General Chemistry, **10e Cdn (Petrucci)**
Chapter 20   Electrochemistry

1) The E_{cell} for the following concentration cell at 25°C is 0.006.
Pt | H_2 (g, 0.025 atm) | H^+ (0.012 M)   ‖ ‖ H^+ (1 M) | H_2 (g, 1 atm) | Pt
$2 H^+(aq) + 2 e^- \rightarrow H_2(g)$ $E° = 0.$ V
Answer: FALSE

Reference: Section 20-4

2) The hydrogen standard electrode is the most convenient standard electrode to use.
Answer: FALSE

Reference: Section 20-4

3) $E°_{cell}$ is the standard cell potential.
Answer: TRUE

Reference: Section 20-2

4) Choose the INCORRECT statement.
A) Electrons are transferred in oxidation-reduction reactions.
B) A strip of metal in a solution of ions of that metal is an electrode potential.
C) Reduction is the gain of electrons.
D) Oxidation is the loss if electrons.
E) A salt bridge maintains electrical contact between two half cells.
Answer: B

Reference: Section 20-1

5) Choose the INCORRECT statement.
A) An electrode is often a strip of metal.
B) An electrode in a solution of its ions is a half cell.
C) An electrochemical cell is a half cell.
D) The electromotive force (emf) is the cell potential.
E) The cell potential is the potential difference between the half cells.
Answer: C

Reference: Section 20-1

6) Choose the INCORRECT statement.

A) A cell diagram is a symbolic way to show cell components.

B) An anode is where oxidation occurs.

C) A cathode is where reduction occurs.

D) Half cells in a cell diagram are separated by a single vertical line.

E) The anode is on the left in a cell diagram.
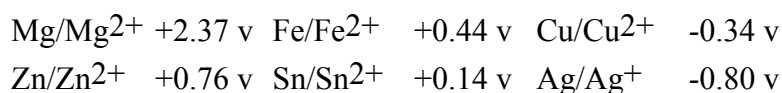
Answer: D

Reference: Section 20-1

7) Choose the INCORRECT statement.

A) A double vertical line separates half cells in a cell diagram.

B) A single vertical line separates phases in a cell diagram.

C) A voltaic cell is a galvanic cell.

D) Voltaic cells produce an electron flow.

E) Electrolytic cells are cells where electron flow is caused by spontaneous reactions.

Answer: E

Reference: Section 20-1

8) Choose the correct statement based on the following oxidation potentials.
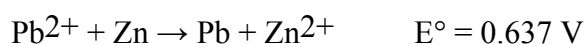
Mg/Mg^{2+} +2.37 v Fe/Fe^{2+} +0.44 v Cu/Cu^{2+} -0.34 v

Zn/Zn^{2+} +0.76 v Sn/Sn^{2+} +0.14 v Ag/Ag^+ -0.80 v

A) Mg will not displace Zn^{2+} from solution

B) Cu will displace Sn^{2+} from solution

C) Fe will displace Zn^{2+} from solution

D) Fe will displace H^+ from solution

E) Sn will displace Fe^{2+} from solution

Answer: D

Reference: Section 20-2

9) In a zinc-lead cell the reaction is:

$Pb^{2+} + Zn \rightarrow Pb + Zn^{2+}$ $E° = 0.637$ V

Which of the following statements about this cell is FALSE?

A) The zinc electrode is the cathode.

B) The reaction will go in the direction indicated.

C) The shorthand notation is Zn | Zn^{2+} ‖ Pb^{2+} | Pb

D) The actual cell voltage is less than +0.637 volts because of concentration polarization and possible other factors.

E) The lead electrode is positively charged.

Answer: A

Reference: Section 20-1


10) Choose the INCORRECT statement.

A) When a half reaction is reversed, the sign of the potential is changed.

B) Reversing a half reaction makes it a reduction potential.

C) Each electrochemical cell consists of a reduction half cell and an oxidation half cell.

D) A voltaic cell is also called a battery.

E) The potential difference of a cell is the voltage of the cell.

