

# Redox Reactions JEE Main PYQ – 1

Total Time: 1 Hour

Total Marks: 100

## Instructions

### Instructions

1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

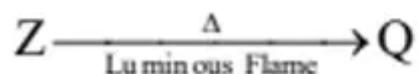
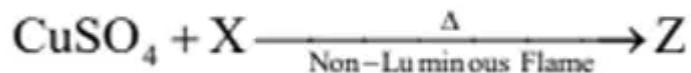
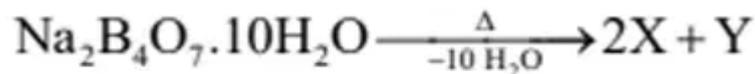
### Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

## Redox Reactions

1. Oxidation state of central metal of  $Z$  and  $Q$  are:

(+4, -1)



- a. +2 and +1
- b. +1 and +2
- c. +2 and +2
- d. +1 and +1

2. 500 ml, 1.2M KI is completely react with 0.2M, 500 ml  $\text{KMnO}_4$  solution in basic medium.  $\text{I}^-$  is oxidised to  $\text{I}_2$ . The liberated  $\text{I}_2$  react with 0.1 M  $\text{Na}_2\text{S}_2\text{O}_3$  solution. Then find volume (in L) of  $\text{Na}_2\text{S}_2\text{O}_3$  solution required to completely react with liberated  $\text{I}_2$ .

(+4, -1)

- a. 1 L
- b. 2 L
- c. 3 L
- d. 4 L

3. For the reaction:

(+4, -1)



1 mole of  $\text{Cl}_2$  is passed into 2 litre, 2 M KOH solution. Determine the molarity of  $\text{Cl}^-$ ,  $\text{ClO}^-$  and  $\text{OH}^-$  respectively.

- a. 1 M, 0.5 M, 0.5 M

- b. 0.5 M, 0.5 M, 1 M
- c. 1 M, 1 M, 0.5 M
- d. 0.5 M, 1 M, 0.5 M

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4. Consider the reaction: (+4, -1)



If 12 g of Mg reacts with excess HCl, choose the incorrect statement.

- a. Moles of Mg used = 0.5 mol
- b. Moles of  $\text{H}_2$  produced = 0.5 mol
- c. Volume of  $\text{H}_2$  at STP = 11.2 L
- d. Mass of  $\text{MgCl}_2$  formed = 47.5 g

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5.  $x$  &  $y$  are the number of moles of electrons involved respectively during oxidation of  $\text{I}^-$  to  $\text{I}_2$  &  $\text{S}^{2-}$  to S by acidified  $\text{K}_2\text{Cr}_2\text{O}_7$ . The value of  $x + y$  is? (+4, -1)

- a. 12
- b. 6
- c. 18
- d. 9

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6. The oxidation state of 'Cr' in the final product formed by reaction between KI and acidified  $\text{K}_2\text{Cr}_2\text{O}_7$  is: (+4, -1)

- a. +2
- b. +6
- c. +4
- d. +3

7. If  $K_2Cr_2O_7$  ( $200\text{ cm}^3, x \times 10^{-3}\text{ M}$ ) reacts with  $0.6\text{ M}, 750\text{ cm}^3$  Mohr's salt then find value of  $x$ ? (+4, -1)

- a. 375
- b. 750
- c. 150
- d. 500

8. In the following reaction: (+4, -1)



Mangante ion undergoes disproportionation in acidic medium to form:

- a.  $\text{MnO}_2, \text{MnO}_4^{2-}$
- b.  $\text{MnO}_4, \text{MnO}_2$
- c.  $\text{MnO}_2, \text{Mn}_2\text{O}_3$
- d.  $\text{MnO}_4, \text{MnO}$

9.  $K_2Cr_2O_7$  is heated with  $KCl$  in pressure of  $H_2SO_4$ . Find the correct match of product with their oxidation state. (+4, -1)

- a.  $\text{CrO}_2\text{Cl}_2, +6$
- b.  $\text{Cr}_2\text{O}_2\text{Cl}_2, +6$
- c.  $\text{Cr}_2\text{O}_2\text{Cl}_2, +5$
- d.  $\text{CrO}_2\text{Cl}_2, +5$

10. When  $8.74\text{ g MnO}_2$  is treated with  $\text{HCl}$ , then what will be the weight of  $\text{Cl}_2(g)$  obtained? Molar mass of  $\text{MnO}_2 = 87.4\text{ g/mol}$ . (+4, -1)

- a. 7.1 g
- b. 17.1 g
- c. 14.2 g
- d. 3.55 g

11. Match the following and choose the correct option.

(+4, -1)

**List-I:**

- (a)  $[\text{Ag}(\text{NH}_3)_2]^+$       (b) Zn-Hg/HCl      (c)  $\text{NH}_2\text{-NH/KOH}$       (d)  $\text{Cu}^{2+}/\text{OH}^-$

**List-II:**

- (i) Fehling solution      (ii) Clemmensen reduction      (iii) Tollen's reagent      (iv) Wolff-Kishner reduction

r reduction

- a. a → (i), b → (ii), c → (iii), d → (iv)
- b. a → (iv), b → (iii), c → (ii), d → (i)
- c. a → (iii), b → (ii), c → (iv), d → (i)
- d. a → (i), b → (ii), c → (iv), d → (iii)

