Chemistry · Transition Elements

Introduction to Transition Elements

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Multiple choice questions — 65 questions

1 The electron configuration of the last vertical column of the (d)-block elements is .....

(A) ns^2 , nd^{10} (B) ns^2 , nd^5 (C) ns^2 , $(n-1)d^{10}$ (D) ns^2 , $(n-1)d^5$

2 The elements that are most similar in properties are .....

(A) Ni , Zn , Cu (B) Cr , Mn , Fe (C) Fe , Co , Ni (D) Co , Ni , Cu

3 Which vertical group in the periodic table contains the largest number of elements?

(A) VB (B) VIIB (C) VIIIB (D) VIII

4 Which of the following describes the elements whose electron configuration ends with the two sublevels ns^2 , $(n-1)d^3$?

(A) They lie in the third column of the periodic table.

(B) They lie in group (VB).

(C) They lie in the tenth column of the periodic table.

(D) They lie in group (IIIB).

5 A transition metal that resists corrosion and is non-toxic, so it bonds well with bones. What is the name of this metal?

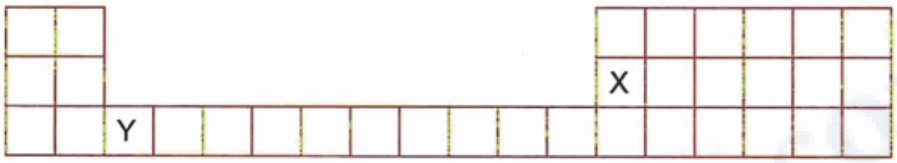
(A) Nickel. (B) Cobalt. (C) Chromium. (D) Titanium.

6 An element that is as hard as steel is .....

(A) iron. (B) zinc. (C) titanium. (D) nickel.

7 The opposite figure shows a part of the modern periodic table.

The distinguishing property of the alloy made of element (Y) and element (X) is .....



(A) it has a low melting point. (B) it has a high density.

(C) it is very hard. (D) it cannot be shaped.

8 Which of the following substances is not used in making batteries?

(A) Cd (B) MnO_2 (C) Co (D) Sc

9 Each of the following shows the economic importance of some oxides of 3d elements, except .....

(A) the rubber industry.
(B) detecting the positions of welded joints.
(C) a pigment in the ceramics industry.
(D) making the dry cell.

10 Each of the following is a compound of transition elements, except .....

(A) the substance used to make pigments.
(B) the substance used in the paint industry.
(C) the surface of a piece of chromium exposed to weather conditions.
(D) the substance used as a catalyst in making magnets.

11 From the opposite equation : $4K_2Cr_2O_7 \xrightarrow{(\Delta)} 4K_2CrO_4 + 3O_2 + 2X$

Compound (X) is used in .....

(A) making pigments. (B) preserving food.
(C) the rubber industry. (D) tanning leather.

12 The opposite figure shows a part of the modern periodic table of elements.

Which of the following describes element (M)?



(A) It lies in group 1B.
(B) It is used in coating metals to protect them from reduction.
(C) It looks like carbon.
(D) It can be magnetized.

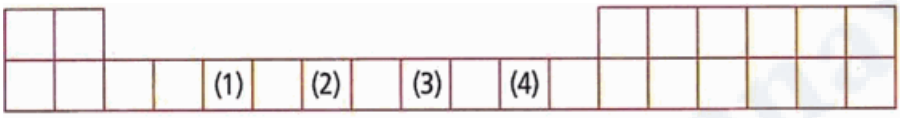
13 H_2SO_4 can be kept in a container made of .....

(A) iron.
(B) an alloy of (Sc , Al).
(C) cobalt-60.
(D) an alloy of (Ni , steel).

14 Each of the following describes the transition element (M) which lies in the first transition series and resists weather conditions, except .....

(A) It lies in the fourth period of the periodic table.
(B) It is used in tanning leather.
(C) One of its compounds is used in making pigments.
(D) It is used in making soft-drink cans.

15 The opposite figure shows a part of the modern periodic table.
The two elements whose sulphates are each used to kill fungi are .....



(A) (1) , (2)
(B) (2) , (3)
(C) (3) , (4)
(D) (2) , (4)

16 Each of the following describes a (d)-block element used to protect iron from rusting, except .....

(A) It lies in group (IIB).
(B) Its oxide is used in the rubber industry.
(C) It lies in column (12) of the periodic table.
(D) It is used in making heating coils.

17 Two (d)-block elements (X) , (Y) are used in making one of the rechargeable batteries, if element (Y) lies in the fifth period of the periodic table, then elements (X) , (Y) are .....

(A) (X) : chromium , (Y) : cadmium.
(B) (X) : nickel , (Y) : cadmium.
(C) (X) : zinc , (Y) : yttrium.
(D) (X) : nickel , (Y) : zinc.

18 The two alloys (X) , (Y) have the following properties :

• Alloy (X) : strong and of low density.

• Alloy (Y) : heavy but resists corrosion.

Which of the following is a suitable use of each of the two alloys (X) , (Y)?

(A) (X) : aircraft , (Y) : spacecraft.

(B) (X) : railway lines , (Y) : aircraft.

(C) (X) : spacecraft , (Y) : bridge supports.

(D) (X) : bridge supports , (Y) : railway lines.

---

19 A transition element (A) whose oxide molecules are larger than its atoms, and an element (B) used in the hydrogenation of oils.

Which of the following is one of the uses of the alloy made of (A) , (B)?

(A) Electric furnaces.

(B) Car springs.

(C) MiG fighter aircraft.

(D) Spacecraft.

---

20 Element (A) is as hard as steel, and element (B) has scandium added to it to form an alloy that is light and very hard.

Which of the following is incorrect?

(A) Element (A) is non-toxic and lies in the fourth period.

(B) Alloys of element (B) with manganese resist corrosion.

(C) The strength of element (A) is greater than that of element (B) at high temperatures.

(D) The two elements (A , B) are elements of the first transition series.

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21 For each of the following elements, the number of its group B in the periodic table can be found from the sum of the electrons in the two sublevels ns , (n−1)d in its electron configuration, except .....

(A) $_{21}Sc$

(B) $_{28}Ni$

(C) $_{25}Mn$

(D) $_{23}V$

---

22 The oxidation numbers of the elements of the first transition series in their compounds range between .....

(A) +1 : +7

(B) +2 : +8

(C) +2 : +7

(D) +3 : +7

---

23 Which of the following pairs of elements have more than one oxidation state in their compounds?

(A) Cr , Zn (B) Sc , Cu (C) Ti , Mn (D) Zn , Co

24 Which of the following represents the electron configuration of an ion of one of the elements of the first transition series?

(A) [Ar] , $4s^1$, $3d^{10}$ (B) [Ar] , $4s^1$, $3d^9$ (C) [Ar] , $4s^2$, $3d^8$ (D) [Ar] , $3d^{10}$

25 The two oxidation states that most of the transition metals of the fourth period of the periodic table have in common are .....

(A) +1 , +2 (B) +2 , +3 (C) +3 , +4 (D) +4 , +5

26 All the elements of the following groups have the oxidation state +2 , except the elements of group .....

(A) VIIB (B) VIB (C) IIB (D) IIIB

27 Which of the following ions has the largest number of unpaired electrons in its orbitals?

(A) Cu^{2+} (B) Fe^{2+} (C) Co^{4+} (D) Cr^{3+}

28 The number of unpaired electrons in the cation of the compound $CoCl_2$ is .....

(A) 2 (B) 3 (C) 4 (D) 5

29 When scandium reacts with :

- oxygen, it produces compound (X).
- chlorine, it produces compound (Y).
- dilute hydrochloric acid, it produces ion (Z).

Which of the following is correct?

(A) (X) : Sc_2O_3 , (Y) : $ScCl_3$, (Z) : $Sc^{3+}(aq)$

(B) (X) : Sc_2O_3 , (Y) : $ScCl_2$, (Z) : $Sc^{3+}(aq)$

(C) (X) : ScO , (Y) : $ScCl_2$, (Z) : $Sc^{2+}(aq)$

(D) (X) : ScO , (Y) : $ScCl_3$, (Z) : $Sc^{2+}(aq)$

30 The oxidation number of the cation of the compound used in making luminous paints is .....

(A) +2 (B) +3 (C) +1 (D) +4

31 The 3d sublevel is half-filled in the two ions .....

(A) Fe^{2+} , Mn^{3+} (B) Fe^{3+} , Mn^{2+} (C) Cr^{3+} , Mn^{2+} (D) Co^{2+} , Fe^{2+}

32 If the electron configuration of the ion M^{3+} is [Ar] , $3d^5$, then the atomic number of this transition element (M) is .....

