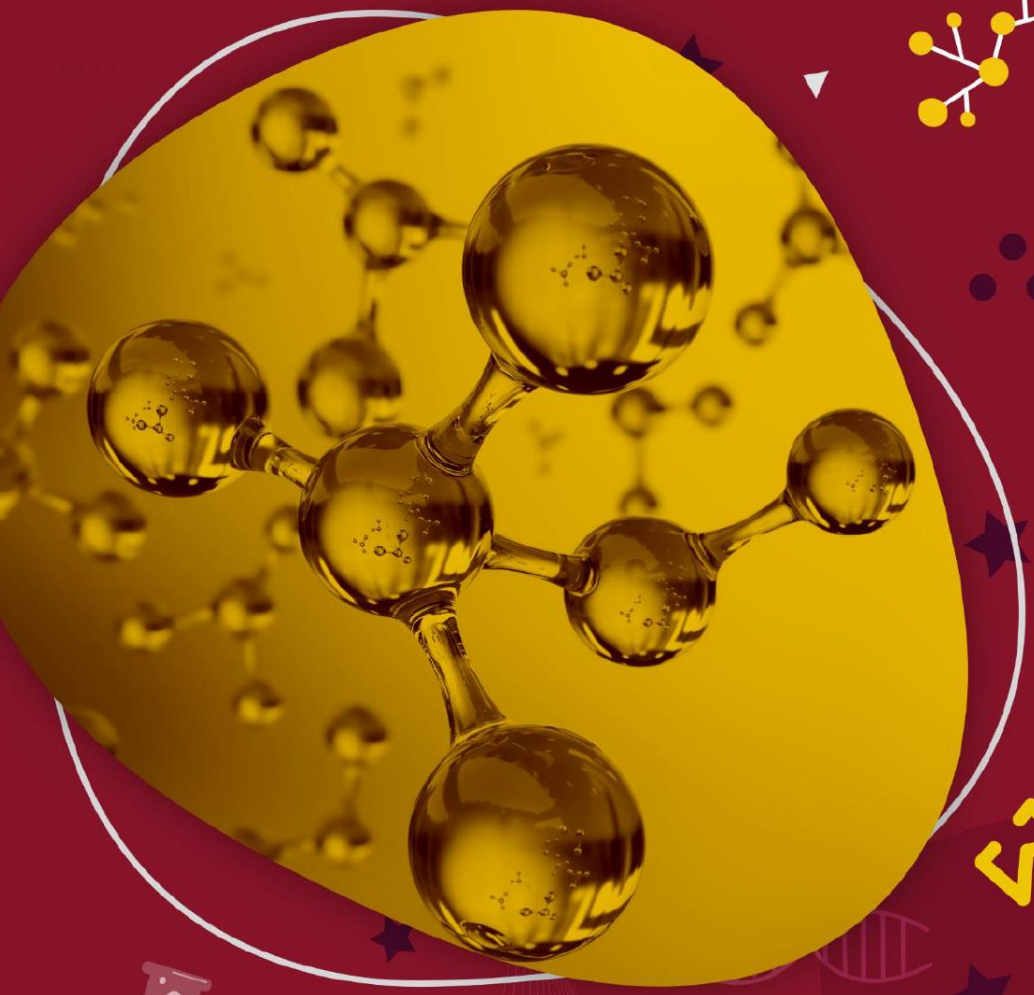
CHEMISTRY

12 Advanced

Mr. Hesham Eltoukhy

Redox Reactions



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My dear students

Mr. Hesham Eltoukhy Mr. Hesham Eltoukhy Mr. Hesham Eltoukhy

In your hands are papers in chemistry for grade 12 advanced. Here is a detailed explanation of the contents and method of study.

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These papers contain a complete explanation of everything in the book, in addition to all the book's questions and previous year's questions, knowing that they do not replace the textbook, and the papers consist of three parts.

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Part One (Explanation and Questions)

Detailed explanation with questions on each objective.

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Part Two (Questions with answers)

Additional questions on each section with answers at the end of each section.

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Part Three (Exams of last years)

Previous years exam questions with answers at the end of each exam.

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Part One (Explanation and Questions)

Detailed explanation with questions on each objective.

Sec. (1) Oxidation and Reduction

Oxidation Number: The number of electrons lost, gained, or shared from an atom of an element to form a bond.

Rules for calculating oxidation numbers	Example
1) The oxidation number of a pure element (uncombined) is zero	Na, Cl_2, P_4 = 0
2) The oxidation number of a monoatomic ion is equal to ion charge	Ca^{2+}= +2, Br^-= –1
3) The oxidation number of fluorine in its compounds is –1	LiF (F = –1)
4) The oxidation number of oxygen in most of its compounds is –2	NO_2 (O = –2)
5) The oxidation number of hydrogen in most of its compounds is +1	H_2CO_3 (H = +1)
6) The oxidation number of group 1 metals in their compounds is +1	LiBr (Li = +1)
7) The oxidation number of group 2 metals in their compounds is +2	$MgSO_4$ (Mg = +2)
8) The oxidation number of aluminum in its compounds is +3	Al_2O_3 (Al = +3)

Why is the oxidation number –2 not used for oxygen if the oxidation number of oxygen is to be calculated? → Because oxygen has special cases of oxidation numbers.

Why is the oxidation number +1 not used for hydrogen if the oxidation number of hydrogen is to be calculated? → Because hydrogen has special cases of oxidation numbers.

The oxidation number of Cl, Br, I in their compounds is –1 (if they are the highest electronegativity in the compound or to the right side in the compound)

The sum of the oxidation numbers of neutral compounds is zero.

The sum of the oxidation numbers of a polyatomic ion is equal to the charge of the ion.

1) What is the oxidation number of the underlined element in: $H\underline{Cl}O_3$?

a. +3

b. –3

c. +5

d. –5

2) What is the oxidation number of the underlined element in: $\underline{S}O_3^{2-}$?

a. +4

b. +6

c. +3

d. +1

3) What is the oxidation number of the underlined element in: $\underline{As}O_4^{3-}$?

a. –8

b. +5

c. –5

d. +8

4) What is the oxidation number of the underlined element in: $\underline{N}H_4^+$?

a. +1

b. –1

c. –3

d. +4

5) What is the oxidation number of the underlined element in: $Na\underline{Cl}O_4$?

a. +7

b. +5

c. +3

d. +1

6) What is the oxidation number of the underlined element in: $\underline{Cr}_2O_7^{2-}$?

a. +7

b. +4

c. +12

d. +6

7) What is the oxidation number of the underlined element in: $Al\underline{P}O_4$?

a. +5

b. +8

c. –5

d. +4

8) What is the oxidation number of the underlined element in: $Ca_3\underline{N}_2$?

a. +2

b. –3

c. +3

d. –2

9) What is the oxidation number of the underlined element in: $\underline{B}_4O_7^{2-}$?