12. When 10 mL of an aqueous solution of  $\text{Fe}^{2+}$  ions was titrated in the presence of dil  $\text{H}_2\text{SO}_4$  using diphenylamine indicator, 15 mL of 0.02 M solution of  $\text{K}_2\text{Cr}_2\text{O}_7$  was required to get the end point. The molarity of the solution containing  $\text{Fe}^{2+}$  ions is  $x \times 10^{-2}$  M. The value of  $x$  is \_\_\_\_\_. (Nearest integer)

(+4, -1)

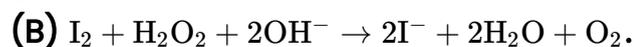
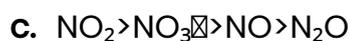
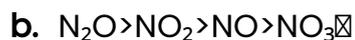
13. 10.0 mL of 0.05 M  $\text{KMnO}_4$  solution was consumed in a titration with 10.0 mL of given oxalic acid dihydrate solution. The strength of given oxalic acid solution is \_\_\_\_\_  $\times 10^{-2}$  g/L. (Round off to the Nearest Integer).

(+4, -1)

14. The oxidation states of nitrogen in NO,  $\text{NO}_2$ ,  $\text{N}_2\text{O}$  and  $\text{NO}_3$  are in the order of :

(+4, -1)

- a.  $\text{NO} > \text{NO}_2 > \text{N}_2\text{O} > \text{NO}_3$



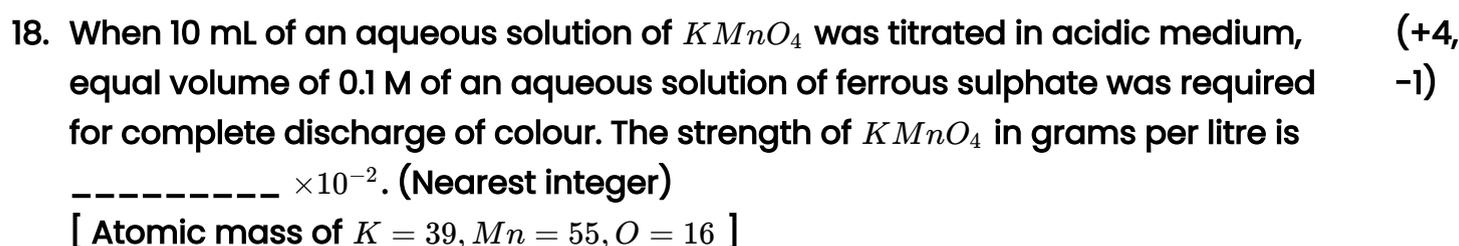
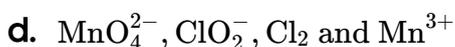
Choose the correct option.

a.  $H_2O_2$  acts as oxidising agent in (A) and (B).

b.  $H_2O_2$  acts as reducing agent in (A) and (B).

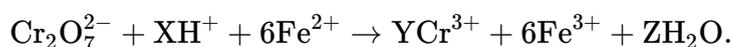
c.  $H_2O_2$  acts as oxidizing and reducing agent respectively.

d.  $H_2O_2$  acts as reducing and oxidising agent respectively.



19.  $\text{KMnO}_4$  acts as an oxidising agent in acidic medium. 'X' is the difference between the oxidation states of Mn in reactant and product. 'Y' is the number of 'd' electrons present in the brown red precipitate formed at the end of the acetate ion test with neutral ferric chloride. The value of  $X + Y$  is \_\_\_\_\_ . (+4, -1)

20. See the following chemical reaction: (+4, -1)



The sum of  $X$ ,  $Y$ , and  $Z$  is \_\_\_\_\_.

21. The standard reduction potential values of some of the p-block ions are given below. Predict the one with the strongest oxidizing capacity. (+4, -1)

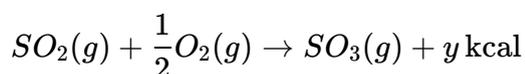
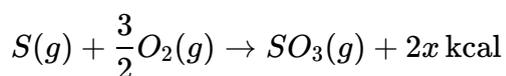
a.  $E_{\text{I}^-/\text{I}_2}^\circ = +1.26 \text{ V}$

b.  $E_{\text{Al}^{3+}/\text{Al}}^\circ = -1.66 \text{ V}$

c.  $E_{\text{Pb}^{4+}/\text{Pb}^{2+}}^\circ = +1.67 \text{ V}$

d.  $E_{\text{Sn}^{4+}/\text{Sn}^{2+}}^\circ = +1.15 \text{ V}$

22. The heat of formation of  $\text{SO}_2(g)$  is given by: (+4, -1)



a.  $\frac{2x}{y} \text{ kcal}$

b.  $x + y \text{ kcal}$

c.  $y - 2x \text{ kcal}$

d.  $2x + y \text{ kcal}$

---

23. Given below are two statements:

(+4, -1)

**Statement (I):** The first ionization energy of Pb is greater than that of Sn.

**Statement (II):** The first ionization energy of Ge is greater than that of Si.

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

- Statement I is true but Statement II is false
- Both Statement I and Statement II are false
- Statement I is false but Statement II is true
- Both Statement I and Statement II are true

24. Match the LIST-I with LIST-II (Redox Reactions).

(+4, -1)