Answer: B

Reference: Section 20-2

11) Determine E°$_{cell}$ for the reaction: 2 Al + 3 Zn^{2+} → 2 Al^{3+} + 3 Zn. The half reactions are:

Al^{3+}(aq) + 3 e- → Al(s) $E° = -1.676$ V

Zn^{2+}(aq) + 2 e- → Zn(s) $E° = -0.763$ V
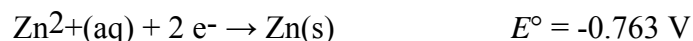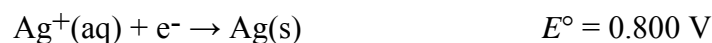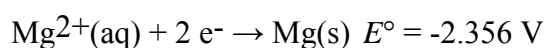
A) 0.913 V

B) -2.439 V

C) 2.439 V

D) -1.063 V

E) -0.913 V

Answer: A

Reference: Section 20-2

12) Determine E°$_{cell}$ for the reaction: 2 Ag$^+$ + Mg → 2 Ag + Mg^{2+}. The half reactions are:

Mg^{2+}(aq) + 2 e- → Mg(s) $E° = -2.356$ V
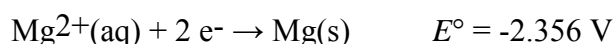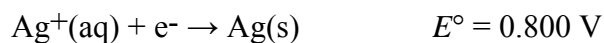
Ag$^+$(aq) + e- → Ag(s) $E° = 0.800$ V

A) 0.756 V

B) -0.756 V

C) 3.156 V

D) -1.556 V

E) 1.556 V

Answer: C

Reference: Section 20-2

13) For the reaction: $Mg(s) + AgNO_3(aq) \rightarrow Ag(s) + Mg(NO_3)_2(aq)$

$$Ag^+(aq) + e^- \rightarrow Ag(s) \qquad E° = 0.800 \text{ V}$$
$$Mg^{2+}(aq) + 2 e^- \rightarrow Mg(s) \qquad E° = -2.356 \text{ V}$$

Is the reaction spontaneous and why?

A) No, Mg(s) does not react with Ag^+.

B) No, $E°$ is a positive value.

C) No, $E°$ is a negative value.

D) Yes, $E°$ is a positive value.

E) Yes, $E°$ is a negative value.

Answer: D

Reference: Section 20-3

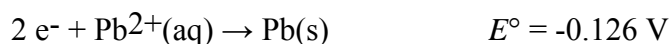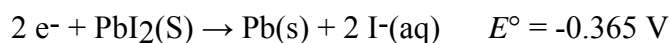14) What is the cell diagram for the spontaneous cell involving the $Fe^{3+} \mid Fe^{2+}$ (0.771V) half cell and the $Zn^{2+} \mid Zn$ (-0.763 V) half cell?

A) $Fe^{2+}(aq) \mid Fe^{3+}(aq) \parallel Zn^{2+}(aq) \mid Zn(s)$

B) $Pt(s) \mid Fe^{2+}(aq), Fe^{3+}(aq) \parallel Zn^{2+}(aq) \mid Zn(s)$

C) $Zn(s) \mid Zn^{2+}(aq) \parallel Fe^{3+}(aq) \mid Fe^{2+}(aq) \mid Pt(s)$

D) $Zn(s) \mid Zn^{2+}(aq) \parallel Fe^{3+}(aq) \mid Fe^{2+}(aq)$

E) $Zn(s) \mid Zn^{2+}(aq) \parallel Fe^{3+}(aq) \mid Fe^{2+}(aq) \mid Zn(s)$

Answer: C

Reference: Section 20-3

15) Calculate the K_{sp} of lead iodide from the following standard electrode potentials, at 25°C:

$$2 e^- + PbI_2(S) \rightarrow Pb(s) + 2 I^-(aq) \qquad E° = -0.365 \text{ V}$$
$$2 e^- + Pb^{2+}(aq) \rightarrow Pb(s) \qquad E° = -0.126 \text{ V}$$

A) 8×10^{-9}

B) 9×10^{-5}

C) 2×10^{-17}

D) 5×10^{-13}

E) 6×10^{-5}

Answer: A

Reference: Section 20-3

16) In the cell $Fe^{2+} \mid Fe^{3+} \parallel Cu^{2+} \mid Cu$ which will increase the cell voltage the most?

A) Halve $[Cu^{2+}]$.

B) Halve $[Fe^{2+}]$.

C) Double $[Cu^{2+}]$.

D) Double $[Fe^{2+}]$.

E) Cut Cu electrode in half.

