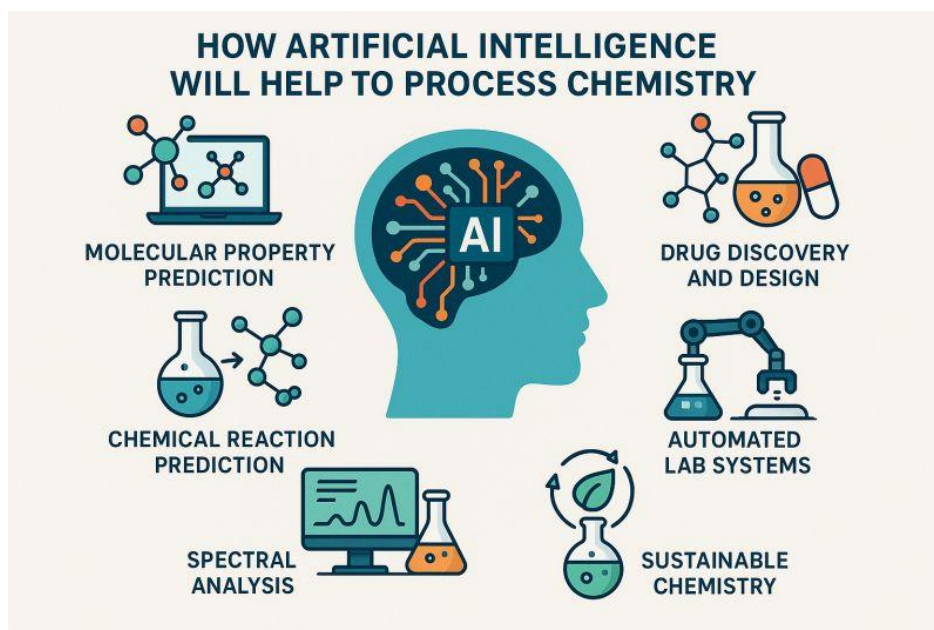


1. INVESTIGATORY PROJECT : on any of the provided topics.
2. PRACTICAL : All the experiments done are to be written in the practical file.
3. ASSIGNMENT : All the assignment questions of chapter 1 (some basic concepts of chemistry) and chapter 7 (redox reactions) to be solved in the chemistry register itself along with all solved and unsolved NCERT questions.

### **INVESTIGATORY PROJECT**



A chemistry project bridges theoretical knowledge with real-world applications. It builds practical laboratory skills, critical thinking, and a deeper understanding of how the central science drives everyday life—from pharmacology and material science to environmental sustainability.

**Computational thinking (CT)** is a systematic problem-solving process that involves breaking down complex issues into manageable steps, identifying patterns, and designing step-by-step algorithms to find solutions.

**Artificial Intelligence (AI)** is a branch of computer science focused on building systems capable of performing tasks that typically require human intelligence.

Artificial Intelligence (AI) and Computational Techniques (CT) are revolutionizing chemistry by automating data analysis, optimizing reaction conditions, and predicting complex molecular properties.

**Integrating Computational Thinking (CT) and Artificial Intelligence (AI) into your Class XII Chemistry**

**Investigatory Project is an excellent way to align with modern [CBSE academic frameworks](#).**

**By using the four pillars of CT—**

**Decomposition,**

**Pattern Recognition,**

**Abstraction, and**

**Algorithmic Thinking—along side Python or no-code AI tools (like Orange or Google Teachable Machine), you can upgrade a traditional laboratory experiment into a cutting-edge data science project.**

# Some TOP Chemistry-AI AND CT based investigatory Project Ideas

## 1. Predictive Chemical Kinetics & Reaction Rate Simulator

- **Traditional Core:** Measuring how concentration, temperature, or catalysts affect the rate of a chemical reaction (e.g., the reaction between Sodium Thiosulphate and Hydrochloric acid).
- **CT & AI Extension:** Collect laboratory reaction time data across various temperatures and concentrations. Use Python (pandas and scikit-learn) to build a Linear Regression model that predicts the reaction rate for values you haven't tested in the lab.
- **Pillars of CT:**
  - *Decomposition:* Breaking down the variables affecting reaction kinetics.
  - *Algorithmic Thinking:* Writing a Python script to compute rate constants and plot curves automatically.

