Redox Reactions & Hydrogen & Environmental Chemistry

1. Given below are two statements :

   Statement I : H_2O_2 can act as both oxidising and reducing agent in basic medium.

   Statement II : In the hydrogen economy, the energy is transmitted in the form of dihydrogen.

   In the light of the above statement, choose the correct answer from the options given below:

   A. Both statement I and statement II are false

   B. Statement I is true but statement II is false

   C. Both statement I and statement II are true

   D. Statement I is false but statement II is true

   (a) H_2O_2 can acts as both oxidising and reducing agent in basic medium.

   (i) $2Fe^{2+} + H_2O_2 \rightarrow 2Fe^{3+} + 2OH^-$

   In this reaction, H_2O_2 acts as oxiding agent.

   (ii) $2\overset{+7}{M}nO_4^- + 3H_2O_2 \rightarrow 2\overset{+4}{M}nO_2 + 3O_2 + 2H_2O + 2OH^-$

   In this reaction, H_2O_2 acts as reducing agent.

   (b) The basic principle of hydrogen economy is the transportation and storage of energy in the form of liquids or gaseous dihydrogen.

   Advantage of hydrogen economy is that energy is transmitted in the form of dihydrogen and not as electric power

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2. An example of a disproportionation reaction is:

A. $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$

B. $2MnO_4^- + 10I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$

C. $2CuBr \rightarrow CuBr_2 + Cu$

D. $2NaBr + Cl_2 \rightarrow 2NaCl + Br_2$

(A) $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$

-In this reaction, manganese has $+7$ oxidation state in $KMnO_4$ and $+6$ and $+4$ oxidation states in K_2MnO_4 and MnO_2 respectively. This indicates manganese is only getting reduced. So, this reaction is not a disproportionation reaction.

(B) $2MnO_4^- + 10I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$
-In this reaction, manganese has $+7$ oxidation state in MnO_4^- and $+2$ oxidation state in the product side.

Thus, in this reaction as well manganese is getting reduced. So, this reaction is not a disproportionation reaction.

(C) $2CuBr \rightarrow CuBr_2 + Cu$
-In this reaction, copper is $+1$ in $CuBr$ and $+2$ oxidation state in $CuBr_2$and zero oxidation state elemental form. This implies, In this reaction copper is getting both oxidized as well as reduced. Therefore, this reaction is an example of a disproportionation reaction.

(D) $2NaBr + Cl_2 \rightarrow 2NaCl + Br_2$
In this reaction, sodium is $+1$ in both the reactant side as well as the product side. This is just an example of a displacement reaction not a disproportionation reaction.

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3. In order to oxidise a mixture of one mole of each of $FeC_2O_4,\ Fe_2(C_2O_4)_3,\ FeSO_4$ and $Fe_2(SO_4)_3$ in acidic medium, the number of moles of $KMnO_4$ required is :

- **A.** 2
- **B.** 1
- **C.** 3
- **D.** 1.5

Change in oxidation state for respective species:

$Fe^{2+} \rightarrow Fe^{3+} + e^-$

$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$

$MnO_4^- \rightarrow Mn^{2+} + 5e^-$

There will be no change in the oxidation state of $Fe_2(SO_4)_3$ as Fe is already in the highest oxidation state.

Using equivalence concept:

$n_{eq}(KMnO_4) = n_{eq}[FeC_2O_4] + n_{eq}[Fe_2(C_2O_4)_3] + n_{eq}[FeSO_4]$
Let n be the number of moles of $KMnO_4$
$n \times 5 = (1 \times 3) + (1 \times 6) + (1 \times 1)$
$5n = 10$

$\therefore n = 2$

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4. Given standard reduction potentials:
$Co^{3+} + e^- \rightarrow Co^{2+}; E^o = +1.81\ V$
$Pb^{4+} + 2e^- \rightarrow Pb^{2+}; E^o = +1.67\ V$
$Ce^{4+} + e^- \rightarrow Ce^{3+}; E^o = +1.61\ V$
$Bi^{3+} + 3e^- \rightarrow Bi; E^o = +0.20\ V$

oxidizing power of the species will increase in the order:

✗ **A.** $Ce^{4+} < Pb^{4+} < Bi^{3+} < Co^{3+}$

✓ **B.** $Bi^{3+} < Ce^{4+} < Pb^{4+} < Co^{3+}$

✗ **C.** $Co^{3+} < Ce^{4+} < Bi^{3+} < Pb^{4+}$

✗ **D.** $Co^{3+} < Pb^{4+} < Ce^{4+} < Bi^{3+}$

Lower the reduction potential, lower is the tendency of species to get reduced and hence less oxidizing power.
Standard reduction potential increases in the order:
$Bi^{3+} < Ce^{4} < Pb^{4+} < Co^{3+}$
Hence the oxidizing power of the species will increase in the same order i.e.
$Bi^{3+} < Ce^{4} < Pb^{4+} < Co^{3+}$

5. Given that $E^o_{O_2/H_2O} = +1.23V$;

$E^o_{S_2O_8^{2-}/SO_4^{2-}} = 2.05V$

$E^o_{Br_2/Br^-} = +1.09V$

$E^o_{Au^{3+}/Au} = +1.4V$

The strongest oxidising agent is:

- ✗ **A.** Au^{3+}
- ✗ **B.** O_2
- ✓ **C.** $S_2O_8^{2-}$
- ✗ **D.** Br_2

$S_2O_8^{2-}$ is correct

Higher the reduction potential of the species, stronger oxidising power is of the species.

The standard reduction potential is the highest for $S_2O_8^{2-}\ to\ SO_4^{2-}$.

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6. Consider the following reduction processes:

$Zn^{2+} + 2e^- \rightarrow Zn(s); E^o = -0.76\ V$
$Ca^{2+} + 2e^- \rightarrow Ca(s); E^o = -2.87\ V$
$Mg^{2+} + 2e^- \rightarrow Mg(s); E^o = -2.36\ V$
$Ni^{2+} + 2e^- \rightarrow Ni(s); E^o = -0.25\ V$

The reducing power of the metals increases in the order:

A. $Ca < Zn < Mg < Ni$

B. $Ni < Zn < Mg < Ca$

C. $Zn < Mg < Ni < Ca$

D. $Ca < Mg < Zn < Ni$

Lower the reduction potential , higher is the tendency of the species to get oxidised and hence better will be reducing power. So, according to the given data correct order will be:
$Ni < Zn < Mg < Ca$

7. In the reaction of oxalate with permanganate in acidic medium, the number of electrons involved in producing one molecule of CO_2 is:

A. 1

B. 10

C. 2

D. 5

The balanced reaction of oxalate with permanganate in an acidic medium is

$2KMnO_4 + 5H_2C_2O_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O$

The number of electrons involved in producing one molecule of CO_2 are :

$$= \frac{\text{No.of electron involved in balanced reaction}}{\text{No.of moles of } CO_2 \text{ produced}} = \frac{10}{10} = 1$$

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8. Dihydrogen of high purity (>99.95%) is obtained through:

A. The electrolysis of acidified water using Pt electrodes.

B. The electrolysis of warm $Ba(OH)_2$ solution using Ni electrodes.

C. The reaction of Zn with dilute HCl

D. The electrolysis of brine solution.

Pure hydrogen gas can be obtained by the electrolysis of warm $Ba(OH)_2$ solution using Pt or Ni electrodes. As water does not conduct electricity very well, it is usual to electrolyse aqueous solution of $Ba(OH)_2$. The gases produced at anode and cathode must be kept seperate.
Reactions occusirng at anode and cathode are:
Anode:

$$2OH^- \rightarrow H_2O + \frac{1}{2}O_2 + 2e^-$$

Cathode:

$$2H_2O + 2e^- \rightarrow 2OH^- + H_2$$

Overall reaction being

$$H_2O \rightarrow H_2 + \frac{1}{2}O_2$$

Option (b) is correct.

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9. The metal that gives hydrogen gas upon treatment with both acid as well as base is :

- **A.** Zinc
- **B.** Iron
- **C.** Magnesium
- **D.** Mercury

Generally, metals react with acids and produce hydrogen gas but the metals do not react with bases and give off hydrogen gas.
Zinc and aluminium are the exceptions in this case. Both of them can react with acid and with base such metals are known as amphoteric metals.
Amphoteric metals are those that can react both as an acid and as a base.
Many metals such as zinc, copper. Aluminium forms amphoteric oxides or hydroxides.
For zinc .
(A).Zinc can react with strong acid such as HCl to give off H_2. The reaction can be written as :
$Zn + 2HCl \rightarrow ZnCl_2 + H_2$
(B). The reaction of zinc (Zn) with a base $NaOH$ also produces hydrogen.
The reaction is :
$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$
Option (a) is correct

10. Hydrogen has three isotopes (A), (B) and (C). If the number of neutron(s) in (A), (B) and (C) respectively, are (x), (y) and (z), the sum of (x), (y) and (z) is :