	LIST-I (Redox Reaction)		LIST-II (Type of Redox Reaction)
A.	$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \xrightarrow{\Delta} \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$	I.	Disproportionation reaction
B.	$2\text{NaH}(\text{s}) \xrightarrow{\Delta} 2\text{Na}(\text{s}) + \text{H}_2(\text{g})$	II.	Combination reaction
C.	$\text{V}_2\text{O}_5(\text{s}) + 5\text{Ca}(\text{s}) \xrightarrow{\Delta} 2\text{V}(\text{s}) + 5\text{CaO}(\text{s})$	III.	Decomposition reaction
D.	$2\text{H}_2\text{O}_2(\text{aq}) \xrightarrow{\Delta} 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$	IV.	Displacement reaction

Choose the correct answer from the options given below:

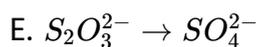
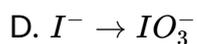
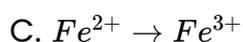
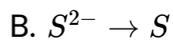
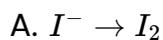
- A-IV, B-I, C-II, D-III
- A-II, B-III, C-I, D-IV

c. A-II, B-III, C-IV, D-I

d. A-III, B-IV, C-I, D-II

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25. Which of the following oxidation reactions are carried out by both  $K_2Cr_2O_7$  (+4, -1) and  $KMnO_4$  in acidic medium?



Choose the correct answer from the options given below:

a. A, B and C Only

b. A, D and E Only

c. B, C and D Only

d. C, D and E Only

## Answers

### 1. Answer: a

#### Explanation:

##### Concept:

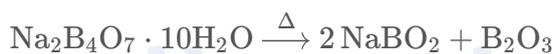
Borax bead test is used to identify metal ions based on color changes and oxidation states in different flames.

Heating borax produces boric oxide and sodium metaborate.

Transition metal salts form colored metaborates.

Oxidation state of metal depends on flame conditions.

#### Step 1: Decomposition of Borax



Thus:



#### Step 2: Reaction with Copper Sulphate



In  $Z$ , copper exists as  $\text{Cu}^{2+}$ .

#### Step 3: Heating in Luminous Flame



In  $Q = \text{Cu}_2\text{O}$ , copper is in +1 oxidation state.

**Final Conclusion:**

Oxidation state in $Z = +2$ ,    Oxidation state in $Q = +1$
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### 2. Answer: c

## Explanation:

Step 1: Reaction of  $\text{KMnO}_4$  with  $\text{KI}$ .

In basic medium,  $\text{KMnO}_4$  is generally reduced to  $\text{MnO}_2$ . Change in oxidation state of Mn:  $+7 \rightarrow +4$ .

n-factor for  $\text{KMnO}_4 = 3$ .

Moles of  $\text{KMnO}_4 = M \times V = 0.2 \times 0.5 = 0.1 \text{ mol}$ .

Equivalents of  $\text{KMnO}_4 = 0.1 \times 3 = 0.3 \text{ Eq}$ .

The problem states  $\text{KI}$  "completely reacts", implying  $\text{KI}$  is in excess or sufficient.

However, usually the oxidant determines the yield of  $\text{I}_2$ .

According to the principle of equivalence: Equivalents of Oxidant = Equivalents of Reductant ( $\text{I}^-$ ) oxidized = Equivalents of  $\text{I}_2$  formed.

So, Equivalents of  $\text{I}_2$  liberated =  $0.3 \text{ Eq}$ .

Step 2: Titration of  $\text{I}_2$  with  $\text{Na}_2\text{S}_2\text{O}_3$ .

Reaction:  $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$ .

n-factor for Hypo ( $\text{S}_2\text{O}_3^{2-}$ ) is 1 (avg oxidation state change  $+2 \rightarrow +2.5$ , change per molecule is 1 electron).

Equivalents of  $\text{Na}_2\text{S}_2\text{O}_3$  required = Equivalents of  $\text{I}_2$ .

$M_{\text{hypo}} \times V_{\text{hypo}} \times n_{\text{hypo}} = 0.3$ .

$0.1 \times V \times 1 = 0.3$ .

$V = 3 \text{ L}$ .

### 3. Answer: b

## Explanation:

Step 1: Balanced reaction in cold  $\text{KOH}$ .



Step 2: Initial moles of reactants.

Moles of  $\text{Cl}_2 = 1$

Moles of  $\text{KOH} = 2 \times 2 = 4$

Step 3: Stoichiometric consumption.

1 mole  $\text{Cl}_2$  consumes 2 moles  $\text{KOH}$

Remaining  $\text{KOH} = 4 - 2 = 2$  moles

Step 4: Calculation of molarity.

Moles of  $\text{Cl}^-$  formed = 1

Moles of  $\text{ClO}^-$  formed = 1

Volume = 2 L

$$[\text{Cl}^-] = \frac{1}{2} = 0.5 \text{ M}$$

$$[\text{ClO}^-] = \frac{1}{2} = 0.5 \text{ M}$$

$$[\text{OH}^-] = \frac{2}{2} = 1 \text{ M}$$

#### 4. Answer: d

##### Explanation:

###### Step 1: Understanding the Question:

We are given a chemical reaction and the mass of one reactant (Magnesium). We need to analyze four statements related to the stoichiometry of this reaction and identify the one that is incorrect. For such problems, it's important to decide whether to use approximate or more precise atomic masses. Using precise values is generally safer.

