9

10.

11.

12.

Objective Questions I (Only one correct option)

- Thermal decomposition of a Mn compound (X) at 513 K results in compound (Y), MnO₂ and a gaseous product. MnO₂ reacts with NaCl and concentrated H₂SO₄ to give a pungent gas Z. X, Y and Z, respectively, are (2019 Main, 12 April II)

 (a) K₃MnO₄, K₂MnO₄ and Cl₂
 (b) K₂MnO₄, KMnO₄ and SO₂
 (c) KMnO₄, K₂MnO₄ and Cl₂
 (d) K₂MnO₄ and Cl₂
- The pair that has similar atomic radii is

 (a) Mn and Re
 (b) Ti and Hf
 (c) Sc and Ni
 (d) Mo and W
- The correct order of the first ionisation enthalpies is (2019 Main, 10 April II)

(a)	Mn < Ti < Zn < Ni	(b) $Ti < Mn < Zn < Ni$
(c)	Zn < Ni < Mn < Ti	(d) $Ti < Mn < Ni < Zn$

- 4. The highest possible oxidation states of uranium and plutonium, respectively, are (2019 Main, 10 April II)
 (a) 7 and 6
 (b) 6 and 7
 (c) 6 and 4
 (d) 4 and 6
- **5.** Consider the hydrated ions of Ti^2 , V^2 , Ti^3 and Sc^3 . The correct order of their spin-only magnetic moment is

(2019 Main, 10 April I)

(2019 Main, 8 April I)

(a)
$$Sc^{3+} < Ti^{3+} < Ti^{2+} < V^{2+}$$
 (b) $Sc^{3+} < Ti^{3+} < V^{2+}$ Ti^{2+}
(c) $Ti^3 Ti^2 Sc^{3+} V^2$ (d) $V^2 Ti^2 Ti^3 Sc^3$

The maximum number of possible oxidation states of actinoides are shown by (2019 Main, 9 April II)

(a) berkelium, (Bk) and californium (Cf)

(b) nobelium (No) and lawrencium (Lr)

(c) actinium (Ac) and thorium (Th)

(d) neptunium (Np) and plutonium (Pu)

7. The lanthanide ion that would show colour is

(a)	Gd^3	(b)	Sm
(c)	La ³	(d)	Lu^3

8. The correct order of atomic radii is (2019 Main, 12 Jan II)
(a) Ho > N > Eu > Ce
(b) N > Ce > Eu > Ho
(c) Eu > Ce > Ho > N
(d) Ce > Eu > Ho > N

<u>A</u>	4 KOH, O <u>2</u>	² 2 <u>B</u> (Gree	2H ₂	O_2			
3 <u>B</u>	4 HCl	2 <u>C</u> (Purple)	MnO ₂	2 2H	I ₂ O		
2 <u>C</u>	H_2O , KI	2 <u>A</u>	2KOH	<u>D</u>			
In th	ie above s	equence	ofreact	ions, <u>-</u>	<u>4</u> and <u>1</u> (2), respect 019 Main,	ively, are 11 Jan II)
(a) I	ZI and KM	[n()	(b) M	-0 and	I KIO	
(a) 1			(10_2 and		
(c) ł	KI and K_2	MnO_4	(d) KI	O_3 and	MnO_2	
The	element	that usu	ally doe	es not	show	variable o	oxidation
state	es is				(2	2019 Main	, 11 Jan I)
(a) S	Sc	(b) Cu	(c) Ti		(d) V	
The	71 st electr	ron of an	element	t X wit	th an at	omic nur	ber of 71
anto	vinto the	orbital	elemen		()		10 1 11
ente	is into the	orbitar			(2	019 Main,	IO Jan II)
(a) 4	f	(b) 6 <i>p</i>	(c) 5 <i>d</i>		(d) 6 <i>s</i>	
The	effect of	lanthand	oid cont	ractio	n in the	lanthand	oid series
af al	lamanta h	read la			//		10 1
ore	lements o	y and la	rge mea	ns	(2	2019 Main	, 10 Jan I)
(a) i	ncrease in	atomic ra	adii and c	lecreas	se in ion	ic radii	

- (b) decrease in both atomic and ionic radii
- (c) increase in both atomic and ionic radii
- (d) decrease in atomic radii and increase in ionic radii
- 13. The transition element having least enthalpy of atomisation is (2019 Main, 9 Jan II) (a) Zn (b) V (c) Fe (d) Cu

(i)
$$ZnO + Na_2O$$
 Na_2ZnO_2 ii) $ZnO + CO_2$ $ZnCO_3$ a) base and acid(b) base and basec) acid and acid(d) acid and base

15. Sodium salt of an organic acid 'X' produces effervescence with conc. H_2SO_4 . 'X' reacts with the acidified aqueous CaCl₂ solution to give a white precipitate which decolourises acidic solution of KMnO₄. 'X' is (2017 Main)

(a) C_6H_5COONa	(b) HCOONa
(c) CH ₃ COONa	(d) $Na_2C_2O_4$

16. Which of the following combination will produce H_2 gas? (2017 Adv.)

(a) Fe metal and conc. HNO₃
(b) Cu metal and conc. HNO₃
(c) Au metal and NaCN (*aq*) in the presence of air
(d) Zn metal and NaOH (*aq*)

- 17. Which of the following compounds is metallic and ferromagnetic? (2016 Main)
 (a) CrO₂
 (b) VO₂
 (c) MnO₂
 (d) TiO₂
- 18. The reaction of zinc with dilute and concentrated nitric acid, respectively, produce (2016 Main)
 (a) NO₂ and NO (b) NO and N₂O (c) NO₂ and N₂O (d) N₂O and NO₂
- 19. The geometries of the ammonia complexes of Ni², Pt² and Zn², respectively, are (2016 Main)
 (a) octahedral, square planar and tetrahedral
 (b) square planar, octahedral and tetrahedral
 (c) tetrahedral, square planar and octahedral
 (d) octahedral, tetrahedral and square planar
- 20. Which of the following compounds is not yellow coloured? (2015 Main)
 (a) Zn₂ [Fe (CN)₆]
 (b) K₃ [Co (NO₂)₆]