a. +1

b. +6

c. +3

d. –3

10) What is the oxidation number of the underlined element in: K$\underline{Br}$?

a. –1

b. +1

c. –2

d. +2

11) What is the oxidation number of the underlined element in: $H\underline{N}O_3$?

a. +5

b. +3

c. +1

d. +2

12) What is the oxidation number of the underlined element in: $\underline{I}O_4^-$?

a. +1

b. +5

c. +7

d. +3

13) What is the oxidation number of the underlined element in: $\underline{Mn}O_4^-$?

a. +4

b. +3

c. +5

d. +7

14) What is the oxidation number of the underlined element in: $\underline{Sb}_2O_5$?

a. 0

b. +5

c. +2

d. –5

15) What is the oxidation number of the underlined element in: $\underline{W}O_4^{2-}$?

a. +8

b. +6

c. +4

d. +2

16) What is the oxidation number of the underlined element in: $\underline{N}H_2^-$?

a. +2

b. –1

c. –2

d. –3

17) What is the oxidation number of the underlined element in: $CaCrO_4$?

a. +6

b. +4

c. +8

d. +2

18) What is the oxidation number of the underlined element in: $NaHSO_4$?

a. +1

b. +4

c. +6

d. –6

19) What is the oxidation number of the underlined element in: $Fe(NO_3)_2$?

a. +5

b. +2

c. +3

d. +4

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11	a	12	c	13	d	14	b	15	b
16	d	17	a	18	c	19	a		

20) Which of the following substances has an oxidation number of nitrogen = +3?

a. NH_3

b. N_2O_4

c. NO_3^-

d. NO_2^-

21) Which of the following substances has an oxidation number of bromine = +5?

a. BrO_2^-

b. BrO_3^-

c. BrO_4^-

d. BrO^-

22) Which of the following substances has an oxidation number of oxygen = –1?

a. O_2

b. H_2O

c. OF_2

d. BaO_2

23) Which of the following substances has an oxidation number of carbon = 0?

a. $C_2O_4^{2-}$

b. $C_6H_{12}O_6$

c. H_2CO_3

d. CH_4

24) Which of the following substances has an oxidation number of hydrogen = –1?

a. OH^-

b. HCl

c. H_2O

d. KH

Oxidation and Reduction

Oxidation reaction: A reaction in which a reactant lose electron. — e^- with products

Reduction reaction: A reaction in which a reactant gain electron. — e^- with reactants

25) Which of the following half-reactions represents an oxidation process?

a. $I_2 + 2e^- \rightarrow 2I^-$

b. $K \rightarrow K^+ + e^-$

c. $Ag^+ + e^- \rightarrow Ag$

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

26) Which of the following half-reactions represents a reduction process?

a. $2Cl^- \rightarrow Cl_2 + 2e^-$

b. $Na \rightarrow Na^+ + e^-$

c. $Ca \rightarrow Ca^{2+} + 2e^-$

d. $O_2 + 4e^- \rightarrow 2O^{2-}$

Change in oxidation number

Oxidation reaction: A reaction in which the oxidation number increases.

The oxidation number of the element in the reactants < products

Reduction reaction: A reaction in which the oxidation number decreases.

The oxidation number of the element in the reactants > products

Oxidation-reduction reaction: The reaction in which electrons are transferred from one substance to another.

or The reaction during which the oxidation number changes.

or A reaction in which electrons are shared between atoms.

The union of a substance with oxygen is also one of the definitions of oxidation.

Oxidation and reduction are concomitant processes, (oxidation cannot occur unless reduction also occurs).

number of lost electrons = number of gained electrons

$$\overset{0}{2Na} \rightarrow \overset{+1}{2Na^+} + 2e^-$$

oxidation

$$\overset{0}{Cl_2} + 2e^- \rightarrow \overset{-1}{2Cl^-}$$

reduction

$$2Na + Cl_2 \rightarrow 2Na^+ + 2Cl^-$$

Oxidation-reduction

$0 \rightarrow +1$

$0 \rightarrow -1$

Oxidation-reduction reaction

Why do metals have positive oxidation numbers?	Because the electronegativity of metals is low, they lose electrons.
Why do nonmetals have negative oxidation numbers?	Because the electronegativity of nonmetals is high, they gain electrons.

The light from the party sticks results from a chemical reaction. When the glass capsule is broken inside the plastic tube, a reaction occurs between two chemicals and electrons are transferred, turning the chemical energy into light.



Why are combustion and single replacement reactions a reaction?	Because the oxidation number changes during the reaction.
Why are double replacement reactions not an oxidation-reduction reaction?	Because the oxidation number does not change during the reaction.
When do synthesis and decomposition reactions represent an oxidation-reduction reaction?	If the oxidation number changes during the reaction.

1) Synthesis: $2Na_{(s)} + Cl_{2(g)} \rightarrow 2NaCl_{(s)}$

- has the net ionic equation
  - $2Na_{(s)} + Cl_{2(g)} \rightarrow 2Na^{+} + 2Cl^{-}$
- represents oxidation-reduction reaction
  - oxidation numbers changes
  - 2 electrons are transferred from the sodium atoms to the chlorine molecule

2) Decomposition: $H_2CO_{3(aq)} \rightarrow H_2O_{(l)} + CO_{2(g)}$

- does not represent oxidation-reduction reaction
  - No transfer of electrons occurs during the reaction
  - The oxidation numbers of the elements do not change during the reaction
  - No sharing of electrons occurs during the reaction

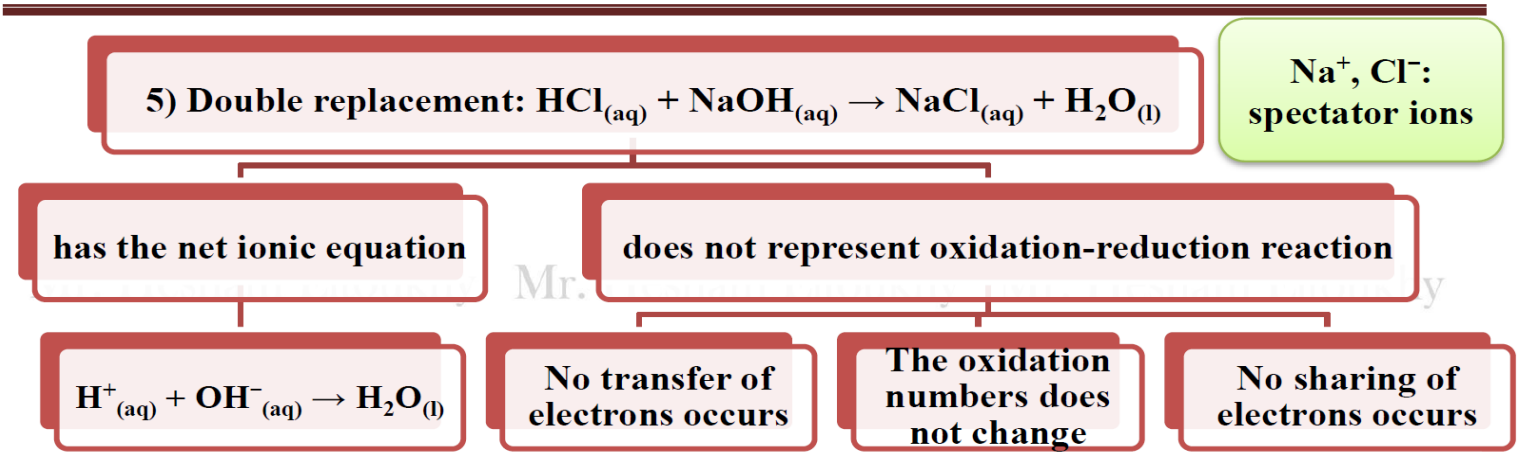
3) Combustion: $2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$