Approximate Molar Masses:  $\text{Mg} = 24 \text{ g/mol}$ ,  $\text{H} = 1 \text{ g/mol}$ ,  $\text{Cl} = 35.5 \text{ g/mol}$ .

More Precise Molar Masses:  $\text{Mg} = 24.3 \text{ g/mol}$ ,  $\text{Cl} = 35.45 \text{ g/mol}$ .

###### Step 2: Key Formula or Approach:

1. Calculate the moles of the reactant ( $\text{Mg}$ ) using  $\text{Moles} = \text{Mass} / \text{Molar Mass}$ .
2. Use the stoichiometric coefficients from the balanced equation to find the moles of products ( $\text{H}_2$  and  $\text{MgCl}_2$ ).
3. Calculate the volume of  $\text{H}_2$  gas at STP (1 mole = 22.4 L).
4. Calculate the mass of  $\text{MgCl}_2$  produced ( $\text{Mass} = \text{Moles} \times \text{Molar Mass}$ ).
5. Compare the calculated values with each statement.

###### Step 3: Detailed Explanation using approximate masses (often intended for such questions):

Let's use  $M(\text{Mg}) = 24 \text{ g/mol}$  and  $M(\text{Cl}) = 35.5 \text{ g/mol}$ .

- **Statement (A): Moles of  $\text{Mg}$  used = 0.5 mol**

Moles of  $\text{Mg} = \frac{12 \text{ g}}{24 \text{ g/mol}} = 0.5 \text{ mol}$ . This statement is correct.

- **Statement (B): Moles of  $\text{H}_2$  produced = 0.5 mol**

From the reaction, 1 mole of  $\text{Mg}$  produces 1 mole of  $\text{H}_2$ . So, 0.5 mol of  $\text{Mg}$  produces 0.5

mol of  $H_2$ . This statement is correct.

- **Statement (C): Volume of  $H_2$  at STP = 11.2 L**

Volume of  $H_2$  = Moles  $\times$  Molar Volume at STP =  $0.5 \text{ mol} \times 22.4 \text{ L/mol} = 11.2 \text{ L}$ . This statement is correct.

- **Statement (D): Mass of  $MgCl_2$  formed = 47.5 g**

Molar mass of  $MgCl_2$  =  $M(\text{Mg}) + 2 \times M(\text{Cl}) = 24 + 2 \times 35.5 = 24 + 71 = 95 \text{ g/mol}$ .

From the reaction, 1 mole of Mg produces 1 mole of  $MgCl_2$ . So, 0.5 mol of Mg produces 0.5 mol of  $MgCl_2$ .

Mass of  $MgCl_2$  = Moles  $\times$  Molar Mass =  $0.5 \text{ mol} \times 95 \text{ g/mol} = 47.5 \text{ g}$ . This statement is also correct.

#### Analysis of Discrepancy:

With standard approximate molar masses, all statements appear correct. This usually implies that the question requires using more precise molar masses, and the "incorrect" statement is the one that deviates most from the precise calculation.

#### Step 3 (Re-evaluation with precise masses):

$M(\text{Mg}) = 24.305 \text{ g/mol}$ .  $M(\text{Cl}) = 35.453 \text{ g/mol}$ .

- Moles of Mg =  $\frac{12}{24.305} = 0.4937 \text{ mol}$ . Statement (A) has a slight error.

- Moles of  $H_2$  produced = 0.4937 mol. Statement (B) has a slight error.

- Volume of  $H_2$  at STP =  $0.4937 \times 22.414 = 11.066 \text{ L}$ . Statement (C) has a slight error.

- Molar mass of  $MgCl_2$  =  $24.305 + 2(35.453) = 95.211 \text{ g/mol}$ .

- Mass of  $MgCl_2$  formed =  $0.4937 \times 95.211 = 47.00 \text{ g}$ .

The value given in statement (D) is 47.5 g. The difference is  $47.5 - 47.0 = 0.5 \text{ g}$ . This represents a significant deviation compared to the precision of the input data. Thus, statement (D) is the most incorrect.

#### Step 4: Final Answer:

Statement (D) is the incorrect statement when calculated with precise atomic masses.

## 5. Answer: a

### Explanation:

The reduction of 1 mole of  $\text{Cr}_2\text{O}_7^{2-}$  requires 6 moles of electrons.

$x$ : Moles of electrons involved during oxidation of  $\text{I}^- \rightarrow \text{I}_2$ .

$3 \times (2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-) \implies 6\text{e}^-$ .  $x = 6$ .

$y$ : Moles of electrons involved during oxidation of  $\text{S}^{2-} \rightarrow \text{S}$ .

$$3 \times (\text{S}^{2-} \rightarrow \text{S} + 2\text{e}^-) \implies 6\text{e}^-. y = 6.$$

$$\text{Sum of } x + y = 6 + 6 = 12.$$


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## 6. Answer: d

### Explanation:

Step 1: Acidified potassium dichromate ( $\text{K}_2\text{Cr}_2\text{O}_7$ ) acts as a strong oxidizing agent.

Step 2: In acidic medium, iodide ions ( $\text{I}^-$ ) are oxidized to iodine ( $\text{I}_2$ ), while dichromate ions are reduced.