## 2. AI-Based Food Adulteration and Purity Classifier

- **Traditional Core:** Testing for common adulterants in daily food items (e.g., starch in milk, metanil yellow in turmeric, argemone oil in mustard oil).
- **CT & AI Extension:** Take photographs of pure samples and intentionally adulterated samples under consistent lighting. Train an AI Image Classification model using Google Teachable Machine or Python OpenCV to instantly identify and classify whether a sample food image is "Pure" or "Adulterated".
- **Pillars of CT:**
  - *Pattern Recognition:* Spotting subtle color anomalies or texture changes in pure vs. impure substances.
  - *Abstraction:* Filtering out background noise from photos to isolate the food item.

## 3. Water Quality Index (WQI) Prediction using COMPUTATIONAL THINKING

- **Traditional Core:** Analyzing local water samples for pH, Total Dissolved Solids (TDS), and Hardness.
- **CT & AI Extension:** Gather a dataset of water chemical parameters (you can mix your lab data with open-source public datasets like Kaggle's Water Potability dataset). Build a K-Nearest Neighbors (KNN) or Random Forest classifier using no-code tools like Orange Data Mining to classify whether a given chemical combination makes water "Safe" or "Unsafe" for drinking.
- **Pillars of CT:**
  - *Pattern Recognition:* Correlating combinations of high TDS and low pH with toxic water profiles.
  - *Algorithmic Thinking:* Designing a clear decision-tree workflow for water safety approval.

## 4. Molecular Property & Boiling Point Predictor for Hydrocarbons

- **Traditional Core:** Studying the structural properties and functional groups of organic compounds (Alcohols, Carboxylic Acids, Hydrocarbons).
- **CT & AI Extension:** Create a dataset linking the number of carbon atoms, molecular weight, and branching type to the boiling points of alkanes/alcohols. Use a Multiple Linear Regression model in Python to predict the boiling points of complex organic structures.
- **Pillars of CT:**
  - *Pattern Recognition:* Observing how molecular symmetry and surface area alter intermolecular forces (Van der Waals forces).
  - *Abstraction:* Representing real physical molecules as numeric inputs (vectors) for a computer code.

## 5. Optimization of Biodiesel Production Efficiency

- **Traditional Core:** Extracting essential oils or creating biodiesel from used cooking oil or vegetable waste.
- **CT & AI Extension:** Conduct experiments altering variables like oil-to-methanol ratio, catalyst concentration (NaOH/KOH), and temperature. Feed this multi-variable chemistry data into a Regression Machine Learning model to find the absolute optimized mathematical formula for maximizing biodiesel yield.
- **Pillars of CT:**

- **Decomposition:** Separating independent physical variables (heat, catalyst weight) from dependent variables (yield efficiency).

#### 6. Green chemistry in household products

- **Decomposition:** Breaking down a cleaning product into its functional components (e.g., surfactants, chelating agents, enzymes, and fragrances).
- **Pattern Recognition:** Using AI to analyze massive databases of chemical properties, identifying which natural extracts (like fruit enzymes) are the most effective at breaking down grease or neutralizing odors.
- **Abstraction:** Removing unnecessary experimental variables and focusing purely on molecular structures that yield high performance while maintaining a low carbon and toxicity footprint.
- **Algorithm Design:** Developing specific formulas that optimize dilution ratios, minimize water usage, and ensure the final product degrades safely in water treatment systems.