- has the net ionic equation
  - $2Mg + O_2 \rightarrow 2Mg^{2+} + 2O^{2-}$
- represents oxidation-reduction reaction
  - oxidation numbers changes
  - One atom of magnesium gives 2 electrons to each oxygen atom

4) Single replacement: $2KBr_{(aq)} + Cl_{2(g)} \rightarrow 2KCl_{(aq)} + Br_{2(aq)}$

K^{+}: spectator ion

- has the net ionic equation
  - $2Br^{-}_{(aq)} + Cl_{2(g)} \rightarrow 2Cl^{-}_{(aq)} + Br_{2(aq)}$
- represents oxidation-reduction reaction
  - oxidation numbers changes
  - 2 electrons are transferred from the bromide ion to the chlorine molecule



27) Why does the oxidation number decrease in a reduction reaction?

a. gaining electrons
b. losing electrons
c. addition of OH^- ions
d. addition of H_3O^+ ions

28) In the half-reaction: $Ag^+ + e^- \rightarrow Ag$, why do silver ions change into silver atoms?

a. silver ions ionized
b. silver ions are oxidized
c. silver ions are reduced
d. the oxidation number of silver ions does not change

29) In an oxidation-reduction reaction, CO turns into CO_2, how many electrons are lost or gained from C?

a. lose one electron
b. lose two electrons
c. gain one electron
d. gain two electrons

30) In an oxidation-reduction reaction, MnO_4^- turns into MnO_4^{2-}, how many electrons are gained or lost from Mn?

a. lose one electron
b. lose two electrons
c. gain one electron
d. gain two electrons

31) In the reaction: $2K + Br_2 \rightarrow 2K^+ + 2Br^-$, which species is reduced?

a. K

b. Br_2

c. K^+

d. Br^-

32) Which of the following changes represents an oxidation process?

a. $ClO^- \rightarrow Cl^-$

b. $VO^{2+} \rightarrow VO_3^-$

c. $NO_2^- \rightarrow N_2$

d. $CrO_4^{2-} \rightarrow Cr_2O_7^{2-}$

33) Which of the following changes represents a reduction process?

a. $Fe^{2+} \rightarrow Fe^{3+}$

b. $NH_3 \rightarrow NO_2$

c. $Cr_2O_7^{2-} \rightarrow Cr^{3+}$

d. $H_2S \rightarrow SO_4^{2-}$

34) What is the total number of electrons transferred during the balanced reaction?

$$2Na + 2H^+ \rightarrow 2Na^+ + H_2?$$

a. a transfer of 2 electrons from Na to H^+

b. a transfer of 1 electron from Na to H^+

c. a transfer of 2 electrons from H^+ to Na

d. a transfer of 1 electron from H^+ to Na

35) What is the total number of electrons transferred during the balanced reaction?

$$2Ce + 3Cu^{2+} \rightarrow 3Cu + 2Ce^{3+}$$

a. a transfer of 3 electrons from Ce to Cu^{2+}

b. a transfer of 6 electrons from Ce to Cu^{2+}

c. a transfer of 3 electrons from Cu^{2+} to Ce

d. a transfer of 6 electrons from Cu^{2+} to Ce

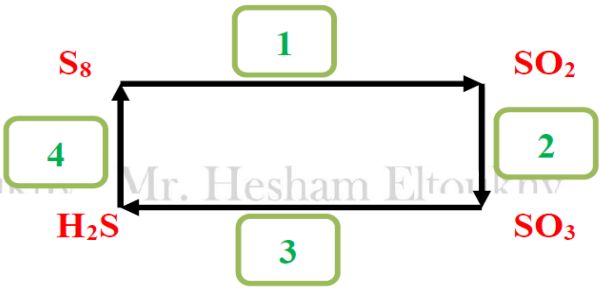
36) What step represents the reduction process in the following diagram?

a. 1

b. 2

c. 3

d. 4



37) Which of the following reactions is an oxidation-reduction reaction?

a. $2HI \rightarrow H_2 + I_2$

b. $HCl + NaOH \rightarrow NaCl + H_2O$

c. $CaCO_3 \rightarrow CaO + CO_2$

d. $AgNO_3 + NaBr \rightarrow NaNO_3 + AgBr$

38) Which of the following reactions is not an oxidation-reduction reaction?

a. $N_2 + O_2 \rightarrow 2NO$

b. $H_2O + SO_2 \rightarrow H_2SO_3$

c. $H_2 + Cl_2 \rightarrow 2HCl$

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

39) Which of the following statements is incorrect for the reaction?

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

a. the oxidation number of nitrogen changes from –3 to +1

b. the oxidation number of nitrogen changes from +5 to +1

c. does not represent an oxidation-reduction reaction

d. the oxidation number of nitrogen in N_2O is +1

40) Which of the following statements is true for the following redox reaction?

$$ClO_4^-{}_{(aq)} + Br^-{}_{(aq)} \rightarrow Cl^-{}_{(aq)} + Br_{2(l)}$$

a. the oxidation number of Cl changes from –1 to +4

b. the oxidation number of Cl changes from –1 to zero

c. the oxidation number of Br changes from –1 to zero

d. the oxidation number of Br changes from –1 to 2

41) Which of the following half-reactions represents a reduction process?

a. $H_2S \rightarrow S + 2e^- + 2H^+$

b. $SO_2 + 4e^- + 2H_2O \rightarrow S + 4OH^-$

c. $[Mn(CN)_6]^{4-} \rightarrow [Mn(CN)_6]^{3-} + e^-$

d. $Al \rightarrow Al^{3+} + 3e^-$

42) Which of the following is reduced in the reaction? $2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$

a. Al^{3+} b. Al

c. Cu^{2+} d. Cu

43) In an oxidation-reduction reaction, MnO_4^- turns into Mn^{2+}, how many electrons are lost or gained from Mn?

