

Transition and Inner transition Elements

EXERCISE [PAGES 190 - 191]

Exercise | Q 1.01 | Page 190

Choose the most correct option.

Which one of the following is dimagnetic.

1. Cr^{2+}
2. Fe^{3+}
3. Mn^{2+}
4. Zn^{2+}

Solution: Zn^{2+}

Exercise | Q 1.02 | Page 190

Choose the most correct option.

Most stable oxidation state of titanium is _____.

1. +2
2. +3
3. +4
4. +5

Solution: Most stable oxidation state of titanium is +4.

Exercise | Q 1.03 | Page 190

Choose the most correct option.

Components of Nichrome alloy are _____.

1. Ni, Cr, Fe
2. Ni, Cr, Fe, C
3. Ni, Cr
4. Cu, Fe

Solution: Components of Nichrome alloy are Ni, Cr.

Exercise | Q 1.04 | Page 190

Choose the most correct option.

Most stable oxidation state of Ruthenium is _____.

1. +2
2. +4
3. +8
4. +6

Solution: Most stable oxidation state of Ruthenium is +8.

Exercise | Q 1.05 | Page 190

Choose the most correct option.

Stable oxidation states for chromium are _____.

1. +2, +3
2. +3, +4
3. +4, +5
4. +3, +6

Solution: Stable oxidation states for chromium are +3, +6.

Exercise | Q 1.06 | Page 190

Choose the most correct option.

Electronic configuration of Cu and Cu^{1+} are _____.

1. $3d^{10} 4s^0$; $3d^9 4s^0$
2. $3d^9 4s^1$; $3d^9 4s^0$
3. $3d^{10} 4s^1$; $3d^{10} 4s^0$
4. $3d^8 4s^1$; $3d^{10} 4s^0$

Solution: Electronic configuration of Cu and Cu^{1+} are $3d^{10} 4s^1$; $3d^{10} 4s^0$.

Exercise | Q 1.07 | Page 190

Choose the most correct option.

Which of the following have d^0s^0 configuration?

1. Sc^{3+}
2. Ti^{4+}
3. V^{5+}
4. All of the above

Solution: All of the above

Exercise | Q 1.08 | Page 190

Choose the most correct option.

Magnetic moment of a metal complex is 5.9 B.M. Number of unpaired electrons in the complex is _____.

1. 2
2. 3
3. 4
4. 5

Solution: Magnetic moment of a metal complex is 5.9 B.M. Number of unpaired electrons in the complex is 5.

Exercise | Q 1.09 | Page 190

Choose the most correct option.

In which of the following series all the elements are radioactive in nature

1. Lanthanides
2. Actinides
3. d-block elements
4. s-block elements

Solution: Actinides

Exercise | Q 1.1 | Page 190

Choose the most correct option.

Which of the following sets of ions contain only paramagnetic ions?

1. Sm^{3+} , Ho^{3+} , Lu^{3+}
2. La^{3+} , Ce^{3+} , Sm^{3+}
3. La^{3+} , Eu^{3+} , Gd^{3+}
4. Ce^{3+} , Eu^{3+} , Yb^{3+}

Solution: Ce^{3+} , Eu^{3+} , Yb^{3+}

Exercise | Q 1.11 | Page 191

Choose the most correct option.

Which actinoid, other than uranium, occur in a significant amount naturally?

1. Thorium
2. Actinium
3. Protactinium
4. Plutonium

Solution: Thorium

Exercise | Q 1.12 | Page 191

Choose the most correct option.

The flux added during the extraction of iron from haematite is its?

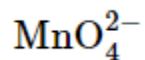
1. Silica
2. Calcium carbonate
3. Sodium carbonate
4. Alumina

Solution: Calcium carbonate

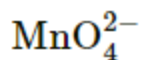
Exercise | Q 2.01 | Page 191

Answer the following

What is the oxidation state of Manganese in



Solution:



Let the oxidation state of Mn be x.

$$\therefore x + 4(-2) = -2$$

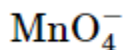
$$\therefore x - 8 = -2$$

$$\therefore x = +6$$

Exercise | Q 2.01 | Page 191

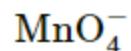
Answer the following

What is the oxidation state of manganese in:



?