(A) 24 (B) 25 (C) 26 (D) 27

33 Which of the following shows the correct order of the following cations according to the number of unpaired electrons?

(A) $Ti^{2+} < Cr^{3+} < Fe^{2+} < Mn^{2+}$ (B) $Cr^{3+} < Ti^{2+} < Mn^{2+} < Fe^{2+}$

(C) $Cr^{3+} < Fe^{2+} < Mn^{2+} < Ti^{2+}$ (D) $Fe^{2+} < Ti^{2+} < Mn^{2+} < Cr^{3+}$

34 Which of the following describes the isotope of the transition element used to detect malignant tumours?

(A) It is used in making surgical instruments.

(B) Its atomic number is 60

(C) Its electron configuration : [Ar] , $4s^1$, $3d^5$

(D) Number of its unpaired electrons = 3

35 In which of the following pairs of groups of the periodic table do the elements differ in the number of unpaired electrons?

(A) 3 , 11 (B) 4 , 10 (C) 5 , 9 (D) 6 , 12

36 The opposite table shows ions of some elements of the first transition series.
Which of the following is used in modern car batteries?

Number of unpaired electrons	Ion symbol
zero	W^{2+}
1	X^{3+}
5	Y^{4+}
3	Z^{4+}

(A) (W) (B) (X) (C) (Y) (D) (Z)

37 Which of the following describes one of the (d)-block elements in the fourth period of the modern periodic table?

(A) Silver has the electron configuration : ns^1 , $(n-1)d^{10}$

(B) Scandium has more than one oxidation state.

(C) The 3d sublevel is completely filled with electrons in the Cu^+ ion

(D) There are 3 unpaired electrons in the Fe^{2+} ion

38 Which of the following ions have the electron configuration [Ar] , $3d^6$?

(A) Co^{2+} , Mn^{2+} (B) Cr^{3+} , Fe^{3+} (C) Mn^{3+} , Cr^{2+} (D) Co^{3+} , Fe^{2+}

39 In which of the following cases is the manganese ion most stable?

(A) MnO_4^{2-} (B) Mn_2O_3 (C) Mn^{5+} (D) MnO

40 A metal (M) exists in the form of the following oxides and ions :

• MO_2 • M_2O_3 • HMO_4^- • MO_4^-

Which of the following is the metal (M)?

(A) Chromium. (B) Manganese. (C) Iron. (D) Cobalt.

41 The oxide of a transition element (MO) has 26 electrons in its cation.
Which metal follows element (M) in the same period of the periodic table?

(A) Co (B) Ni (C) Cu (D) Zn

42 The compound MXY_4 is used as an insecticide and a fungicide.

What are the oxidation numbers of each of (M) , (X) , (Y) in this compound?

(A) (M) : +3 , (X) : +5 , (Y) : −2

(B) (M) : +2 , (X) : +6 , (Y) : −2

(C) (M) : +2 , (X) : +6 , (Y) : −8

(D) (M) : +1 , (X) : +7 , (Y) : −2

---

43 From the following table, which of the following is correct?

(A) MnO_2 : the oxidation number of manganese in it is +4 , $KMnO_4$: used to disinfect water , $MnSO_4$: is one of the alloys of manganese.

(B) MnO_2 : used to reduce H_2SO_4 , $KMnO_4$: the oxidation number of manganese in it is +7 , $MnSO_4$: used as a drier for inks.

(C) MnO_2 : reacts with Al forming Mn , Al_2O_3 , $KMnO_4$: used to detect malignant tumours , $MnSO_4$: the oxidation number of manganese in it is +2.

(D) MnO_2 : the oxidation number of manganese in it is +4 , $KMnO_4$: added to fish tanks to fight parasites , $MnSO_4$: protects crops from fungi.

---

44 Among the properties of the metal (M), which lies in the first transition series, are that :

• it is as hard as steel but less dense than it.

• its stable chloride is MCl_4

• it reacts with water according to the equation : $M(s) + 2H_2O(v) \xrightarrow{(\Delta)} MO_2(s) + 2H_2(g)$

Another property of this metal is that it is .....

(A) brittle in the pure state.

(B) toxic to the human body.

(C) stronger than aluminium at high temperatures.

(D) a strong oxidizing agent.

---

45 The ion of the metal (M) in the compound MO_2 has 3 electrons in the 3d sublevel

What is the formula of the sulphate of the metal (M) in which 3d has 5 electrons, and what is this compound used for?

(A) $M(SO_4)_2$ / an oxidizing agent.

(B) MSO_4 / making the dry cell.

(C) $M(SO_4)_2$ / an insecticide.

(D) MSO_4 / a fungicide.

---

46 The transition metal (M) used in tanning leather has something in common with the first metal known to man, which is .....

(A) the ability to form the metal chloride MCl_3

(B) the number of electrons in the 4s sublevel

(C) its use in making fungicides.

(D) the number of electrons in the 3d sublevel

---

47 The metals of the first transition series react with halogens.

Which of the following represents the most stable metal halides?

(A) $FeCl_3$, VBr_3 , $TiCl_2$

(B) $MnBr_3$, VCl_4 , $TiCl_4$

(C) $FeCl_3$, VF_5 , $TiCl_4$

(D) $FeCl_2$, VCl_5 , $TiBr_3$

---

48 What is the chemical formula of yttrium sulphide?

(A) Y_3S_2 (B) YS (C) Y_2S_3 (D) YS_3

---

49 Nanoparticles of the oxide of the transition metal (M) can stop ultraviolet rays from reaching the skin.

Each of the following is a possible oxidation of this metal and its ions, except .....

(A) $M \rightarrow M^{2+}$ (B) $M^{2+} \rightarrow M^{4+}$ (C) $M \rightarrow M^{3+}$ (D) $M^{3+} \rightarrow M^{5+}$

---

50 The transition metal (M) that can be magnetized does not give an oxidation state whose electron configuration is .....

(A) d^5 (B) d^6 (C) d^7 (D) d^1

---

51 In the reaction : $2KMnO_4 + 16HCl \rightarrow 5Cl_2 + 2MnCl_2 + 2KCl + 8H_2O$

A reduction process is indicated by the formation of .....

(A) Cl_2 (B) $MnCl_2$ (C) H_2O (D) KCl

---

52 The two compounds KXO_4 , K_2XO_4 can change into each other.

What is the oxidation number of the transition element (X) in the oxidizing agent and in the reducing agent of them, respectively?

(A) +7 , +6 (B) +5 , +6 (C) +7 , +7 (D) +5 , +7

---

53 The following compounds can act as an oxidizing agent or a reducing agent in chemical reactions, except .....

(A) FeO (B) MnO (C) Sc_2O_3 (D) Cr_2O_3

54 Which metal has an oxide with the chemical formula M_2O_3 that is used in making pigments?

(A) V (B) Ti (C) Cr (D) Mn

55 The metal (M), which lies in the fourth period and group 3B of the periodic table, reacts with sulphuric acid, forming hydrogen and a salt whose chemical formula is .....

(A) MSO_4 (B) $M_2(SO_4)_3$ (C) $M(SO_4)_3$ (D) $M_3(SO_4)_2$

56 Which of the following represents the electron configuration of a non-transition element?

(A) ns^2 , $(n-1)d^5$ (B) ns^2 , $(n-1)d^{10}$ (C) ns^1 , $(n-1)d^5$ (D) ns^1 , $(n-1)d^{10}$

57 Which of the following groups of elements includes only one main transition element?

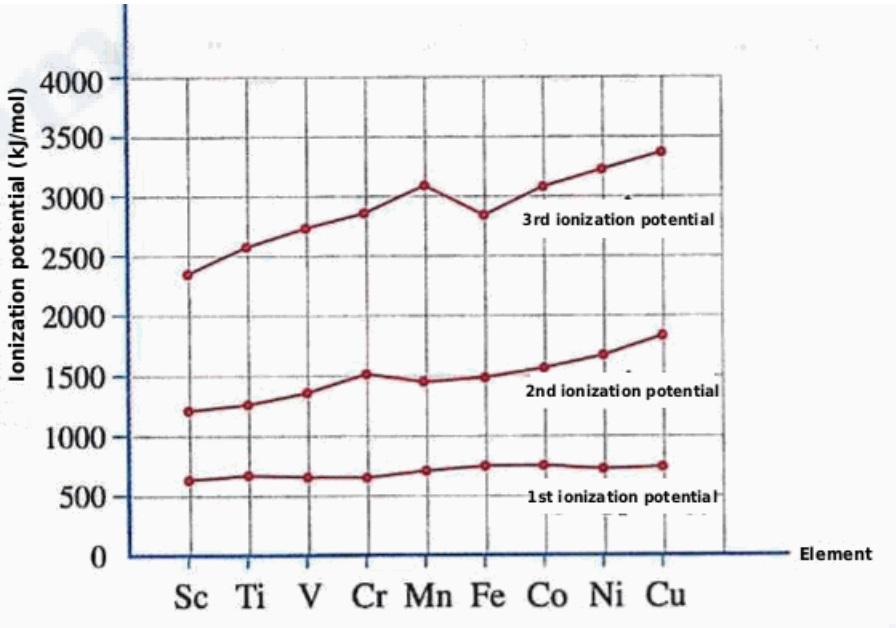
(A) Ni , Co , Fe (B) Cd , Ag , Cu (C) Zn , Ti , Mn (D) Y , Th , Hg

58 The largest ionization potential of a transition metal that has two unpaired electrons in the (n−1)d sublevel is the .....