#### Apart from all the above-mentioned topics, students can also do research on the following topics-

1. Ascorbic Acid (Vitamin C) Depletion: Quantifying Vitamin C in fresh citrus juices using iodometric titration and studying degradation over heat exposure.
2. Analysis of food preservatives and find their E numbers.
3. Toothpaste analysis and finding the presence of different mentioned ions.
4. Chemical kinetics in art conservation.
5. Analysis of biscuits and finding their nutritional benefits.
6. Comparison between natural food color and synthetic food color.
7. Comparing fresh coconut water and packed coconut water and comparing their nutritional benefits.
8. Chemicals of aromatherapy.
9. Analysis of packed milk and identify the presence of different nutrients as mentioned on the label.
10. Photography and light sensitive materials.
11. To find out the presence of Nickel in different samples of chocolates through qualitative and quantitative analysis.
12. Natural pigments and dyes.
13. Chemical analysis of different samples of water.
14. Analysis of different samples of packed juices.
15. Alternative energy sources from biomass.
16. Food adulteration in packed food items and loose items . . .
17. Identifying various components used in manufacturing cosmetic products.
18. Identifying the presence of Oxalate Ions in packed Guava Fruit juice ripened fruit and comparing the data with different stages of ripening.
19. Comparison of herbal and non-herbal products.
20. Hydrogen sulfide implications on easing NaCl induced toxicity in egg plant and tomato seedlings.

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- Cover page
- Certificate
- Acknowledgement
- Index
- **Abstract-** Include the keywords
- **Statement of Problem-** A clear statement of the problem/need that has given rise to the project
- **Objectives-** General & specific objectives of topic
- **Introduction-** Purpose, scientific principle involved, reactions, advantages, disadvantages, current examples, case presentation and beneficiary satisfaction.

- **Problem question-** (specific, concrete questions to which concrete answers can be given) and/ or hypotheses
- Materials/Resources required
- **Procedure-** Describe the experiments proposed or the observations planned to make and the detailed process of analysis of data/observations. Methods proposed should be feasible and be able to adequately answer problem question.
- **Observations/Data gathered-** Using the procedures mentioned in introduction, experiments should be conducted and data should be recorded. Interesting things that happened during the conduct of experiments should also be recorded.
- **Testing & analysis-** Data should be interpreted in terms of proposed hypothesis. It should be tabulated and interpreted with the help of graphs if possible. The interpretation should be done in an honest manner even if it does not support proposed hypothesis.
- Discussion of result
- **Conclusion-** Reporting and writing up the report. Discussion of new learning from the study may be covered under conclusion. This may have possible suggestions for future studies.
- **Limitation of the study-** The limitations of the study are those features of design or procedure that might have affected the interpretation of the results of study. The limitations are alternatively interpreted as flaws.
- **Summary** or shortcomings due to flawed methodology, observations, small number of experiments or non-peer reviewed nature of study etc.
- **Evidence-** Photos showcasing the student performing the experiment.
- **References-** Google, Slideshare, Scribd, American Chemical Society, Science Direct and NCERT textbooks etc.