(c) $(NH_4)_3 [As (Mo_3O_{10})_4]$ (d) $BaCrO_4$

- **21.** Which series of reactions correctly represents chemical relations related to iron and its compound? (2014 Main)
 - (a) Fe $^{\text{Dil. H}_2\text{SO}_4}$ FeSO₄ $^{\text{H}_2\text{SO}_4,\text{O}_2}$ Fe₂(SO₄)₃ Heat Fe
 - (b) Fe ^{O₂, Heat} FeO ^{Dil. H₂SO₄} FeSO₄ ^{Heat} Fe
 - (c) Fe ^{Cl₂, Heat} FeCl₃ ^{Heat, air} FeCl₂ ^{Zn} Fe
 - (d) Fe O_2 , Heat Fe₂O₄ CO, 600 C FeO CO, 700 C Fe
- **22.** Four successive members of the first row transition elements listed below with atomic numbers. Which one of them is expected to have the highest $E_{M^{3+}/M^{2+}}$ value? (2013 Main)

(a) Cr (Z = 24) (b) Mn (Z = 25)(c) Fe (Z = 26) (d) Co (Z = 27)

 zH^+

xMnO₄ yC₂O₄²

23. Consider the following reaction, (2013 Main)

 $x \text{Mn}^{2+}$ $2y \text{CO}_2$ $\frac{z}{2} \text{H}_2 \text{O}$

The values of x, y and z in the reaction are, respectively (a) 5, 2 and 16 (b) 2, 5 and 8(c) 2, 5 and 16 (d) 5, 2 and 8

- 24. Which of the following arrangements does not represent the correct order of the property stated against it? (2013 Main)
 (a) V²⁺ Cr²⁺ Mn²⁺ Fe²⁺: paramagnetic behaviour
 (b) Ni²⁺ Co²⁺ Fe²⁺ Mn²⁺: ionic size
 (c) Co³⁺ Fe³⁺ < Cr³⁺ < Sc³⁺: stability in aqueous solution
 - (d) Sc < Ti < Cr < Mn: number of oxidation states

- 25. The colour of light absorbed by an aqueous solution of CuSO₄ is (2012)
 (a) orange-red (b) blue-green
 (c) yellow (d) violet
- **26.** Which of the following will not be oxidised by O_3 ? (2005) (a) KI (b) FeSO₄ (c) KMnO₄ (d) K₂MnO₄
- 27. Which of the following pair is expected to exhibit same colour in solution? (2005, 1M)
 (a) VOCl₂; FeCl₂ (b) CuCl₂; VOCl₂
 (c) MnCl₂; FeCl₂ (d) FeCl₂; CuCl₂
- **28.** When I is oxidised by MnO_4 in alkaline medium, I converts into (2004) (a) IO_3 (b) I_2 (c) IO_4 (d) IO
- 29. The pair of compounds having metals in their highest oxidation state is (2004, 1M)
 (a) MnO₂, FeCl₃
 (b) [MnO₄], CrO₂Cl₂
 (c) [Fe(CN)₆]³, [Co(CN)₃]
 (d) [NiCl₄]², [CoCl₄]
- (NH₄)₂ Cr₂O₇ on heating gives a gas which is also given by
 (a) heating NH₄NO₂
 (b) heating NH₄NO₃
 (c) Mg₃N₂ H₂O
 (d) Na(comp.) + H₂O₂
- When MnO₂ is fused with KOH, a coloured compound is formed, the product and its colour is (2003, 1M)
 (a) K₂MnO₄, purple green (b) KMnO₄, purple
 (c) Mn₂O₃, brown (d) Mn₃O₄, black
- **32.** Amongst the following, identify the species with an atom in + 6 oxidation state (2000, 1M) (a) MnO₄ (b) Cr(CN)³₆ (c) NiF²₆ (d) CrO₂Cl₂
- 33. On heating ammonium dichromate, the gas evolved is
 (a) oxygen
 (b) ammonia
 (1999, 2M)
 (c) nitrous oxide
 (d) nitrogen
- 34. In the dichromate dianion (1999, 2M)
 (a) 4 Cr—O bonds are equivalent
 (b) 6 Cr—O bonds are equivalent
 (c) all Cr—O bonds are equivalent
 - (d) all Cr—O bonds are non-equivalent
- 35. Which of the following compounds is expected to be coloured? (1997, 1M)
 (a) Ag₂SO₄ (b) CuF₂ (c) MgF₂ (d) CuCl
- 36. Ammonium dichromate is used in some fireworks. The green coloured powder blown in the air is (1997, 1M)
 (a) CrO₃ (b) Cr₂O₃ (c) Cr (d) CO
- **37.** The reaction which proceed in the forward direction is (a) $Fe_2O_3 + 6HCl$ $2FeCl_3 + 3H_2O$ (1991, 1M) (b) $NH_3 + H_2O + NaCl$ $NH_4Cl + NaOH$ (c) $SnCl_4 + Hg_2Cl_2$ $SnCl_2 + 2HgCl_2$ (d) $2CuI + I_2 + 4H^+$ $2Cu^{2+} + 4KI$

- **38.** Zinc-copper couple that can be used as a reducing agent is obtained by (1984, 1M)
 - (a) mixing of zinc dust and copper gauge
 - (b) zinc coated with copper
 - (c) copper coated with zinc
 - (d) zinc and copper wires welded together
- **39.** How many unpaired electrons are present in Ni²⁺? (a) 0 (b) 2 (1981, 1M) (c) 4 (d) 8
- **40.** One of the constituent of German silver is(1980, 1M)(a) Ag(b) Cu(c) Mg(d) Al
- 41. Which of the following dissolves in concentrated NaOH solution? (1980, 1M)
 (a) Fe (b) Zn (c) Cu (d) Ag

