphere protects people on the earth

A. due to its diamagnetic nature

B. due to its blue colour

C. due to absorption of radiation of wavelength at 255nm

D. by destroying chlorofluoro carbons

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer C due to absorption of radiation of wavelength at 255nm

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Ozone's Hartley band (200–300 nm, max ≈ 255 nm) absorbs harmful UV-C/UV-B before it reaches the surface.
- Therefore the answer is (C).

FINAL: (C) due to absorption of radiation of wavelength at 255nm

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: C

A — **due to its diamagnetic nature**

Why (C) is the key — Ozone's Hartley band (200–300 nm, max ≈ 255 nm) absorbs harmful UV-C/UV-B before it reaches the surface.

B — **due to its blue colour**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D — **by destroying chlorofluoro carbons**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q46

The biological functions of carbonic anhydrase and carboxypeptidase A, respectively, are

A. interconversion of CO_2 and carbonates and hydrolysis of peptide bond

B. gene regulation and interconversion of CO_2 and carbonates

C. gene regulation and hydrolysis of peptide bond

D. interconversion of CO_2 and carbonates and gene regulation

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A interconversion of CO_2 and carbonates and hydrolysis of peptide bond

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Carbonic anhydrase interconverts CO_2 and bicarbonate; carboxypeptidase A hydrolyses the C-terminal peptide bond.
- Therefore the answer is (A).

FINAL: (A) interconversion of CO_2 and carbonates and hydrolysis of peptide bond

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **gene regulation and interconversion of CO_2 and carbonates**

Why (A) is the key — Carbonic anhydrase interconverts CO_2 and bicarbonate; carboxypeptidase A hydrolyses the C-terminal peptide bond.

C **gene regulation and hydrolysis of peptide bond**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **interconversion of CO_2 and carbonates and gene regulation**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q47

In human body cis- platinhydrolyzes to diaqua complex and modifies the DNA structure by binding to

A. N-atom of guanine base

B. N-atom of adenine base

C. O-atom of cytosine base

D. O-atom of thymine base

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A N-atom of guanine base

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- cis-$[Pt(NH_3)_2(H_2O)_2]^{2+}$ binds the N7 atoms of two adjacent guanines (1,2-intrastrand cross-link), kinking the DNA and blocking replication.
- Therefore the answer is (A).

FINAL: (A) N-atom of guanine base

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **N-atom of adenine base**

Why (A) is the key — cis-$[Pt(NH_3)_2(H_2O)_2]^{2+}$ binds the N7 atoms of two adjacent guanines (1,2-intrastrand cross-link), kinking the DNA and blocking replication.

C **O-atom of cytosine base**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **O-atom of thymine base**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q48

In vitro reaction of an excess of O_2 with free heme B in aqueous medium the end product is

A. hematin

B. [O_2--Fe(III)-protoporphyrin-IX]

C. heme B(O_2)

D. oxoferrylprotoporphyrin-IX cation radical

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A hematin

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Without the protein pocket, heme B + O_2 in water forms a peroxo-bridged dimer that collapses irreversibly to the Fe(III) μ-oxo dimer / hydroxo-Fe(III) species — hematin.
- Therefore the answer is (A).

FINAL: (A) hematin

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **[O_2--Fe(III)-protoporphyrin-IX]**

Why (A) is the key — Without the protein pocket, heme B + O_2 in water forms a peroxo-bridged dimer that collapses irreversibly to the Fe(III) μ-oxo dimer / hydroxo-Fe(III) species — hematin.

C **heme B(O_2)**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **oxoferrylprotoporphyrin-IX cation radical**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q49

Carboxypeptidase contains:

A. Zn (II) and hydrolyses CO_2

B. Zn (II) and hydrolyses peptide bonds

C. Mg (II) and hydrolyses CO_2

D. Mg (II) and hydrolyses peptide bonds

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer B Zn (II) and hydrolyses peptide bonds

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Carboxypeptidase enzyme contains Zn^{+2} ion and it cleaves (hydrolyses) the carboxy terminal amino acid from a peptide chain. [CSIR DEC 2011] Explanation as extracted from the printed page; notation may be imperfect.
- Therefore the answer is (B).