Answer: D

Reference: Section 20-4

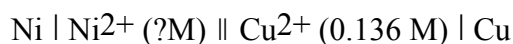17) Which of the following are commonly used as alternate standard electrodes:

I) $Ag(s) \mid AgCl(s) \mid Cl^- (1.0\ M)$

II) $Hg(l) \mid HgCl_2(s) \mid Cl^- (1.0\ M)$

III) $Ag(s) \mid AgCl(s) \mid Cl^- (0.1\ M)$

IV) $Hg(l) \mid Hg_2Cl_2(s) \mid Cl^- (1.0\ M)$

V) $Hg(s) \mid Hg_2Cl_2(s) \mid Cl^- (1.0\ M)$

A) I) and V)

B) II) and IV)

C) I) and IV)

D) II) and III)

E) I) and III)

Answer: C

Reference: Section 20-4

18) Consider the cell:

    $Ni \mid Ni^{2+} (?M) \parallel Cu^{2+} (0.136\ M) \mid Cu$

    Ni^{2+}/Ni $E° = -0.257\ V$

    Cu^{2+}/Cu $E° = 0.340\ V$

The measured potential of the cell is 0.621 V. What is $[Ni^{2+}]$ at 25°C?
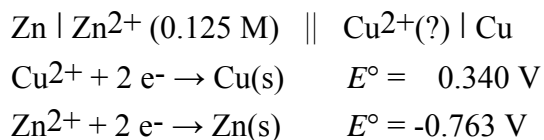
A) $2 \times 10^{-2}\ M$

B) 1 M

C) $4 \times 10^{-42}\ M$

D) 0.05 M

E) 0.4 M

Answer: A

Reference: Section 20-4

19) What is the concentration of Cu^{2+} in the following cell at 25°C if the cell voltage is 1.253 V?

$\qquad$ Zn | Zn^{2+} (0.125 M) ‖ Cu^{2+}(?) | Cu

$\qquad$ $Cu^{2+} + 2\ e^- \rightarrow Cu(s)$ $\qquad$ $E° =$ 0.340 V

$\qquad$ $Zn^{2+} + 2\ e^- \rightarrow Zn(s)$ $\qquad$ $E° = -0.763$ V

A) 0.6 M

B) 1×10^{-2} M

C) 1×10^{-6} M

D) 9×10^{-4} M

E) 4×10^{-4} M

Answer: C

Reference: Section 20-4

20) Choose the INCORRECT statement.

A) Corrosion of metals is an oxidation-reduction process.

B) Rust is a form of corrosion.

C) Metals can be protected by cathodic protection.

D) Cathodic protection is attaching a more active metal to the protected metal.

E) The active metal is called a sacrificial cathode.

Answer: E (The active metal is called sacrificial **anode**.)

Reference: Section 20-6

21) How many coulombs would be needed to deposit all of the Ag^+ ion from 600 mL of a solution 0.250 M in Ag^+?

A) 1.45×10^7 C
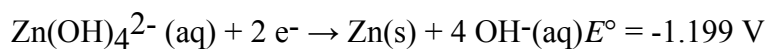
B) 1.56×10^6 C

C) 1.45×10^4 C

D) 2.41×10^4 C

E) 1.56×10^4 C

Answer: C

22) The following half-reactions are used in the zinc-air battery.

$$Zn(OH)_4{}^{2-} (aq) + 2\ e^- \rightarrow Zn(s) + 4\ OH^-(aq) \quad E° = -1.199\ V$$

$$O_2(g) + 2\ H_2O(l) + 4\ e^- \rightarrow 4\ OH^-(aq) \qquad E° = +0.401\ V$$

How much charge is transferred per gram Zn(s) in this voltaic cell?