Step 3: Oxidation states:

$$\text{Cr in } \text{Cr}_2\text{O}_7^{2-} = +6$$

Step 4: During the reaction, chromium gets reduced to  $\text{Cr}^{3+}$ .

Step 5: Balanced ionic equation:



Step 6: Hence, chromium in the final product exists as  $\text{Cr}^{3+}$ .

Therefore, oxidation state of chromium is +3.

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## 7. Answer: a

### Explanation:

The reaction is between  $\text{K}_2\text{Cr}_2\text{O}_7$  (oxidant) and Mohr's salt ( $\text{Fe}^{2+}$ , reductant) in acidic medium.

For  $\text{K}_2\text{Cr}_2\text{O}_7$ :  $\text{Cr}(+6) \rightarrow \text{Cr}(+3)$ ,  $n$ -factor ( $n_1$ ) is  $2 \times 3 = 6$ .

For Mohr's salt ( $\text{Fe}^{2+}$ ):  $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$ ,  $n$ -factor ( $n_2$ ) is 1.

At equivalence point: Milli-equivalents of  $\text{K}_2\text{Cr}_2\text{O}_7$  = Milli-equivalents of  $\text{Fe}^{2+}$ .

$$M_1V_1n_1 = M_2V_2n_2.$$

$$(x \times 10^{-3}) \times (200) \times 6 = (0.6) \times (750) \times 1.$$

$$x \times 10^{-3} \times 1200 = 450.$$

$$x \times 1.2 = 450.$$

$$x = \frac{450}{1.2} = 375.$$


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## 8. Answer: a

### Explanation:

#### Step 1: Understanding the reaction.

The manganate ion  $\text{MnO}_4^-$  undergoes a disproportionation reaction in acidic medium, meaning it breaks into two different species:  $\text{MnO}_2$  and  $\text{MnO}_4^{2-}$ .

#### Step 2: Conclusion.

The correct answer is **(1)**  $\text{MnO}_2, \text{MnO}_4^{2-}$  as per the given reaction sequence.

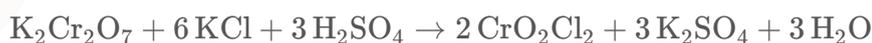
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## 9. Answer: a

### Explanation:

#### Step 1: Understand the reaction.

When potassium dichromate ( $\text{K}_2\text{Cr}_2\text{O}_7$ ) is heated with potassium chloride (KCl) in the presence of sulfuric acid ( $\text{H}_2\text{SO}_4$ ), the reaction forms  $\text{CrO}_2\text{Cl}_2$  (chromyl chloride). The chromium in  $\text{CrO}_2\text{Cl}_2$  is in the +6 oxidation state. The reaction can be summarized as:



#### Step 2: Identify the oxidation states.

In the product  $\text{CrO}_2\text{Cl}_2$ , the oxidation state of chromium is +6, which matches the given option. Thus, the correct answer is  $\text{CrO}_2\text{Cl}_2$ , with chromium in the +6 oxidation state.

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## 10. Answer: a

### Explanation:

#### Step 1: Write the chemical reaction.

The reaction between manganese dioxide ( $\text{MnO}_2$ ) and hydrochloric acid (HCl) produces chlorine gas ( $\text{Cl}_2$ ) according to the following balanced equation:



**Step 2: Use stoichiometry.**

From the balanced equation, 1 mole of  $\text{MnO}_2$  produces 1 mole of  $\text{Cl}_2$ .

**Step 3: Calculate the moles of  $\text{MnO}_2$ .**

The molar mass of  $\text{MnO}_2$  is 87.4 g/mol. So, the moles of  $\text{MnO}_2$  in 8.74 g is:

$$\text{moles of MnO}_2 = \frac{8.74 \text{ g}}{87.4 \text{ g/mol}} = 0.1 \text{ mol}$$

**Step 4: Calculate the moles of  $\text{Cl}_2$ .**

Since 1 mole of  $\text{MnO}_2$  produces 1 mole of  $\text{Cl}_2$ , the moles of  $\text{Cl}_2$  produced is also 0.1 mol.

**Step 5: Calculate the mass of  $\text{Cl}_2$ .**

The molar mass of chlorine gas ( $\text{Cl}_2$ ) is 70.9 g/mol. Therefore, the mass of  $\text{Cl}_2$  produced is:

$$\text{mass of Cl}_2 = 0.1 \text{ mol} \times 70.9 \text{ g/mol} = 7.1 \text{ g}$$

Thus, the weight of  $\text{Cl}_2$  obtained is 7.1 g.

---

**11. Answer: c****Explanation:****Step 1: Analyzing the reactions.**

- (a)  $[\text{Ag}(\text{NH}_3)_2]^+$  is the Tollen's reagent, which is used for the detection of aldehydes.
- (b)  $\text{Zn-Hg/HCl}$  is used in the Clemmensen reduction, a reduction method for carbonyl compounds.
- (c)  $\text{NH}_2\text{-NH/KOH}$  is used in the Wolff-Kishner reduction, which reduces aldehydes and ketones to hydrocarbons.
- (d)  $\text{Cu}^{2+}/\text{OH}^-$  forms Fehling solution, used to test for reducing sugars.

**Step 2: Conclusion.**

Matching the items correctly gives the answer: (3) a  $\rightarrow$  (iii), b  $\rightarrow$  (ii), c  $\rightarrow$  (iv), d  $\rightarrow$  (i).