Solution:



Let the oxidation state of Mn be x.

$$\therefore x + 4(-2) = -1$$

$$\therefore x - 8 = -1$$

$$\therefore x = +7$$

Exercise | Q 2.02 | Page 191

Answer the following

Give uses of KMnO_4

Solution:

Uses of KMnO_4 :

- i. Used as an antiseptic.
- ii. Used for unsaturation tests in the laboratory.
- iii. Used in the volumetric analysis of reducing agents.
- iv. Used for detecting halides in qualitative analysis.
- v. Used as a powerful oxidizing agent in the laboratory and industry.

Exercise | Q 2.03 | Page 191

Answer the following

Why salts of Sc^{3+} , Ti^{4+} , V^{5+} are colourless?

Solution:

- i. Condensed electronic configurations of Sc^{3+} , Ti^{4+} , V^{5+} are: Sc^{3+} : $[\text{Ar}] 3d^0$; Ti^{4+} : $[\text{Ar}] 3d^0$; V^{5+} : $[\text{Ar}] 3d^0$
- ii. The ions Sc^{3+} , Ti^{4+} and V^{5+} have completely empty d-orbitals i.e., no unpaired electrons are present. Thus, their salts are colourless, as d-d transitions are not possible.

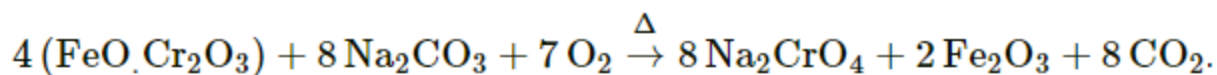
Exercise | Q 2.04 | Page 191

Answer the following

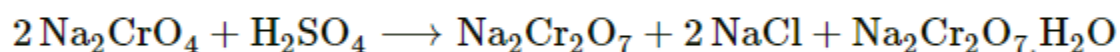
Which steps are involved in the manufacture of potassium dichromate from chromite ore?

Solution:**Preparation of potassium dichromate:**

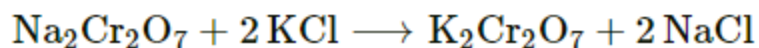
In the industrial production, finely powdered chromite ore ($\text{FeO} \cdot \text{Cr}_2\text{O}_3$) is heated with anhydrous sodium carbonate (Na_2CO_3) and flux of lime in the air in a reverberatory furnace.



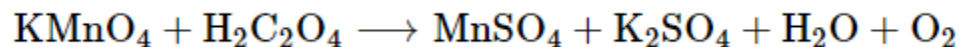
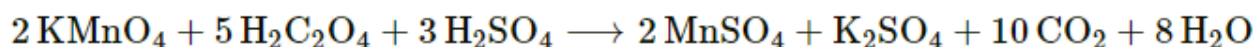
Sodium chromate (Na_2CrO_4) formed in this reaction is then extracted with water and treated with concentrated sulphuric acid to get sodium dichromate and hydrated sodium sulphate:



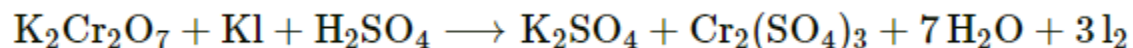
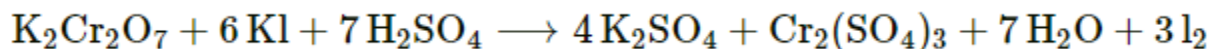
Addition of potassium chloride to a concentrated solution of sodium dichromate precipitates less soluble orange-red coloured potassium dichromate, $\text{K}_2\text{Cr}_2\text{O}_7$.

**Exercise | Q 2.05 | Page 191****Answer the following**

Balance the following equation

**Solution:****Exercise | Q 2.05 | Page 191****Answer the following**

Balance the following equation

**Solution:****Exercise | Q 2.06 | Page 191****Answer the following**

What are the stable oxidation states of plutonium, cerium, manganese, Europium?

Solution:

The stable oxidation state of plutonium is +4, cerium is +2, +3, +4, manganese is +2 to +7 and europium is +2, +3.

Exercise | Q 2.07 | Page 191**Answer the following**

Write the probable electronic configuration of chromium and copper.

