Redox Titration in Chemistry Questions with Solutions

Q1. Which of the following are redox titrations?

a.) Iodometric titration
b.) Acid-base titration
c.) Complexometric titration
d.) All of the above

Correct Answer – (d.) All of the above

Q2. The ____ can detect the endpoint of a titration involving the reaction of MnO_4^- to Mn^{2+}.

a.) Use of oH probe
b.) Disappearance of the pink colour of the MnO_4
c.) Addition of an indicator like methyl orange
d.) Use of red or blue litmus

Correct Answer – (b.) Disappearance of the pink colour of the MnO_4

Q3. Due to which of the following reasons can potassium permanganate not be prepared as a primary standard?

a.) It has a relatively low molar mass.
b.) It only reacts in an acidic solution.
c.) Its solutions are volatile.
d.) It is not highly soluble in water.

Correct Answer – (c.) Its solutions are volatile.

Q4. Excess KI reacts with $CuSO_4$ solution, and then $Na_2S_2O_3$ solution is added to it. Which of the statements is incorrect for this reaction?

a.) $Na_2S_2O_3$ is oxidised
b.) CuI_2 is formed
c.) Cu_2I_2 is formed
d.) Evolved I_2 is reduced

Correct Answer – (b.) CuI_2 is formed.

Q5. Dichromate ion reduces to ______ ion in an acidified solution of potassium dichromate (VI).

a.) Chromate (V) ions
b.) Chromium (III) ions
c.) Chromium (II) ions
d.) Chromium (IV) ions

Correct Answer – (b.) Chromium (III) ions

Q6. What is the principle of redox titrations?

Answer. The oxidation-reduction titrations work on the principle that the oxidation process involves electron loss while the reduction process involves electron gain.

Q7. How is the endpoint of a redox titration determined?

Answer. When we add a redox indicator to the titrand, the indicator imparts a colour based on the potential of the solution. As the potential of the solution changes due to the addition of titrant, the indicator changes oxidation state and colour, signalling the endpoint.

Q8. What is the redox titration curve?

Answer. To evaluate a redox titration, first, determine the shape of its titration curve. The titration curve in an acid-base titration or a complexation titration shows how the concentration of H_3O^+ (as pH) or M^{n+} (as pM) changes as the titrant is added. It is more convenient to monitor the potential of the titration reaction rather than the concentration of one species during a redox titration.

Q9. What are the types of redox titrations?

Answer. Redox titrations are named after the titrant used, and they are:
- A bromine (Br_2) titrant is used in bromometry.
- Cerimetry makes use of cerium(IV) salts.
- Potassium dichromate is used in dichrometry.
- Iodine is used in iodometry (I_2).
- Potassium permanganate is used in permanganometry.

Q10. What is the principle of redox titration?

Answer. If the following conditions are met, a redox reaction can be used as the basis for a titration:
- The redox reaction must be rapid and nearly complete (less than 99% success rate is unacceptable).
- The endpoint must be quantifiable or identifiable using a colour indicator or potentiometry.
- Stoichiometric electron exchange means that the redox systems (oxidising and reducing agents) must be adequate and equal.

Q11. Give the general sequence for calculations in redox titration.

Answer. The general sequence for calculating redox titration is as follows:

- Write down the half equations for the oxidant and reductant.
- Determine the overall equation.
- Determine the amount of manganate(VII) or dichromate(VI) used.
- From the overall redox equation, calculate the ratio of moles of oxidant to moles of reductant.
- Determine the number of moles in the reductant sample solution.
- Determine the number of moles of reductant in the original solution.
- Determine either the concentration of the original solution or the percentage of reductant in a known quantity of the sample.

Q12. In dilute sulfuric acid, an iron tablet weighing 0.960 g was dissolved. To reach the endpoint, an average titre of 28.50 cm^3 of 0.0180 mol dm^{-3} potassium manganate(VII) solution was required. What is the iron percentage of the tablet in terms of mass?

Answer. The equation of the reaction is:
MnO_4^- (aq) + $8H^+$ (aq) + $5Fe^{2+}$ → Mn^{2+} (aq) + $5Fe^{3+}$ (aq) + $4H_2O$ (l)

Number of moles of MnO_4^- = 0.0180 × 0.0285 = 0.000513 = 5.13×10^{-4} moles.

According to the balanced equation, the molar ratio of permanganate and ferrous ions is 1:5
Therefore, moles of iron (II) = 5 × 5.13 × 10^{-4} = 2.565 × 10^{-3} moles
Mass of iron (II) = 56 × 2.565 × 10^{-3} = 0.14364 g
% by mass of iron = 90.14364/0.960) × 100 = 15%

Q13. A 32.15 mL sample of MoO_4^{2-}(aq) solution was passed through a Jones reductor (a zinc powder column) to convert all of the MoO_4^{2-}(aq) to Mo3+ (aq). For the reaction given, the filtrate required 20.85 mL of 0.09550 M $KMnO_4^-$(aq).
MnO_4^-(aq) + Mo^{3+}(aq) → Mn^{2+} (aq) + MoO_2^{2+} (aq)
Balance this equation, and determine the concentration of the original MoO_4^{2-} (aq) solution.

Answer. Half reactions:
$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$
$2H_2O + Mo^{3+} \rightarrow MoO_2^{2+} + 4H^+ + 3e^-$

The balanced equation is:
$4H^+ + 3MnO_4^-$ $5Mo^{3+} \rightarrow 3Mn^{2+} + 5MoO_2^{2+} + 2H_2O$

Moles of permanganate required:
0.09550 mol L^{-1} × 0.02085 L = 0.001991175 mol
Moles of molybdate required:
According to the balanced equation, the molar ratio of permanganate and molybdate is 3:5.
Therefore, 0.001991175 × (5/3) = 0.003318625 mol molybdate.