a. lose 2 electrons b. lose 5 electrons

c. gain 2 electrons d. gain 5 electrons

44) How many electrons are transferred in the balanced reaction?

$$2Br^- + Cl_2 \rightarrow Br_2 + 2Cl^-$$

a. a transfer of 1 electron from Br^- to Cl_2

b. a transfer of 2 electrons from Br^- to Cl_2

c. a transfer of 1 electron from Cl_2 to Br^-

d. a transfer of 2 electrons from Cl_2 to Br^-

45) Which of the following statements is true for the oxidation-reduction reaction?

$$2Zn + O_2 \rightarrow 2ZnO$$

a. the oxidation number of O changes from 0 to –1

b. the oxidation number of O changes from –2 to 0

c. the oxidation number of Zn changes from 0 to +2

d. the oxidation number of Zn changes from +1 to 0

46) What is the spectator ion in the reaction? $MgI_2 + Br_2 \rightarrow MgBr_2 + I_2$

a. Mg^{2+}

b. I_2

c. Br_2

d. Br^-

47) Which of the following changes represents an oxidation reaction?

a. $ClO^- \rightarrow Cl^-$

b. $CrO_4^{2-} \rightarrow Cr$

c. $VO_2^{2-} \rightarrow VO_3^{2-}$

d. $NO_2^- \rightarrow N_2$

48) Which of the following reactions is not an oxidation-reduction reaction?

a. $H_2O + CO_2 \rightarrow H_2CO_3$

b. $N_2 + 2O_2 \rightarrow 2NO_2$

c. $H_2 + I_2 \rightarrow 2HI$

d. $2NaCl + F_2 \rightarrow 2NaF + Cl_2$

49) What is the total change in the oxidation number of chlorine in the following redox reaction? $ClO_3^- + 6Fe^{2+} + 6H^+ \rightarrow Cl^- + 6Fe^{3+} + 3H_2O$

a. –1

b. –6

c. 0

d. –5

41	b	42	c	43	d	44	b	45	c
46	a	47	c	48	a	49	b		

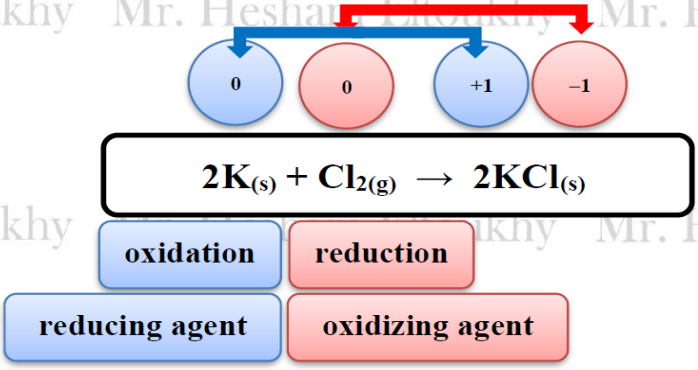
Oxidizing agents and reducing agents

The reactant loses electrons → oxidation takes place → represent reducing agent → electrons transfer → The reactant gains electrons → reduction takes place → represent oxidizing agent

Reducing agent: A substance that reduces another substance by losing electrons.

Oxidizing agent: A substance that oxidizes another substance by gaining electrons.

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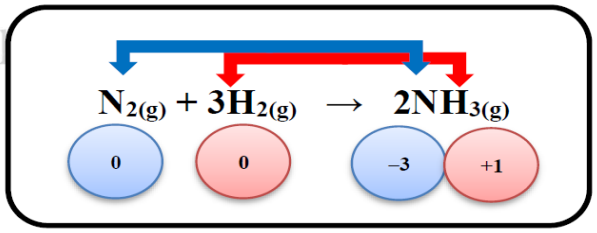
Electrons transfers from the reducing agent to the oxidizing agent.

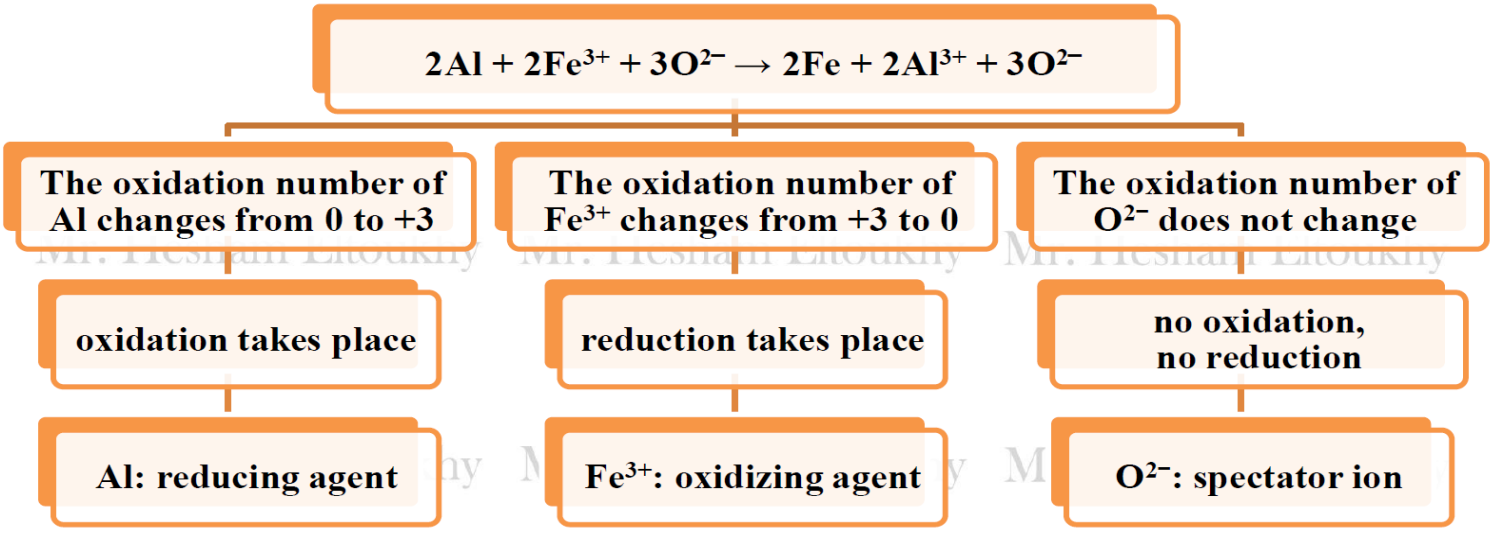
Using NaClO sodium hypochlorite laundry bleach leads to the oxidation of stains and dyes, as it is an oxidizing agent.

Some redox reactions involve changes in the oxidation number of compounds in which the bonds are covalent.

The reaction to form ammonia is an oxidation-reduction reaction, even though the reactants and products are molecular compounds?