(A) second ionization potential. (B) third ionization potential.
(C) fourth ionization potential. (D) fifth ionization potential.

59 From the opposite graph :

Each of the following is correct, except .....



(A) The second ionization potential of copper is greater than the second ionization potential of the other elements of the first transition series.

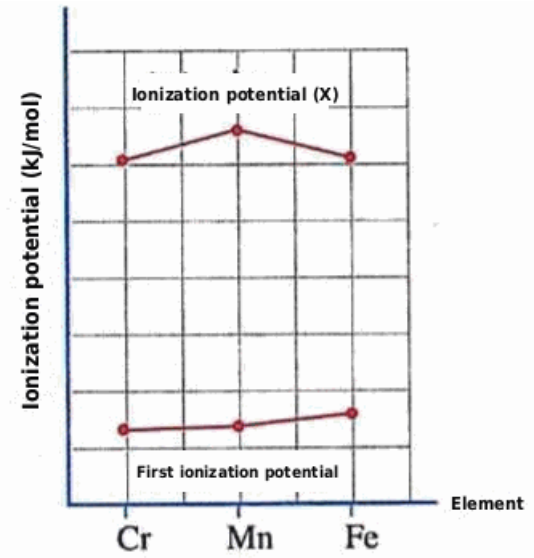
(B) The second ionization potential of chromium is greater than the second ionization potential of manganese.

(C) The first ionization potential of the elements of the first transition series increases by a large difference as their atomic numbers increase.

(D) The third ionization potential of manganese is greater than the first ionization potential of scandium.

60 From the opposite graph :

the ionization potential (X) represents the .....



(A) fifth ionization potential.

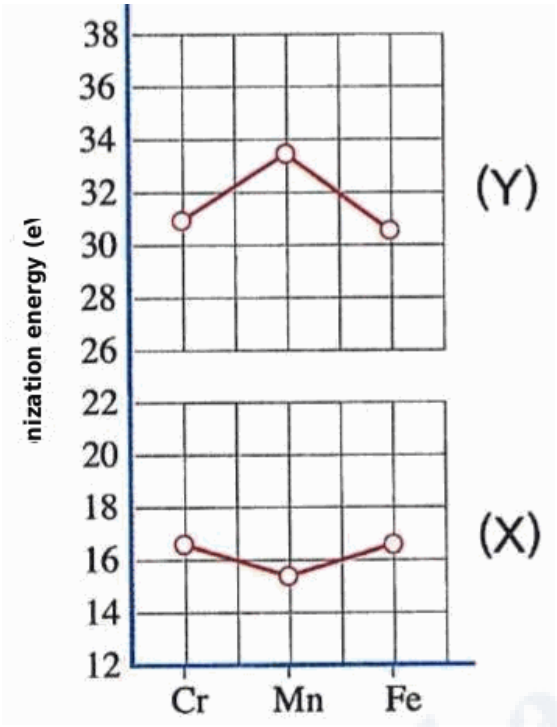
(B) fourth ionization potential.

(C) third ionization potential.

(D) second ionization potential.

61 The opposite graph shows the trend of the two ionization energies (X) , (Y) for some metals of the first transition series.

Which of the following is correct?



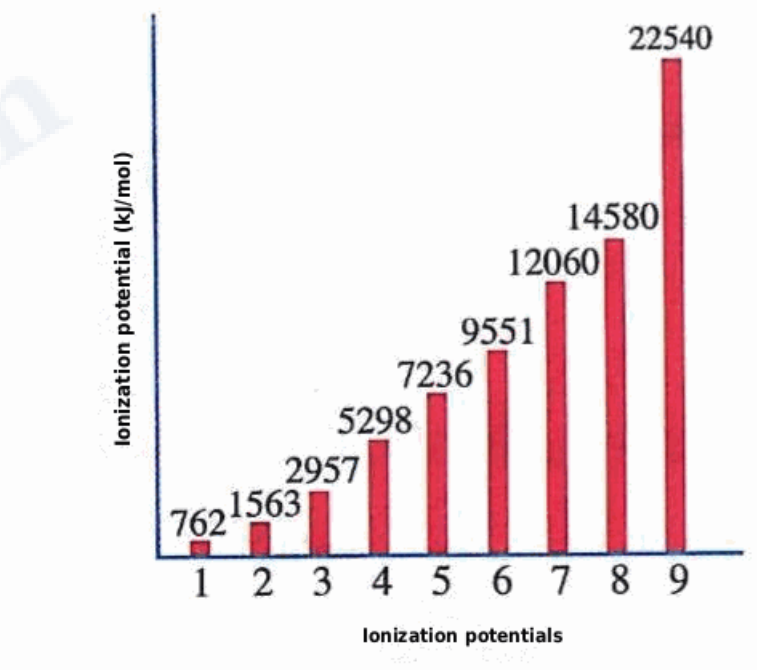
(A) (X) : first ionization potential , (Y) : second ionization potential.

(B) (X) : second ionization potential , (Y) : third ionization potential.

(C) (X) : third ionization potential , (Y) : fourth ionization potential.

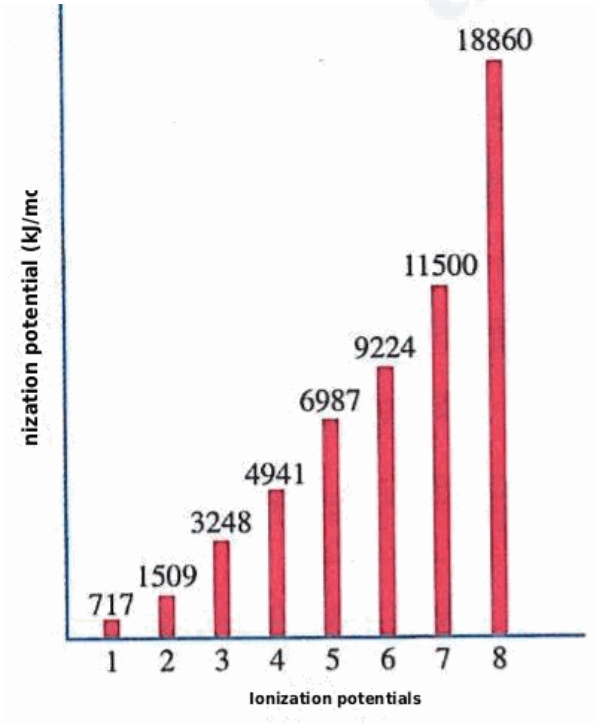
(D) (X) : fourth ionization potential , (Y) : fifth ionization potential.

62 The opposite graph shows the ionization potentials of the metal .....



(A) titanium. (B) chromium. (C) iron. (D) vanadium.

63 The opposite graph shows the ionization potentials of a transition element whose electron configuration is .....



(A) [Ar] , $4s^1$, $3d^5$ (B) [Ar] , $4s^2$, $3d^5$ (C) [Ar] , $4s^2$, $3d^6$ (D) [Ar] , $4s^1$, $3d^{10}$

64 The following table shows the first four ionization potentials of one of the transition elements (M) :

The oxidation state of element (M) in which an electron was removed from a complete main energy level is .....

4th	3rd	2nd	1st	Ionization potential
7090.6	2388.6	1235	633.1	Ionization potential (kJ/mol)

(A) M^{+} (B) M^{2+} (C) M^{3+} (D) M^{4+}

65 The following table shows the ionization potentials of four transition elements in (kJ/mol) :

Which of the previous elements has one of its compounds used as a catalyst in making superconducting magnets?

6th	5th	4th	3rd	2nd	1st	Ionization pot. / Element
9224	6987	4941	3248	1509	717	(W)
9551	7236	5298	2957	1563	762	(X)
–	–	11540	2745	1811	578	(Y)
12360	6299	4507	2828	1412	651	(Z)

(A) (W) (B) (X) (C) (Y) (D) (Z)

Essay questions — 9 questions

1 The transition element (X) has 12 radioactive isotopes :

(1) Determine the group of element (X) in the periodic table.