- **A.** 4
- **B.** 3
- **C.** 2
- **D.** 1

Hydrogen has three isotopes:

Isotopes	Number of neutrons
Protium $({}^1_1H)$	0
Deutrium $({}^2_1H)$	1
Tritium $({}^3_1H)$	2

The sum is 3

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11. NaH is an example of:

- **A.** Electron-rich hydride
- **B.** Molecular hydride
- **C.** Saline hydride
- **D.** Metallic hydride

Saline hydrides are also called ionic hydride. Metals having electronegativity lower than hydrogen form such hydride. All elements of group 1 and group 2 when heated form ionic hydride. Metallic hydrides are also called interstitial hydride.
sodium being group 1 element forms a saline hydride.
$2Na + H_2 \rightarrow 2NaH$

12. The total number of isotopes of hydrogen and number of radioactive isotopes among them, respectively, are :

- **A.** 2 and 0
- **B.** 3 and 2
- **C.** 3 and 1
- **D.** 2 and 1

Total number of isotopes of hydrogen is 3 namely protium , deuterium , and tritium
Only tritium is a radioactive element
Correct option is (c)

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13. $5\ g$ of zinc is treated separately with an excess of
(a) dilute hydrochloric acid and
(b) aqueous sodium hydroxide.
The ratio of the volumes of H_2 evolved in these two reactions is :

- ✔ **A.** 1 : 1
- ✘ **B.** 2 : 1
- ✘ **C.** 1 : 4
- ✘ **D.** 1 : 2

$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$
$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

According to stoichiometry in both the reaction, equal number of moles of H_2 is evolved.
Hence, option "a" is correct.

14. The synonym for water gas when used in the production of methanol is:

- ✘ **A.** Natural gas
- ✘ **B.** Laughing gas
- ✔ **C.** Syn gas
- ✘ **D.** Fuel gas

$\text{Water gas} \rightarrow CO + H_2$

It is also called syn gas because it is used for synthesis of methanol.

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15. The temporary hardness of water is due to:

- ✔ **A.** $Ca(HCO_3)_2$
- ✘ **B.** $NaCl$
- ✘ **C.** Na_2SO_4
- ✘ **D.** $CaCl_2$

Permanent hardness is due to the presence of dissolved chlorides and sulphates of Calcium, Magnesium, Iron, and other heavy elements. Temporary hardness is caused by bicarbonates of Calcium and Magnesium. Thus, $Ca(HCO_3)_2$ is responsible for temporary hardness of water.

Hence, option (a) is correct.

16. The one that is NOT suitable for the removal of permanent hardness of water is :

- ✘ **A.** Treatment with sodium carbonate
- ✘ **B.** Calgon's method
- ✔ **C.** Clark's method
- ✘ **D.** Ion-exchange method

Temporary hardness of water is removed by Clark's method and boiling. While permanent hardness of water is removed by treatment with sodium carbonate (Na_2CO_3), Calgon's method and ion-exchange method.

Hence, option (c) is correct.

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17. The type of pollution that gets increased during the day time and in the presence of O_3 is

- **A.** Reducing smog
- **B.** Acid rain
- **C.** Global warming
- **D.** Oxidising smog

In presence of ozone(O_3), oxidising smog gets increased during the day time because automobiles and factories produce main components of the photo chemical smog (oxidising smog) results from the action of sunlight on unsaturated hydrocarbon and nitrogen oxide. Ozone is strong oxidising agent and can react with the unburnt hydrocarbons in the polluted air to produce chemicals.

18. The green house gas/es is (are):
(A) Carbon dioxide (B) Oxygen
(C) Water vapour (D) Methane

Choose the most appropriate answer from the options given below:

- **A.** (A), (C) and (D) only
- **B.** (A) and (B) only
- **C.** (A) and (C) only
- **D.** (A) only

A greenhouse gas is a gas that absorbs and emits radiant energy within the thermal infrared range, causing the greenhouse effect. The primary greenhouse gases in Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

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19. Reducing smog is a mixture of

A. Smoke, fog and $CH_2 = CH - CHO$

B. Smoke, fog and SO_2

C. Smoke, fog and N_2O_3

D. Smoke, fog and O_3

Classical smog is a mixture of smoke, fog and SO_2 Chemically it is a reducing mixture and so it is called as reducing smog.

