

28 .1 GENERAL PHYSICAL AND CHEMICAL PROPERTIES OF TRANSITION ELEMENTS

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Introduction

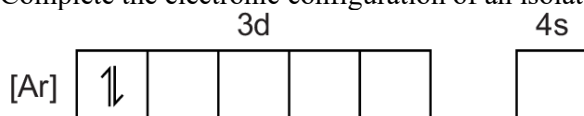
- Write down the electronic configuration of: i) a titanium atom (Ti) ii) a titanium ion (Ti^{2+})
.....
.....
- Give the electronic configuration of an isolated Ti^{3+} ion.
 $1s^2$ [1]
- Complete the shorthand electronic configurations of Fe and Fe^{3+} .
Fe [Ar]
 Fe^{3+} [Ar] [1]
- Complete the electronic configuration of an isolated gaseous Fe^{2+} ion.
 $1s^2$ [1]
- The most common oxidation states of cobalt are +2 and +3.
Complete the electronic configurations of the following free ions.
 - Co^{2+} [Ar].....
 - Co^{3+} [Ar] [1]
- Copper is a transition element.
Complete the electronic configurations of a Cu^+ ion and a Cu^{2+} ion.
 Cu^+ ion: [Ar]
 Cu^{2+} ion: [Ar]
- (i) Complete the electronic configuration of an isolated gaseous Fe^{3+} ion.
 $1s^2$ [1]
(ii) Name two transition elements whose isolated gaseous atoms have the same number of electrons in the 3d subshell as an isolated gaseous Fe^{3+} ion.
..... [1]
- Complete the electrons in boxes diagram in Fig. 1.1 to show the electronic configuration of a copper(II) ion.



Fig. 1.1

9. Complete the electronic configuration of an isolated gaseous nickel(II) ion, Ni^{2+} .

[1]



10. Define a transition element.

.....

 [1]

11. Silver, Ag, is a metal in the d-block of the Periodic Table.
 Silver can form compounds containing either Ag^+ or Ag^{2+} ions.
 Explain why silver is a transition element.

.....
 [1]

12. The transition elements are able to form stable complexes with a wide range of molecules and ions.
 State the meaning of *transition element*.

.....

 [1]

13. Explain why scandium (which forms only one ion, Sc^{3+}) and zinc (which forms only one ion, Zn^{2+}) are not called transition elements.

Properties of the transition elements

14. Titanium is a transition element in Period 4. It is commonly found as TiO_2 in minerals.

Identify **two** typical properties of transition elements.

1
 2 [1]

15. Vanadium is a transition element in Period 4 of the Periodic Table.
 Vanadium shows typical chemical properties of transition elements, including variable oxidation states.
 State two other typical chemical properties of transition elements.

1.
 2. [1]

3. Compare the melting point and density of iron with those of calcium, an s-block element in the fourth period.

melting point

density [1]

4. State how the melting point and density of iron compare to those of calcium.

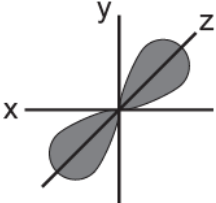
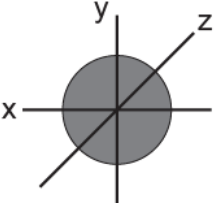
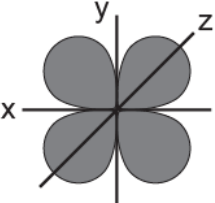
.....

.....

[1]

shape of a $3d_{xy}$ orbital and $3d_{z^2}$ orbital

5. Sketches of the shapes of some atomic orbitals are shown.
Identify the type of orbital: s, p, or d.

shape of orbital			
type of orbital			

[1]

6. Sketch the shape of a $3d_{xy}$ orbital in Fig. 2.1.

[2]

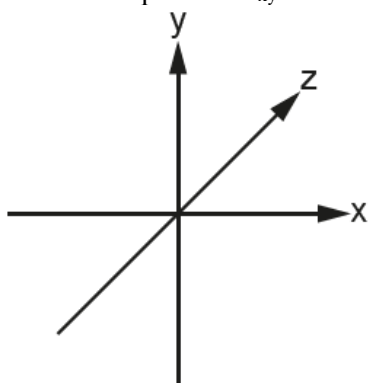
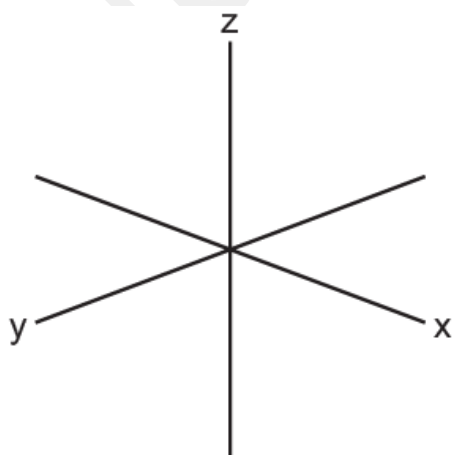


Fig. 2.1

7. Sketch the shape of a $3d_{z^2}$ orbital.

[1]