(2) Write the chemical formula of the sulphide of element (X) whose cation has 3 unpaired electrons.

2 The metal (Y) lies in the fifth period and group 3B of the periodic table :

(1) What is the electron configuration of the metal (X) that precedes it in the same group?

(2) What are the properties of the alloy of element (X) with aluminium?

3 One of the compounds of manganese is $Mn_3(PO_4)_2$:

(1) Write the electron configuration of the manganese ion in this compound.

(2) Is the cation of this compound easy or difficult to oxidize? Explain.

4 The transition metal (M) combines with chlorine forming the compound MCl_2 , and the cation of this compound has 24 electrons :

(1) What is the name of the metal (M)?

(2) Write the electron configuration of this metal in its most stable oxidation state.

5 From the electron configuration of the two highest-energy sublevels of chromium, copper and zinc, determine :

(1) the similarity between copper and zinc.

(2) the difference between copper and chromium.

6 The compound MSO_4 is used as an insecticide and a fungicide :

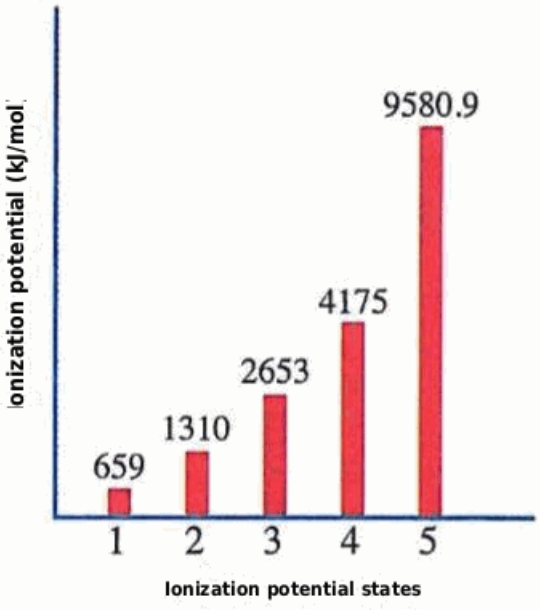
(1) Write the electron configuration of the ion of the metal (M) in this compound.

(2) Why is the second ionization potential of this metal greater than its first ionization potential?

7 The opposite graph shows the ionization potentials of the metal (M), which lies in the first transition series :

(1) How many sublevels are completely filled with electrons in the stable ion of this metal?

(2) Write the chemical formula of the oxide of this metal and state its importance.



8 The two cations X^{3+} , Y^{2+} have the same electron configuration [Ar] , $3d^4$:

(1) What is the name of each of the two metals (X) , (Y)?

(2) Write the chemical formulas of the compounds of (X) , (Y) that always act as oxidizing agents.

9 When sulphur dioxide gas is passed into a solution containing the permanganate ion, the violet colour of the solution disappears, and the reaction is shown by the following ionic equation :

$5SO_2 + 2MnO_4^- + 2H_2O \rightarrow 5SO_4^{2-} + 2Mn^{2+} + 4H^+$

From this reaction, deduce a property that shows that manganese is a transition element, and explain the role of MnO_4^- in this reaction.

Past exam questions — 37 questions

1 An element of the first transition series, one of whose compounds is used in pigments.
Which of the following choices shows the electron configuration of the ion of this element in this compound?
(Sample exam 2026)

(A) $[_{18}Ar]$, $4s^1$, $3d^5$ (B) $[_{18}Ar]$, $3d^3$ (C) $[_{18}Ar]$, $4s^2$, $3d^3$ (D) $[_{18}Ar]$, $3d^2$

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2 Which of the following shows the electron configuration of an ion of a non-transition element?
(Sample exam 2026)

(A) X^{3+} : [Ne] , $3s^2$, $3p^6$
(B) Y^{2+} : [Ar] , $3d^6$
(C) Z^{2+} : [Ne] , $3s^2$, $3p^6$
(D) W^{3+} : [Kr] , $4d^7$

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3 Four test tubes (X) , (Y) , (Z) , (W) each contain a salt solution as in the following table : (X) : $Mn(NO_3)_2$, (Y) : $Fe(NO_3)_3$, (Z) : $Ti(NO_3)_3$, (W) : $V(NO_3)_5$
Which of these tubes must be covered so that the composition of the solution inside it does not change?
(Sample exam 2026)

(A) X (B) Y (C) Z (D) W

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4 Which of the following shows the electron configuration of an ion of a transition element and a use of one of the compounds of this ion?
(Sample exam 2026)

(A) $[_{18}Ar]$, $3d^3$ / in the dry car battery.
(B) $[_{18}Ar]$ / a catalyst in the contact process.
(C) $[_{18}Ar]$ / in artificial joints.
(D) $[_{18}Ar]$, $3d^6$ / in the hydrogenation of oils.

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5 Element (X) of the first transition series has its (d) sublevel complete with electrons.
Which of the following shows the type of the element and the electron configuration of the ion of this element in the compound X_2O ?
(Sample exam 2026)

(A) transition , [Ar] , $3d^{10}$
(B) transition , [Ar] , $3d^9$
(C) non-transition , [Ar] , $3d^{10}$
(D) non-transition , [Ar] , $3d^9$

6 Element (X) is one of the elements of the first transition series; its (d) sublevel is complete with electrons, and it has no unpaired electrons in any oxidation state.
Which of the following shows the type of the element and the electron configuration of the ion of this element in the compound XO ?
(Sample exam 2026)

(A) transition , [Ar] , $3d^{10}$
(B) transition , [Ar] , $3d^{9}$
(C) non-transition , [Ar] , $3d^{10}$
(D) non-transition , [Ar] , $3d^{9}$

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7 Two elements (A) , (B) of the first transition series; the +2 ion of each of them contains four unpaired electrons, and element (A) is less dense than element (B).
Which of the following shows a use of each of (A) , (B)?
(Sample exam 2026)

(A) (A) : in making soft-drink cans , (B) : in reinforced concrete.
(B) (A) : in coating metals to protect them from rusting , (B) : in heating coils.
(C) (A) : in tanning leather , (B) : in making surgical instruments.
(D) (A) : in making pigments , (B) : a catalyst in making ammonia.

---

8 Three successive elements (A) , (B) , (C) of the first transition series; element (C) has twice the number of unpaired electrons in (B) and three times the number in element (A).
Which of the following shows the uses of the elements (A) , (B) , (C)?
(Sample exam 2026)

(A) (A) : the dry cell , (B) : coating metals , (C) : the composition of Fehling's solution
(B) (A) : hydrogenation of oils , (B) : heating coils , (C) : luminous paints
(C) (A) : an oxidizing and disinfecting substance , (B) : galvanization , (C) : making magnets
(D) (A) : artificial joints , (B) : making car springs , (C) : coating metals

---

9 Element (X) is one of the elements of the second transition series, and its electron configuration ends with $ns^{(n-3)}$, $(n-1)d^{2n}$

Which of the following shows the type of element (X) and its use?

(Sample exam 2026)

(A) Transition, and used in making coins.

(B) Transition, and used with a non-transition element in making rechargeable batteries.

(C) Non-transition, and used with a transition element in making rechargeable batteries.

(D) Non-transition, and its oxide is used in making rubber and paints.

---

10 A main transition element (X) whose (d) sublevel has two unpaired electrons in the oxidation state $(+3)$.

Which of the following oxidation states results in breaking a main energy level complete with electrons for this element?

(Sample exam 2026)

(A) X^{7+} (B) X^{6+} (C) X^{5+} (D) X^{4+}

---

11 A transition element (X) of the first transition series; the number of unpaired electrons in its (d) sublevel is twice the number of unpaired electrons in copper.

Each of the following is a use of element (X), except .....

(Sample exam 2026)

(A) coating metals to protect them from corrosion.

(B) a catalyst in changing vegetable oils into artificial ghee.

(C) it forms with chromium an alloy that resists corrosion.

(D) it forms with aluminium an alloy used in making MiG aircraft.