20. Which of the following statement(s) is/(are) incorrect reason(s) for eutrophication?

(1) Excess usage of fertilisers
(2) Excess usage of detergents
(3) Dense plant population in water bodies
(4) Lack of nutrients in water bodies that prevent plant growth

Choose the most appropriate answer from the options given below.

A. (4) Only

B. (1) only

C. (2) and (4) only

D. (3) only

Eutrophication is when a body of water becomes overly enriched with minerals and nutrients that induce excessive growth of plants and algae. This process may result in oxygen depletion of the water body.
So, (4) is incorrect.

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21. (A) Methane leads to both global warming and photochemical smog
(B) Methane is generated from paddy fields
(C) Methane is a stronger global warming gas than CO_2
(D) Methane is a part of reducing smog

The statements that are true :

A. (A), (B), (C) only

B. (A), (B), (D) only

C. (A) and (B) only

D. (B), (C), (D) only

- CH_4 causes global warming and also a constituent of photochemical smog. It is a part of oxidising smog.
- CH_4 is generated from paddy fields.
- Due to high heat capacity, CH_4 is a stronger global warming causing gas than CO_2.

22. Which one of the following statements is not correct?

A. Eutrophication leads to increase in the oxygen level in water

B. Eutrophication indicates that water body is polluted

C. Eutrophication leads to anaerobic conditions

D. The dissolved oxygen concentration below 6 ppm inhibits fish growth

The lack of oxygen kills all other forms of aquatic life such as fish and plants. Fertilizers contain phospates as additives. The addition of phosphates in water enhances algae growth. Such profuse growth of algae, covers the water surface and reduces the oxygen concentration in water. This leads to anaerobic conditions, commonly with accumulation of abnoxious decay and animal death. Thus, bloom-infested water inhibits the growth of other living organisms in the water body. This process in which nutrient enriched water bodies support a dense plant population, which kills animal life by depriving it of oxygen and results in subsequent loss of biodiversity is known as eutrophication.

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23. Biochemical Oxygen Demand (BOD) is the amount of oxygen required (in ppm):

- **A.** for the photochemical breakdown of waste present in $1\ m^3$ volume of a water body.
- **B.** by bacteria to break-down organic waste in a certain volume of a water sample.
- **C.** for sustaining life in a water body.
- **D.** by anaerobic bacteria to break down inorganic waste present in a water body.

The amount of oxygen required by bacteria to break down the organic matter present in a certain volume of a sample of water is called Biochemical Oxygen Demand (BOD).
So, option B is correct.

24. The statement that is not true about ozone is:

- **A.** in the stratosphere, CFCs release chlorine free radicals (Cl) which reacts with O_3 to give chlorine dioxide radicals.
- **B.** in the stratosphere, it forms a protective shield against UV radiation.
- **C.** It is a toxic gas and its reaction with NO gives NO_2
- **D.** in the atmosphere, it is depleted by CFCs.

In presence of sunlight CFC's molecule divides & release chlorine free radical, which react with ozone give chlorine monoxide radical $(ClO^{\bullet})$

$$CF_2Cl_2(g) \xrightarrow{UV} \dot{C}l(g) + \dot{C}F_2Cl(g)$$

$$\dot{C}l(g) + O_3(g) \rightarrow ClO^{\bullet}(g) + O_2(g)$$

$$ClO^{\bullet}(g) + O(g) \rightarrow Cl^{\bullet}(g) + O_2(g)$$

Redox Reactions & Hydrogen & Environmental Chemistry

25. Thermal power plants can lead to :

- ✗ **A.** Eutrophication
- ✓ **B.** Acid rain
- ✗ **C.** Ozone layer depletion
- ✗ **D.** Blue baby syndrome

Burning of fossil fuels (which contain sulphur and nitrogen matter) such as coal and oil in power station and furnaces produce sulphur dioxide and nitrogenous oxides which causes acid rain.
Option (b) is correct

26. The correct statements(s) among (a) - (b) regarding acid rain is (are):

(a) It can corrode water pipes

(b) It can damage structures made up of stone.