FINAL: (B) Zn (II) and hydrolyses peptide bonds

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: B

A **Zn (II) and hydrolyses CO_2**

Why (B) is the key — Carboxypeptidase enzyme contains Zn^{+2} ion and it cleaves (hydrolyses) the carboxy terminal amino acid from a peptide chain. [CSIR DEC 2011] Explanation as extracted from the printed page; notation may be imperfect.

C **Mg (II) and hydrolyses CO_2**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **Mg (II) and hydrolyses peptide bonds**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q50

Under physiological condition, oxygen is binding to deoxyhemoglobin and deoxymyoglobin, the binding curve and its pH dependence, respectively, are

A. Sigmoidal and pH dependent; hyperbolic and pH independent

B. Hyperbolic and pH independent:sigmoidal and pH dependent

C. Sigmoidal and pH independent;hyperbolic and pH dependent

D. Hyperbolic and pH dependent:sigmoidal and pH independent

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A Sigmoidal and pH dependent; hyperbolic and pH independent

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Hemoglobin (tetramer) binds O_2 cooperatively → sigmoidal curve, and shows the Bohr effect (pH dependent). Myoglobin (monomer) → hyperbolic, pH independent.
- Therefore the answer is (A).

FINAL: (A) Sigmoidal and pH dependent; hyperbolic and pH independent

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **Hyperbolic and pH independent:sigmoidal and pH dependent**

Why (A) is the key — Hemoglobin (tetramer) binds O_2 cooperatively → sigmoidal curve, and shows the Bohr effect (pH dependent). Myoglobin (monomer) → hyperbolic, pH independent.

C **Sigmoidal and pH independent;hyperbolic and pH dependent**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **Hyperbolic and pH dependent:sigmoidal and pH independent**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q51

Consider the following transformation, reactions in the context of co-enzyme B_{12} (A) 1, 2-Carbon shift (B) Hydration of CO_2 (C) Benzene to phenol (D) dimethyl sulfide to demethyl sulfoxide The correct statement(s) for co-enzyme B_{12} is/are

A. A, C, D

B. A, B only

C. B, C only

D. A only

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer D A only

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Coenzyme B_{12} enzymes catalyse radical 1,2-carbon-skeleton shifts; CO_2 hydration (Zn), arene hydroxylation and sulfoxidation are not B_{12} chemistry — A only.
- Therefore the answer is (D).

FINAL: (D) A only

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: D

A

A, C, D

Why (D) is the key — Coenzyme B_{12} enzymes catalyse radical 1,2-carbon-skeleton shifts; CO_2 hydration (Zn), arene hydroxylation and sulfoxidation are not B_{12} chemistry — A only.

B

A, B only

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

C

B, C only

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q52

The metal present at the active site of the protein carboxypeptidase A is

A. Zinc

B. molybdenum

C. magnesium

D. cobalt

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A Zinc

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Carboxypeptidase A is a zinc hydrolase: Zn^{2+} polarises the peptide carbonyl and activates water for hydrolysis of C-terminal residues.
- Therefore the answer is (A).

FINAL: (A) Zinc

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **molybdenum**

Why (A) is the key — Carboxypeptidase A is a zinc hydrolase: Zn^{2+} polarises the peptide carbonyl and activates water for hydrolysis of C-terminal residues.

C **magnesium**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **cobalt**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q53

In biological systems, the metal ions involved in electron transport are

A. Na^{+} and K^{+}

B. Zn^{2+} and Mg^{2+}

C. Ca^{2+} and Mg^{2+}

D. Cu^{2+} and Fe^{3+}

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer D Cu^{2+} and Fe^{3+}

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Electron transport proteins use redox-active metals: Fe (cytochromes, Fe–S clusters) and Cu (blue copper proteins, cytochrome c oxidase).
- Therefore the answer is (D).

