The Mineral Chameleon: Potassium Permanganate

Potassium permanganate is made by fusing pyrolusite (MnO_2) with KOH and an oxidiser to give dark green potassium manganate (Mn +6). In neutral or acidic water manganate disproportionates ($3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$), the 'mineral chameleon' Glauber saw; commercially it is oxidised at an anode. In acid MnO_4^- takes 5 electrons to give almost colourless Mn^{2+} (so it is its own indicator in titrations); in neutral or faintly alkaline solution it takes 3 electrons and gives brown MnO_2.

Name: Date: Score: ____ / 24

A. Fill in the blanks

1. $KMnO_4$ is prepared from the manganese ore called ____.

2. Fusion of MnO_2 with KOH and an oxidiser gives dark ____ potassium manganate.

3. In acid, one permanganate ion accepts ____ electrons.

4. In neutral medium, permanganate is reduced to brown ____.

5. A reaction in which the same element is both oxidised and reduced is called ____.

B. True or False

6. Potassium manganate is paramagnetic. True / False

7. $KMnO_4$ needs an external indicator in redox titrations. True / False

8. In acid, MnO_4^- is reduced to Mn^{2+}. True / False

9. Commercially, manganate is converted to permanganate by electrolytic oxidation. True / False

10. The oxidation state of Mn in $KMnO_4$ is +6. True / False

C. Assertion and reason

11. Assertion (A): $KMnO_4$ is a self-indicator.
Reason (R): Purple MnO_4^- becomes almost colourless Mn^{2+}, so the first excess drop shows pink.

(a) Both A and R are true, and R explains A
(b) Both A and R are true, but R does not explain A
(c) A is true, R is false
(d) A is false, R is true

Answer: _____

12. Assertion (A): Permanganate gives MnO_2 in neutral solution but Mn^{2+} in acid.
Reason (R): The number of electrons it accepts depends on the medium (3 vs 5).

(a) Both A and R are true, and R explains A
(b) Both A and R are true, but R does not explain A
(c) A is true, R is false
(d) A is false, R is true

Answer: _____

D. Choose the correct option

13. The colour of the permanganate ion is:

(a) green
(b) purple
(c) brown
(d) colourless

Answer: _____

14. In $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$, Mn changes:

(a) +6 to +7 and +4 (b) +7 to +2

(c) +4 to +6 (d) +6 to +2

Answer: _____

15. In neutral medium, MnO_4^- accepts:

(a) $1e^-$ (b) $3e^-$

(c) $5e^-$ (d) $7e^-$

Answer: _____

16. The end point in a $KMnO_4$–Fe^{2+} titration is:

(a) colourless (b) pale pink

(c) green (d) brown

Answer: _____

17. Which is diamagnetic?

(a) MnO_4^{2-} (b) MnO_4^-

(c) Mn^{3+} (d) Mn^{2+}

Answer: _____

18. In acid, $KMnO_4$ oxidises oxalate to:

(a) CO (b) CO_2

(c) HCOOH (d) CH_4

Answer: _____

E. Numerical problems

19. How many moles of Fe^{2+} are oxidised by 0.04 mol MnO_4^- in acid?

20. How many moles of I_2 are formed when 2 mol MnO_4^- react with excess I^- in acid?

F. Short answer questions

21. Describe the preparation of $KMnO_4$ from pyrolusite with equations.

22. Write the half-reactions of permanganate in acidic and neutral media.

23. Give the ionic equations for acidified $KMnO_4$ with Fe^{2+} and with iodide.

G. Match the columns

24. Match each item in Column A with the correct item in Column B.

Column A	Column B	Your answer
1. MnO_4^{2-}	(a) purple, Mn +7, diamagnetic	1 → ____
2. MnO_4^{-}	(b) green, Mn +6, paramagnetic	2 → ____

Detailed solutions

1. pyrolusite

2. green

3. five

4. MnO_2

5. disproportionation

6. True. Mn(VI) is $3d^1$.

7. False. It is a self-indicator.

8. True. $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$.

9. True. $MnO_4^{2-} \rightarrow MnO_4^- + e^-$.

10. False. It is +7.

11. (a) No separate indicator.

12. (a) The medium decides the product.

13. (b) purple. MnO_4^-.

14. (a) +6 to +7 and +4. Disproportionation.

15. (b) $3e^-$. $\rightarrow MnO_2$.

16. (b) pale pink. First excess MnO_4^-.

17. (b) MnO_4^-. d^0.

18. (b) CO_2. At about 333 K.

19. ratio 1 : 5. **Answer: 0.20 mol**

20. $2 \times 5e^- = 10e^-$; $2I^- \rightarrow I_2 + 2e^-$. **Answer: 5 mol**

21. $2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$ (green manganate); then $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$, or commercially electrolytic oxidation $MnO_4^{2-} \rightarrow MnO_4^- + e^-$.

22. Acid: $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ ($E^\circ = 1.52$ V). Neutral / faintly alkaline: $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$ ($E^\circ = 0.59$ V).

23. $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$; $10I^- + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 8H_2O + 5I_2$.

24. 1 → (b), 2 → (a).