---

12 Which of the transition element ions in the following compounds is the easiest to reduce?

(Sample exam 2026)

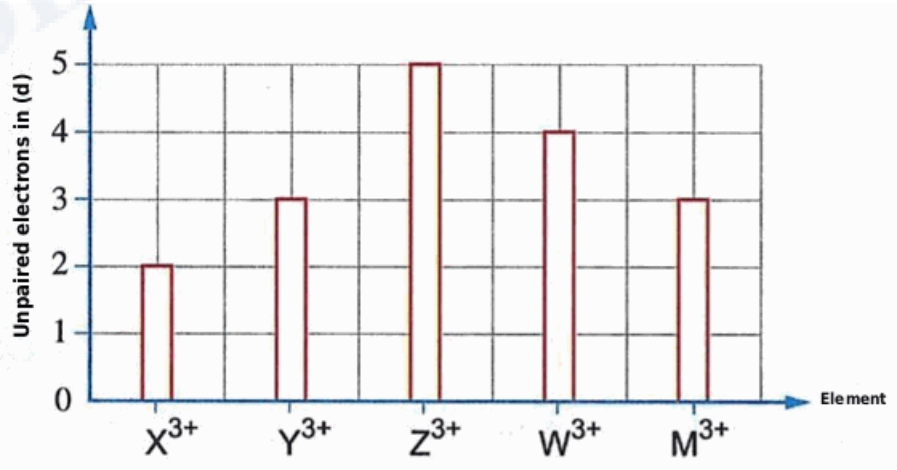
(A) $Mn(NO_3)_3$ (B) $Fe(NO_3)_3$ (C) $Ti(NO_3)_4$ (D) $V(NO_3)_5$

---

13 The opposite graph shows the number of unpaired electrons in the oxidation state $(+3)$ for elements of the first transition series,

Which of the following processes happens most easily?

(Sample exam 2026)



(A) $M^{3+} \longrightarrow M^{4+}$ (B) $X^{3+} \longrightarrow X^{2+}$ (C) $Z^{3+} \longrightarrow Z^{2+}$ (D) $W^{3+} \longrightarrow W^{2+}$

14 (X) , (Y) , (Z) are three transition elements used in medicine :

(X) : one of its alloys is used in surgical instruments.

(Y) : used in artificial joints.

(Z) : one of its isotopes is used in diagnosing and treating malignant tumours.

Which of the following shows the elements (X) , (Y) , (Z)?

(Sample exam 2026)

(A) (X) : chromium , (Y) : cobalt , (Z) : cadmium

(B) (X) : iron , (Y) : titanium , (Z) : cobalt

(C) (X) : cobalt , (Y) : vanadium , (Z) : chromium

(D) (X) : iron , (Y) : titanium , (Z) : vanadium

15 The following table shows the electron configuration of the cations of two elements (X) , (Y) :

X^{2+} : $[_{18}Ar]$, $3d^4$, Y^{2+} : $[_{18}Ar]$, $3d^2$

Which of the following is correct?

(Sample exam 2026)

(A) X^{6+} is difficult to oxidize to X^{7+} (B) Y^{2+} is difficult to oxidize to Y^{4+}

(C) X^{6+} is easily reduced to X^{2+} (D) Y^{4+} is easily reduced to Y^{3+}

16 Element (X) of the first transition series is used in an acid-resistant alloy.
Which of the following represents the electron configuration of the ion X^{3+} ?
(Sample exam 2026)

(A) $[_{18}Ar]$, $3d^3$ (B) $[_{18}Ar]$, $3d^6$ (C) $[_{18}Ar]$, $3d^7$ (D) $[_{18}Ar]$, $3d^4$

17 Which of the following processes represents the most difficult change?
(1st session 2025)

(A) From titanium (III) to titanium (IV).
(B) From vanadium (IV) to vanadium (V).
(C) From iron (III) to iron (II).
(D) From manganese (IV) to manganese (II).

18 The ratio between the number of unpaired electrons in element (A), used as a catalyst in making ammonia, and that in element (B), used as a catalyst in the hydrogenation of oils, equals .....
(Sample exam 2025)

(A) (A) : 2 , (B) : 1 (B) (A) : 1 , (B) : 2 (C) (A) : 3 , (B) : 1 (D) (A) : 1 , (B) : 3

19 If (A) , (B) are two successive elements in the first transition series, and element (B) is the last element that can lose all of its (4s , 3d) electrons, then the ionization potential of element (A) that can break a complete energy level is the .....
(Sample exam 2025)

(A) ninth. (B) seventh. (C) eighth. (D) tenth.

20 (X , Y , Z) are three successive transition elements in the first transition series, and element (X) is used in making rechargeable batteries.
Which of the following shows the electron configuration of the ions of these elements in the following oxides $XO_2 - Y_2O_3 - ZO$?
(Sample exam 2025)

(A) $XO_2 : 3d^6$, $Y_2O_3 : 3d^6$, $ZO : 3d^6$
(B) $XO_2 : 3d^8$, $Y_2O_3 : 3d^6$, $ZO : 3d^8$
(C) $XO_2 : 3d^6$, $Y_2O_3 : 3d^8$, $ZO : 3d^6$
(D) $XO_2 : 3d^8$, $Y_2O_3 : 3d^8$, $ZO : 3d^6$

21 An element (X) of the first transition series whose M level contains twice the number of electrons in the L level

Which of the following is correct for this element?

(Sample exam 2025)

(A) It reacts instantly with acids.

(B) It forms with chromium an alloy with a low melting point.

(C) It is used with cadmium in making rechargeable batteries.

(D) A catalyst in obtaining car petrol from water gas.

---

22 Two successive elements (X) , (Y) of the first transition series, where :

• (X) : is easily oxidized from $X^{2+} \longrightarrow X^{3+}$

• (Y) : is easily oxidized from $Y^{3+} \longrightarrow Y^{4+}$

then the two elements are .....

(2nd session 2024)

(A) (X) : titanium , (Y) : vanadium.

(B) (X) : vanadium , (Y) : chromium.

(C) (X) : cobalt , (Y) : nickel.

(D) (X) : iron , (Y) : cobalt.

---

23 Two elements (A) , (B) of the first transition series; element (A) has two unpaired electrons in the d sublevel, and the d sublevel of element (B) is half-filled.

The alloy made of them is used in .....

(2nd session 2024)

(A) heating coils.

(B) railway rails.

(C) soft-drink cans.

(D) making dry batteries.

---

24 Two elements (X) , (Y) whose cations have the electron configurations :

X^{4+} : $[_{18}Ar]$, $3d^1$

Y^{6+} : $[_{18}Ar]$, $3d^2$

One of the advantages of the alloy made of element (X) with one of the alloys of element (Y) with carbon is that it .....

(Trial exam / March 2023)

(A) is light and very hard.

(B) resists corrosion and is hard.

(C) resists corrosion at high temperatures.

(D) keeps its strength at high temperatures.

---

25 A transition element (X) that lies in the fourth period and has the highest possible oxidation state in it can form all the following compounds except .....
(Trial exam / June 2021)

(A) XCl (B) XCl_2 (C) XCl_3 (D) XCl_4

26 Element (X) is one of the elements of the first transition series, and the electron configuration of one of its ions is $[_{18}Ar]$, $3d^5$
then the element is .....
(2nd session 2021)

(A) Zn (B) V (C) Sc (D) Fe

27 The electron configuration of the ion (X^{3+}) is $[_{18}Ar]$, $3d^6$, so element (X) is used in .....
(2nd session 2022)

(A) car springs. (B) dry batteries.
(C) a fungicide. (D) the hydrogenation of oils.

28 The electron configuration of the ion of the transition element (X) in the compound X_2O_3 has three unpaired electrons,
then the element lies in the periodic table in group number .....
(1st session 2021)

(A) 9 (B) 10 (C) 11 (D) 12

29 The transition element used in the hydrogenation of oils has the electron configuration of its ion M^{3+} .....
(1st session 2021)

(A) $[_{18}Ar]$, $3d^7$ (B) $[_{18}Ar]$, $3d^8$ (C) $[_{18}Ar]$, $4s^2$, $3d^7$ (D) $[_{18}Ar]$, $4s^2$, $3d^8$

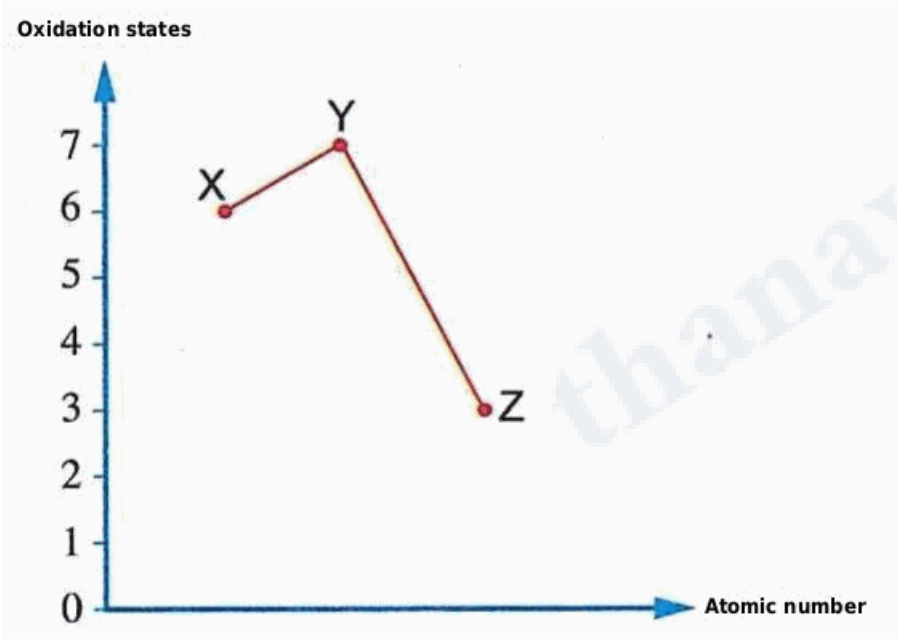
30 Element (X) is one of the coinage metals and is a transition element, and the compounds that prove this are .....
(Trial exam / June 2021)