Objective Questions II

(One or more than one correct option)

- - (b) Mn^3 is an oxidising agent
 - (c) both Cr^2 and Mn^3 exhibit d^4 electronic configuration
 - (d) when Cr^2 is used as a reducing agent, the chromium ion attains d^5 electronic configuration
- **43.** Fe^3 is reduced to Fe^{2+} by using (2015 Adv.) (a) H₂O₂ in presence of NaOH
 - (b) Na_2O_2 in water
 - (c) H_2O_2 in presence of H_2SO_4
 - (d) Na₂O₂ in presence of H_2SO_4
- 44. Which of the following halides react(s) with AgNO₃(aq) to give a precipitate that dissolves in Na₂S₂O₃(aq)?
 (a) HCl
 (b) HF
 (c) HBr
 (d) HI
- **45.** Reduction of the metal centre in aqueous permanganate ion involves (2011)
 - (a) three electrons in neutral medium
 - (b) five electrons in neutral medium
 - (c) three electrons in alkaline medium
 - (d) five electrons in acidic medium
- **46.** Which of the following statement (s) is/are correct? (1998)
 - (a) The electronic configuration of Cr is [Ar] $3d^54s^1$ (Atomic number of Cr = 24)
 - (b) The magnetic quantum number may have a negative value
 - (c) In silver atom, 23 electrons have a spin of one type and 24 of the opposite type (Atomic number of Ag = 47)
 - (d) The oxidation state of nitrogen in HN_3 is -3
- **47.** Which of the following statement(s) is/are correct when a mixture of NaCl and K₂Cr₂O₇ is gently warmed with conc. H₂SO₄? (1998, 2M)
 - (a) A deep red vapours is formed

- Transition and Inner-Transition Elements **235**
 - (b) Vapours when passed into NaOH solution gives a yellow solution of Na₂CrO₄
 - (c) Chlorine gas is evolved
 - (d) Chromyl chloride is formed
- 48. Which of the following alloys contains Cu and Zn?
 (a) Bronze
 (b) Brass
 (1993, 1M)
 (c) Gun metal
 (d) Type metal
- 49. The aqueous solution of the following salts will be coloured in case of (1990, 1M)
 (a) Zn(NO₃)₂ (b) LiNO₃ (c) Co(NO₃)₂ (d) CrCl₃
 (e) potash alum
- **50.** Potassium manganate (K_2MnO_4) is formed when (1988, 2M)
 - (a) chlorine is passed into aqueous KMnO₄ solution
 - (b) manganese dioxide is fused with KOH in air
 - (c) formaldehyde reacts with potassium permanganate in the presence of strong alkali
 - (d) potassium permanganate reacts with conc. H_2SO_4

Assertion and Reason

Read the following questions and answer as per the direction given below :

- (a) Statement I is true; Statement II is true; Statement II is the correct explanation of Statement I.
- (b) Statement I is true; Statement II is true; Statement II is not the correct explanation of Statement I.
- (c) Statement I is true; Statement II is false.
- (d) Statement I is false; Statement II is true.
- 51. Statement I Zn²⁺ is diamagnetic.
 Statement II The electrons are lost from 4s orbital to form Zn²⁺. (1998, 2M)
- **52.** Statement I To a solution of potassium chromate if a strong acid is added, it changes its colour from yellow to orange.

Statement II The colour change is due to the change in oxidation state of potassium chromate. (1988, 2M)

Fill in the Blanks

- **53.** The compound $Y \operatorname{Ba}_2\operatorname{Cu}_3\operatorname{O}_7$ which show super conductivity has copper in oxidation state assuming that the rare earth element Yttrium in its usual +3 oxidation state. (1994, 1M)
- **54.** The outermost electronic configuration of Cr is

(1994, 1M)

- 55. Fehling's solution A consists of an aqueous solution of copper sulphate while Fehling's solution B consists of an alkaline solution of (1990, 1M)
- **56.** The salts and are isostructural. (FeSO₄ 7H₂O, CuSO₄ 5H₂O,MnSO₄ 4H₂O,ZnSO₄ 7H₂O (1990, 1M)
- **57.** Mn^{2+} can be oxidised to MnO_4 by (SnO₂, PbO₂, BaO₂) (1981, 1M)

True/False

- **58.** Dipositive zinc exhibit paramagnetism due to loss of two electrons from 3*d*-orbitals of neutral atom. (1987, 1M)
- **59.** Copper metal reduces Fe^{2+} in an acidic medium. (1982, 1M)

Integer Answer Type Question

- 60. In neutral or faintly alkaline solution, 8 moles of permanganate anion quantitative oxidise thiosulphate anions to produce X moles of a sulphur containing product. The magnitude of X is(2016 Adv.)
- **61.** In dilute aqueous H_2SO_4 the complex diaquadioxalatoferrate (II) is oxidised by MnO_4^- . For this reaction, the ratio of the rate of change of $[H^+]$ to the rate of change of $[MnO_4]$ is

(2015 Adv.)

62. Consider the following list of reagents, acidified $K_2Cr_2O_7$, alkaline KMnO₄, CuSO₄, H₂O₂, Cl₂, O₃, FeCl₃, HNO₃ and Na₂S₂O₃. The total number of reagents that can oxidise aqueous iodide to iodine is (2014 Adv.)