### Rubrics for Assessment of Project

<i>Parameters</i>	<i>Exemplary (3)</i>	<i>Developing (2)</i>	<i>Beginner (1)</i>
<b>Presentation of Factual Information</b>	<ul style="list-style-type: none"> <li>• Relevant to the topic.</li> <li>• Well designed with good flow and appropriate use of pictures and graphs.</li> <li>• Content covers the research well.</li> </ul>	<ul style="list-style-type: none"> <li>• Relevant to the topic.</li> <li>• Well designed with appropriate use of pictures and graphs, but not organised.</li> <li>• Content covered well but has few errors.</li> </ul>	<ul style="list-style-type: none"> <li>• Not relevant to the topic.</li> <li>• Not so well designed. Inappropriate use of pictures and graphs.</li> <li>• Content does not cover all the research.</li> </ul>
<b>Sources</b>	<ul style="list-style-type: none"> <li>• Multiple sources used (books, different websites, journals, etc)</li> </ul>	<ul style="list-style-type: none"> <li>• Few sources used.</li> </ul>	<ul style="list-style-type: none"> <li>• Relied on only one source.</li> </ul>
<b>Project report &amp; Data collection</b>	<ul style="list-style-type: none"> <li>• Well defined problem with clear cut objectives and methodology.</li> <li>• Key concepts clearly specified and explained technically.</li> <li>• Work is well summarized and concluded.</li> </ul>	<ul style="list-style-type: none"> <li>• Well defined problem and methodology but objectives are not clear.</li> <li>• Key concepts specified and explained technically.</li> <li>• Work is well summarized and concluded.</li> </ul>	<ul style="list-style-type: none"> <li>• Poorly defined problem with un-clear objectives and not so appropriate methodology.</li> <li>• Key concepts specified but not explained technically.</li> <li>• Work is not summarized and concluded properly.</li> </ul>
<b>Depth of understanding</b>	<ul style="list-style-type: none"> <li>• Good understanding of the relevance of the project.</li> <li>• Extensive knowledge of not only the project but the related domain as well.</li> </ul>	<ul style="list-style-type: none"> <li>• Fair understanding of the relevance of the project.</li> <li>• Extensive knowledge of the project but not of the related domain.</li> </ul>	<ul style="list-style-type: none"> <li>• Poor understanding of the relevance of the project.</li> <li>• Little knowledge of the project and the domain around but not sufficient.</li> </ul>
<b>Interpretation and conclusion</b>	<ul style="list-style-type: none"> <li>• In correlation with data and aim of project.</li> <li>• Clear conclusions based on findings.</li> </ul>	<ul style="list-style-type: none"> <li>• In correlation with data and aim of project.</li> <li>• Conclusions not based on findings.</li> </ul>	<ul style="list-style-type: none"> <li>• Not in correlation with data and aim of project.</li> <li>• No conclusions.</li> </ul>
<b>Journal</b>	<ul style="list-style-type: none"> <li>• Daily entries with details of discussions and brainstorming sessions with the teacher.</li> </ul>	<ul style="list-style-type: none"> <li>• Daily entries without details.</li> </ul>	<ul style="list-style-type: none"> <li>• Random entries.</li> </ul>

## **ASSIGNMENT QUESTIONS**

### **CHAPTER- 1 (SOME BASIC CONCEPTS OF CHEMISTRY)**

1. The empirical formula and molecular mass of a compound are  $\text{CH}_2\text{O}$  and 180 g respectively. What will be the molecular formula of the compound?

- (a)  $\text{C}_9\text{H}_{18}\text{O}_9$                       (b)  $\text{CH}_2\text{O}$                       (c)  $\text{C}_6\text{H}_{12}\text{O}_6$                       (d)  $\text{C}_2\text{H}_4\text{O}_2$

2. What will be the mass of one atom of C-12 in grams?

- (a)  $1.993 \times 10^{-23}$  g                      (c)  $1.993 \times 10^{-22}$  g  
(b)  $1.993 \times 10^{-21}$  g                      (d)  $1.993 \times 10^{-24}$  g

3. The number of atoms present in one mole of an element is equal to Avogadro number. Which of the following elements contains the greatest number of atoms?

- (a) 4g He                      (b) 46g Na                      (c) 0.40 g Ca                      (d) 12 g He

4. What will be the molarity of a solution, which contains 5.85 g of NaCl (s) per 500 mL?

- (a) 4 mol  $\text{L}^{-1}$                       (b) 20 mol  $\text{L}^{-1}$                       (c) 0.2 mol  $\text{L}^{-1}$                       (d) 2 mol  $\text{L}^{-1}$

5. If 500 mL of a 5 M solution is diluted to 1500 mL, what will be the molarity of the solution obtained?

- (a) 1.5 M                      (b) 1.6 M                      (c) 0.017 M                      (d) 1.59 M

6. One mole of any substance contains  $6.022 \times 10^{23}$  atoms/molecules. Number of molecules of  $\text{H}_2\text{SO}_4$  present in 100 mL of 0.02 M  $\text{H}_2\text{SO}_4$  solution is \_\_\_\_\_

- (a)  $12.044 \times 10^{20}$  molecules                      (b)  $6.022 \times 10^{23}$  molecules  
(c)  $1 \times 10^{23}$  molecules                      (d)  $12.044 \times 10^{23}$  molecules

7. Which of the following has the highest mass?

- (a) 50 g of iron                      (b) 5 moles of nitrogen gas  
(c) 1 g atom of silver                      (d)  $5 \times 10^{23}$  atoms of carbon