(A) X_2O_3 , XO (B) XCl , XO (C) X_2O_3 , X_2O (D) X_2O_3 , XCl

31 Two elements (X) , (Y) of the first transition series, each of which has a compound used as a fungicide,
then the two elements lie in the groups .....
(1st session 2022)

(A) 1B , 7B (B) 1B , 2B (C) 3B , 2B (D) 2B , 7B

32 The opposite graph shows the relation between the atomic number of three successive transition elements X , Y , Z and some of their oxidation numbers.
The groups in which they probably lie are .....
(Trial exam / June 2021)



(A) X : VIB , Y : VIIB , Z : VIII (B) X : IB , Y : IIB , Z : IIIB
(C) X : IVB , Y : VB , Z : BIV (D) X : IIIB , Y : VIB , Z : VB

33 Based on the atomic numbers and the possible oxidation states of the following elements :
($_{25}$Mn , $_{17}$Cl , $_{22}$Ti , $_{28}$Ni)
Which of the following is correct?
(1st session 2022)

(A) $FeCl_3$ is difficult to obtain from $FeCl_2$ (B) $MnCl_2$ is easily obtained from $MnCl_3$
(C) $NiCl_7$ is easily obtained (D) $TiCl_4$ is difficult to obtain

34 If the electron configurations of the cations of some transition elements are :

A^{2+} : $[_{18}Ar]$, $3d^3$, B^{2+} : $[_{18}Ar]$, $3d^5$

Which of the following processes happens easily?

(1st session 2023)

(A) Reduction of (B^{7+}) to (B^{3+}).

(B) Reduction of (A^{5+}) to (A^{3+}).

(C) Oxidation of (B^{2+}) to (B^{3+}).

(D) Oxidation of (A^{3+}) to (A^{5+}).

---

35 Which of the following transition elements has the largest first ionization potential?

(Trial exam / June 2021)

(A) $Ni \longrightarrow Ni^+$ (B) $V \longrightarrow V^+$ (C) $Sc \longrightarrow Sc^+$ (D) $Ti \longrightarrow Ti^+$

---

36 A main transition element, one of whose oxidation states, X^{3+} , makes the d sublevel contain 2 electrons.

The ionization potential of the element is very high in the oxidation state .....

(Trial exam / June 2021)

(A) X^{6+} (B) X^{3+} (C) X^{5+} (D) X^{4+}

---

37 You have the following compounds : $KMnO_4$, K_2MnO_4 , MnO_2

It is easy to obtain .....

(2nd session 2023)

(A) K_2MnO_4 from $KMnO_4$ by oxidation.

(B) $KMnO_4$ from K_2MnO_4 by oxidation.

(C) MnO_2 from $KMnO_4$ by reduction.

(D) K_2MnO_4 from MnO_2 by reduction.

Answer key and solutions

Multiple choice questions

1 C	2 C	3 D	4 B	5 D	6 C	7 C	8 D	9 B	10 B
11 A	12 D	13 D	14 D	15 D	16 D	17 B	18 C	19 A	20 D
21 B	22 A	23 C	24 D	25 B	26 D	27 C	28 B	29 A	30 A
31 B	32 C	33 A	34 D	35 D	36 C	37 C	38 D	39 D	40 B
41 C	42 B	43 D	44 C	45 D	46 B	47 C	48 C	49 D	50 D
51 B	52 A	53 C	54 C	55 B	56 B	57 D	58 D	59 C	60 C
61 B	62 C	63 B	64 D	65 D					

1 **Answer (C)**

The last column of the (d)-block is group IIB (column 12)
and its electron configuration is ns^2 , $(n-1)d^{10}$

2 **Answer (C)**

The metals Fe, Co and Ni are neighbours in the same period and in group VIII
so they show a great horizontal similarity in properties

3 **Answer (D)**

Group VIII includes three columns (8, 9 and 10) in each transition series
so it is the group with the largest number of elements

4 **Answer (B)**

The configuration ns^2 , $(n-1)d^3$ is that of vanadium V
and the sum of the ns and (n−1)d electrons = 5 , so it lies in group VB

5 **Answer (D)**

Titanium resists corrosion and is non-toxic, so it bonds with bones and is used in bone and joint implants

6 **Answer (C)**

Titanium is as hard as steel but less dense than it

7 **Answer (C)**

Y lies in group IIIB, so it is scandium Sc , and X is aluminium Al

The alloy of Sc with Al is light and very hard

8 **Answer (D)**

Cd, MnO_2 and Co are used in making batteries

but scandium is not used in them

9 **Answer (B)**

Detecting welding positions uses the radioactive isotope cobalt-60 itself, not an oxide

while the other oxides are used in rubber, ceramics and the dry cell

10 **Answer (B)**

11 **Answer (A)**

On heating $K_2Cr_2O_7$, K_2CrO_4 and O_2 form, and compound (X) is Cr_2O_3

Chromium(III) oxide is used in making pigments

12 **Answer (D)**

Element M is the seventh element in the first transition series, i.e. cobalt Co

and cobalt can be magnetized

13 **Answer (D)**

Iron and the Sc/Al alloy react with H_2SO_4, and cobalt-60 is radioactive

The alloy of nickel with steel resists corrosion and the action of acids, so H_2SO_4 can be kept in it

14 **Answer (D)**

M is chromium: it is in the fourth period, resists weather conditions and is used in tanning leather, and one of its compounds is used in pigments

but soft-drink cans are not made of chromium

15 **Answer (D)**

Elements (2) and (4) are manganese and copper

The sulphate of each of them ($MnSO_4$ and $CuSO_4$) is used to kill fungi

16 **Answer (D)**

The element is zinc (group IIB, column 12); it is used in coating iron and its oxide is used in the rubber industry

but heating coils are made of an alloy of nickel and chromium, not zinc

17 **Answer (B)**

The rechargeable nickel–cadmium battery

Cadmium lies in the fifth period (Y) and nickel is (X)

18 **Answer (C)**

The strong, low-density alloy (X) is used in spacecraft

The heavy, corrosion-resistant alloy (Y) is used in bridge supports

19 **Answer (A)**

(B) is nickel, used in the hydrogenation of oils, and (A) is chromium

The alloy of nickel and chromium (nichrome) is used in the coils of electric furnaces

20 **Answer (D)**

(A) is titanium, and (B) is aluminium

Aluminium is not an element of the first transition series, so statement (D) is incorrect

21 **Answer (B)**

The group B number equals the sum of the ns and (n−1)d electrons for Sc, V and Mn

but for nickel Ni the sum is 10 ($4s^2$ $3d^8$) while its group number is VIIIB

22 **Answer (A)**

Oxidation numbers in the first transition series range from +1 (in copper) to +7 (in manganese)

23 **Answer (C)**

Ti (+2, +3 and +4) and Mn (from +2 to +7) have more than one oxidation state

while Sc and Zn have only one state (+3 and +2)

24 **Answer (D)**

[Ar] , $3d^{10}$ is the electron configuration of the ion Cu^+ (after losing the 4s electron)

while the other configurations belong to neutral atoms

25 **Answer (B)**

Most of the transition metals of the fourth period share the oxidation states +2 and +3

26 **Answer (D)**

The elements of group IIIB (Sc and Y) have the oxidation state +3 only

27 **Answer (C)**

Number of unpaired electrons: Cu^{2+} ($3d^9$) = 1 , Fe^{2+} ($3d^6$) = 4 , Cr^{3+} ($3d^3$) = 3 , Co^{4+} ($3d^5$) = 5

so the largest is Co^{4+}

28 **Answer (B)**

Co^{2+} has the configuration [Ar] $3d^7$, so the number of unpaired electrons is 3