Subjective Questions

63. (B) Moist air MCl_4 (A)White fumes (M = Transition (purple colour))

Identify the metal M and hence MCl_4 . Explain the difference in colours of MCl_4 and A. (2005)

- **64.** Give reasons : CrO_3 is an acid anhydride. (1999, 2M)
- **65.** A compound of vanadium has a magnetic moment of 1.73 BM. Work out the electronic configuration of the vanadium ion of the compound. (1997)
- **66.** Write balanced equations for the following
 - (i) Oxidation of hydrogen peroxide with potassium permanganate in acidic medium.
 - (ii) Reaction of zinc with dilute nitric acid. (1997, 2M)

67. Complete and balance the following reactions (i) $[MnO_4]^2$ H⁺ $[MnO_4]$ H₂O

	-				
(ii)	$SO_2(aq)$	$Cr_2O_7^2$	$2\mathrm{H}^+$	++	(1994, 2M)

- **68.** Complete and balance the following reaction. $(NH_4)_2 S_2 O_8 H_2 O MnSO_4 \dots + \dots + \dots$ (1993, 1M)
- **69.** Write the balanced chemical equations for the following reactions.
 - (i) A mixture of potassium dichromate and sodium chloride is heated with concentrated H₂SO₄.
 - (ii) Potassium permanganate is added to a hot solution of manganous sulphate. (1990, 2M)
- **70.** Complete and balance the following reactions.

(i)
$$Mn^{2+}$$
 PbO₂ MnO_4 H₂O
(ii) Ag^+ AsH₃ H₃AsO₃ H⁺ (1987 2M

- **71.** Give reason in one or two sentences "Most transition metal compounds are coloured."(**1986**, **1M**)
- **72.** Show with balanced equations for the reactions when
 - (i) potassium permanganate interacts with manganese dioxide in the presence of potassium hydroxide.
 - (ii) potassium ferricyanide is heated with concentrated sulphuric acid. (1985, 2M)
- **73.** State the conditions under which the following preparations are carried out. Give necessary equations which need not be balanced.

"Potassium permanganate from manganese dioxide"

- (1983, 1M)
- 74. Complete and balance the following reactions (1983, 2M)
 (i) Zn NO₃ Zn²⁺ NH₄⁺
 - (ii) $Cr_2O_7^2$ C_2H_4O $C_2H_4O_2$ Cr^{3+}

1.	(c)	2.	(d)	3.	(d)	4.	(b)
5.	(a)	6.	(d)	7.	(b)	8.	(c)
9.	(b)	10.	(a)	11.	(c)	12.	(b)
13.	(a)	14.	(d)	15.	(d)	16.	(d)
17.	(a)	18.	(d)	19.	(a)	20.	(a)
21.	(d)	22.	(d)	23.	(c)	24.	(a)
25.	(a)	26.	(c)	27.	(b)	28.	(a)
29.	(b)	30.	(a)	31.	(a)	32.	(d)
33.	(d)	34.	(b)	35.	(b)	36.	(b)

Answers

37.	(a)	38. (b)	39.	(b)	40.	(b)
41.	(b)	42. (a, b, c)	43.	(a, b)	44.	(a, c, d)
45.	(a, c, d)	46. (a, b, c, d)	47.	(a, b, d)	48.	(b, c)
49.	(c, d)	50. (b, c)	51.	(b)	52.	(c)
53.	<i>x</i> 7/3	54. $3d^54s^1$	55.	Rochelle sal	lt	
56.	$FeSO_4$ 7H ₂ O	and $ZnSO_4$ 7H	$_2O$		57.	PbO_2
58 .	F	59. F	60.	(6)	61.	(8)
62.	(7)					

Hints & Solutions

1. Thermal decomposition of Mn compound (*X*), i.e. $KMnO_4$ at 513 K results in compound *Y*(i.e. K_2MnO_4), MnO_2 and a gaseous product. MnO_2 reacts with NaCl and concentrated H_2SO_4 to give a pungent gas *Z*(i.e. Cl_2). The reactions involved are as follows :

 $\begin{array}{ccccccc} 2 \operatorname{KMnO_4} & {}^{513 \operatorname{K}} & \operatorname{K_2MnO_4} & \operatorname{MnO_2} & \operatorname{O_2}(g) \\ \operatorname{MnO_2} & 4 \operatorname{NaCl} & 4 \operatorname{H_2SO_4} \\ & & \operatorname{MnCl_2} & 4 \operatorname{NaHSO_4} & 2 \operatorname{H_2O} & \operatorname{Cl_2}(g) \\ & & & & (Z) \\ & & & & & \\ \end{array}$

- 2. The pair that has similar atomic radii is Mo and W. It is due to lanthanoid contraction. The factor responsible for lanthanoid contraction is the imperfect shielding of one electron by another in the same set of orbitals. Shielding of 4 *f* is very less due to its diffused shape. As a result, nuclear charge increases. Hence, Mo and W have similar atomic radii.
- **3.** The 3*d*-transition series is
 - Sc Ti Cr Mn Fe Co Ni Cu Zn V Atomic number 21 22 27 23 24 25 26 28 29 Outermost 3d⁸4s² 3d¹⁰4s² $3d^{2}4s^{2}$ $3d^{5}4s^{2}$ Electronic Configuration

In 1st ionisation, one electron will be removed from $4s^2$ subshell/orbital.

With increase in atomic number (Z), i.e. with increase in number of protons in the nucleus, effective nuclear charge (Z^*) also increases from Sc to Zn.

IE Z^*

So, IE order of the given elements will be,

Ti < Mn < Ni < Zn

4. Actinoids show a variety of oxidation states due to comparable energies of 5 f, 6d and 7s energy levels.

In the actinoids family (5 f-block), uranium (U) neptunium (Np), plutonium (Pu) and americium (Am) have highest possible oxidation states of 6, 7, 7 and 6 respectively.