FINAL: (D) Cu^{2+} and Fe^{3+}

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: D

A **Na^+ and K^+**

Why (D) is the key — Electron transport proteins use redox-active metals: Fe (cytochromes, Fe–S clusters) and Cu (blue copper proteins, cytochrome c oxidase).

B **Zn^{2+} and Mg^{2+}**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

C **Ca^{2+} and Mg^{2+}**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q54

Among the following pair of metal ions present in Nature, the first one functions as an electrontransfer agent and the second one catalyzes the hydrolysis reactions. The correct pair is

A. Fe and Zn

B. Mg and Fe

C. Co and Mo

D. Ca and Cu

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A Fe and Zn

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Fe (cytochromes, Fe–S proteins) carries electrons; Zn (carboxypeptidase, carbonic anhydrase) is the classic Lewis-acid hydrolysis catalyst.
- Therefore the answer is (A).

FINAL: (A) Fe and Zn

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **Mg and Fe**

Why (A) is the key — Fe (cytochromes, Fe–S proteins) carries electrons; Zn (carboxypeptidase, carbonic anhydrase) is the classic Lewis-acid hydrolysis catalyst.

C **Co and Mo**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **Ca and Cu**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q55

The red color of oxyhaemoglobin is mainly due to the

A. d-d transition

B. metal to ligand charge transfer transition

C. ligand to metal charge transfer transition

D. intraligand π - π^* transition

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer D intraligand π - π^* transition

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- The intense colour of oxy-Hb comes from the porphyrin π–π* (Soret ~415 nm and Q bands ~540/577 nm) of the low-spin Fe(II) heme; d–d bands are far weaker.
- Therefore the answer is (D).

FINAL: (D) intraligand π - π^* transition

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A‖ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: D

A **d-d transition**

Why (D) is the key — The intense colour of oxy-Hb comes from the porphyrin π–π* (Soret ~415 nm and Q bands ~540/577 nm) of the low-spin Fe(II) heme; d–d bands are far weaker.

B **metal to ligand charge transfer transition**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

C **ligand to metal charge transfer transition**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q56

Among the given pH values, the O_2 binding efficiency of hemoglobin is maximum at

A. 6.8

B. 7.0

C. 7.2

D. 7.4

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer D 7.4

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Bohr effect: lower pH (more H^+/CO_2) stabilises deoxy-Hb and releases O_2. O_2 affinity is therefore highest at the highest pH listed, 7.4 (lungs).
- Therefore the answer is (D).

FINAL: (D) 7.4

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A‖ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: D

A **6.8**

Why (D) is the key — Bohr effect: lower pH (more H^+/CO_2) stabilises deoxy-Hb and releases O_2. O_2 affinity is therefore highest at the highest pH listed, 7.4 (lungs).

B **7.0**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

C **7.2**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_\parallel$ in EPR.

Q57

Identify the function of hemocyanin and the metal responsible for it

A. O_2 transport and Fe

B. O_2 transport and Cu

C. electron transport and Fe

D. electron transport and Cu

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer B O_2 transport and Cu

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Hemocyanin (molluscs, arthropods) binds O_2 as peroxide between two Cu centres ($Cu(I)_2 \rightarrow Cu(II)_2–O_2^{2-}$); it is an O_2 transporter, blue when oxygenated.
- Therefore the answer is (B).

FINAL: (B) O_2 transport and Cu

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_\parallel$ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: B

A — **O_2 transport and Fe**

Why (B) is the key — Hemocyanin (molluscs, arthropods) binds O_2 as peroxide between two Cu centres ($Cu(I)_2 \rightarrow Cu(II)_2–O_2^{2-}$); it is an O_2 transporter, blue when oxygenated.

C — **electron transport and Fe**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D — **electron transport and Cu**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_\parallel$ in EPR.

Q58

During oxygen transport by hemerythrin, oxygen is bound as

A. O_2^- to one Fe(III) only

B. HO_2^- to one Fe(III) only

C. O_2^{2-} to one Fe(II) and one Fe(III)

D. O_2^{2-} to two Fe(II)

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer B HO_2^- to one Fe(III) only

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Hemerythrin: deoxy Fe(II)Fe(II) → oxy Fe(III)Fe(III) with O_2 reduced to hydroperoxide (HO_2^-) bound end-on to one Fe(III) and H-bonded to the μ-oxo bridge.
- Therefore the answer is (B).