8. There are five different 3d orbitals.
Sketch the shape of a $3d_{z^2}$ orbital in Fig. 1.2.

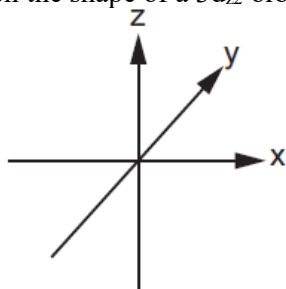
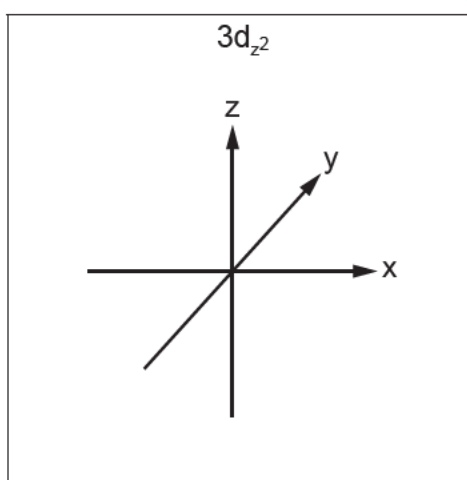
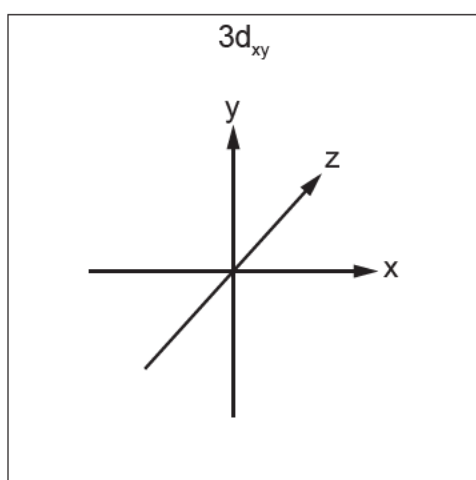


Fig. 1.2

9. A transition element is a d-block element which forms one or more stable ions with incomplete d-orbitals.
(a) Two of the 3d orbitals are the $3d_{xy}$ orbital and the $3d_{z^2}$ orbital.
Sketch the shapes of these two orbitals.



[1]

Variable oxidation states

10. Explain why the maximum oxidation state of manganese is +7.
11. The oxidation number of manganese can vary. What is its oxidation number in the following compounds?
a. MnO_2 b. MnO_4
12. Deduce the oxidation states of iron in:
 $[\text{Fe}(\text{CN})_6]^{4-}$ $[\text{Fe}(\text{CN})_5\text{NO}]^{2-}$ [1]
13. Concentrated acidified H_2O_2 can react with V^{2+} to form red VO_2^{3+} ions.
 VO_2^{3+} contains vanadium combined with the peroxide anion, O_2^{2-} .
Deduce the oxidation state of vanadium in VO_2^{3+} .

..... [1]

14. Deduce the oxidation numbers of chromium in $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ and in Cr_2O_3 .

$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ Cr_2O_3 [1]

15. $[\text{MnCl}_4]^{2-}$ is a complex ion.
Deduce the oxidation state of manganese in $[\text{MnCl}_4]^{2-}$.

oxidation state = ... [1]

16. Give the formulae of two oxides of iron. State the oxidation number of iron in each compound.

.....
..... [1]

17. Fe^{2+} ions can be oxidised to Fe^{3+} ions under alkaline conditions by suitable oxidising agents.
Iron is a transition element. Explain why iron forms stable compounds in both the +2 and the +3 oxidation states.

..... [1]

18. Copper can form stable complexes in the +1 and +2 oxidation states.
Explain why transition elements have variable oxidation states.

.....
..... [1]

19. Iron is a transition metal in Group 8 of the Periodic Table.
Explain why iron has variable oxidation states.

.....
.....
..... [1]

Formation of complex ions

20. Explain why transition elements form complexes.

.....
..... [1]

21. (a) The most common zinc mineral contains zinc(II) sulfide, ZnS.
 (i) Complete the electrons in boxes diagram in Fig. 1.1 to show the electronic configuration of a zinc(II) ion. [1]

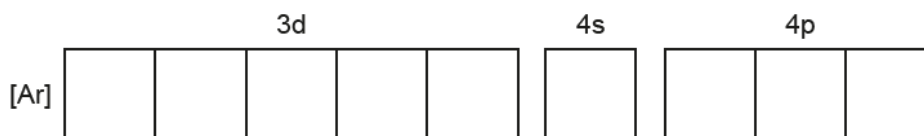


Fig. 1.1

- (ii) Explain why transition elements can form complex ions.

.....
 [1]

22. Transition metal atoms and transition metal ions form complexes by combining with ligands.
 (a) Explain why transition elements form complex ions. [1]

23. When aqueous citrate ions, $\text{C}_6\text{H}_5\text{O}_7^{3-}$, are added to $\text{Ti}^{3+}(\text{aq})$, the $[\text{Ti}(\text{C}_6\text{H}_5\text{O}_7)_2]^{3-}(\text{aq})$ complex forms.
 Explain, in terms of d-orbitals, why Ti^{3+} is able to form complex ions.

.....
 [1]

Transition elements as catalysts

24. Catalysts may be homogeneous or heterogeneous.
 Platinum is a transition element. Explain why transition elements behave as catalysts.

.....

 [1]

25. Transition elements behave as catalysts and can form complex ions.
 Explain why transition elements behave as catalysts. [2]