A) 5.90×10^3 C
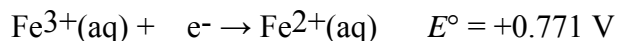
B) 2.95×10^3 C

C) 1.47×10^3 C

D) 3.39×10^{-4} C

E) 1.69×10^{-4} C

Answer: B

23) Determine $E°_{cell}$ for the reaction: $MnO_4{}^- + 8\ H^+ + 5\ Fe^{2+} \rightarrow Mn^{2+} + 4\ H_2O + 5\ Fe^{3+}$. The half reactions are:

$$Fe^{3+}(aq) + \quad e^- \rightarrow Fe^{2+}(aq) \qquad E° = +0.771\ V$$
$$MnO_4{}^-(aq) + 8\ H^+(aq) + 5\ e^- \rightarrow Mn^{2+}(aq) + 4\ H_2O(l) \quad E° = 1.507\ V$$

A) -2.34 V

B) -2.28 V

C) 2.28 V

D) -0.74 V

E) 0.74 V

Answer: E

24) Will magnesium metal displace Al^{3+} ion from an aqueous solution?
$$Mg^{2+}(aq) + 2\ e^- \rightarrow Mg(s) \quad E° = -2.356\ V$$
$$Al^{3+}(aq) + 3\ e^- \rightarrow Al(s) \quad E° = -1.676\ V$$
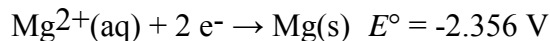
A) No, since $E°_{cell}$ is negative.

B) Yes, since $E°_{cell}$ is negative.

C) No, the reverse reaction is spontaneous.

D) Yes, since $E°_{cell}$ is positive.

E) No, the system is at equilibrium.

Answer: D

25) The standard Gibbs energy change for the following voltaic cell is $\Delta G° = -89.3$ kJ at 25°C.

What is $E°_{cell}$? $Cu(s) \mid Cu^{2+}(aq) \parallel Ag^+(aq) \mid Ag(s)$

A) +0.463 V
B) -0.926 V
C) -0.463 V
D) +0.926 V
E) +0.231 V
Answer: A

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76. Suppose that a fully charged lead-acid battery contains 1.50L of 5.00 M H_2SO_4. What will be the concentration of H_2SO_4 in the battery after 2.50A of current is drawn from the battery for 6 h?

Ans: $Pb_{(s)}+ PbO_{2(s)}+2\ H^+_{(aq)}+2\ HSO_4^-_{(aq)}\rightarrow PbSO_{4(s)}+2\ H_2O_{(l)}$ (The cell reaction during discharge 放電狀態下)

  Initial amount of H_2SO_4= 1.50L $\times$ $\dfrac{5.00\ \text{mole } H_2SO_4}{1\ \text{L solution}}$= 7.50 mole H_2SO_4

  H_2SO_4 consumed=6.0 h$\times \dfrac{3600s}{1\ h} \times \dfrac{2.50\ C}{1\ s} \times \dfrac{1\text{mole } e^-}{96485\ C} \times \dfrac{2\ \text{mole } SO_4^-}{2\ \text{mole } e^-} \times \dfrac{1\ \text{mole} H_2SO_4}{1\ \text{mole } SO_4^-}$

= 0.56 mole H_2SO_4

Final H_2SO_4 concentration= $\dfrac{7.50\ \text{mole}-0.56\ \text{mole}}{1.50\ L}$ = 4.63 M

Chapter 23   The Transition Elements

1) The lanthanide contraction is due to the poor shielding effect of the f-electrons and the higher nuclear charge.
Answer: TRUE

2) The high melting points of transition elements result from a lack of sufficient electrons and orbitals for good metallic bonding.
Answer: FALSE
Diff: 1   Type: TF

3) Titanium tetrachloride has replaced white lead as the pigment in white paints.
Answer: FALSE   (**Titanium dioxide** has replaced white lead as the pigment in white paints.)

4) Galvanized steel is iron coated with cadmium   to prevent rust.
Answer: FALSE

5) Which of the following is **uncharacteristic** for the elements of the first transition series? (Which of the following statements is not true?)
A) an inner core of electrons in the argon configuration
B) two 4s electrons for eight elements, and one 4s electron for Cr and Cu
C) a number of 3d electrons ranging from one for Sc to ten for Cu and Zn
D) except for Sc and Ti, only minor variation in atomic radii
E) only one possible oxidation state per element, different for each
Answer: E

6) Choose the INCORRECT statement about the transition elements.
A) The atomic radii increases to the right across the periodic table.
B) The first ionization energy is about the same as the Group 2 (IIA) elements.
C) The lanthanide contraction is responsible for the second and third series of transition elements being very similar in atomic radii.
D) The lanthanide contraction is due to the f electrons not screening as well as other electrons.
E) The electron configuration of cobalt and copper are anomalous.
Answer: A

