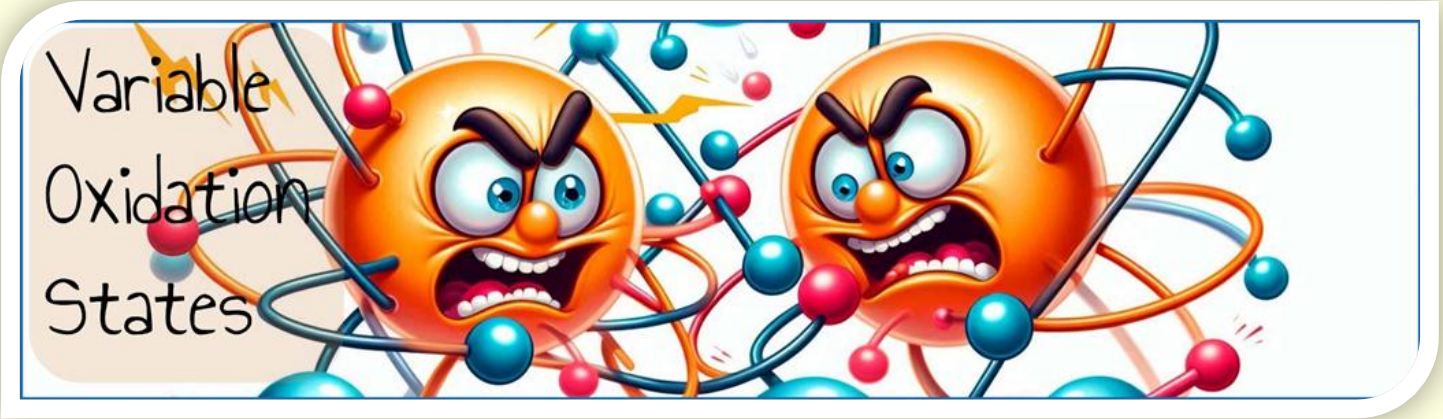

Answer all the questions below as fully as you can then check your answers

1. Define the term "oxidation state" and explain why transition metals exhibit variable oxidation states.

2. Which of the following describes the colour of V^{3+} in aqueous solution?

a) Yellow b) Green c) Blue d) Violet

3. What is the oxidation state of vanadium in VO_2^+?

a) +2 b) +3 c) +4 d) +5

4. Complete the table below to show the oxidation states and colours of all the stable vanadium species in an acidic solution, including vanadate, dioxovanadium, oxovanadium, vanadium (III) and vanadium (II) ions. Include the formula for the complexes anions present.

Oxidation state	Ion	complex	colour

5. Describe the role of powdered zinc in acid when reducing vanadium species and the associated colour changes, write equations to show these reduction reactions.

6. Explain why adding acid to vanadate to form dioxovanadium ions is not a redox reaction.

7. Which species is formed when Cr^{2+} is oxidized by air?
   a) CrO_4^{2-} b) Cr^{3+} c) $Cr_2O_7^{2-}$ d) Cr^{6+}

8. Fill in the blanks for the chromate-dichromate equilibrium:

   In acidic conditions the chromate ion, CrO_4^{2-} is converted into the dichromate ion; $Cr_2O_7^{2-}$ by the addition of _____, resulting in a colour change from _____ to _____.

9. When Cr^{3+} is reduced using zinc in acid, _____ ions are formed, which are _____ in colour.

Answers

1. Define the term "oxidation state" and explain why transition metals exhibit variable oxidation states.

Answer:

The oxidation state is the charge an atom would have if all bonds were completely ionic. Transition metals exhibit variable oxidation states because of the similar energies of their 3d and 4s orbitals, allowing electrons from both to participate in bonding.

2. Which of the following describes the colour of V^{3+} in aqueous solution?

a) Yellow b) Green c) Blue d) Violet

Answer: b) Green

3. What is the oxidation state of vanadium in VO_2^+?

a) +2 b) +3 c) +4 d) +5

Answer: d) +5

4. Complete the table below to show the oxidation states and colours of all the stable vanadium species in an acidic solution, including vanadate, dioxovanadium, oxovanadium, vanadium (III) and vanadium (II) ions. Include the formula for the complexes anions present.

Answer:

Oxidation state	Ion	complex	colour
V(V)	$VO_2^{+}{}_{(aq)}$ Dioxovanadium	$[VO_2(H_2O)_4]^+$	Yellow
V(IV)	$VO^{2+}{}_{(aq)}$ oxovanadium	$[VO(H_2O)_5]^{2+}$	Blue
V(III)	V^{3+}	$[V(H2O)_4Cl_2]^+$	Green
V(II)	V^{2+}	$[V(H_2O)_6]^{2+}$	violet

5. Describe the role of powdered zinc in acid when reducing vanadium species and the associated colour changes, write equations to show these reduction reactions.

   Answer:

   Powdered zinc acts as a reducing agent, sequentially reducing vanadium through its oxidation states:

1. VO_2 (yellow) to VO_2^+ (blue):

   $VO_2^+ + 2H^+ + e \rightarrow VO^{2+} + H_2O$
2. VO^{2+} (blue) to V^{3+} (green):

   $VO^{2+} + 2H^+ + e \rightarrow V^{3+}$
3. V^{3+} (green) to V^{2+} (violet):

   $V^{3+} + e \rightarrow V^{2+}$

6. Explain why adding acid to vanadate to form dioxovanadium ions is not a redox reaction.

   Answer:

   This is not a redox reaction because there is no change in the oxidation state of vanadium. The reaction involves protonation:

   $VO^{3-} + 2H^+ \rightarrow VO_2^+ + H_2O$

7. Which species is formed when Cr2+Cr2+ is oxidized by air?

   a) CrO_4^{2-} b) Cr^{3+} c) $Cr_2O_7^{2-}$ d) Cr^{6+}

Answer: b) Cr^{3+}

8. Fill in the blanks for the chromate-dichromate equilibrium:

   In acidic conditions the chromate ion, CrO_4^{2-} is converted into the dichromate ion; $Cr_2O_7^{2-}$ by the addition of _____, resulting in a colour change from _____ to _____.

Answer:

In acidic conditions the chromate ion, CrO_4^{2-} is converted into the dichromate io ; $Cr_2O_7^{2-}$ by the addition of acid, resulting in a colour change from yellow to orange.

9. When Cr^{3+} is reduced using zinc in acid, _____ ions are formed, which are _____ in colour.

Answer:

When Cr^{3+} is reduced using zinc in acid, Cr^{2+} ions are formed, which are blue in colour.