8. Which of these solutions have same molar concentration? (multiple options are also possible for this question)

- (a) 49 g  $\text{H}_2\text{SO}_4$  per litre of solution  
(b) 49 g  $\text{H}_3\text{PO}_4$  per litre of solution  
(c) 73 g HCl per litre of solution  
(d) 63 g  $\text{HNO}_3$  per litre of solution

9. Match the following-

(i) 88 g of $\text{CO}_2$	(a) 0.25 mol
(ii) $6.022 \times 10^{23}$ molecules of $\text{H}_2\text{O}$	(b) 2 mol
(iii) 5.6 litres of O, at STP	(c) 1 mol
(iv) 96 g of O	(d) $6.022 \times 10^{23}$ molecules
(v) 1 mol of any gas	(e) 3 mol

- (a) i-c, ii-b, iii-a, iv-e, v-d                      (c) i-b, ii-c, iii-a, iv-e, v-d  
(b) i-a, ii-c, iii-b, iv-e, v-d                      (d) i-d, ii-c, iii-a, iv-e, v-b

10. Which of the following has a larger number of atoms: 1 gram of K or 1 gram of  $\text{Cl}_2$  ?

11. When the density of the solution is  $3.12 \text{ g mL}^{-1}$ , the mass of 1.5 mL solution is \_\_\_\_\_.

12. Calculate the percentage of water of crystallization in the sample of blue vitriol ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ).

**Given below are two statements labelled as Assertion (A) and Reason (R). Select the most appropriate answer from the options given below:**

- (a) Both A and R are true and R is the correct explanation of A.  
(b) Both A and R are true but R is not the correct explanation of A.  
(c) A is true but R is false.  
(d) A is false but R is true.

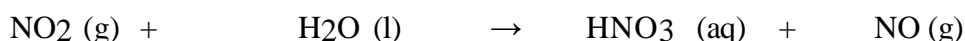
13. Assertion (A): The empirical mass of ethene is half of its molecular mass.

Reason (R): The empirical formula represents the simplest whole-number ratio of various atoms present in a compound.

14. Assertion (A): Combustion of 16 g of methane gives 18 g of water. Reason (R): In the combustion of methane, water is one of the products.

### MOLE CONCEPT

15. In the commercial manufacture of nitric acid, how many moles of NO<sub>2</sub> produce 7.33 mol of HNO<sub>3</sub> in the reaction-



16. One mole of any given substance contains  $6.022 \times 10^{23}$  atoms/molecules. A number of molecules of H<sub>2</sub>SO<sub>4</sub> that are present in 100 mL of 0.02 M H<sub>2</sub>SO<sub>4</sub> solution are \_\_\_\_\_.

17. Two containers of equal capacity A1 and A2 contain 10 grams of oxygen gas and ozone gas respectively. Which of the two will have a greater number of oxygen atoms and which will have a greater number of molecules?

18. Potassium bromide KBr contains 32.9 % by mass of potassium. If 6.40 g of bromine reacts with 3.60 g of potassium, calculate the number of moles of potassium that combine with bromine to form KBr.

19. Two acids H<sub>2</sub>SO<sub>4</sub> and H<sub>3</sub>PO<sub>4</sub> are neutralized separately by the same amount of an alkali when sulphate and dihydrogen orthophosphate are formed respectively. Find the ratio of the masses of H<sub>2</sub>SO<sub>4</sub> and H<sub>3</sub>PO<sub>4</sub>.

### MASS PERCENT AND % COMPOSITION

20. Calculate the mass percent of calcium, phosphorus and oxygen in calcium phosphate Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>.

### LIMITING REAGENT

21. The reactant which is entirely consumed in the reaction is known as a limiting reagent. In the reaction  $2A + 4B \rightarrow 3C + 4D$ , when 5 moles of A react with 6 moles of B, then

- (i) Which is the limiting reagent?  
(ii) Calculate the amount of C formed.