---

## 12. Answer: 18 – 18

### Explanation:

#### Step 1: Understanding the Concept:

Titration between  $Fe^{2+}$  and  $K_2Cr_2O_7$  is a redox titration where  $Fe^{2+}$  is oxidized to  $Fe^{3+}$  and  $Cr_2O_7^{2-}$  is reduced to  $Cr^{3+}$  in acidic medium.

At the equivalence point, the number of equivalents of the reducing agent ( $Fe^{2+}$ ) is equal to the number of equivalents of the oxidizing agent ( $K_2Cr_2O_7$ ).

#### Step 2: Key Formula or Approach:

Equivalents of Reducing Agent = Equivalents of Oxidizing Agent

$$(M_1 \times n_1) \times V_1 = (M_2 \times n_2) \times V_2$$

Where  $n$  is the n-factor (change in oxidation state per molecule).

#### Step 3: Detailed Explanation:

##### 1. Determine n-factors:

For  $Fe^{2+} \rightarrow Fe^{3+} + e^-$ , n-factor ( $n_1$ ) = 1.

For  $Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$ , the oxidation state of Cr changes from +6 to +3.

Since there are 2 Cr atoms in  $K_2Cr_2O_7$ , n-factor ( $n_2$ ) =  $2 \times (6 - 3) = 6$ .

##### 2. Calculate Molarity of $Fe^{2+}$ :

Given:  $V_1 = 10$  mL,  $V_2 = 15$  mL,  $M_2 = 0.02$  M.

$$M_1 \times 1 \times 10 = 0.02 \times 6 \times 15$$

$$10 \times M_1 = 1.8$$

$$M_1 = 0.18 \text{ M}$$

##### 3. Convert to requested format:

The molarity is  $x \times 10^{-2}$  M.

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

So,  $x = 18$ .

**Step 4: Final Answer:**

The value of  $x$  is 18.

---

**13. Answer: 1575 – 1575**

**Explanation:**

Step 1: Write the balanced redox reaction.

In acidic medium, permanganate ion ( $\text{MnO}_4^-$ ) is reduced and oxalate ion ( $\text{C}_2\text{O}_4^{2-}$ ) is oxidized.

Reduction half-reaction:  $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$  (n-factor for  $\text{KMnO}_4$  is 5)

Oxidation half-reaction:  $\text{C}_2\text{O}_4^{2-} \rightarrow 2\text{CO}_2 + 2\text{e}^-$  (n-factor for oxalic acid is 2)

The balanced overall reaction is:  $2\text{MnO}_4^- + 5\text{C}_2\text{O}_4^{2-} + 16\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 10\text{CO}_2 + 8\text{H}_2\text{O}$ .

The stoichiometric ratio is 2 moles of  $\text{KMnO}_4$  to 5 moles of oxalic acid.

Step 2: Use the titration equivalence formula.

At the equivalence point,  $M_1V_1n_1 (\text{KMnO}_4) = M_2V_2n_2 (\text{Oxalic Acid})$ .

Let  $M_{ox}$  be the molarity of the oxalic acid solution.

$$(0.05 \text{ M})(10.0 \text{ mL})(5) = (M_{ox})(10.0 \text{ mL})(2).$$

$$0.05 \times 5 = M_{ox} \times 2.$$

$$0.25 = 2 \times M_{ox}.$$

$$M_{ox} = \frac{0.25}{2} = 0.125 \text{ M}.$$

Step 3: Calculate the strength in g/L.

Strength (g/L) = Molarity (mol/L)  $\times$  Molar Mass (g/mol).

The solute is oxalic acid dihydrate,  $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ .

Molar Mass =  $(2 \times 1.01) + (2 \times 12.01) + (4 \times 16.00) + 2 \times (18.02) = 2.02 + 24.02 + 64.00 + 36.04 = 126.08 \text{ g/mol}$ . We can approximate it as 126 g/mol.

Strength =  $0.125 \text{ mol/L} \times 126 \text{ g/mol} = 15.75 \text{ g/L}$ .

Step 4: Express the answer in the required format.

The question asks for the strength in units of  $\times 10^{-2} \text{ g/L}$ .

Strength =  $15.75 \text{ g/L} = 1575 \times 10^{-2} \text{ g/L}$ .

The integer value is 1575.

---

**14. Answer: d**

### Explanation:

**Step 1:** Calculate the oxidation state ( $x$ ) for Nitrogen in each:

$$NO_3^-: x + 3(-2) = -1 \implies x = +5$$

$$NO_2: x + 2(-2) = 0 \implies x = +4$$

$$NO: x + (-2) = 0 \implies x = +2$$

$$N_2O: 2x + (-2) = 0 \implies x = +1$$

**Step 2:** Arrange in descending order:  $+5 > +4 > +2 > +1$ . The order is  $NO_3^- > NO_2 > NO > N_2O$ .

---

### 15. Answer: b

#### Explanation:

**Step 1:** In (A), Chlorine in HOCl (+1) is reduced to  $Cl^-$  (-1). Thus  $H_2O_2$  is the reducing agent.

**Step 2:** In (B), Iodine ( $I_2$ ) in oxidation state 0 is reduced to  $I^-$  (-1). Thus  $H_2O_2$  is the reducing agent.