FINAL: (B) HO_2^- to one Fe(III) only

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: B

A — **O_2^- to one Fe(III) only**

Why (B) is the key — Hemerythrin: deoxy Fe(II)Fe(II) → oxy Fe(III)Fe(III) with O_2 reduced to hydroperoxide (HO_2^-) bound end-on to one Fe(III) and H-bonded to the μ-oxo bridge.

C — **O_2^{2-} to one Fe(II) and one Fe(III)**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D — **O_2^{2-} to two Fe(II)**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q59

At pH 7.2 and 10 Torr oxygen partial pressure, the extent of O_2 binding is

A. high for both haemoglobin and myoglobin

B. high for haemoglobin and low for myoglobin

C. high for myoglobin and low for haemoglobin

D. low for both haemoglobin and myoglobin

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer C high for myoglobin and low for haemoglobin

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- At 10 Torr myoglobin ($P_{50} \approx 2$ Torr) is nearly saturated, whereas hemoglobin ($P_{50} \approx 26$ Torr) is largely deoxygenated — that is how Hb unloads O_2 to Mb in muscle.
- Therefore the answer is (C).

FINAL: (C) high for myoglobin and low for haemoglobin

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: C

A **high for both haemoglobin and myoglobin**

Why (C) is the key — At 10 Torr myoglobin ($P_{50} \approx 2$ Torr) is nearly saturated, whereas hemoglobin ($P_{50} \approx 26$ Torr) is largely deoxygenated — that is how Hb unloads O_2 to Mb in muscle.

B **high for haemoglobin and low for myoglobin**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **low for both haemoglobin and myoglobin**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q60

Amongst the following, the group that is bound to the metal ion in coenzyme B_{12} is

A. methyl

B. cyanide

C. adenosyl

D. hydroxyl

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer C adenosyl

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Coenzyme B_{12} (adenosylcobalamin) has a 5′-deoxyadenosyl group bound to Co via a Co–C bond; methylcobalamin carries methyl, and cyanocobalamin (vitamin B_{12}) carries CN^-.
- Therefore the answer is (C).

FINAL: (C) adenosyl

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: C

A **methyl**

Why (C) is the key — Coenzyme B_{12} (adenosylcobalamin) has a 5′-deoxyadenosyl group bound to Co via a Co–C bond; methylcobalamin carries methyl, and cyanocobalamin (vitamin B_{12}) carries CN^-.

B **cyanide**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **hydroxyl**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_\parallel$ in EPR.

Q61

The v_O-O resonance Raman stretching frequency (in cm^{-1}) of the O_2 coordinated to iron centre in oxyhemoglobin is nearly

A. 1100

B. 850

C. 1550

D. 1950

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A 1100

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Bound O_2 in oxyhaemoglobin is superoxide-like, ν(O–O) ≈ 1100 cm^{-1} (a).
- Therefore the answer is (A).

FINAL: (A) 1100

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **850**

Why (A) is the key — Bound O_2 in oxyhaemoglobin is superoxide-like, ν(O–O) ≈ 1100 cm^{-1} (a).

C **1550**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **1950**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q62

The coordination geometries around the copper ion of plastocyanin (a blue-copper protein) in oxidized and reduced form, respectively are

A. tetrahedral and square-planar

B. square-planar and tetrahedral

C. distorted tetrahedral for both

D. ideal tetrahedral for both

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer C distorted tetrahedral for both

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Plastocyanin's type-1 Cu site (2 His, Cys, Met) is a distorted tetrahedral geometry in both Cu(II) and Cu(I) forms — the 'entatic' state that makes electron transfer fast.
- Therefore the answer is (C).