5. The spin only magnetic moment () of each ion can be calculated as :

 $\sqrt{n(n-2)}$ BM

 $[\because n \text{ No. of unpaired electron(s)}]$ *n*, i.e. higher the number of unpaired electron, higher will be the value of .

Metal ion	Ζ	n (for metal ion)	<i>M</i> (BM)	Nature
Ti ²	22	2 $(3d^2)$	$\sqrt{8}$	Paramagnetic
V^2	23	$3(3d^3)$	$\sqrt{15}$	Paramagnetic
Ti ³	22	$1 (3d^{1})$	$\sqrt{3}$	Paramagnetic
Sc^3	21	$0(3d^0)$	0	Diamagnetic

Thus, the correct order of spin only magnetic moments of given hydrated ions will be

 Sc^3 Ti^3 Ti^2 V^2

- **6.** The maximum number of possible oxidation states of actinoids are shown by neptunium (Np) and plutonium (Pu). These actinoids exhibit oxidation states of 3, 4, 5 and 6.
- 7. The lanthanide ion that would show colour is Sm^3 . Colour of a compound depends on the number of electrons in 4 *f*-orbitals. Electronic configuration of given lanthanides are as follows:

Gd ³	$4f^{7}$
Sm^3	$4f^{5}$
La ³	$4f^{0}$
Lu ³	$4 f^{14}$

 Gd^3 have half-filled 4 *f*-orbitals.

 La^3 have no electron in 4 *f*-orbitals.

 Lu^3 have fully-filled 4 *f*-orbitals.

Only Sm^3 contain $4 f^5$. The electrons can easily undergoes excitation. That result in a formation of colour.

8. The correct order of atomic radii is

Europium (Eu) > Cerium (Ce) > Holmium (Ho) > Nitrogen (N)						
199 pm	183 pm	176 pm	65 pm			

Note

- N being the member of *p*-block and second period, have the smallest radii.
- (ii) Rest of all the 3 members are lanthanides with Eu having stable half-filled configuration thus with bigger size than rest two.
- (iii) Among Ce and Ho, Ce has larger size which can be explained on the basis of "Lanthanoid contraction".
- **9.** When $MnO_2(A)$ is fused with alkali in presence of air then potassium manganate (*B*) is formed. Potassium manganate (*B*) is of green colour which disproportionate in a neutral or acidic solution to produce potassium permanganate (*C*). Potassium permanganate (*C*) in presence of acidic medium oxidises iodide to iodate.

The reaction can be shown as:

(i)
$$2 \operatorname{MnO}_{2}$$

(i) $2 \operatorname{MnO}_{2}$
(A)
(i) $2 \operatorname{MnO}_{2}$
(A)
(B)
Potassium manganate
(Green)
(ii) $3 \operatorname{K}_{2} \operatorname{MnO}_{4}$
(B)
 7
(C)
Potassium
permanganate
(purple)
(C)
Potassium
Potassi

(iii)
$$2 \underset{(C)}{\overset{7}{\text{KI}}} \underset{(A)}{\overset{KI}{\text{H}_2}} \overset{4}{2 \underset{(A)}{\overset{4}{\text{MnO}_2}}} 2 \underset{(D)}{\overset{4}{\text{KIO}_3}} 2 \underset{(D)}{\overset{5}{\text{KOH}}} \underset{(D)}{\overset{5}{\text{KIO}_3}} \overset{5}{\overset{5}{\text{MnO}_2}}$$

Thus, A and D are MnO_2 and KIO_3 respectively.

10. The most stable oxidation states in the compounds of the given transition metals of 3d-series are,

Sc: 3; Ti: 3, 4; V: 2, 3, 4, 5; Cu: 1, 2

The electronic configuration of Sc (Z = 21) is [Ar] $3d^1$, $4s^2$. Due to the presence of only one 3d-electron (no pairing energy) and two 4s-electrons, they easily ionise to achieve most stable 3 oxidation state.

11. In the lanthanoid series, atomic number of fourteen 4 *f*-block elements ranges from 58 (Ce) to 71 (Lu).

Ytterbium, Yb(Z 70) has electronic configuration : [Xe] $4 f^{14} 6s^2$. So, the 71nth electron of lutetium, Lu (Z 71) should enter into 5*d* orbital and its (here, Lu is 'X') electronic configuration will be : [Xe] $4 f^{14} 5d^1 6s^2$. It happens so, because *f*-block elements have general electronic configuration, (*n* 2) f^{1} ¹⁴ (*n* 1) d^{1} ¹⁰ ns^2 . Therefore, option (c) is correct.

12. Lanthanoid contraction in the lanthanoid series takes place due to the presence of electron(s) in the 4 *f*-orbitals. *f*-orbitals have poor shielding effect. As a result, the effective nucleur charge will be more experienced by the 5*d* and 6*s*- electrons and it will cause contraction or decrease in both atomic and ionic radii.

13. For transition metals,

 $H_{\text{Atomisation}}$ Strength of metallic bonding

Number of unpaired electrons in the metal atom

For the given 3*d*-transition metals,

V Fe Cu Zn

$$3d^34s^2 \quad 3d^64s^2 \quad 3d^{10}4s^1 \quad 3d^{10}4s^0$$

 $n \quad 3 \quad n \quad 4 \quad n \quad 0 \quad n \quad 0$
[:: $n \quad \text{no. of unpaired electrons]}$

 $H_{\text{Atomisation}} (\text{kJ mol}^{-1}) = 515 \ 418 \ 339 \ 130$

So, absence of unpaired d-electrons and larger size of Zn atoms, make the crystal lattice of Zn less closely packed.

