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

True/False Questions

1. Transition metals can have multiple oxidation states due to the availability of both 4s and 3d electrons for bonding.

2. The only stable oxidation state of manganese is +2.

3. High oxidation states of transition metals are often found when bonded to electronegative elements like oxygen or fluorine.

4. The ion Cr^{2+} is blue and is a strong oxidising agent.

5. Which of the following is the correct oxidation state of vanadium in VO^{2+}?

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

6. What is the main species present in a basic solution containing chromium ions?

a) $Cr_2O_7^{2-}$ b) CrO_4^{2-}

c) Cr^{3+} d) Cr^{2+}

7. Which transition metal forms a violet ion with the formula $[V(H_2O)_6]^{2+}$?

a) Vanadium b) Chromium c) Iron d) Nickel

8. Why do transition metals exhibit variable oxidation states?

9. Write the electron configuration of a V^{3+} ion.

10. Explain why chromium metal in the +6 oxidation state (Cr^{6+}) is found in compounds like chromate and dichromate ions.

11. Describe the colour changes observed during the reduction of VO_2^+ ions with zinc in acid. Include equations for each step.

12. Compare the oxidation states of chromium and their associated colours, explaining the equilibria between CrO_4^{2-} and $Cr_2O_7^{2-}$.

13. Calculate the oxidation number of chromium in potassium dichromate ($K_2Cr_2O_7^{2-}$)

b. A solution of Fe^{2+} is oxidised to Fe^{3+}. Write the half-equation for this reaction and state whether Fe^{2+} acts as a reducing or oxidising agent.

Answers

1. Transition metals can have multiple oxidation states due to the availability of both 4s and 3d electrons for bonding.

Answer: True

2. The only stable oxidation state of manganese is +2.

Answer: False

3. High oxidation states of transition metals are often found when bonded to electronegative elements like oxygen or fluorine.

Answer: True

4. The ion Cr^{2+} is blue and is a strong oxidising agent.

Answer: False (it is a reducing agent)

5. Which of the following is the correct oxidation state of vanadium in VO^{2+}?

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

Answer: d) +5

6. What is the main species present in a basic solution containing chromium ions?

a) $Cr_2O_7^{2-}$

b) CrO_4^{2-}

c) Cr^{3+}

d) Cr^{2+}

Answer: b) CrO_4^{2-}

7. Which transition metal forms a violet ion with the formula $[V(H_2O)_6]^{2+}$?

a) Vanadium b) Chromium c) Iron d) Nickel

Answer: a) Vanadium

8. Why do transition metals exhibit variable oxidation states?

Answer: Transition metals exhibit variable oxidation states because the 4s and 3d electrons have similar energy levels and can be lost during bonding.

9. Write the electron configuration of a V^{3+} ion.

Answer: [Ar] $3d^2$

10. Explain why chromium metal in the +6 oxidation state (Cr^{6+}) is found in compounds like chromate and dichromate ions.

Answer: Cr^{6+} ion is stabilised in chromate ($CrO4^{2-}$) and dichromate ($Cr_2O_7^{2-}$) ions due to bonding with the highly electronegative oxygen atoms.

11. Describe the colour changes observed during the reduction of VO_2^+ ions with zinc in acid. Include equations for each step.

Answer:

The yellow VO_2^+ (oxidation state +5) is reduced to blue VO^{2+}

$$VO_{2(aq)}^{+} + 2H^{+} + e \rightleftharpoons VO^{2+}_{(aq)} + H_2O_{(aq)}$$

Further reduction produces green V^{3+}

$$VO^{2+} + 2H^{+} + e \rightleftharpoons V^{3+}_{(aq)} + H_2O_{(l)}$$

Finally, violet V^{2+} is formed:

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

12. Compare the oxidation states of chromium and their associated colours, explaining the equilibria between CrO_4^{2-} and $Cr_2O_7^{2-}$.

Answer:

Chromium has oxidation states of +2 (blue), +3 (green/violet), and +6 (yellow CrO_4^{2-} and orange $Cr_2O_7^{2-}$.The equilibrium between chromate and dichromate ions depends on pH:

$$2CrO_4^{2-} + 2H^{+} \rightleftharpoons Cr_2O_7^{2-} + H_2O$$

In acidic conditions, the solution turns orange due to the presence of the dichromate ion ($Cr_2O_7^{2-}$) in basic conditions, it remains yellow due to the presence of the chromate ion ($Cr_2O_7^{2-}$)

13. Calculate the oxidation number of chromium in potassium dichromate ($K_2Cr_2O_7^{2-}$)

Answer:

Cr = +6.

b. A solution of Fe^{2+} is oxidised to Fe^{3+}. Write the half-equation for this reaction and state whether Fe^{2+} acts as a reducing or oxidising agent.

Answer:

$$Fe^{2+} \rightarrow Fe^{3+} + e-$$

Fe^{2+} acts as a reducing agent.