29 **Answer (A)**

Sc forms the oxide Sc_2O_3, the chloride $ScCl_3$ and the ion Sc^{3+} because its only oxidation state is +3

30 **Answer (A)**

Luminous paints are made of zinc sulphide ZnS

and the oxidation number of Zn^{2+} is +2

31 **Answer (B)**

3d is half-filled ($3d^5$) in Fe^{3+} and Mn^{2+}

32 **Answer (C)**

M^{3+} has the configuration [Ar] $3d^5$, so its number of electrons is 18 + 5 = 23

so the neutral atom has 26 electrons, i.e. Fe (atomic number 26)

33 **Answer (A)**

Number of unpaired electrons: Ti^{2+} ($3d^2$) = 2 , Cr^{3+} ($3d^3$) = 3 , Fe^{2+} ($3d^6$) = 4 , Mn^{2+} ($3d^5$) = 5

so the increasing order is $Ti^{2+} < Cr^{3+} < Fe^{2+} < Mn^{2+}$

34 **Answer (D)**

The isotope used to detect tumours is cobalt-60 , and the configuration of its atom is [Ar] $4s^2$ $3d^7$

The number of its unpaired electrons = 3 , and 60 is the mass number, not the atomic number

35 **Answer (D)**

Groups 3 and 11 have one unpaired electron, 4 and 10 have two, and 5 and 9 have three

Group 6 has six unpaired electrons ($4s^1$ $3d^5$) and group 12 has zero, so they differ

36 **Answer (C)**

Y^{4+} has 5 unpaired electrons, i.e. $3d^5$, so the atom has 27 electrons and it is cobalt
and cobalt is used in modern car batteries

37 **Answer (C)**

Cu^+ has the configuration [Ar] $3d^{10}$, so the 3d sublevel is full
Silver is in the fifth period, scandium has one oxidation state, and Fe^{2+} has 4 unpaired electrons

38 **Answer (D)**

Co^{3+} $(27 - 3 = 24$ electrons) and Fe^{2+} $(26 - 2 = 24$ electrons) have the configuration [Ar] $3d^6$

39 **Answer (D)**

The most stable state of manganese is Mn^{2+} , where 3d is half-filled ($3d^5$)
which is found in MnO

40 **Answer (B)**

MO_2 , M_2O_3 and MO_4^- show the oxidation states +4 , +3 and +7 , and HMO_4^- shows +6
and this variety of oxidation states is a property of manganese

41 **Answer (C)**

The cation M^{2+} has 26 electrons, so the atom has 28 electrons and it is nickel
and the element that follows it in the period is copper Cu

42 **Answer (B)**

The compound MXY_4 used as an insecticide and fungicide is $CuSO_4$
so the oxidation number of M is +2 , X (sulphur) is +6 , and Y (oxygen) is −2

43 **Answer (D)**

$KMnO_4$ is added to fish tanks to fight parasites, and manganese is +4 in MnO_2
$MnSO_4$ protects crops from fungi
while $MnSO_4$ is not an alloy, and $KMnO_4$ is not used to detect tumours

44 **Answer (C)**

The metal M is titanium (its stable chloride is $TiCl_4$ and it reacts with steam forming TiO_2)
Its strength is higher than that of aluminium at high temperatures

45 **Answer (D)**

In MO_2 , M^{4+} has 3 electrons in 3d , so the metal is manganese Mn (Mn^{4+} $3d^3$)

Manganese sulphate $MnSO_4$ has Mn^{2+} ($3d^5$) and is used as a fungicide

46 **Answer (B)**

Chromium is used in tanning leather, and copper is the first metal known to man

Both have one electron in 4s (Cr: $4s^1$ $3d^5$, Cu: $4s^1$ $3d^{10}$)

47 **Answer (C)**

The most stable halides are $FeCl_3$, VF_5 and $TiCl_4$

48 **Answer (C)**

Yttrium Y has the oxidation state +3 and sulphur −2

so the formula is Y_2S_3

49 **Answer (D)**

Titanium oxide TiO_2 blocks ultraviolet rays, and the oxidation states of Ti are +2 , +3 and +4

so the change from M^{3+} to M^{5+} is not possible because Ti does not reach +5

50 **Answer (D)**

The metals that can be magnetized are Fe, Co and Ni

Iron gives Fe^{3+} (d^5) and Fe^{2+} (d^6) and cobalt gives Co^{2+} (d^7), and none of them gives a d^1 state

51 **Answer (B)**

In the reaction, Mn is reduced from +7 in $KMnO_4$ to +2 in $MnCl_2$

so the formation of $MnCl_2$ shows reduction

52 **Answer (A)**

The oxidizing agent is the one in which X has the higher oxidation state (KXO_4 : +7)

and the reducing agent is K_2XO_4 (+6)

53 **Answer (C)**

A compound that acts as both an oxidizing and a reducing agent has an intermediate oxidation state

In Sc_2O_3, Sc is in the +3 state, which is its only state, so it is neither oxidized nor reduced

54 **Answer (C)**

Chromium oxide Cr_2O_3 is used in making pigments

55 **Answer (B)**

The metal M is scandium Sc and its oxidation state is +3

so the salt is $M_2(SO_4)_3$

56 **Answer (B)**

The configuration ns^2 , $(n-1)d^{10}$ is that of zinc Zn (group IIB)

and it is not a transition element because d is full in its atom and its ions

57 **Answer (D)**

D: Y is a main transition element, Th is an inner transition element, and Hg is not considered a transition element

so this group contains only one main transition element

58 **Answer (D)**

The element is titanium ($4s^2$ $3d^2$); it has two unpaired electrons in 3d

After removing four electrons (4s and d), the fifth comes from the inner 3p sublevel, so the fifth ionization potential is the largest

59 **Answer (C)**

The first ionization potential of the elements of the series increases with the atomic number by a very small difference, not a large one

so statement (C) is the wrong one

60 **Answer (C)**

Curve (X) has a peak at manganese because Mn^{2+} is half-filled ($3d^5$), so removing the third electron is difficult

so it is the third ionization potential

61 **Answer (B)**

(Y) has its peak at manganese; it is the third ionization potential because Mn^{2+} ($3d^5$) is stable

(X) has its lowest value at Mn, so it is the second ionization potential (Mn^+ has the configuration $4s^1$ $3d^5$ and loses the electron easily)

62 **Answer (C)**

The first ionization potentials 762 , 1563 , 2957 and 5298 kJ/mol match iron

63 **Answer (B)**

There is a big jump after the seventh ionization potential (11500 to 18860)
i.e. the element has 7 valence electrons, and it is manganese [Ar] $4s^2$ $3d^5$

64 **Answer (D)**

The big jump is between the third ionization potential (2388) and the fourth (7090)
i.e. the fourth electron was removed from a complete main level, so the oxidation state is M^{4+}

65 **Answer (D)**

Element (Z), with ionization potentials 651 , 1412 , 2828 , 4507 and 6299 , matches vanadium
The compound V_2O_5 is used as a catalyst in making superconducting magnets

Essay questions

1 **Model answer**

The transition element that has 12 radioactive isotopes is cobalt.
(1) Group (9) (VIII).
(2) The chemical formula of cobalt(II) sulphide : CoS

2 **Model answer**

The electron configuration of the metal (Y) : [Kr] , $4d^1$, $5s^2$
(1) $_{21}Sc$: [Ar] , $3d^1$, $4s^2$
(2) The alloy is light and very hard.

3 **Model answer**

The oxidation number of manganese in the compound : +2
(1) $_{25}Mn$: [Ar] , $3d^5$, $4s^2$ $\Longrightarrow$ Mn^{2+} : [Ar] , $3d^5$
(2) Manganese in this compound is difficult to oxidize to Mn^{3+} , because the manganese ion is more stable when its 3d sublevel is half-filled with electrons.

4 **Model answer**

The oxidation number of the metal (M) in the compound MCl_2 is +2 , so the atomic number of element (M) = 2 + 24 = 26
(1) Iron $_{26}Fe$
(2) $_{26}Fe$: [Ar] , $3d^6$, $4s^2$ $\Longrightarrow$ Fe^{3+} : [Ar] , $3d^5$

5 **Model answer**

$_{24}Cr$: [Ar] , $3d^5$, $4s^1$

$_{29}Cu$: [Ar] , $3d^{10}$, $4s^1$

$_{30}Zn$: [Ar] , $3d^{10}$, $4s^2$

(1) The 3d sublevel is completely filled with electrons in both Cu and Zn

(2) The 3d sublevel is completely filled with electrons in Cu , while it is half-filled in Cr

6 **Model answer**

The compound $CuSO_4$ is used as an insecticide and a fungicide, and the oxidation number of copper in it is +2

(1) $_{29}Cu$: [Ar] , $3d^{10}$, $4s^1 \Longrightarrow Cu^{2+}$: [Ar] , $3d^9$

(2) Because it breaks an energy level that is complete with electrons, which needs a large amount of energy.