22. Calcium carbonate reacts with aqueous HCl to give CaCl<sub>2</sub> and CO<sub>2</sub> according to the reaction given below:



What mass of CaCl<sub>2</sub> will be formed when 250 mL of 0.76 M HCl reacts with 1000 g of CaCO<sub>3</sub>? Name the limiting reagent. Calculate the number of moles of CaCl<sub>2</sub> formed in the reaction.

### EMPIRICAL FORMULA

23. A crystalline salt on being rendered anhydrous loses 45.6 % of its weight. The percentage composition of the anhydrous salt is- Aluminium= 10.5 %, potassium= 15.1 %, sulphur=24.8 % and oxygen= 49.6 %. Find the simplest formula of the anhydrous and crystalline salt.

24. An organic compound containing C, H and O gave the following composition: C=40.687 %, H=5.058 %, O=54.228 %

The vapour density of the compound is 59. Calculate the molecular formula of the compound.

25. An organic compound containing C, H and O gave the following composition: C=40.687 %, H=5.058 %, O=54.228 %. The vapour density of the compound is 59. Calculate the molecular formula of the compound.

26. A crystalline salt on being rendered anhydrous loses 45.6 % of its weight. The percentage composition of the anhydrous salt is- Aluminium= 10.5 %, potassium= 15.1 %, sulphur=24.8 % and oxygen= 49.6 %. Find the

simplest formula of the anhydrous and crystalline salt.

27. Hydrogen gas is prepared in the laboratory by reacting dilute HCl with granulated zinc. The following reaction takes place.  $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$ . Calculate the volume of hydrogen gas liberated at STP when 32.65 g of zinc reacts with HCl. 1 mol of a gas occupies 22.7 L volume at STP; atomic mass of Zn = 65.3 u.

### CONCENTRATION OF SOLUTIONS

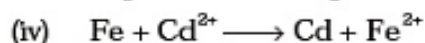
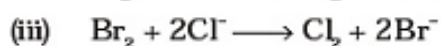
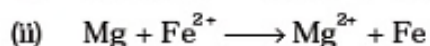
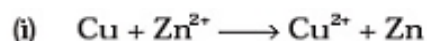
28. When the glucose concentration ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) in the blood is  $0.9 \text{ g L}^{-1}$ , what would be the molarity of glucose found in the blood?
29. When 500 mL of a given 5 M solution is diluted to 1500 mL, what would be the molarity of the new solution?
30. If the density of methanol is  $0.793 \text{ Kg L}^{-1}$ , what is its volume needed for making 2.5 L of its 0.25 M solution?
31. The density of the 3 molal solution of NaOH is  $1.110 \text{ g mL}^{-1}$ . Calculate the molarity of the solution.
32. If 4 g of NaOH dissolves in 36 g of  $\text{H}_2\text{O}$ , calculate the mole fraction of each component in the solution. Also, determine the molarity of solution (specific gravity of solution is  $1 \text{ g mL}^{-1}$ )
33. Calcium carbonate reacts with aqueous HCl to give  $\text{CaCl}_2$  and  $\text{CO}_2$  according to the reaction,  $\text{CaCO}_3 (\text{s}) + 2 \text{HCl} (\text{aq}) \rightarrow \text{CaCl}_2 (\text{aq}) + \text{CO}_2 (\text{g}) + \text{H}_2\text{O} (\text{l})$   
What mass  $\text{CaCO}_3$  is required to react completely with 25 ml of 0.75 M HCl ?



When 1 L of 0.1 M sulphuric acid solution is allowed to react with 1 L of 0.1 M sodium hydroxide solution, what will be the amount of sodium sulphate formed and what will be its molarity in the solution so obtained?