Solution:

- i. The probable (expected) electronic configuration of chromium is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^2$ or $[\text{Ar}] 3d^4 4s^2$.
- ii The probable (expected) electronic configuration of copper is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9 4s^2$ or $[\text{Ar}] 3d^9 4s^2$.

Exercise | Q 2.08 | Page 191**Answer the following**

Why nobelium is the only actinoid with a +2 oxidation state?

Solution:

- i. The electronic configuration of nobelium (No) is $[\text{Rn}] 5f^{14} 6d^0 7s^2$.
- ii. After losing 2 electrons No forms No^{2+} ion, which is stable due to completely filled 5f-orbitals.
- iii. Such extra stability due to completely filled orbital is not acquired by any other actinoid in their +2 oxidation state.

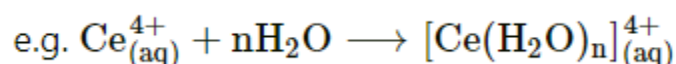
Hence, nobelium is the only actinoid with a +2 oxidation state.

Exercise | Q 2.09 | Page 191**Answer the following**

Explain with the help of a balanced chemical equation, why the solution of Ce(IV) is acidic.

Solution:

- i. According to Lewis acid theory, a species that can accept a pair of electrons is an acid.
- ii. The electronic configuration of Ce is $[\text{Xe}] 4f^1 5d^1 6s^2$ and that of Ce(IV) is $[\text{Xe}]$.
- iii. Ce(IV) can accept lone pairs of electrons from water molecules in its vacant orbitals to form the complex.



Hence, the solution of Ce(IV) is acidic in nature.

Exercise | Q 2.1 | Page 191

Answer the following

What is meant by 'shielding of electrons' in an atom?

Solution:

- i. The decrease in the force of attraction exerted by the nucleus on the valence electrons due to the presence of electrons in the inner shells is called the shielding effect.
- ii. As a result of the shielding effect, the effective nuclear charge experienced by the valence electron is less than the actual nuclear charge.

Exercise | Q 2.11 | Page 191

Answer the following

The atomic number of an element is 90. Is this element diamagnetic or paramagnetic?

Solution:

The electronic configuration of element with atomic number = 90 is $[\text{Rn}] 5f^0 6d^2 7s^2$.

There are two unpaired electrons in the 6d orbital of the element. Hence, it is paramagnetic.

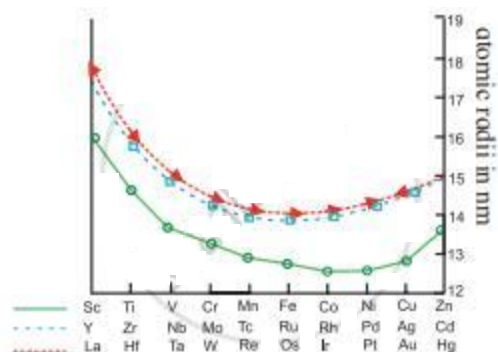
Exercise | Q 3.01 | Page 191

Answer the following

Explain the trends in atomic radii of d block elements.

Solution:

- i. Atomic radii of the elements of the transition series decrease gradually from left to right.
- ii. As we move across a transition series from left to right, the nuclear charge increases by one unit at a time.
- iii. The last filled electron enters a penultimate $(n - 1)d$ subshell. However, d orbitals in an atom are less penetrating or more diffused and, therefore d electrons offer smaller screening effects.
- iv. The result is that effective nuclear charge also increases as the atomic number increases along with a transition series. Hence, the atomic radii gradually decrease across a transition series from left to right.



Trends in atomic radii of d block elements

Exercise | Q 3.02 | Page 191

Answer the following

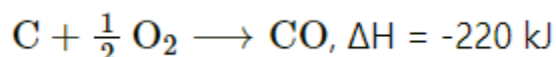
Name different zones in the Blast furnace. Write the reactions taking place in them.

Solution:

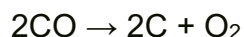
Reduction (Smelting): This step is carried out in a blast furnace. The charge containing ore and limestone is introduced into the furnace through a cup and cone arrangement. In this arrangement, the cone enables uniform distribution of charge and the cup prevents the loss of gases. A blast of preheated air is introduced into the furnace below the bosh. The charge and hot air come in contact with each other and various reactions take place.

