One Element, Six Oxidation States: Why Transition Metals Vary

The ns and (n−1)d electrons of a transition metal are close in energy, so both can take part in bonding. Manganese ($3d^5\ 4s^2$) shows every state from +2 to +7; the most states occur in the middle of the series, Sc shows only +3 and Zn only +2, and the states change in steps of one.

Name: Date: Score: ____ / 15

A. Fill in the blanks

1. Transition metals show variable oxidation states because the ns and (n−1)____ electrons are close in energy.

2. Manganese shows oxidation states from +2 to +____.

3. The oxidation state of Mn in $KMnO_4$ is +____.

4. Zinc shows only the +____ oxidation state.

B. True or False

5. The most oxidation states occur in the middle of the 3d series. True / False

6. Scandium shows +2 to +7. True / False

7. Oxidation states of transition elements usually differ by one. True / False

C. Assertion and reason

8. Assertion (A): Manganese shows oxidation states from +2 to +7.
Reason (R): Both its 4s and 3d electrons can take part in bonding.

(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: _____

9. Assertion (A): Zinc shows only +2.
Reason (R): Zinc has the largest atomic radius in the 3d series.

(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

10. Oxidation state of Mn in MnO_2:

(a) +2
(b) +3
(c) +4
(d) +7

Answer: _____

11. Highest oxidation state of vanadium ($3d^3\ 4s^2$):

(a) +3
(b) +4
(c) +5
(d) +6

Answer: _____

12. Most oxidation states in the 3d series:

(a) Sc (b) Mn

(c) Cu (d) Zn

Answer: _____

E. Numerical problems

13. What is the oxidation state of Cr in $K_2Cr_2O_7$?

F. Short answer questions

14. Why does the number of oxidation states rise to a maximum at Mn and then fall?

G. Match the columns

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

Column A	Column B	Your answer
1. Sc	(a) only +2	1 → ____
2. Mn	(b) only +3	2 → ____
3. Zn	(c) +2 to +7	3 → ____
4. Fe	(d) +2 and +3 (differ by one)	4 → ____

Detailed solutions

1. d

2. 7

3. 7

4. 2

5. True. Manganese, +2 to +7.

6. False. Scandium shows only +3.

7. True. For example Fe^{2+} and Fe^{3+}.

8. (a) R explains A.

9. (c) A true; R false: Sc is the largest; zinc's full $3d^{10}$ is not used.

10. (c) +4. $x + 2(-2) = 0$.

11. (c) +5. Five electrons.

12. (b) Mn. +2 to +7.

13. $2(+1) + 2x + 7(-2) = 0$. **Answer: 6**

14. Up to Mn more electrons (4s + 3d) are available; after Mn the d electrons pair up and fewer are used, and Zn's full d^{10} leaves only +2.

15. 1 → (b), 2 → (c), 3 → (a), 4 → (d). Each element matches its oxidation states.