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CHEMISTRY WORKSHEET

# MIXED REDOX PRACTICE

Course: SCH4U Grade 12 Chemistry

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## 50 Practice Problems with Answers and Detailed Solutions

**FULL** worksheet contains 50 representative problems on:

✓ oxidation numbers, ✓ redox half-reactions, ✓ balancing redox equations, ✓ galvanic cells, ✓ standard and non-standard cell potentials, ✓ electrolysis, ✓ Faraday's law, ✓ custom redox tables.

All problems are designed to reflect style and difficulty commonly seen on quizzes, tests, and final exams. Detailed solutions are included to help students understand the reasoning behind every step.

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### PART A - FUNDAMENTAL PROBLEMS

Problems 1-15. Simple calculations and basic applications

### PART B - INTERMEDIATE PROBLEMS

Problems 16-30. Typical unit test questions involving multiple steps

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### PART C - ADVANCED PROBLEMS

Problems 31-40. More challenging calculations requiring deeper understanding

### PART D - CHALLENGE PROBLEMS

Problems 41-50. Difficult exam-style questions combining multiple concepts

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SUITABLE FOR:

quizzes, unit tests and final exam preparation

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## Section 1 - Essential Information

This page includes only the formulas and habits needed to solve calorimetry problems efficiently

| Formula                      | Use                                                 |
|------------------------------|-----------------------------------------------------|
| $q = m \cdot \Delta T$       | Heat gained or lost by a substance                  |
| $\Delta T = T_f - T_i$       | Temperature change with sign                        |
| $q_{cal} = C_{cal} \Delta T$ | Heat absorbed by a calorimeter                      |
| $q_{sys} = -q_{surrounds}$   | Sign convention for coffee-cup and bomb calorimetry |
| $q_{cal} + q_{sys} = 0$      | Heat exchange between substances                    |
| $\Delta H = q_{surrounds}$   | Enthalpy change at constant pressure                |

**Important definitions:** coffee-cup calorimetry is usually constant pressure, so  $q_p$  can be used for  $\Delta H$ . Bomb calorimetry is constant volume, so the result is commonly treated as  $\Delta U$  for ICNMR-style calculations.

**Fast method:** identify what gains heat, identify what loses heat, convert volumes to masses when density is given, calculate  $\Delta T$  carefully, include  $C_{cal}$  when provided, then apply the sign convention at the end.

**Important notes:** for dilute aqueous solutions, use density = 1.00 g/mL and  $c = 4.184 \text{ J/g } ^\circ\text{C}$  only when stated or clearly assumed. For reactions, the solution and calorimeter are surroundings, while the chemical reaction is the system.

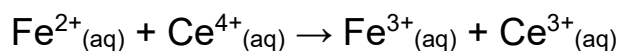
**Common mistakes:** using only one solution volume after mixing, forgetting that  $q_{surrounds}$  has the opposite sign of  $q_{sys}$ , ignoring the limiting reagent, mixing J and kJ, and using the sample mass instead of moles when a molar amount is requested.

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## Section 2 - Practice Problems

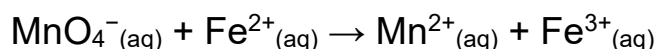
### Part A - Fundamental Problems

**Problem 8.** Balance the redox equation.



### Part B - Intermediate Problems

**Problem 16.** Balance the redox equation in acidic solution.



### Part C - Advanced Problems

**Problem 32.** Balance the redox equation in acidic solution.



### Part D - Challenge Problems

**Problem 45.** Concentrated aqueous NaCl is electrolyzed using inert electrodes. Write the main cathode reaction, anode reaction, and overall reaction.

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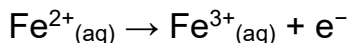
## Section 3 - Solutions

### Problem 8 Solution

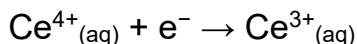
**Given:**  $\text{Fe}^{2+}$  is oxidized to  $\text{Fe}^{3+}$ , and  $\text{Ce}^{4+}$  is reduced to  $\text{Ce}^{3+}$ .

**Find:** The balanced redox equation.

Each  $\text{Fe}^{2+}$  ion loses one electron.



Each  $\text{Ce}^{4+}$  ion gains one electron.



Because the electron coefficients are already equal, the half-reactions combine in a 1:1 ratio. The total charge is +6 on both sides.

**Final answer:**  $\text{Fe}^{2+}_{(\text{aq})} + \text{Ce}^{4+}_{(\text{aq})} \rightarrow \text{Fe}^{3+}_{(\text{aq})} + \text{Ce}^{3+}_{(\text{aq})}$ .

### Problem 16 Solution

**Given:**  $\text{MnO}_4^{-}$  is reduced to  $\text{Mn}^{2+}$ , and  $\text{Fe}^{2+}$  is oxidized to  $\text{Fe}^{3+}$  in acidic solution.