**Step 3:** In both cases,  $H_2O_2$  is oxidized to  $O_2$  (0).

---

### 16. Answer: 173 - 173

#### Explanation:

**Step 1:**  $n$ -factor for  $CrO_4^{2-} \rightarrow Cr(OH)_4^-$ :  $Cr(+6) \rightarrow Cr(+3)$ , change = 3.

**Step 2:**  $n$ -factor for  $S_2O_3^{2-} \rightarrow 2SO_4^{2-}$ : Average  $S(+2) \rightarrow S(+6)$ , change =  $2 \times (6 - 2) = 8$ .

**Step 3:** Equivalents of Oxidant = Equivalents of Reductant.

**Step 4:**  $(M_1 \times n_1 \times V_1) = (M_2 \times n_2 \times V_2)$ .

**Step 5:**  $0.154 \times 3 \times V_1 = 0.25 \times 8 \times 40$ .

**Step 6:**  $0.462V_1 = 80 \implies V_1 = 80/0.462 \approx 173.16$  mL.

---

### 17. Answer: d

#### Explanation:

### Step 1: Understanding the Concept:

A disproportionation reaction is a redox reaction in which the same element undergoes both oxidation and reduction simultaneously. This is only possible if the element is in an intermediate oxidation state and can move to both a higher and a lower oxidation state.

### Step 2: Detailed Explanation:

- Species in their highest oxidation state (like  $Mn^{+7}$  in  $MnO_4^-$ ,  $Cr^{+6}$  in  $Cr_2O_7^{2-}$ ,  $Cl^{+7}$  in  $ClO_4^-$ ) cannot be further oxidized, so they cannot disproportionate.
- $F_2$  is the most electronegative element and can only have an oxidation state of 0 or -1. It cannot be oxidized, so it doesn't disproportionate.
- **Let's check Option (D):**
- 1.  **$MnO_4^{2-}$ :** Mn is in +6. It can disproportionate to  $MnO_4^-$  (+7) and  $MnO_2$  (+4) in acidic medium.
- 2.  **$ClO_2^-$ :** Cl is in +3. It can go up to  $ClO_3^-$  (+5) and down to  $Cl^-$  (-1).
- 3.  **$Cl_2$ :** Cl is in 0. In alkaline solution, it disproportionates to  $Cl^-$  (-1) and  $ClO^-$  (+1).
- 4.  **$Mn^{3+}$ :** In aqueous solution, it disproportionates to  $Mn^{2+}$  and  $MnO_2$  (+4).

### Step 3: Final Answer:

The set in option (D) contains species that all undergo disproportionation.

## 18. Answer: 316 – 316

### Explanation:

#### Step 1: Understanding the Concept:

In a redox titration, the total equivalents of the oxidizing agent must equal the total equivalents of the reducing agent.

#### Step 2: Detailed Explanation:

In acidic medium:

$n$ -factor for  $KMnO_4$  ( $Mn^{+7} \rightarrow Mn^{2+}$ ) is 5.

$n$ -factor for  $FeSO_4$  ( $Fe^{2+} \rightarrow Fe^{3+}$ ) is 1.

Equivalents of  $KMnO_4$  = Equivalents of  $FeSO_4$

$$N_1V_1 = N_2V_2$$

$$(M_1 \times 5) \times 10 = (0.1 \times 1) \times 10$$

$$5M_1 = 0.1 \implies M_1 = \frac{0.1}{5} = 0.02 M$$

Molar mass of  $KMnO_4 = 39 + 55 + (4 \times 16) = 158 \text{ g/mol}$ .

Strength in g/L = Molarity  $\times$  Molar mass

$$\text{Strength} = 0.02 \times 158 = 3.16 \text{ g/L}$$

Given Strength =  $x \times 10^{-2}$ :

$$3.16 = 316 \times 10^{-2}$$

**Step 3: Final Answer:**

The value of  $x$  is 316.

---

19. Answer: 10 – 10

**Explanation:**

To solve the given problem, we need to determine variables X and Y, and then compute X + Y.

Firstly, let's address the compound  $KMnO_4$  acting as an oxidizing agent in acidic medium. In this scenario, Mn is reduced from +7 oxidation state to +2:

- Initial oxidation state of Mn = +7
- Final oxidation state of Mn = +2

The difference X is the change in oxidation state:

$$X = 7 - 2 = 5$$

Next, we consider the number of 'd' electrons in the brown-red precipitate at the end of the acetate ion test with neutral ferric chloride (typically  $Fe(OH)_3$  which is red-brown).

The oxidation state of iron in  $Fe(OH)_3$  is +3. In this state, the electron configuration of Fe is:

- **Atomic number of Fe** = 26: Configuration for Fe (neutral) = [Ar] 4s<sup>2</sup> 3d<sup>6</sup>
- For Fe<sup>3+</sup>: 3d<sup>5</sup> (since 2 electrons are removed from 4s and 1 from 3d)

Thus, the number of 'd' electrons, **Y = 5**.

Therefore, the computed value:

$$X + Y = 5 + 5 = 10$$

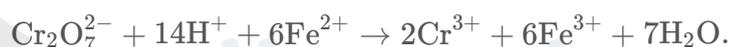
This value is within the provided range 10, 10.