Reference: Section 23-1

7) Choose the INCORRECT statement about the transition elements.
A) They have high melting points.
B) They are good electrical conductors.
C) They have moderate to extreme hardness.
D) They are *d*-block and *f*-block elements.
E) They generally have positive reduction potentials.
Answer: E

Reference: Section 23-1

8) Choose the INCORRECT statement about the most common oxidation state of transition elements.
A) For Ti, it is +4.
B) For Sc, it is +2.
C) For V, it is +5.
D) For Cr, it is +6.
E) For Mn, it is +7.
Answer: B

Reference: Section 23-1

9) Choose the INCORRECT statement about transition elements.
A) Coordination compounds are formed by coordinate covalent bonds.
B) The metal ions provide empty *d* orbitals in coordination compounds.
C) The ligand supplies one or more pairs of electrons that form coordinate bonds in coordination compounds.
D) Colored compounds and solutions occur because of electronic transitions that occur within partially filled *d* orbitals.
E) Paramagnetism is due to paired electrons.
Answer: E

Reference: Section 23-1

10) Choose the INCORRECT statement about transition elements.
A) Ferromagnetism occurs only in elements with paired electrons.

B) Ferromagnetism is unique to Fe, Co and Ni.

C) Ferromagnetism occurs due to atoms combining in the solid state in domains.

D) Paramagnetism is due to unpaired electrons.

E) Ferromagnetism requires that interatomic distances be of the right magnitude to generate domains.

Answer: A

Reference: Section 23-1

11) Which of the following metals form compounds with the highest oxidation states?

A) V

B) Ti

C) Mn

D) Y

E) Sc

Answer: C

Diff: 1   Type: MC

Reference: Section 23-1

12) A property that is common to both main group and transition metals is that both types:

A) have high electronegativities

B) include a very active metal

C) are found in many oxidation states

D) exhibit color in compounds

E) exhibit at least one oxidation state equal to their periodic group number

Answer: E

Reference: Section 23-1

13) Transition group elements differ from main group metals in several ways. Which differences   of the following are correct?

A) many of the metals and their compounds having catalytic activity

B) many of the hydrated cations having distinctive colors

C) most of their compounds having bonds that involve d orbitals

D) many of the metals being paramagnetic, but none ferromagnetic

E) most having more than one common oxidation state

Answer: D

14) Which of the following transition elements is unreactive towards aqueous hydrochloric acid?
A) zinc
B) titanium
C) scandium
D) iron
E) copper
Answer: E

15) Choose the INCORRECT statement.
A) Hydrometallurgy handles materials as aqueous solutions.
B) The three steps of hydrometallurgy are leaching, purification and/or concentration and precipitation.
C) Leaching is adding chemicals to eat away the ore, leaving the metal.
D) Purification in hydrometallurgy is to remove impurities and concentrate solutions.
E) Purification in hydrometallurgy may include evaporation of water, ion exchange, and/or use of activated charcoal.
Answer: C

Chapter 24 Complex Ions and Coordination Compounds

1) A complex is any species involving coordination of ligands to a metal center.
Answer: TRUE

2) Enantiomers are isomers which are not chiral.
Answer: FALSE

3) Some wavelengths of light are the correct energy to be used to promote electrons to higher energy levels and are thus lost from white light.   The loss of these wavelengths causes solutions of transition elements to be colored.

Answer: TRUE

Reference: Section 24-7

4) Sequestering is using a chelating agents to reduce a free cation concentration to the point that the cation will not react to form objectionable products.

Answer: TRUE

Reference: Section 24-11

5) Which combination of central species and net charge is FALSE for complex ions or coordination compounds?

A) neutral metal atom, positive net charge

B) neutral metal atom, zero net charge

C) metal cation, zero net charge

D) metal cation, positive net charge

E) metal cation, negative net charge

Answer: A

Reference: Section 24-1

6) Which of the following metal ions can have coordination numbers of either 4 or 6?

A) Ag^+

B) Ca^{2+}

C) Cu^+

D) Ni^{2+}

E) Au^+

Answer: D

Reference: Section 24-1

7) The $[Fe(CN)_6]^{3-}$ complex ion:

A) exhibits square planar geometry

B) is diamagnetic

C) exhibits octahedral geometry

D) has two unpaired electrons

E) has four unpaired electrons

Answer: C

Reference: Section 24-1

8) Choose the INCORRECT statement.