14. Zinc oxide (ZnO) when react with Na_2O it act as acid while with CO_2 it act as base. Therefore, it is an amphoteric oxide.

$$\begin{array}{ccc} ZnO + Na_2O & Na_2ZnO_2\\ Acid & Base & Salt \\ ZnO + CO_2 & ZnCO_3\\ Base & Acid & Salt \end{array}$$

15. The reaction takes place as follows

$$\begin{array}{ccc} Na_2C_2O_4 + H_2SO_4 & Na_2SO_4 + H_2O & + CO_{Effervescence} \\ (X) & (Conc.) \\ Na_2C_2O_4 + CaCl_2 & CaC_2O_4 + 2NaCl_{White ppt.} \\ 5CaC_2O_4 & 2KMnO_4 \\ Purple & 8H_2SO_4 & K_2SO_4 & 5CaSO_4 \\ \end{array}$$

16.
$$Zn_{\text{Amphoteric}}$$
 2NaOH Na₂ZnO₂ H₂

17. Only three elements iron (Fe), cobalt (Co) and nickel (Ni) show ferromagnetism at room temperature. CrO_2 is also a metallic and ferromagnetic compound which is used to make magnetic tapes for cassette recorders.

18.
$$Zn + 4HNO_3$$
 $Zn (NO_3)_2 + 2H_2O + 2NO_2$
 $4Zn + 10HNO_3$ $4Zn (NO_3)_2 + N_2O + 5H_2O$

- **19.** $[Ni(NH_3)_6]^{2+} sp^3d^2$ octahedral $[Pt(NH_3)_4]^{2+} dsp^2$ square planar $[Zn(NH_3)_4]^{2+} sp^3$ tetrahedral
- **20.** $Zn_2[Fe(CN)_6]$, $K_3[Co(NO_2)_6]$ and $(NH_4)_3As [Mo_3O_{10}]_4$ show colour due to *d*-*d* transition while BaCrO₄ is coloured due to charge transfer phenomenon.

Further according to spectrochemical series the strong ligand possessing complex has higher energy and hence lower wavelength. Therefore, complexes containing NO_2 , NH_4 , O^2

etc., ligands show yellow colour while ${\rm CN}~$ forces the complex to impart white colour.

Spectrochemical series

I Br S² SCN Cl NO₃ N₃ F OH $C_2O_4^2$ H₂O NCS CH₃CN py NH₃ en bipy Phen NO₂ PPh₃ CN CO

21. PLAN Analyse each reaction given in the question and choose the correct answer on the basis of oxidation state and stability of iron compounds. Use the concept of Ellingham diagram to solve this problem.

The correct reactions are as follows:

(a) Fe + dil. H₂SO₄ FeSO₄ + H₂
H₂SO₄ + 2FeSO₄ +
$$\frac{1}{2}$$
O₂ Fe₂(SO₄)₃ + H₂O
Fe₂(SO₄)₃ Fe₂O₃(s) + 3SO₃

The given reaction is incorrect in question

22. SRP value normally increases from left to right in the period of *d*-block elements. Some SRP value are exceptionally higher due to stability of product ion. e.g.

$$E_{\text{Mn}^{3+}/\text{Mn}^{2+}}$$
 1.57 V; $E_{\text{Co}^{3+}/\text{Co}^{2}}$ 1.97 V

Thus, $E_{M^{3+}/M^{2+}}$ is highest for Co.

23. The half equations of the reaction are MnO_4 Mn^{2+}

$$C_2O_4^2$$
 CO_2

The balanced half equations are

$$MnO_4$$
 8H 5e Mn^{2+} 4H₂O

$$C_2O_4^2$$
 2CO₂ 2e

On equating number of electrons, we get $2MnO_4$ 16H 10e $2Mn^{2+}$ 8H-

$$10H 10e 21VIII 8H_2C$$

$$5C_2O_4^2$$
 10CO₂ 10

On adding both the equations, we get

$$2MnO_4$$
 $5C_2O_4$ $16H$ $2Mn^{2+}$ 2 $5CO_2$ $\frac{16}{2}H_2C$

Thus x, y and z are 2, 5 and 16 respectively.

- **24.** (a) V^2 3 unpaired electrons Cr² 4 unpaired electrons
 - Mn^2 5 unpaired electrons
 - Fe^2 4 unpaired electrons

$$V^2 Cr^2 < Fe^{2+} Mn^{2+}$$

(b) Ionic size decreases from left to right in the same period.

(c) (As per data from NCERT)

$$\begin{array}{c} {\rm Co}^3 \ / \ {\rm Co}^{2+} & 1.97; \\ {\rm Fe}^{3+} \ / {\rm Fe}^{2+} & 0.77; \\ {\rm Cr}^{3+} \ / \ {\rm Cr}^{2+} & 0.41 \end{array}$$

 Sc^{3+} is highly stable (It does not show 2).

- (d) The oxidation states increases as we go from group 3 to group 7 in the same period.
- **25.** The aqueous solution of $CuSO_4$ consist of the complex $[Cu(H_2O)_4]^{2^+}$ ion which absorbed in orange-red region and impart deep blue colouration to solution.
- **26.** $KMnO_4$ is itself a very strong oxidising agent, O_3 cannot oxidise it.
- **27.** In CuCl₂, Cu²⁺ has d^9 configuration, exhibit *d-d* transition and show colour. Similarly in VOCl₂, V⁴⁺ has d^1 configuration, can exhibit *d-d* transition and show colour.

$$28. MnO_4 + I + OH MnO_4^2 + IO_3$$

- **29.** In MnO_4 , Mn^{7+} is in highest oxidation state possible for Mn. In CrO_2Cl_2 , Cr^{6+} is in highest oxidation state possible for Cr.
- **30.** Ammonium dichromate on heating produces $N_2(g)$. NH_4NO_2 also gives N_2 on heating :

 $\begin{array}{ll} ({\rm NH}_4)_2 {\rm Cr}_2 {\rm O}_7 & {\rm N}_2 + {\rm Cr}_2 {\rm O}_3 + 4 {\rm H}_2 {\rm O} \\ \\ {\rm NH}_4 {\rm NO}_2 & {\rm N}_2 + 2 {\rm H}_2 {\rm O} \end{array}$

31. K_2MnO_4 (purple green) is formed which is the first step of preparation of KMnO₄.

$$2MnO_2 + 4KOH + O_2 \qquad \qquad K_2MnO_4 + 2H_2O$$

Purple green

32. In CrO_2Cl_2 , Cr is in + 6 oxidation state because Cl is in (-1) and, oxygen is in (-2) oxidation states.

33.
$$(NH_4)_2Cr_2O_7$$
 $N_2 + Cr_2O_3 + 4H_2O$

34. The structure of dichromate ion is :

Exhibit resonance phenomena. Except the bridged Cr—O—Cr, all Cr—O bonds are equivalent.