FINAL: (C) distorted tetrahedral for both

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: C

A **tetrahedral and square-planar**

Why (C) is the key — Plastocyanin's type-1 Cu site (2 His, Cys, Met) is a distorted tetrahedral geometry in both Cu(II) and Cu(I) forms — the 'entatic' state that makes electron transfer fast.

B **square-planar and tetrahedral**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **ideal tetrahedral for both**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q63

The O_2 coordinated to metal ion centres in oxy-myoglobin and oxy-hemocyanin exists, respectively, as

A. superoxide and peroxide

B. superoxide and superoxide

C. peroxide and peroxide

D. superoxide and oxygen

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A superoxide and peroxide

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Oxy-Mb: Fe(III)–O_2^- (superoxide, end-on, ν(O–O) ≈ 1100 cm^{-1}). Oxy-hemocyanin: $Cu(II)_2$–(μ-η^2:η^2-O_2^{2-}) peroxide (ν ≈ 750 cm^{-1}).
- Therefore the answer is (A).

FINAL: (A) superoxide and peroxide

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **superoxide and superoxide**

Why (A) is the key — Oxy-Mb: Fe(III)–O_2^- (superoxide, end-on, ν(O–O) ≈ 1100 cm^{-1}). Oxy-hemocyanin: $Cu(II)_2$–(μ-η^2:η^2-O_2^{2-}) peroxide (ν ≈ 750 cm^{-1}).

C **peroxide and peroxide**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **superoxide and oxygen**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q64

Which one of the following is a non-heme protein?

A. hemoglobin

B. myoglobin

C. hemocyanin

D. cytochrome P-450

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer C hemocyanin

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Hemocyanin contains a dicopper site with no heme. Hemoglobin, myoglobin and cytochrome P-450 are all heme (iron porphyrin) proteins.
- Therefore the answer is (C).

FINAL: (C) hemocyanin

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: C

A **hemoglobin**

Why (C) is the key — Hemocyanin contains a dicopper site with no heme. Hemoglobin, myoglobin and cytochrome P-450 are all heme (iron porphyrin) proteins.

B **myoglobin**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **cytochrome P-450**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q65

The correct statement(s) about the concentration of Na^+ and K^+ ions in animal cells is/are:

A. $[K^+]$ inside the cell < $[K^+]$ outside the cell

B. $[Na^+]$ inside the cell < $[Na^+]$ outside the cell

C. $[Na^+]$ inside the cell > $[Na^+]$ outside the cell

D. $[K^+]$ inside the cell > $[K^+]$ outside the cell

ANSWER: (b) and (d)

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
The Na^+/K^+-ATPase pumps K^+ in and Na^+ out: inside the cell $[K^+] \approx 140$ mM > outside ≈ 5 mM, and $[Na^+]$ inside ≈ 10 mM < outside ≈ 145 mM.

Q66

The metal ion of an enzyme involved in hydration of CO_2 is

A. Cu(II)

B. Fe(II)

C. Mg(II)

D. Zn(II)

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer D Zn(II)

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Carbonic anhydrase is a Zn(II) enzyme (d).
- Therefore the answer is (D).

FINAL: (D) Zn(II)

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: D

A **Cu(II)**
Why (D) is the key — Carbonic anhydrase is a Zn(II) enzyme (d).

B **Fe(II)**
Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

C **Mg(II)**
Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q67

Low-spin iron(III) centre is present in

A. deoxy form of hemoglobin

B. oxy form of hemoglobin

C. hemocyanin

D. carbonic anhydrase

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer B oxy form of hemoglobin

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Oxyhaemoglobin is formulated as low-spin Fe(III)–superoxide (b).
- Therefore the answer is (B).

FINAL: (B) oxy form of hemoglobin

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: B

A **deoxy form of hemoglobin**

Why (B) is the key — Oxyhaemoglobin is formulated as low-spin Fe(III)–superoxide (b).

C **hemocyanin**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **carbonic anhydrase**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q68

Carbonic anhydrase is an example of

A. Hydrolysis enzyme

B. Redox enzyme

C. O_2 transport protein

D. Heme protein

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A Hydrolysis enzyme

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Carbonic anhydrase (Zn^{2+} enzyme) catalyses the hydration of CO_2 / dehydration of HCO_3^- — a hydrolytic (hydrase/lyase-type) enzyme, not a redox, transport or haem protein.
- Therefore the answer is (A).