Because one of the atoms lost electrons (H), and the other atom gained electrons (N).





50) What is the reducing agent, the oxidizing agent in the reaction?

$$Fe + 2Ag^+ \rightarrow Fe^{2+} + 2Ag$$

choice	reducing agent	oxidizing agent
a.	Fe^{2+}	Ag
b.	Ag	Fe^{2+}
c.	Fe	Ag^+
d.	Ag^+	Fe

51) What is the reducing agent in the reaction? $2Fe_{(s)} + 6HBr_{(aq)} \rightarrow 2FeBr_{3(s)} + 3H_{2(g)}$

a. H_2

b. Fe

c. HBr

d. $FeBr_3$

52) What is the oxidizing agent in the reaction? $H_2S + Cl_2 \rightarrow S + 2HCl$

a. Cl_2

b. H_2S

c. S

d. HCl

53) Which of the following statements is true for the reaction? $Mg + I_2 \rightarrow MgI_2$

a. the oxidation number of I changes from 0 to –2

b. the oxidation number of Mg changes from 0 to +1

c. I_2 represents spectator ion

d. Mg is a reducing agent

54) What is the reducing agent in the reaction?

$$8H^+ + Sn + 6Cl^- + 4NO_3^- \rightarrow SnCl_6^{2-} + 4NO_2 + 4H_2O$$

a. H^+ b. Sn

c. Cl^- d. NO_3^-

55) What is the oxidizing agent in the reaction? $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

a. O_2 b. NH_3

c. H_2O d. NO

56) Which of the following statements is true for the reaction?

$$Mg + 2Ag^+ \rightarrow Mg^{2+} + 2Ag$$

a. the oxidation number of Ag increases during the reaction

b. an oxidation process of Ag^+ takes place

c. Mg represents a stronger oxidizing agent than Ag

d. Mg is a stronger reducing agent than Ag

57) What does oxygen represent when hydrogen peroxide is decomposed?

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

a. a reducing agent only

b. an oxidizing agent only

c. reducing agent and oxidizing agent

d. does not represent a reducing agent or an oxidizing agent

54	b	55	a	56	d	57	c		

Sec. (2) Balancing Redox Equations

Balancing Redox Equations using half-reactions method

1) Calculate the oxidation numbers of atoms in the equation.	Using the rules for the oxidation number.
2) Write the half- reactions.	Oxidation half-reaction, half-reduction reaction.
3) Balance each half-reaction individually.	
a) Balance the atoms whose oxidation number changes.	By adding coefficients to the elements whose oxidation number has changed.
b) Balance of oxygen.	Add H_2O to balance the difference in oxygen atoms between the two sides.
c) Balance of hydrogen.	Add H^+ to balance the difference in hydrogen atoms between the two sides.
d) Balance the charge.	Add e^- to balance the change in oxidation number of the element in the equation.
4) Equal of charge.	Number of lost electrons = number of gained electrons
5) Get the balanced equation.	Subtract the same types on two different sides, add the same types on the same side.
6) Check the balance.	The number of atoms and the charges on both sides are equal.

Balancing Redox Equations in basic solution

Add the number of OH^- equal to the number of H^+ in the final balanced equation, to get H_2O

$$H^+ + OH^- \rightarrow H_2O$$

x mol x mol x mol

The H_2O molecules produced at both ends can be canceled to obtain a balanced equation in a basic solution.

58) What is the balanced equation for the following redox equation?

(using half-reactions method, in acidic solution)

$$MnO_4^-{}_{(aq)} + Sn^{2+}{}_{(aq)} \rightarrow Mn^{2+}{}_{(aq)} + Sn^{4+}{}_{(aq)}$$

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a. $5Sn^{2+} + 8H^+ + 2MnO_4^- \rightarrow 5Sn^{4+} + 2Mn^{2+} + 4H_2O$

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b. $Sn^{2+} + 16H^+ + MnO_4^- \rightarrow Sn^{4+} + Mn^{2+} + 8H_2O$

c. $5Sn^{2+} + 16H^+ + 2MnO_4^- \rightarrow 5Sn^{4+} + 2Mn^{2+} + 8H_2O$

d. $2Sn^{2+} + 8H^+ + 5MnO_4^- \rightarrow 2Sn^{4+} + 5Mn^{2+} + 4H_2O$

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59) What is the balanced equation for the following redox equation?

(using half-reactions method, in acidic solution)

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$$S + NO_3^- \rightarrow SO_3 + NO_2$$

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a. $S + 6NO_3^- + 6H^+ \rightarrow SO_3 + 6NO_2 + 3H_2O$

b. $S + NO_3^- + 6H^+ \rightarrow SO_3 + NO_2 + 3H_2O$

c. $S + 6NO_3^- + 2H^+ \rightarrow SO_3 + 6NO_2 + H_2O$

d. $S + 6NO_3^- \rightarrow SO_3 + 6NO_2$

60) What is the balanced equation for the following redox equation?

(using half-reactions method, in acidic solution)

$$I_2 + MnO_4^- \rightarrow Mn^{2+} + IO^-$$

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a. $I_2 + MnO_4^- + H_2O \rightarrow Mn^{2+} + 2IO^- + 2H^+$

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b. $5I_2 + 2MnO_4^- + 2H_2O \rightarrow 2Mn^{2+} + 10IO^- + 4H^+$

c. $5I_2 + 2MnO_4^- \rightarrow 2Mn^{2+} + 10IO^-$

d. $I_2 + MnO_4^- \rightarrow Mn^{2+} + 2IO^-$

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61) What is the balanced equation for the following redox equation?

(using half-reactions method, in acidic solution)

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$$Cr_2O_7^{2-}{}_{(aq)} + I^-{}_{(aq)} \rightarrow I_{2(s)} + Cr^{3+}{}_{(aq)}$$

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a. $Cr_2O_7^{2-} + 2I^- \rightarrow I_2 + 2Cr^{3+}$

b. $Cr_2O_7^{2-} + 3I^- + 7H^+ \rightarrow 3I_2 + 2Cr^{3+} + 7H_2O$

c. $Cr_2O_7^{2-} + 6I^- + 14H^+ \rightarrow 3I_2 + 2Cr^{3+} + 7H_2O$

d. $Cr_2O_7^{2-} + 6I^- + 2H^+ \rightarrow 3I_2 + Cr^{3+} + H_2O$

62) What is the balanced equation for the following redox equation?

(using half-reactions method, in acidic solution)

$$NO_2^- \rightarrow NO + NO_3^-$$

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a. $3NO_2^- + H^+ \rightarrow 2NO + NO_3^-$

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b. $3NO_2^- + 2H^+ \rightarrow 2NO + NO_3^- + H_2O$

c. $2NO_2^- + 2H^+ \rightarrow NO + NO_3^- + H_2O$

d. $3NO_2^- \rightarrow 2NO + NO_3^-$

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63) What is the balanced equation for the following redox equation?