Chemical reactions taking place in different zones of the blast furnace:

a. Zone of combustion: This is 5-10 m from the bottom. The hot air blown through the tuyers reacts with coke from the charge to form CO.



The reaction is highly exothermic; thus, the temperature of this zone is around 2000 K. Some of the CO formed dissociates to form finely divided carbon.



The hot gas rich in CO rises upwards in the blast furnace. The charge coming down gets heated and reacts with CO. Thus, CO acts as a fuel and also as a reducing agent.

b. Zone of reduction (22-25 m near the top): Here, the temperature is around 900 K.

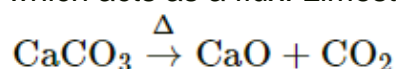
Fe_2O_3 is reduced to spongy iron by CO.



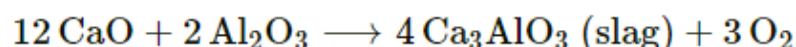
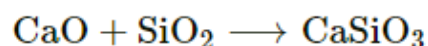
Some amount of Fe_2O_3 is reduced to iron by carbon.



c. Zone of slag formation (20 m height from the bottom): The gangue present in the ore is converted to slag. This slag can be used for making a road foundation. The temperature of this zone is 1200 K. The gangue contains silica, alumina, and phosphates. Removal of this gangue is effected by adding lime-stone in the charge, which acts as a flux. Limestone decomposes to give CaO (quick lime).



CaO combines with gangue to form molten slag of calcium silicate and calcium aluminate.



d. Zone of fusion (15 m height from the bottom): MnO_2 and $\text{Ca}_3(\text{PO}_4)_2$ present in the iron ore are reduced to Mn and P. Some of the silica is also reduced to Si. The spongy iron coming down in the furnace melt absorbs impurities like C, Si, Mn, P, and S. This molten iron collects at the bottom in the furnace. The slag is lighter floats on the surface of molten iron. Molten slag and iron are collected through separate outlets. Molten iron is poured into moulds. These solid blocks are called pigs. This iron contains about 4% of carbon. When pig iron is remelted, run into moulds, and cooled, it becomes cast iron. The waste gases containing N_2 , CO, and CO_2 escape through the outlet at the top. These hot gases are used for preheating the blast of air.

Exercise | Q 3.03 | Page 191

Answer the following

What are the differences between cast iron, wrought iron, and steel?

Solution:

Cast iron	Wrought iron	Steel
i. Hard and brittle	i. Very soft	i. Neither too hard nor too soft.
ii. Contains 4% carbon.	ii. Contains less than 0.2% carbon	ii. Contains 0.2 to 2% carbon

iii. Used for making pipes, manufacturing automotive parts, pots, pans, utensils, etc.	iii. Used for making pipes, bars for stay bolts, engine bolts and rivets, etc.	iii. Used in buildings infrastructure, tools, ships, automobiles, weapons, etc.
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Exercise | Q 3.04 | Page 191

Answer the following

Iron exhibits +2 and +3 oxidation states. Write their electronic configuration. Which will be more stable? Why ?

Solution:

- Electronic configuration of Fe^{2+} : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$
- Electronic configuration of Fe^{3+} : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$
- Fe^{3+} is more stable than Fe^{2+} . This is due to the presence of half filled 'd' orbital in Fe^{3+} .

Exercise | Q 3.05 | Page 191

Answer the following

Give the similarities and differences in elements of 3d, 4d, and 5d series.

Solution:

i. Similarities in physical properties:

- All d block elements are lustrous and shining.
- They are hard and have a high density.
- They have high melting and boiling points.
- They are good electrical and thermal conductors.
- They have high tensile strength and malleability.
- They can form alloys with transition and non-transition elements.
- Many metals and their compounds are paramagnetic.
- Most of the metals are efficient catalysts.

ii. Similarities in chemical properties:

- All d block elements are electropositive metals.
- They exhibit variable valencies and form coloured salts and complexes.
- They are good reducing agents.
- They form insoluble oxides and hydroxides.