FINAL: (A) Hydrolysis enzyme

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B — **Redox enzyme**

Why (A) is the key — Carbonic anhydrase (Zn^{2+} enzyme) catalyses the hydration of CO_2 / dehydration of HCO_3^- — a hydrolytic (hydrase/lyase-type) enzyme, not a redox, transport or haem protein.

C — **O_2 transport protein**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D — **Heme protein**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

Q69

The correct option for the metal ion present in the active site of myoglobin, hemocyanin and vitamin B_{12}, respectively, is

A. iron, iron and zinc

B. molybdenum, iron and copper

C. iron, copper and cobalt

D. molybdenum, copper and cobalt

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer C iron, copper and cobalt

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Myoglobin: Fe (heme); hemocyanin: Cu (dicopper); vitamin B_{12}: Co (corrin).
- Therefore the answer is (C).

FINAL: (C) iron, copper and cobalt

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: C

A **iron, iron and zinc**

Why (C) is the key — Myoglobin: Fe (heme); hemocyanin: Cu (dicopper); vitamin B_{12}: Co (corrin).

B **molybdenum, iron and copper**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **molybdenum, copper and cobalt**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q70

Among the following, the biomolecule with a direct metal-carbon bond is

A. coenzyme B_{12}

B. nitrogenase

C. chlorophyll

D. hemoglobin

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A coenzyme B_{12}

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- Coenzyme B_{12} contains a genuine Co–C σ-bond (to 5′-deoxyadenosyl) — the only known natural organometallic cofactor. Nitrogenase has Fe–S/Mo, chlorophyll Mg–N, hemoglobin Fe–N.
- Therefore the answer is (A).

FINAL: (A) coenzyme B_{12}

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **nitrogenase**

Why (A) is the key — Coenzyme B_{12} contains a genuine Co–C σ-bond (to 5′-deoxyadenosyl) — the only known natural organometallic cofactor. Nitrogenase has Fe–S/Mo, chlorophyll Mg–N, hemoglobin Fe–N.

C **chlorophyll**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **hemoglobin**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

Q71

During the binding of O_2 to myoglobin (consider 'heme' in xy-plane), the molecular orbital of O_2 and atomic orbital of Fe involved in the formation of the σ-bond is

A) π^* and d_z²

B) π^* and d_xz

C) π and d_xz

D) π and d_z²

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Bioinorganic Chemistry – General

PYQ FREQUENCY
Very High · 20 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Correct Answer A π^* and d_z²

CONCEPT

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

↓

LOGIC / WORKING

- O_2 binds end-on along z: the σ-bond is formed by donation from the filled O_2 π* orbital into the empty Fe d_z² orbital; the d_xz/d_yz orbitals give π back-bonding.
- Therefore the answer is (A).

FINAL: (A) π^* and d_z²

SHORTCUT / EXAM TRICK

Oxy-Hb is diamagnetic (low-spin Fe(II)/Fe(III)–superoxide); deoxy-Hb is paramagnetic high-spin Fe(II).

COMMON MISTAKE

Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

EXAM TIP

Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A‖ in EPR.

MEMORY TRICK

'Fe carries, Cu transfers, Zn hydrolyses, Mg harvests light'.

Why the Other Options Are Wrong

Correct answer: A

B **π^* and d_{xz}**

Why (A) is the key — O_2 binds end-on along z: the σ-bond is formed by donation from the filled O_2 π* orbital into the empty Fe d_z^2 orbital; the d_xz/d_yz orbitals give π back-bonding.

C **π and d_{xz}**

Ruled out: Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).

D **π and d_z^2**

Ruled out: Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small A∥ in EPR.