(using half-reactions method, in basic solution)

$$N_2O_{(g)} + ClO^-_{(aq)} \rightarrow NO_2^-{}_{(aq)} + Cl^-_{(aq)}$$

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a. $N_2O + 2ClO^- + 2OH^- \rightarrow 2NO_2^- + 2Cl^- + H_2O$

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b. $N_2O + ClO^- + 2OH^- \rightarrow 2NO_2^- + Cl^- + H_2O$

c. $N_2O + 2ClO^- + H_2O \rightarrow 2NO_2^- + 2Cl^- + 2H^+$

d. $N_2O + ClO^- + H_2O \rightarrow 2NO_2^- + Cl^- + 2H^+$

64) What is the balanced equation for the following redox equation?

(using half-reactions method, in acidic solution)

$$Br^- + MnO_4^- \rightarrow Mn^{2+} + Br_2$$

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a. $10Br^- + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 5Br_2 + 8H_2O$

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b. $2Br^- + 2MnO_4^- + 8H^+ \rightarrow 2Mn^{2+} + Br_2 + 4H_2O$

c. $2Br^- + MnO_4^- + 16H^+ \rightarrow Mn^{2+} + Br_2 + 8H_2O$

d. $10Br^- + MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 5Br_2 + 4H_2O$

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65) What is the balanced equation for the following redox equation?

(using half-reactions method, in acidic solution)

$$ClO_4^- + Br^- \rightarrow Cl^- + Br_2$$

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a. $ClO_4^- + 4Br^- + 8H^+ \rightarrow Cl^- + 2Br_2 + 4H_2O$

b. $ClO_4^- + 8Br^- + 8H^+ \rightarrow Cl^- + 4Br_2 + 4H_2O$

c. $ClO_4^- + 8Br^- + 2H^+ \rightarrow Cl^- + 4Br_2 + H_2O$

d. $ClO_4^- + 4Br^- + 2H^+ \rightarrow Cl^- + 2Br_2 + H_2O$

66) What is the balanced equation for the following redox equation?

(using half-reactions method, in acidic solution)

$$Cr_2O_7^{2-}{}_{(aq)} + NO_2^-{}_{(aq)} \rightarrow Cr^{3+}{}_{(aq)} + NO_3^-{}_{(aq)}$$

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a. $Cr_2O_7^{2-} + NO_2^- + 4H^+ \rightarrow 2Cr^{3+} + NO_3^- + 2H_2O$

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b. $Cr_2O_7^{2-} + NO_2^- + 8H^+ \rightarrow 2Cr^{3+} + NO_3^- + 4H_2O$

c. $Cr_2O_7^{2-} + 3NO_2^- + 8H^+ \rightarrow 2Cr^{3+} + 3NO_3^- + 4H_2O$

d. $Cr_2O_7^{2-} + 3NO_2^- + 4H^+ \rightarrow 2Cr^{3+} + 3NO_3^- + 2H_2O$

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67) What is the balanced equation for the following redox equation?

(using half-reactions method, in basic solution)

$$BrO_2 + N_2O_4 \rightarrow BrO_3^- + NO_2^-$$

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a. $H_2O + 2BrO_2 + N_2O_4 \rightarrow 2BrO_3^- + 2NO_2^- + 2H^+$

b. $2OH^- + 2BrO_2 + N_2O_4 \rightarrow 2BrO_3^- + 2NO_2^- + H_2O$

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c. $4OH^- + 2BrO_2 + N_2O_4 \rightarrow 2BrO_3^- + 2NO_2^- + 2H_2O$

d. $2H_2O + 2BrO_2 + N_2O_4 \rightarrow 2BrO_3^- + 2NO_2^- + 4H^+$

Answer Key	64	a	65	b	66	c	67	b

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Part Two (Questions with answers)

Additional questions on each section with answers at the end of each section.

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Section (1) Practices

Glossary	
Oxidation number	The number of electrons lost, gained, or shared from an atom of an element to form a bond.
Oxidation reaction	A reaction in which the reactant loses electrons.
	A reaction in which the oxidation number increases.
Reduction reaction	A reaction in which the reactant gains electrons.
	A reaction in which the oxidation number decreases.
Oxidation-reduction reaction	The reaction in which electrons are transferred from one substance to another.
	The reaction in which the oxidation number changes.
	A reaction in which electrons are shared between atoms.
Spectator ion	An ion whose oxidation number does not change during the reaction.
Reducing agent	A substance that reduces another substance by losing electrons.
oxidizing agent	A substance that oxidizes another substance by gaining electrons.

Essay Questions		
1	Why must oxidation and reduction reactions always occur together?	If an atom or ion loses electrons, other atoms must gain them.
2	What is the role of oxidizing agents and reducing agents in redox reactions? How do each change in the reaction?	Oxidizing agent: causes another substance to be oxidized by gaining electrons. Reducing agent: causes another substance to be reduced by losing electrons.
3	What is the basic feature of redox reactions?	All redox reactions involve the transfer of electrons.
4	Why don't all oxidation reactions involve oxygen?	In the past, the word oxidation referred to reactions involving oxygen, but currently it refers to the loss of electrons by a substance.

5	How does the oxidation number in oxidation processes relate to the number of electrons lost? How is the oxidation number in reduction processes related to the number of electrons gained?	The change in oxidation number is equal to the number of electrons lost in the oxidation process and gained in the reduction process.
6	Considering that each of the following are stable compounds, what can you infer about the oxidation state of the element phosphorus in its compounds? PH_3, PCl_3, P_2H_4, PCl_5, H_3PO_4, Na_3PO_4	Phosphorus has several oxidation states (-3, +3, +5), which makes phosphorus very flexible in combining with nonmetals.
7	What are the reasons for the difference in the colors of the chromium compounds shown in the figure? 	Variation in oxidation numbers of chromium.
8	What are the reasons for the difference in the colors of the copper compounds shown in the figure? 	Variation in oxidation numbers of copper.