- **35.** $\operatorname{Cu}^{2+}(3d^9)$ undergo *d-d* transition, exhibit colour.
- **36.** Ammonium dichromate $[(NH_4)_2Cr_2O_7]$ on heating decomposes producing green powder of Cr_2O_3 and $N_2(g)$ is evolved.
- **37.** Fe_2O_3 is a basic oxide, neutralised by HCl spontaneously forming $FeCl_3$ and water.
- **38.** Zinc coated with copper is used as a reducing agent.
- **39.** The valence shell electronic configuration of Ni^{2+} is :



- **40.** German silver is an alloy of copper (56%), Zn (24%) and Ni(20%).
- 41. Zn being amphoteric, dissolves in both acid and base :

$$Zn + 2NaOH$$
 $Na_2ZnO_2 + H_2$

- **42.** In aqueous solution $Cr^2 (3d^4)$ acts as a reducing agent, oxidising itself to $Cr^3 (3d^3)$ that gives a completely half-field t_{2g} level in octahedral ligand field of H₂O.
 - (b) $Mn^3 (3d^4)$ is an oxidising agent as it is reduced to $Mn^2 (3d^5)$, a completely half-filled stable configuration.
 - (c) Both Cr^{2+} and Mn^{3+} have d^4 configuration.

(d) $3d^4 \operatorname{Cr}^{2+}(aq) = {}^{\mathrm{R.A}} \operatorname{Cr}^{3+}(aq) + e^{-}$

Hence (d) is wrong statement.

- **43.** H_2O_2 is alkaline medium acts as reducing agent, reduces Fe^{3+} to Fe^{2+} . In acidic medium the same H_2O_2 oxidises Fe^{2+} to Fe^{3+} .
- **44.** Solubilities of silver halides in water decreases from fluoride (AgF) to iodide (AgI). Silver fluoride is readialy soluble in water, hence when AgNO₃ solution is added to HF solution (HF being weak acid, its solution maintain very low concentration of F) no precipitate of AgF is formed.

HCl, HBr and HI being all strong acid, forms precipitates of AgCl, AgBr and AgI when $AgNO_3$ solution is added to their aqueous solution.

$$HCl(aq) + AgNO_3(aq)$$
 $AgCl(s) + HNO_3(aq)$
Curdy white $HBr(aq) + AgNO_3(aq)$ $AgBr(s) + HNO_3(aq)$
Pale yellow $Hl(aq) + AgNO_3(aq)$ $AgI(s) + HNO_3(aq)$
Value

The solubilities decreases from AgCl to AgI, AgCl dissolves in aqueous ammonia, AgBr dissolves only slightly in concentrated ammonia while AgI does not dissolve in ammonia solution.

 $Na_2S_2O_3$ solution dissolve all three, AgCl, AgBr, AgI by forming complex $[Ag(S_2O_3)_2]^3$ as $S_2O_3^2$ is a stronger complexing agent than ammonia.

45. In neutral medium

$$\frac{\text{MnO}_{4}^{-}}{\text{MnO}_{2}} \left(\frac{\text{Mn}^{7+} + 3e^{-}}{\text{Mn}^{4+}} \right)$$

In alkaline medium
$$\frac{\text{MnO}_{4}^{-}}{\text{MnO}_{2}} \left(\frac{\text{Mn}^{7+} + 3e^{-}}{\text{Mn}^{4+}} \right)$$

In acidic medium

$$MnO_4^ Mn^{2+}$$
 $(Mn^{7+} + 5e^- Mn^{2+})$

46. Cr :
$$[Ar]3d^54s^1$$

Magnetic quantum number : -l.....0....+l.

Ag $(4d^{10}5s^1)$ All paired electrons have opposite spin. The last one has unpaired spin.

47.
$$4\text{NaCl} + \text{K}_2\text{Cr}_2\text{O}_7 + 6\text{H}_2\text{SO}_4$$

Chromyl chloride
(red vapour)
 $+ 4\text{NaHSO}_4 + 2\text{KHSO}_4 + 3\text{H}_2\text{O}_4$

$$CrO_2Cl_2 + 4NaOH$$
 $Na_2CrO_4 + 2NaCl + 2H_2O$
yellow solution

48. Brass = Cu and Zn Gun metal = Cu, Sn, Zn Bronze = Cu and Sn Type metal = Pb, Sn, Sb

- **49.** $\operatorname{Co}^{2+}(3d^7)$ and $\operatorname{Cr}^{3+}(3d^3)$ have allowed *d*-*d* transition, therefore produces coloured aqueous solution.
- **50.** 2KOH + MnO₂ + O₂ K_2 MnO₄ + H₂O HCHO + KMnO₄ + 2KOH K_2 MnO₄ + H₂O + HCOOH
- **51.** Both Statement I and Statement II are independently true but Statement II is not the correct explanation of Statement I. Diamagnetism is due to lack of unpaired electron in Zn^{2+} (3*d*¹⁰).
- 52. Statement I is true but Statement II is false :

$$\begin{array}{ll} K_2 CrO_4 \ + \ H_2 SO_4 & \qquad K_2 Cr_2 O_7 \ + \ K_2 SO_4 \ + \ H_2 O \\ \text{Yellow} & \qquad \text{Orange} \end{array}$$

In both K_2CrO_4 and $K_2Cr_2O_7$, chromium is in +6 oxidation state.