Concentration:

0.003318625 mol/0.03215 L = 0.1032 M

Q14. A flask contains 0.2640 g of sodium oxalate, which requires 30.74 mL of potassium permanganate (from a buret) to titrate and turn pink (the endpoint).
This reaction's equation is:
$5Na_2C_2O_4(aq) + 2KMnO_4(aq) + 8H_2SO_4(aq) \rightarrow 2MnSO_4(aq) + K_2SO_4(aq) + 5Na_2SO_4(aq) + 10CO_2(g) + 8H_2O(l)$

a.) How many moles of sodium oxalate are there in the flask?
b.) How many moles of potassium permanganate were titrated into the flask to reach the endpoint?
c.) What is the molecular weight of potassium permanganate?

Answer.
a.) $\frac{0.2640\ g}{134\ g/mol} = 0.001970149 mol$
The number of moles of sodium oxalate in the flask is 0.00197 mol.

b.) According to the balanced equation, the molar ratio of oxalate to permanganate is 5:2.
$$\frac{moles\ of\ oxalate}{moles\ of\ permanganate} = \frac{5}{2}$$
= 0.001970149 mol oxalate ×(⅖) = 0.00078806 mol permanganate
The number of moles of potassium permanganate = 0.0007881 mol.

c.) The molecular weight of potassium permanganate = 0.00078806 mol / 0.03074 L = 0.02564 mol/L

Q15. Potassium dichromate is used to titrate a sample containing an unknown percentage of iron. To reduce all of the iron to Fe^{2+} ions, the sample is dissolved in an H_3PO_4/H_2SO_4 mixture. The solution is then titrated with 0.01625 M $K_2Cr_2O_7$, resulting in the formation of Fe^{3+} and Cr^{3+} ions in an acidic solution. For 1.2765 g of sample, the titration requires 32.26 mL of $K_2Cr_2O_7$.
(a) Using the half-reaction method, balance the net ionic equation.
(b) Determine the iron % in the sample.
(c) Does the sample consist of ferrous iodate, ferrous phosphate or ferrous acetate?

Answer.
a.) $6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$

b.) Determination of Fe(II) in solution:
(0.01625 mol/L) × (0.03226 L) = 0.000524225 mol dichromate
Since the ratio of ferrous ion to dichromate is 6:1
0.000524225 × (6/1) = 0.00314535 mol Fe
0.00314535 mol Fe(II) × 55.845 g/mol = 0.175652 g
% of iron in the sample:

(0.175652 g/1.2765 g) × 100 = 13.76 %

c.) Calculating the % composition of ferrous iodate, ferrous phosphate, or ferrous acetate will help in determining the sample.
Ferrous iodate = $Fe(IO_3)_2$
%Fe = (55.845 / 405.67) = 13.77 %

Ferrous phosphate = $Fe_3(PO_4)_2$
%Fe = (55.845 / 357.48) = 15.62 %

Ferrous acetate $Fe(C_2H_3O_2)_2$
%Fe = (55.845 /173.93) = 32. 11%

Hence, the sample consists of ferrous iodate.

Practice Questions on Redox Titration

Q1. For redox titrations, $KMnO_4$ is acidified by:

a.) HCl
b.) HNO_3
c.) H_2SO_4
d.) All of the above

Correct Answer– (c.) H_2SO_4.

Q2. Which of the following is the colour change when acidified potassium dichromate (VI) is used as an oxidising agent?

a.) Orange to red
b.) Orange to green
c.) Yellow to red
d.) Yellow to green

Correct Answer– (d.) Yellow to green

Q3. What are redox indicators?

Answer. In laboratories, redox indicators (or oxidation-reduction indicators) are used to track redox reactions, calculate approximate redox potentials, and indicate the endpoint of redox titrations. Redox indicators are weak reductants or oxidisers with different colours in their reduced and oxidised forms. The colour change occurs within a specific redox potential transition range, which must include the redox potential of the equivalence point in the redox titration.

When using an oxidising volumetric solution, the indicator's redox potential must be greater than the potential of the solution, whereas when using a reducing volumetric solution, it must be lower.

Q4. 0.500 g of zinc powder reduced a 25.50 mL acidified solution of 0.200 M AO_2^+. What is metal A's final oxidation number?

Answer. The number of moles of zinc = 0.5g / 65.409 $gmol^{-1}$ = 0.0076442 mol
$Zn \rightarrow Zn^{2+} + 2e^-$
Electrons produced = 0.0076442 × 2 = 0.0152884 mol of electrons
MV = moles
0.200 mol L^{-1} × 0.02550 L = 0.00510 mol of AO_2^+
0.0152884 MOL/0.00510 MOL = 2.998 = 2
In AO_2^+, the oxidation number of A is +5, and was reduced to +2.
Therefore, the final oxidation number is +2.

Q5. Titration with a solution containing a known concentration of $S_2O_3^{2-}$ (aq) can be used to determine the amount of I_3^- (aq) in a solution (thiosulfate ion). The balanced equation is used to make the determination:

$I_3^-(aq) + 2S_2O_3^{2-}(aq) \rightarrow 3I^-(aq) + S_4O_6^{2-}(aq)$

Calculate the molarity of I_3^- (aq) in the solution given that it takes 36.40 mL of 0.3300 M $Na_2S_2O_3$(aq) to titrate the I_3^- (aq) in a 15.00 mL sample.

Answer.
The amount of thiosulphate used:
(0.330 mol/L) × (0.03640 L) = 0.012012 mol

According to the balanced equation, the molar ratio of triiodide to thiosulfate is1:2.
0.012012 × (½) = 0.006006 mol of triiodide

Molarity:
0.006006 mol / 0.01500 L = 0.4004 M.