Multiple choice questions

1) What is the oxidation number of the underlined element: $\underline{Fe}_2O_3$?

a. –2 **b. +2**

c. –3 **d. +3**

2) What is the oxidation number of the underlined element: $\underline{Ru}O_4$?

a. +6

b. +8

c. –8

d. –6

3) What is the oxidation number of the underlined element: $\underline{U}O_2^{2+}$?

a. +6 **b. +8**

c. +4 **d. +2**

4) What is the oxidation number of the underlined element: $\underline{O}F_2$?

a. –2

b. +1

c. –1

d. +2

5) What is the oxidation number of the underlined element: $K\underline{O}_2$?

a. –2 b. –1

c. $-\frac{1}{2}$ d. $+\frac{1}{2}$

6) What is the oxidation number of K in KBr?

a. +1

b. –1

c. +2

d. –2

7) What is the oxidation number of Br in KBr?

a. +1

b. –1

c. +2

d. –2

8) What is the oxidation number of Mn in $KMnO_4$?

a. +3

b. –3

c. +7

d. –7

9) What is the oxidation number of Ni in $Ni(CN)_2$?

a. +2

b. –2

c. +4

d. –4

10) What is the oxidation number of Se in SeO_4^{2-}?

a. –6

b. +6

c. –4

d. +4

11) What is the oxidation number of Cl in Cl_2?

a. –2

b. –1

c. +1

d. 0

12) What is the oxidation number of Xe in XeF_6?

a. –6

b. +6

c. –1

d. +1

13) Which of the following substances has an oxidation number for Cl = +7?

a. Cl_2

b. $HClO_4$

c. HCl

d. $HClO_2$

14) Which of the following substances has an oxidation number for S = +4?

a. S_8

b. CaS

c. HSO_3^-

d. SO_4^{2-}

15) Which of the following substances has an oxidation number for N = –3?

a. NH_3

b. NO_3^-

c. N_2O_4

d. N_2

16) Which of the following substances has an oxidation number for S = –2?

a. S_8

b. $S_2O_3^{2-}$

c. Na_2SO_4

d. K_2S

17) Which of the following substances has an oxidation number for S = +2?

a. H_2S

b. $S_2O_3^{2-}$

c. SO_3^{2-}

d. HSO_4^-

18) Which of the following substances has an oxidation number for N = +4?

a. KNO_3

b. N_2O_5

c. N_2O_4

d. HNO_3

19) Which of the following substances has an oxidation number for P = +3?

a. $H_2PO_3^-$

b. P_2O_5

c. H_3PO_4

d. PO_4^{3-}

20) Which of the following substances has an oxidation number for S = +4?

a. HSO_3^-

b. H_2SO_4

c. SO_3

d. SO_4^{2-}

21) How is the oxidation number of sulfur different in sulfite ion SO_3^{2-} than in sulfur trioxide SO_3?

choice	S in SO_3^{2-}	S in SO_3
a.	+4	+4
b.	+6	+6
c.	+4	+6
d.	+6	+4

22) What is the order of the following substances in terms of oxidation numbers of nitrogen? N_2H_4, NH_3, N_2, NO_3^-

a. least: $N_2 \rightarrow NO_3^- \rightarrow NH_3 \rightarrow N_2H_4$ least

b. least: $N_2 \rightarrow N_2H_4 \rightarrow NH_3 \rightarrow NO_3^-$ least

c. least: $NH_3 \rightarrow NO_3^- \rightarrow N_2 \rightarrow N_2H_4$ least

d. least: $NH_3 \rightarrow N_2H_4 \rightarrow N_2 \rightarrow NO_3^-$ least

23) What is the order of the following substances in terms of oxidation numbers of phosphorus? PH_3, PCl_3, P_2H_4, H_3PO_4

a. least: $PH_3 \rightarrow PCl_3 \rightarrow P_2H_4 \rightarrow H_3PO_4$ least

b. least: $PH_3 \rightarrow P_2H_4 \rightarrow PCl_3 \rightarrow H_3PO_4$ least

c. least: $PCl_3 \rightarrow H_3PO_4 \rightarrow P_2H_4 \rightarrow PH_3$ least

d. least: $PCl_3 \rightarrow PH_3 \rightarrow H_3PO_4 \rightarrow P_2H_4$ least

24) What is the order of the following substances in terms of oxidation numbers of oxygen? OF_2, H_2O_2, NO, O_2

a. least: $NO \rightarrow H_2O_2 \rightarrow O_2 \rightarrow OF_2$ least

b. least: $H_2O_2 \rightarrow O_2 \rightarrow OF_2 \rightarrow NO$ least

c. least: $O_2 \rightarrow H_2O_2 \rightarrow NO \rightarrow OF_2$ least

d. least: $OF_2 \rightarrow NO \rightarrow O_2 \rightarrow H_2O_2$ least

25) Which of the following reactions represents a reduction reaction?

a. $Zn \rightarrow Zn^{2+}$

b. $F_2 \rightarrow 2F^-$

c. $Fe^{2+} \rightarrow Fe^{3+}$

d. $2Cl^- \rightarrow Cl_2$

26) Which of the following reactions represents an oxidation reaction?

a. $I_2 \rightarrow 2I^-$

b. $Cu^{2+} \rightarrow Cu^+$

c. $IO_4^- \rightarrow IO_3^-$

d. $Na \rightarrow Na^+$

27) In which of the following reactions the oxidation number does not change?

a. $Fe \rightarrow FeO$

b. $C \rightarrow CO_2$

c. $Cr_2O_7^{2-} \rightarrow CrO_4^{2-}$

d. $C_2O_4^{2-} \rightarrow CO_2$

28) What happens in the reaction: $Zn + Cu^{2+} \rightarrow Cu + Zn^{2+}$?

a. Cu is oxidized and Zn^{2+} is reduced

b. Cu is reduced and Zn^{2+} is oxidized

c. Cu^{2+} is oxidized and Zn is reduced

d. Cu^{2+} is reduced and Zn is oxidized

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29) In an oxidation-reduction reaction that converts C to CO_2, how many electrons are lost or gained from C?

a. loses 1 electron

b. loses 4 electrons

c. gain 1 electron

d. gain 4 electrons

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30) Which of the following reactions represents an oxidation-reduction reaction?

a. $2H_2 + O_2 \rightarrow 2H_2O$

b. $LiOH + HNO_3 \rightarrow LiNO_3 + H_2O$

c. $CaCO_3 \rightarrow CaO + CO_2$

d. $CrCl_3 + 3KOH \rightarrow Cr(OH)_3 + 3KCl$

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31) Which of the following reactions is not an oxidation-reduction reaction?

a. $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

b. $NaOH + HCl \rightarrow NaCl + H_2O$

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c. $Cl_2 + H_2O \rightarrow HCl + HClO$

d. $3Br_2 + 2Ga \rightarrow 2GaBr_3$

32) What is the spectator ion in the reaction? $2Fe_{(s)} + 6HBr_{(aq)} \rightarrow 2FeBr_{3(s)} + 3H_{2(g)}$

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a. Fe

b. H^+

c. H_2

d. Br^-

33) What is the reaction of oxidizing agent?

a. Oxidation
b. Neutralization
c. Reduction
d. Combustion

34) In oxidation-reduction reactions, what happens to the reducing agents?

a. Its oxidation number decreases
b. Its oxidation number increases
c. Its oxidation number does not change
d. Gains electrons

35) What is the oxidizing agent in the following reaction?

$$Al_2O_{3(s)} + 3C_{(s)} + 3Cl_{2(g)} \rightarrow 2AlCl_{3(s)} + 3CO_{(g)}$$

a. Al_2O_3
b. Cl_2
c. $AlCl_3$
d. C

36) Which of the following statements is correct regarding the reaction?