53.
$$Y = +3$$
, 2Ba 2 2 4
7 'O' 7 (2) 14
3 4 (14) 3x 0 x $\frac{7}{3}$

- **54.** $3d^54s^1$
- 55. Rochelle salt.
- **56.** $FeSO_4$ 7H₂O and ZnSO₄ 7H₂O
- **57.** PbO₂, a strong oxidising agent, oxidises Mn^{2+} to MnO_4 .
- **58.** $\operatorname{Zn}^{2+}(3d^{10})$ has no unpaired electron-diamagnetic.
- **59.** Cu cannot reduce Fe^{2+}
- **60.** In neutral or faintly alkaline solution, MnO_4 is reduced to MnO_2 and $S_2O_3^2$ is oxidised to SO_4^2 .

$$\begin{array}{c} & & & & & \\ & & & & \\ MnO_4^- & + 1/2 & S_2 & O_3^{2-} & \longrightarrow & SO_4^{2-} & + & MnO_2 \\ & & & +2 & & +6 & & +4 \\ & & & & Change in ON = 3 units & & & \\ \end{array}$$

Thus,
$$4MnO_4 + \frac{3}{2}S_2O_3^2$$
 $3SO_4^2 + 4MnO_2$
or $8MnO_4 + 3S_2O_3^2$ $6SO_4^2 + 8MnO_2$

Thus, moles of SO_4^2 formed by 8 moles of MnO_4 6

- **61.** The balanced redox reaction is $MnO_4 \quad [Fe(H_2O)_2 (C_2O_4)_2]^2 \quad 8H^+ \qquad Mn^2 \quad Fe^3 \\ 4CO_2 \quad 6H_2O \\ \frac{r[H]}{r[MnO_4^-]} \quad \frac{8}{1} \quad 8$
- **62.** Acidified K₂Cr₂O₇, CuSO₄, H₂O₂, Cl₂, O₃, FeCl₃ and HNO₃ oxidise aq. iodide to iodine. Alkaline KMnO₄ oxidise aq. iodide to IO₃.

 $Na_2S_2O_3$ is a strong reducing agent which on reaction with ${\rm I}_2$ produces ${\rm I}$.

$$Na_2S_2O_3 + I_2$$
 2I $Na_2S_4O_6$

Therefore, no reaction takes place between $Na_2S_2O_3$ and iodide ion.

Hence, correct integer is (7).

- **63.** $A = [\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ and $M = \text{Ti}, B = \text{TiO}_2$, Ti(IV) has no electron in 3*d*-orbital, no *d*-*d* transition is possible, therefore $M\text{Cl}_4$ is colourless. In *A*, there is one electron in 3*d*-orbital and its *d*-*d* transition is responsible for colour.
- **64.** CrO_3 is anhydride of chromic acid :

$$CrO_3 + H_2O$$
 H_2CrO_4
Chromic acid

65. $\sqrt{n(n-2)}$ BM where 'n' is number of unpaired electrons.

1.73
$$\sqrt{n(n-2)}$$
 $n = 1; V^4 = 3d$

66. (i) $2KMnO_4 + 5H_2O_2 + 3H_2SO_4$

$$+ 2MnSO_4 + 5O_2 + 8H_2O_4$$

 K_2SO_4

(ii)
$$4Zn + 10HNO_3$$
 $4Zn(NO_3)_2 + N_2O + 5H_2O$

67. (i)
$$3MnO_4^2 + 4H^+$$
 $MnO_2 + 2MnO_4 + 2H_2O$

- (ii) $3SO_2(aq) + Cr_2O_7^2 + 2H^+$ $3SO_4^2 + 2Cr^{3+} + H_2O$
- **68.** $(NH_4)_2S_2O_8 = 2H_2O = MnSO_4 = MnO_2 = 2H_2SO_4 = (NH_4)_2SO_4$
- **69.** (i) $K_2Cr_2O_7 + 4NaCl + 6H_2SO_4$ $2CrO_2Cl_2$ + $4NaHSO_4 + 3H_2O + 2KHSO_4$

(ii)
$$2KMnO_4 + 3MnSO_4 + 2H_2O$$
 $5MnO_2$
+ $K_2SO_4 + 2H_2SO_4$

- **70.** (i) $2Mn^{2+} + 5PbO_2 + 4H^+$ (ii) $6Ag^+ + AsH_3 + 3H_2O$ **6**Ag + H₃AsO₃ + 6H⁺
- **71.** Most transition metals have partially filled *d*-orbitals which absorb in visible region and undergo d-d transition, which is responsible for colour.
- **72.** (i) $2KMnO_4 + 4KOH + MnO_2$ $3K_2MnO_4 + 2H_2O$ (ii) $K_4Fe(CN)_6 + 6H_2SO_4 + 6H_2O$ $2K_2SO_4 + FeSO_4 + 3(NH_4)_2SO_4 + 6CO$
- **73.** Potassium permanganate can be prepared from MnO_2 under the following conditions :

$$MnO_{2} + KOH + O_{2} \xrightarrow{Heat} K_{2}MnO_{4} + H_{2}O$$
$$K_{2}MnO_{4} + Cl_{2} \qquad KMnO_{4} + KCl$$

74. (i)
$$4Zn + NO_3 + 10H^+$$

(ii) $Cr_2O_7^2 + 3C_2H_4O + 8H^+$
 $4Zn^{2+} + NH_4^+ + 3H_2O$
 $3C_2H_4O_2 + 2Cr^{3+} + 4H_2O$