- v. Iron, cobalt, copper, molybdenum, and zinc are biologically important metals.
- vi. They catalyse biological reactions.

iii. Differences:

Although most properties exhibited by d block elements are similar, the elements of the first row differ from second and third rows in the stabilization of higher oxidation states in their compounds.

Exercise | Q 3.06 | Page 191

Answer the following

Explain trends in ionisation enthalpies of d block elements.

Solution:

- i. The ionization enthalpies of transition elements are intermediate between those of s-block or p-block elements. This suggests that transition elements are less electropositive than elements of groups 1 and 2.
- ii. As the atomic number increases across a transition series, the first ionization energy increases with some irregularities.
- iii. Ionization enthalpies for a given element increases from the first ionization enthalpy, IE_1 to the third ionization enthalpy, IE_3 .
- iv. The atoms of elements of the third transition series possess filled 4f-orbitals. 4f orbitals show a poor shielding effect on account of their peculiar diffused shape. As a result, the valence electrons experience a greater nuclear attraction. A greater amount of energy is required to ionize elements of the third transition series. The ionization enthalpies of the elements of the third transition series are, therefore much higher than the first and second series.

Exercise | Q 3.07 | Page 191

Answer the following

What is meant by diamagnetic and paramagnetic? Give one example of diamagnetic and paramagnetic transition metal and lanthanoid metal.

Solution:

The substances with all electrons paired are weakly repelled by magnetic fields. Such substances are called **diamagnetic substances**.

The substances with unpaired electrons are weakly attracted by the magnetic field. Such substances are called **paramagnetic substances**.

Examples:

	Transition metal	Lanthanoid metal

Diamagnetic	Zinc	Ytterbium
Paramagnetic	Titanium	Cerium

Exercise | Q 3.08 | Page 191

Answer the following

Why the ground-state electronic configurations of gadolinium and lutetium are different than expected?

Solution:

Gadolinium and lutetium show different ground-state electronic configurations because the 5d and 4f-orbitals are near to the same energy due to which the next electron goes in 5d-orbital instead of 4f-orbital. This retains the extra stability achieved when the 4f orbital is half-filled and completely filled respectively. Thus, 5d orbital contains one electron in the case of gadolinium and lutetium.

Exercise | Q 3.09 | Page 191

Answer the following

Write the steps involved in the metallurgical process.

Solution:

The various steps involved in the extraction of pure metals from their ores are as follows:

- The concentration of ores
- Conversion of ores into oxides or other desired compounds
- Reduction of ores to form crude metals
- Refining of metals

Exercise | Q 3.1 | Page 191

Answer the following

Cerium and Terbium behave as good oxidising agents in the +4 oxidation state. Explain.

Solution:

- Cerium (Ce) and Terbium (Tb) show +4 oxidation states. Their electronic configurations are given below:



ii. It is clear from the configuration of Ce that Ce^{4+} is favoured by its noble gas configuration. But it can be easily converted into stable Ce^{3+} by a gain of an electron. Due to this reason, Ce^{4+} is a good oxidizing agent.

iii. Similarly, Tb^{4+} ion is stabilized due to a half-filled f-subshell. It can be easily converted into stable Tb^{3+} by gain of an electron. Due to this reason, Tb^{4+} is a good oxidizing agent.

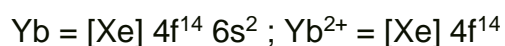
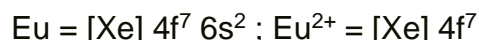
Exercise | Q 3.11 | Page 191

Answer the following

Europium and ytterbium behave as good reducing agents in the +2 oxidation state explain.

Solution:

i. Europium (Eu) and Ytterbium (Yb) show +2 oxidation states. Their electronic configurations are given below:



ii. It is clear from the configuration of Eu that Eu^{2+} is favoured by its half-filled f-subshell. But it can be easily converted into stable Eu^{3+} by the loss of an electron. Due to this reason, Eu^{2+} is a good reducing agent.

iii. Similarly, Yb^{2+} ion is stabilized due to completely filled f-subshell. It can be easily converted into Yb^{3+} by the loss of an electron. Due to this reason, Yb^{2+} is a good reducing agent.