---

## 20. Answer: 23 – 23

### Explanation:

1. Balancing the Reaction: To balance the given reaction in an acidic medium:



2. Identify  $X$ ,  $Y$ , and  $Z$ : -  $X = 14$  (moles of  $\text{H}^+$ ), -  $Y = 2$  (moles of  $\text{Cr}^{3+}$ ), -  $Z = 7$  (moles of  $\text{H}_2\text{O}$ ). 3. Sum of  $X + Y + Z$ :

$$X + Y + Z = 14 + 2 + 7 = 23.$$

Final Answer: 23.

---

## 21. Answer: c

### Explanation:

In order to determine which of the given chemical species has the strongest oxidizing capacity, we need to examine their standard reduction potential values. The species with the highest standard reduction potential will have the strongest oxidizing capacity, as a higher reduction potential indicates a greater tendency to gain electrons and thereby oxidize other substances.

Here are the given standard reduction potentials:

- $E_{\text{I}^-/\text{I}_2}^\circ = +1.26 \text{ V}$

- $E_{\text{Al}^{3+}/\text{Al}}^{\circ} = -1.66 \text{ V}$
- $E_{\text{Pb}^{4+}/\text{Pb}^{2+}}^{\circ} = +1.67 \text{ V}$
- $E_{\text{Sn}^{4+}/\text{Sn}^{2+}}^{\circ} = +1.15 \text{ V}$

Comparing these values,  $E_{\text{Pb}^{4+}/\text{Pb}^{2+}}^{\circ} = +1.67 \text{ V}$  is the highest. Therefore, the ion  $\text{Pb}^{4+}$  has the strongest oxidizing capacity because it more readily accepts electrons to be reduced.

---

## 22. Answer: c

### Explanation:

The heat of formation of  $\text{SO}_2$  is the heat change when 1 mole of  $\text{SO}_2(g)$  is formed from its elements in their standard states.

By using the given reactions, the heat of formation is found to be  $y - 2x$ .

**Final Answer:**  $y - 2x \text{ kcal}$ .

---

## 23. Answer: c

### Explanation:

- Statement (I) is false: The ionisation energy of Pb is lower than that of Sn because Pb is lower in the periodic table and has a higher atomic size.

- Statement (II) is true: Ge has a higher ionisation energy than Si because it is in the same group but higher in the periodic table, so its electrons are closer to the nucleus.

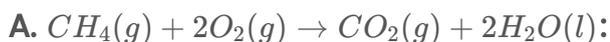
**Final Answer:** Statement I is false but Statement II is true.

---

## 24. Answer: c

### Explanation:

Let's analyze each reaction:



This is a combustion reaction where methane reacts with oxygen to produce carbon dioxide and water.

The oxidation state of carbon changes from -4 to +4, and the oxidation state of oxygen changes from 0 to -2.

This is also a combination reaction.

**So, A is matched with II.**

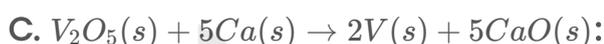


Sodium hydride decomposes into sodium and hydrogen.

The oxidation state of sodium changes from +1 to 0, and the oxidation state of hydrogen changes from -1 to 0.

This is a decomposition reaction.

**So, B is matched with III.**



This is a displacement reaction, where calcium displaces vanadium from its oxide.

Calcium is oxidized from 0 to +2, and vanadium is reduced from +5 to 0.

**So, C is matched with IV.**



Hydrogen peroxide decomposes into water and oxygen.

The oxidation state of oxygen in  $H_2O_2$  is -1, in  $H_2O$  it is -2, and in  $O_2$  it is 0.

This is a disproportionation reaction, where oxygen in  $H_2O_2$  is both oxidized and reduced.

**So, D is matched with I.**

**Final Matching:**

A - II

B - III

C - IV

D - I

**Final Answer:**

The final answer is *A-II, B-III, C-IV, D-I*.

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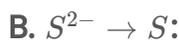
**25. Answer: a**

**Explanation:**

Let's analyze each oxidation reaction:



Both  $K_2Cr_2O_7$  and  $KMnO_4$  can oxidize iodide to iodine in acidic medium.  
**This reaction is possible with both oxidizing agents.**



Both  $K_2Cr_2O_7$  and  $KMnO_4$  can oxidize sulfide to sulfur in acidic medium.  
**This reaction is possible with both oxidizing agents.**



Both  $K_2Cr_2O_7$  and  $KMnO_4$  can oxidize  $Fe^{2+}$  to  $Fe^{3+}$  in acidic medium.  
**This reaction is possible with both oxidizing agents.**



Both  $K_2Cr_2O_7$  and  $KMnO_4$  can oxidize iodide to iodate in acidic medium, but it requires a stronger oxidizing power.

**This reaction is possible under strong conditions, but not always consistent in standard acidic conditions.**



Thiosulfate oxidation to sulfate is more complex and specific to certain oxidizing power and conditions.  $KMnO_4$  typically does not oxidize thiosulfate to sulfate quantitatively in acidic medium, while  $K_2Cr_2O_7$  may do so under vigorous conditions.

**This reaction is not consistently carried out by both oxidizing agents.**

**Therefore**, reactions A, B, and C are the only ones that are *consistently* carried out by both  $K_2Cr_2O_7$  and  $KMnO_4$  under standard acidic conditions.

**Final Answer:**

The final answer is (3) A, B and C only.