TOPIC REVISION

Bioinorganic Chemistry – General

41 PYQs · Last-minute revision

TOPIC SUMMARY

Metal ions in biology: Fe (hemoglobin, myoglobin, cytochromes, Fe–S clusters), Cu (hemocyanin, plastocyanin, cytochrome oxidase), Zn (carbonic anhydrase, carboxypeptidase), Mg (chlorophyll), Co (B_{12}), Mo (nitrogenase, xanthine oxidase), Ni (urease), Mn (PS II); metal toxicity and chelation therapy; cisplatin.

IMPORTANT FORMULA SHEET

- Hb: O_2 binding → Fe^{2+} high-spin (out of plane) to low-spin (in plane)
- Bohr effect: H^+/CO_2 lower O_2 affinity
- Hill coefficient n ≈ 2.8 for Hb (cooperative), 1 for Mb
- Fe–S clusters: [2Fe–2S], [4Fe–4S] (ferredoxins, HiPIP)

FREQUENTLY ASKED CONCEPTS

- Oxidation states and spin of Fe in oxy/deoxy-Hb
- Type 1, 2, 3 copper centres
- Role of distal histidine
- CO poisoning and cytochrome P450
- Chelation agents (EDTA, BAL, desferrioxamine)

COMMON MISTAKES & QUICK NOTES

Watch out:
Assigning Zn a redox role (Zn^{2+} is a Lewis acid, never redox-active); confusing hemocyanin (Cu) with hemerythrin (Fe).
Blue copper proteins: intense LMCT ~600 nm, distorted tetrahedral, small $A_{\parallel}$ in EPR.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q31 Q32 Q33 Q34 Q35 Q36 Q37 Q38 Q39 Q40 Q41 Q42 Q43 Q44 …

Expect 2 question(s) next session on Bioinorganic Chemistry – General.

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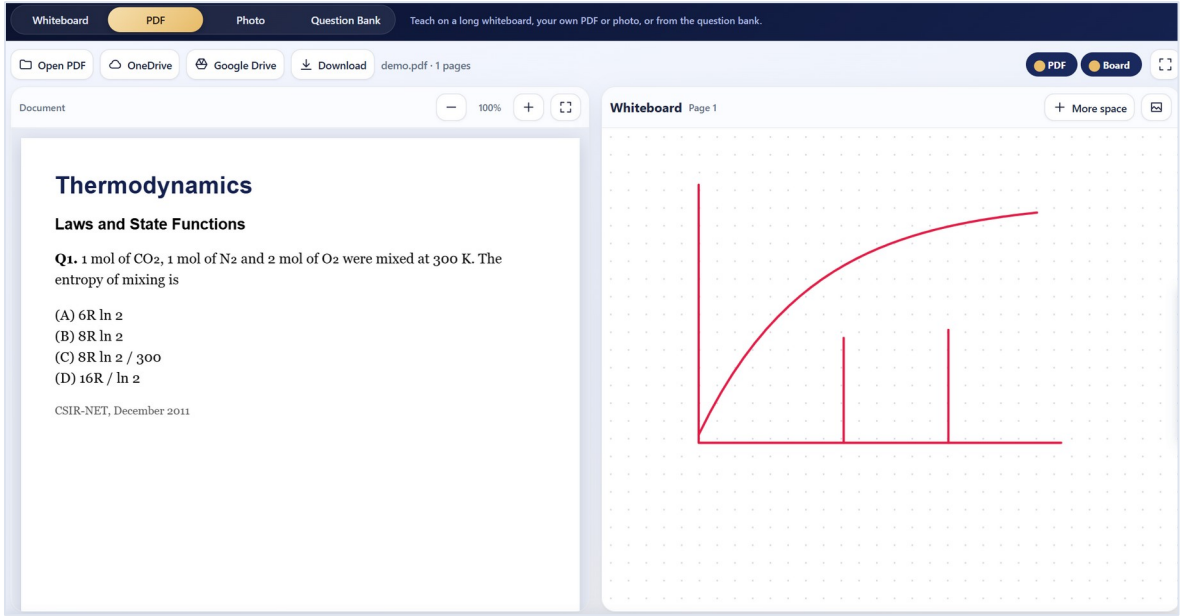
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