### CHAPTER- 7 (REDOX REACTIONS)

1. The reaction-  $\text{Cl}_2(\text{g}) + 2 \text{OH}^- (\text{aq}) \rightarrow \text{ClO}^- (\text{aq}) + \text{Cl}^- (\text{aq}) + \text{H}_2\text{O}(\text{l})$  represents the process of bleaching. Identify and name the species that bleaches the substances due to their oxidising action.
2.  $\text{MnO}_4^{2-}$  undergoes a disproportionation reaction in an acidic medium but  $\text{MnO}_4^-$  does not. Give a reason.
3. Why does fluorine not show a disproportionation reaction?
4. Nitric acid is an oxidising agent and reacts with  $\text{PbO}$ , but it does not react with  $\text{PbO}_2$ . Explain why?
5. Calculate the oxidation number of phosphorus in the following species.  
(a)  $\text{HPO}_3^{2-}$  and (b)  $\text{PO}_4^{3-}$
6. Calculate the oxidation number of each sulphur atom in the following compounds:  
(a)  $\text{Na}_2\text{S}_2\text{O}_3$  (b)  $\text{Na}_2\text{S}_4\text{O}_6$  (c)  $\text{Na}_2\text{SO}_3$  (d)  $\text{Na}_2\text{SO}_4$
7. Find out the oxidation number of chlorine in the following compounds and arrange them in increasing order of oxidation number of chlorine-  
 $\text{NaClO}_4$ ,  $\text{NaClO}_3$ ,  $\text{NaClO}$ ,  $\text{KClO}_2$ ,  $\text{Cl}_2\text{O}_7$ ,  $\text{ClO}_3$ ,  $\text{Cl}_2\text{O}$ ,  $\text{NaCl}$ ,  $\text{Cl}_2$ ,  $\text{ClO}_2$ .
8. On the basis of standard electrode potential values, suggest which of the following reactions would take place? (Consult the book for  $E^\circ$  value).



9. Identify the redox reactions out of the following reactions and identify the oxidising and reducing agents in them.

- (i)  $3\text{HCl}(\text{aq}) + \text{HNO}_3(\text{aq}) \longrightarrow \text{Cl}_2(\text{g}) + \text{NOCl}(\text{g}) + 2\text{H}_2\text{O}(\text{l})$
- (ii)  $\text{HgCl}_2(\text{aq}) + 2\text{KI}(\text{aq}) \longrightarrow \text{HgI}_2(\text{s}) + 2\text{KCl}(\text{aq})$
- (iii)  $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{CO}(\text{g}) \xrightarrow{\Delta} 2\text{Fe}(\text{s}) + 3\text{CO}_2(\text{g})$
- (iv)  $\text{PCl}_3(\text{l}) + 3\text{H}_2\text{O}(\text{l}) \longrightarrow 3\text{HCl}(\text{aq}) + \text{H}_3\text{PO}_3(\text{aq})$
- (v)  $4\text{NH}_3 + 3\text{O}_2(\text{g}) \longrightarrow 2\text{N}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g})$

10. Balance the following equations by the oxidation number method.

- (i)  $\text{Fe}^{2+} + \text{H}^+ + \text{Cr}_2\text{O}_7^{2-} \longrightarrow \text{Cr}^{3+} + \text{Fe}^{3+} + \text{H}_2\text{O}$
- (ii)  $\text{I}_2 + \text{NO}_3^- \longrightarrow \text{NO}_2 + \text{IO}_3^-$
- (iii)  $\text{I}_2 + \text{S}_2\text{O}_3^{2-} \longrightarrow \text{I}^- + \text{S}_4\text{O}_6^{2-}$
- (iv)  $\text{MnO}_2 + \text{C}_2\text{O}_4^{2-} \longrightarrow \text{Mn}^{2+} + \text{CO}_2$

11. Write a balanced chemical equation for the following reactions:

- (i) Permanganate ion ( $\text{MnO}_4^-$ ) reacts with sulphur dioxide gas in an acidic medium to produce  $\text{Mn}^{2+}$  and hydrogensulphate ion. **(Balance by ion electron method)**
- (ii) Reaction of liquid hydrazine ( $\text{N}_2\text{H}_4$ ) with chlorate ion ( $\text{ClO}_3^-$ ) in basic medium produces nitric oxide gas and chloride ion in a gaseous state. **(Balance by oxidation number method)**
- (iii) Dichlorine heptaoxide ( $\text{Cl}_2\text{O}_7$ ) in gaseous state combines with an aqueous solution of hydrogen peroxide in acidic medium to give chlorite ion ( $\text{ClO}_2^-$ ) and oxygen gas. **(Balance by Ion electron method)**