A) A ligand that bonds to the metal ion with more than one atom is unidentate.

B) A chelate is produced by a ligand bonding to the metal ion with two or more donor atoms.

C) In coordination nomenclature, the cations are named before the anions.

D) In coordination nomenclature, the names of the ligands are followed by the name of the central metal ion.

E) Anionic ligands end in -*o* in coordination nomenclature.

Answer: A

Reference: Section 24-2

9) Choose the INCORRECT formula/name combination for ligands.

A) H_2O aqua

B) NH_3 ammine

C) CO   carbonyl

D) NO   nitrito-N-

E) CH_3NH_2 methylamine

Answer: D

Reference: Section 24-2

10) It is known that the sulfhydryl group, ^-SH, forms strong coordinate bonds to certain heavy metal ions. Which of the following do you expect to be the best chelating agent for heavy metal ions?

A) $HS-CH_2-CH(SH)-CH_2-OH$

B) H-SH

C) CH_3-SH

D) $CH_3-S-S-CH_3$

E) SO_4^{2-}

Answer: A

Reference: Section 24-2

11) Which one of the following could be a chelating ligand?
A) NH_3
B) CH_3-CH_2-NH_2
C) NH_2-CH_2-CH_2-NH_2
D) any metal ion
E) CN^-
Answer: C

Reference: Section 24-2

12) Coordination isomerism could be shown by _____.
A) $Li[AlH_4]$
B) $[Ag(NH_3)_2][CuCl_2]$
C) $[Co(NH_3)_4Cl_2]Br$
D) $[Pt(H_2O)_4Cl_2]$
E) $[Fe(CN)_6](NH_3)_3$
Answer: B

Reference: Section 24-3

13) The compound $PtCl_2(en)_2$ [$en = H_2NCH_2NH_2$] is octahedral; therefore we know that:
A) *en* must be a monodentate ligand
B) two moles of Cl^- per mole of $PtCl_2(en)_2$ can be precipitated rapidly by the addition of Ag^+
C) the molecule is nonpolar
D) the compound can have cis and trans isomers
E) Pt always has a coordination of 4
Answer: D

Reference: Section 24-4

14) Choose the correct statement about isomers of $[Pt(H_2O)_2(NH_3)Cl]Br$.

```
I   H2O     NH3        II   H2O       NH3
     \   /                   \     /
      Pd                       Pd
     /   \                   /     \
   Cl      OH2            H2O        Cl
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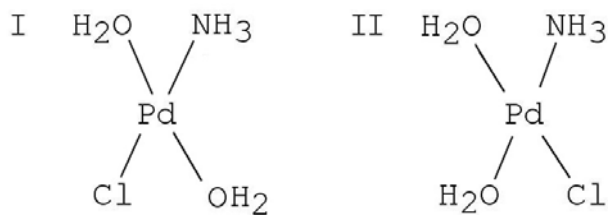
A) I is cis, II is trans.

B) The two molecules are the same.

C) The two molecules are the same but one is turned over.

D) They are not isomers.

E) I is trans, II is cis.

Answer: E

Reference: Section 24-4

15) When $[Ni(NH_3)_4]^{2+}$ is treated with concentrated HCl, two compounds having the same formula, $Ni(NH_3)_4Cl_2$, designated I and II, are formed. Compound I can be converted to compound II by boiling it in dilute HCl. A solution of I reacts with oxalic acid, $H_2C_2O_4$, to form $Ni(NH_3)_4(C_2O_4)$. Compound II does not react with oxalic acid. Compound II is:

A) the cis isomer

B) tetrahedral in shape

C) the trans isomer

D) the same as compound I

E) octahedral in shape

Answer: C

Reference: Section 24-4

16) Which of the following ligands exerts the strongest field?

A) I⁻

B) H_2O

C) ONO⁻

D) NH_3

E) Br⁻

Answer: D

Reference: Section 24-5

17) Which complex ion possesses the largest number of unpaired electrons?

A) $CoCl_4^{2-}$
B) $Cr(NH_3)_6^{2+}$
C) $Cu(NH_3)_4^{2+}$
D) $Mn(CN)_6^{4-}$
E) $Fe(H_2O)_6^{3+}$
Answer: E

Reference: Section 24-6