7 **Model answer**

The graph shows that the fifth ionization potential is much greater than the fourth, so the graph shows the ionization potentials of titanium.

(1) $_{22}Ti$: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^2 \Longrightarrow Ti^{4+}$: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, i.e. five sublevels.

(2) TiO_2 / this compound is used in sunscreen products.

8 **Model answer**

The atomic number of element (X) : 18 + 4 + 3 = 25

The atomic number of element (Y) : 18 + 4 + 2 = 24

(1) (X) : manganese Mn , (Y) : chromium Cr

(2) (X) : $KMnO_4$, (Y) : $K_2Cr_2O_7$

9 **Model answer**

The property : manganese has more than one oxidation state (+7) in MnO_4^- , (+2) in Mn^{2+}

The role of MnO_4^- : it acts as an oxidizing agent.

Past exam questions

1	2	3	4	5	6	7	8	9	10
B	C	C	B	A	C	C	D	C	B
11	12	13	14	15	16	17	18	19	20
D	A	D	B	A	C	C	A	B	A

21	22	23	24	25	26	27	28	29	30
C	D	A	B	A	D	B	B	A	A

31	32	33	34	35	36	37
A	A	B	D	A	A	B

1 **Answer (B)**

The compound used in pigments is Cr_2O_3

Chromium Cr^{3+} has the configuration [Ar] $3d^3$ (it lost $4s^1$ and $3d^2$)

2 **Answer (C)**

Z^{2+} has the configuration [Ne] $3s^2$ $3p^6$, i.e. [Ar] with no d electrons, so the element Ca is a non-transition element

while Y^{2+} and W^{3+} have d electrons

3 **Answer (C)**

Ti^{3+} is easily oxidized to Ti^{4+} by the oxygen of the air

so tube (Z) must be covered

4 **Answer (B)**

V^{5+} has the configuration [Ar] , and its compound V_2O_5 is a catalyst in the contact process

5 **Answer (A)**

Copper Cu_2O contains Cu^+ , whose configuration is [Ar] $3d^{10}$

and copper is a transition element because its ion Cu^{2+} has the incomplete configuration $3d^9$

6 **Answer (C)**

Zn^{2+} has the configuration [Ar] $3d^{10}$, so it has no unpaired electrons

and zinc is a non-transition element because the d level is complete in its atom and in its ion

7 **Answer (C)**

The +2 ion with 4 unpaired electrons: Cr^{2+} ($3d^4$) or Fe^{2+} ($3d^6$)

Chromium is less dense than iron, so (A) is chromium and (B) is iron

Chromium is used in tanning leather and iron in surgical instruments

8 **Answer (D)**

The ratios of unpaired electrons 1 : 1.5 : 3 fit 2 , 3 and 6

i.e. Ti , V and Cr

Ti in artificial joints, V in car springs and Cr in coating metals

9 **Answer (C)**

$ns^{(n-3)}$ with n = 5 means $5s^2$, and $(n-1)d^{2n}$ means $4d^{10}$

The element Cd is non-transition and is used with nickel in Ni–Cd batteries

10 **Answer (B)**

d^2 in the +3 state is vanadium V

V^{5+} reaches the argon configuration [Ar]

Removing a sixth electron, X^{6+} , breaks the complete 3p energy level

11 **Answer (D)**

The number of unpaired electrons is twice that of copper (one), i.e. 2 , so it is nickel Ni

Nickel is used for coating, hydrogenation of oils and an alloy with chromium

while the aluminium alloy for MiG aircraft is that of titanium

12 **Answer (A)**

Mn^{3+} has the configuration $3d^4$ and is reduced to Mn^{2+} , whose configuration $3d^5$ is half-filled and stable

so it is the easiest to reduce

13 **Answer (D)**

W^{3+} has 4 unpaired electrons, i.e. $3d^4$

Its reduction to W^{2+} gives the stable half-filled $3d^5$, so it is the easiest

14 **Answer (B)**

Iron is used in surgical instruments and titanium in artificial joints

and the radioactive cobalt isotope in diagnosing and treating tumours

15 **Answer (A)**

X^{2+} has the configuration $3d^4$, so it is chromium, and its highest oxidation state is +6

X^{6+} has the complete configuration [Ar] , so it is difficult to oxidize to X^{7+}

16 **Answer (C)**

Nickel is the element used in acid-resistant alloys

Ni^{3+} has the configuration [Ar] $3d^7$

17 **Answer (C)**

Fe^{3+} has the half-filled configuration $3d^5$, which is stable

so its reduction to Fe^{2+} is the most difficult of the changes mentioned

18 **Answer (A)**

Iron (ammonia) has 4 unpaired electrons

Nickel (hydrogenation of oils) has two unpaired electrons

The ratio 4 : 2 = 2 : 1

19 **Answer (B)**

Element (B) is Mn because it loses 7 electrons ($4s^2\ 3d^5$)

so (A) is Cr, which loses only 6 electrons and reaches [Ar]

so the seventh ionization potential of Cr breaks a complete level

20 **Answer (A)**

Rechargeable batteries are made of nickel, so the elements are Ni , Co and Fe

Ni^{4+} in NiO_2 , Co^{3+} in Co_2O_3 , and Fe^{2+} in FeO

and the configuration of all three is $3d^6$

21 **Answer (C)**

The M level has 16 electrons, twice the L level (8) , so the element is Ni

Nickel is used with cadmium in the rechargeable Ni–Cd battery

22 **Answer (D)**

Fe^{2+} ($3d^6$) is easily oxidized to Fe^{3+} ($3d^5$)

Co^{3+} ($3d^6$) is oxidized to Co^{4+} ($3d^5$)

so the two elements are iron and cobalt

23 **Answer (A)**

(A) has two unpaired electrons in d , so it is nickel

(B) has a half-filled d level, so it is chromium

The alloy of nickel and chromium (nichrome) is used in heating coils

24 **Answer (B)**

X^{4+} [Ar] $3d^1$ is vanadium

Y^{6+} [Ar] $3d^2$ is iron

The alloy of vanadium with steel resists corrosion and is hard

25 **Answer (A)**

The highest oxidation state in the fourth period is +7 , for manganese

Manganese forms +2 , +3 and +4 and does not form +1

so XCl does not form

26 **Answer (D)**

Fe^{3+} has the configuration [Ar] $3d^5$

Zn^{2+} is $3d^{10}$, Sc^{3+} is [Ar] and so is V^{5+}

27 **Answer (B)**

X^{3+} has the configuration [Ar] $3d^6$, so the number of electrons of the atom is 18 + 6 + 3 = 27 , so it is cobalt

Cobalt is used in making batteries

28 **Answer (B)**

Ni^{3+} has the configuration $3d^7$ and has 3 unpaired electrons

Nickel lies in group 10

29 **Answer (A)**

Nickel is used in the hydrogenation of oils

Ni has the configuration $4s^2$ $3d^8$, and Ni^{3+} loses $4s^2$ and one electron from 3d to become [Ar] $3d^7$

30 **Answer (A)**

31 **Answer (A)**

Copper (group 1B) uses $CuSO_4$ as a fungicide

and manganese (group 7B) has a compound used as a disinfectant and pesticide

32 **Answer (A)**

The numbers 6 , 7 and 3 fit Cr (+6) , Mn (+7) and Fe (+3)

which are in groups VIB , VIIB and VIII

33 **Answer (B)**

Mn^{3+} ($3d^4$) is easily reduced to Mn^{2+} ($3d^5$)

so $MnCl_2$ is easily obtained from $MnCl_3$

34 **Answer (D)**

A^{2+} ($3d^3$) is V and B^{2+} ($3d^5$) is Mn

V^{3+} is oxidized to V^{5+} and reaches the stable [Ar] , so this happens easily

Oxidation of Mn^{2+} to Mn^{3+} is difficult because it breaks the half-filled $3d^5$

and the reduction of V^{5+} is difficult because it is the stable [Ar]

35 **Answer (A)**

Ni has the largest first ionization potential among the elements mentioned

because the effective nuclear charge increases as the atomic number increases

36 **Answer (A)**

X^{3+} with d^2 is vanadium V

V^{5+} has the configuration [Ar] , and removing the sixth electron breaks a complete level

so the ionization potential becomes very high at the state X^{6+}

37 **Answer (B)**

K_2MnO_4 $(+6)$ has Mn^{6+} with the configuration $3d^1$

Its oxidation to $KMnO_4$ $(+7)$ gives $3d^0$, so it is easy