Five More Protons, Same Size: Radius and Ionisation Enthalpy across the 3d Series

Across the 3d series each new electron enters the inner (n−1)d subshell and shields the outer 4s electrons, nearly cancelling the extra nuclear charge. So atomic radii change only slightly and the first ionisation enthalpy rises slowly (631 → 906 kJ/mol), unlike across a normal period.

Name: Date: Score: ____ / 15

A. Fill in the blanks

1. Across the 3d series the added electron enters the inner ____ subshell.

2. Inner d electrons ____ the outer 4s electrons from the added nuclear charge.

3. The highest first ionisation enthalpy in the 3d series is shown by ____.

4. Zr and Hf have nearly equal radii because of ____ contraction.

B. True or False

5. Atomic radii change sharply across the 3d series. True / False

6. The first IE of Zn is higher than that of Sc. True / False

7. Across period 3 the first IE roughly triples. True / False

C. Assertion and reason

8. Assertion (A): Radii change only slightly across a transition series.
Reason (R): The added electrons enter the inner (n−1)d subshell and shield the outer electrons.

(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 has a high first ionisation enthalpy.
Reason (R): Zinc is a liquid at room temperature.

(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. Across the 3d series, radii:

(a) increase sharply
(b) decrease sharply
(c) change only slightly
(d) double

Answer: _____

11. The 3d metal with the highest first IE:

(a) Sc
(b) Cr
(c) Cu
(d) Zn

Answer: _____

12. Metallic radius of Cr:

(a) 186 pm (b) 164 pm

(c) 129 pm (d) 99 pm

Answer: _____

E. Numerical problems

13. By how many kJ/mol does the first IE rise from Sc (631) to Zn (906)?

F. Short answer questions

14. Why does the first IE rise much more across period 3 than across the 3d series?

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) 164 pm, 631 kJ/mol	1 → ____
2. Cr	(b) almost equal radii	2 → ____
3. Zn	(c) highest 1st IE (906)	3 → ____
4. Zr and Hf	(d) 129 pm	4 → ____

Detailed solutions

1. 3d

2. shield

3. zinc

4. lanthanoid

5. False. The change is small.

6. True. 906 vs 631 kJ/mol.

7. True. Na 496 → Ar 1520 kJ/mol.

8. (a) R explains A.

9. (c) A true; R false: mercury is the liquid; zinc's IE is high because $3d^{10}\ 4s^2$ is stable.

10. (c) change only slightly. Shielding nearly balances the extra charge.

11. (d) Zn. Stable $3d^{10}\ 4s^2$.

12. (c) 129 pm. Cr 129, Cu 128 pm.

13. 906 − 631. **Answer: 275**

14. In period 3 the added electrons enter the same outer shell and shield poorly, so the pull grows fast; in the 3d series they enter the inner 3d and shield the outer 4s.

15. 1 → (a), 2 → (d), 3 → (c), 4 → (b). Each item matches its description.