(c) It cannot cause respiratory ailments in animals

(d) It is not harmful for trees

- ✗ **A.** (a), (c) and (d)
- ✗ **B.** (c) and (d)
- ✓ **C.** (a), (b) and (d)
- ✗ **D.** (c) only

(1) Acid rain corrodes water pipes resulting in the leaching of heavy of heavy metals such as iron, lead and copper into the drinking water

(2) Acid rain damages buildings and other structures made of stone or metal

(3) It causes respiratory aliments in human beings and animals

(4) It is harmful for agriculture, trees and plants as it washes down the nutrients needed for its growth

27. $2MnO_4^- + bC_2O_4^{2-} + cH^+ \rightarrow xMn^{2+} + yCO_2 + zH_2O$

If the above equation is balanced with integer coefficients, the value of c is ..... (Round off to the nearest Integer)

Accepted Answers

16

Solution:

Writing the half reaction

oxidation half reaction
$MnO_4^- \rightarrow Mn^{2+}$

balancing oxygen
$MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

balancing Hydrogen
$8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

balancing charge
$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

Reduction half
$C_2O_4^{2-} \rightarrow CO_2$

Balancing carbon
$C_2O_4^{2-} \rightarrow 2CO_2$

Balancing charge
$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$

Net equation
$16H^+ + 2MnO_4^- + 5C_2O_4^{2-} \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$

So c = 16

28. When $10\ mL$ of an aqueous solution of Fe^{2+} ions was titrated in the presence of dil H_2SO_4 using diphenylamine indicator, $15\ mL$of $\ 0.02\ M$ solution of $K_2Cr_2O_7$ was required to get the end point. The molarity of the solution containing Fe^{2+} ions is $x \times 10^{-2}M$. The value of x is ___. (Nearest integer)

Accepted Answers

18

Solution:

The reaction involved in the given titration is,
$Fe^{2+} + Cr_2O_7^{2-} \rightarrow 6Fe^{3+} + 2Cr^{3+}$
Balancing the above equation,
$6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow Fe^{3+} + Cr^{3+} + 7H_2O$

$\text{milli-equivalents of-}Fe^{2+} = \text{milli-equivalents of-}K_2Cr_2O_7$

$M \times 10 \times 1 = 0.02 \times 15 \times 6$

$M = 0.18 = 18 \times 10^{-2}M$

29. In basic medium, CrO_4^{2-} oxidises $S_2O_3^{2-}$ to form $Cr(OH)_4^-$ and SO_4^{2-}. How many mL(nearest integer) of $0.154\ M\ CrO_4^{2-}$ are required to react with $40.0\ \text{mL}$ of $0.246\ M\ S_2O_3^{2-}$?

$[\text{Hint}: 0.0154\ M = 0.154 \times 3\ N\ CrO_4^{2-} \text{ and } 0.246\ M = 0.246 \times 8\ N\ S_2O_3^{2-}]$

Accepted Answers

170

Solution:

The reaction is as follows:

$$8CrO_4^{2-} + 3S_2O_3^{2-} \rightarrow 6SO_4^{2-} + 8Cr(OH)_4^-$$

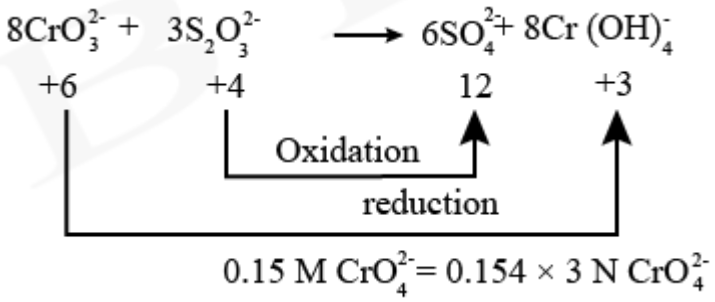
$\text{The normality of } 0.154\ M\ CrO_4^{2-} \text{ is } 0.154 \times 3\ N.$

$\text{Similarity, the normality of } 0.246\ M\ S_2O_3^{2-} \text{ solution is } 0.246 \times 8\ N.$

$N_1V_1 = N_2V_2$

$V \times 0.154 \times 3 = 0.246 \times 8 \times 40$

$V = 170\ \text{mL}.$



30. The volume strength of $8.9\ M\ H_2O_2$ solution calculated at $273\ K$ and $1\ atm$ is _____. ($R = 0.0821\ L\ atmK^{-1}\ mol^{-1}$) (rounded off to the nearest integer)

Accepted Answers

100 100.0 100.00

Solution:

Volume strength of H_2O_2 is the volume of O_2 released on decomposition of one volume of H_2O_2 at STP.
$2H_2O_2 \rightarrow 2H_2O + O_2$
So, 2 moles of H_2O_2 gives 1 mole of O_2
Therefore, 1 mole of H_2O_2 will give $11.2\ L$ of O_2 gas.

Volume strength of H_2O_2 at 1 atm, 273 K = M × 11.2
$= 8.9 \times 11.2$
$= 99.68$
$= 100$
Hence, answer is 100.