**Find:** The balanced redox equation.

Balance the permanganate reduction half-reaction by adding four  $\text{H}_2\text{O}$  molecules to balance oxygen and eight  $\text{H}^{+}$  ions to balance hydrogen. Five electrons are then added to the reactant side to balance charge.



Iron(II) loses one electron during oxidation.



Multiply the iron half-reaction by five so that both half-reactions involve five electrons. Adding them cancels the electrons and gives an equation balanced for atoms and charge.

**Final answer:**  $\text{MnO}_4^{-}_{(\text{aq})} + 8\text{H}^{+}_{(\text{aq})} + 5\text{Fe}^{2+}_{(\text{aq})} \rightarrow \text{Mn}^{2+}_{(\text{aq})} + 4\text{H}_2\text{O}_{(\text{l})} + 5\text{Fe}^{3+}_{(\text{aq})}$ .

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## Problem 32 Solution

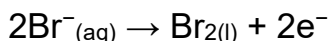
**Given:**  $\text{BrO}_3^-$  reacts with  $\text{Br}^-$  to form  $\text{Br}_2$  in acidic solution.

**Find:** The balanced redox equation.

Bromate is reduced. Balance its three oxygen atoms with three  $\text{H}_2\text{O}$  molecules, its six hydrogen atoms with six  $\text{H}^+$  ions, and the charge with six electrons.



Bromide is oxidized according to:



Multiply the oxidation half-reaction by three, then add. One  $\text{Br}^-$  ion appears on both sides and cancels, leaving five  $\text{Br}^-$  ions as reactants.

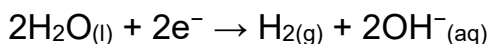
**Final answer:**  $\text{BrO}_3^- (\text{aq}) + 5\text{Br}^- (\text{aq}) + 6\text{H}^+ (\text{aq}) \rightarrow 3\text{Br}_{2(\text{l})} + 3\text{H}_2\text{O} (\text{l})$ .

## Problem 45 Solution

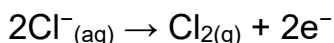
**Given:** Concentrated aqueous  $\text{NaCl}$  is electrolyzed using inert electrodes.

**Find:** The main cathode, anode, and overall reactions.

In aqueous solution,  $\text{Na}^+$  is not reduced because water is reduced more readily. Water gains electrons at the cathode, producing hydrogen gas and hydroxide ions.



In concentrated brine, chloride ions are oxidized at the anode to chlorine gas.



Adding the half-reactions cancels the two electrons. Sodium ions remain in solution and combine with the generated  $\text{OH}^-$  ions, producing  $\text{NaOH}$  in the solution.

**Final answer:** Cathode:  $2\text{H}_2\text{O} (\text{l}) + 2\text{e}^- \rightarrow \text{H}_{2(\text{g})} + 2\text{OH}^- (\text{aq})$ . Anode:  $2\text{Cl}^- (\text{aq}) \rightarrow \text{Cl}_{2(\text{g})} + 2\text{e}^-$ .

Overall:  $2\text{Cl}^- (\text{aq}) + 2\text{H}_2\text{O} (\text{l}) \rightarrow \text{H}_{2(\text{g})} + \text{Cl}_{2(\text{g})} + 2\text{OH}^- (\text{aq})$ .

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## Section 4 - Answer Key

### Part A - Fundamental Problems

| Problem | Final answer                                                                                                                          |
|---------|---------------------------------------------------------------------------------------------------------------------------------------|
| 8       | $\text{Fe}^{2+}_{(\text{aq})} + \text{Ce}^{4+}_{(\text{aq})} \rightarrow \text{Fe}^{3+}_{(\text{aq})} + \text{Ce}^{3+}_{(\text{aq})}$ |

### Part B - Intermediate Problems

| Problem | Final answer                                                                                                        |
|---------|---------------------------------------------------------------------------------------------------------------------|
| 16      | $\text{MnO}_4^- + 8\text{H}^+ + 5\text{Fe}^{2+} \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O} + 5\text{Fe}^{3+}$ |

### Part C - Advanced Problems

| Problem | Final answer                                                                                 |
|---------|----------------------------------------------------------------------------------------------|
| 32      | $\text{BrO}_3^- + 5\text{Br}^- + 6\text{H}^+ \rightarrow 3\text{Br}_2 + 3\text{H}_2\text{O}$ |

### Part D - Challenge Problems

| Problem | Final answer                                                                                                                                                                                                                                      |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 45      | Cathode $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$ ; anode $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$ ; overall $2\text{Cl}^- + 2\text{H}_2\text{O} \rightarrow \text{H}_2 + \text{Cl}_2 + 2\text{OH}^-$ |

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