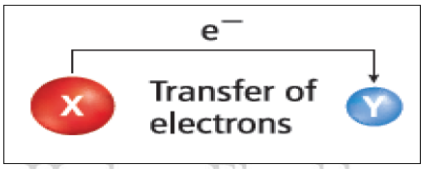
$$Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$$

a. Cu^{2+} is a stronger oxidizing agent than Zn^{2+}
b. Cu is a stronger oxidizing agent than Zn
c. Cu^{2+} is a stronger reducing agent than Zn^{2+}
d. Cu is a stronger reducing agent than Zn

37) Regarding the following oxidation–reduction equation. Which of the following statements is correct? $Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$

a. Zn^{2+} turns into Zn
b. Copper loses two electrons and is reduced
c. Cu turns into Cu^{2+}
d. Oxidation of zinc occurs when two electrons are lost

38) Which statement is incorrect regarding the adjacent chart?



a. X is an oxidizing agent and Y is a reducing agent

b. X is a reducing agent and Y is an oxidizing agent

c. Y gains an electron

d. The oxidation number of X increases and the oxidation number of Y decreases

39) In which of the following reactions does nitrogen (NO_2^- or N_2) act as a reducing agent?

a. $NO_2^-{}_{(aq)} + Cl^-{}_{(aq)} \rightarrow N_2O_{(g)} + ClO^-{}_{(aq)}$

b. $N_2 + 3H_2 \rightarrow 2NH_3$

c. $Cr_2O_7^{2-}{}_{(aq)} + NO_2^-{}_{(aq)} \rightarrow Cr^{3+}{}_{(aq)} + NO_3^-{}_{(aq)}$

d. $3Mg + N_2 \rightarrow Mg_3N_2$

40) Which of the following statements is incorrect for the reaction?

$$Al_2O_3 + 2Cr^{3+} \rightarrow Cr_2O_3 + 2Al^{3+}$$

a. does not represent an oxidation-reduction reaction

b. 3 electrons are transferred from Al to Cr

c. The oxidation number of Cr does not change during the reaction

d. Represents O_2^- spectator ion

41) What is the reducing agent in the reaction?

$$Ca_{(s)} + Zn^{2+}{}_{(aq)} \rightarrow Ca^{2+}{}_{(aq)} + Zn_{(s)}$$

a. $Zn^{2+}{}_{(aq)}$

b. $Ca^{2+}{}_{(aq)}$

c. $Ca_{(s)}$

d. $Zn_{(s)}$

42) If sulfur has oxidation numbers: +6, +4, 0, –2. Does sulfur (–2) act as an oxidizing agent or as a reducing agent, and why?

choice	Agent type	The reason
a.	oxidizing agent	Sulfur exists at its greatest oxidation number, and a reduction process occurs
b.	oxidizing agent	Sulfur exists at its lowest oxidation number, and an oxidation process occurs
c.	reducing agent	Sulfur exists at its highest oxidation number, and a reduction process occurs
d.	reducing agent	Sulfur exists at its lowest oxidation number, and an oxidation process occurs

43) If sulfur has oxidation numbers: +6, +4, 0, –2. Does sulfur (+6) act as an oxidizing agent or as a reducing agent, and why?

choice	Agent type	The reason
a.	oxidizing agent	Sulfur exists at its greatest oxidation number, and a reduction process occurs
b.	oxidizing agent	Sulfur exists at its lowest oxidation number, and an oxidation process occurs
c.	reducing agent	Sulfur exists at its highest oxidation number, and a reduction process occurs
d.	reducing agent	Sulfur exists at its lowest oxidation number, and an oxidation process occurs

44) Which of the following is not a reducing agent in a redox reaction?

a. A substance that is oxidized during the reaction

b. Electron-accepting substance

c. The substance whose oxidation number increases during the reaction

d. Electron-donor substance

45) What are the two redox reactions for the reaction between nickel and copper chloride (II)? $Ni_{(s)} + CuCl_{2(aq)} \rightarrow Cu_{(s)} + NiCl_{2(aq)}$

choice	Oxidation half-reaction	Oxidation half-reaction
a.	$Ni \rightarrow Ni^{+} + e^{-}$	$Cu^{2+} + 2e^{-} \rightarrow Cu$
b.	$Ni \rightarrow Ni^{+} + e^{-}$	$Cu^{+} + e^{-} \rightarrow Cu$
c.	$Ni \rightarrow Ni^{2+} + 2e^{-}$	$Cu^{2+} + 2e^{-} \rightarrow Cu$
d.	$Ni \rightarrow Ni^{2+} + 2e^{-}$	$Cu^{+} + e^{-} \rightarrow Cu$

46) What is the oxidizing agent in the reaction?

$$2NaI_{(aq)} + Cl_{2(aq)} \rightarrow 2NaCl_{(aq)} + I_{2(aq)}$$

a. NaI

b. I_2

c. NaCl

d. Cl_2

47) Why does the oxidation number of sodium not change in the reaction?

$$2NaI_{(aq)} + Cl_{2(aq)} \rightarrow 2NaCl_{(aq)} + I_{2(aq)}$$

a. Na^{+} spectator ion

b. Na^{+} get reduced

c. Na^{+} represents reducing agent

d. Na^{+} get oxidized

48) Which of the following has the highest oxidation number for manganese (Mn)?

a. MnO_2

b. K_2MnO_4

c. MnO

d. $KMnO_4$

49) Which of the following undergoes oxidation in the following reaction?

$$2Na + 2H^+ \rightarrow 2Na^+ + H_2$$

a. Na^+ b. Na

c. H^+ d. H_2

50) Which of the following statements is true regarding the following oxidation–reduction reaction? $2Br^-_{(aq)} + Cl_{2(aq)} \rightarrow 2Cl^-_{(aq)} + Br_{2(aq)}$

a. Oxidation of chlorine Cl_2

b. Reduction of bromide ions Br^-

c. Transfer of electrons from chlorine to bromide ions

d. Transfer of electrons from bromide ions to chlorine

Answer Key

1	d	2	b	3	a	4	d	5	c
6	a	7	b	8	c	9	a	10	b
11	d	12	b	13	b	14	c	15	a
16	d	17	b	18	c	19	a	20	a
21	c	22	d	23	b	24	a	25	b
26	d	27	c	28	d	29	b	30	a
31	b	32	d	33	c	34	b	35	b
36	a	37	d	38	a	39	c	40	b
41	c	42	d	43	a	44	b	45	c
46	d	47	a	48	d	49	b	50	d

Section (2) Practices

Glossary	
Net ionic equation	An ionic equation that includes only the particles involved in the reaction.
Half-reaction	One of the two parts of a redox reaction, i.e. an oxidation reaction or a reduction reaction.
Type	Any chemical particle that participates in a reaction.

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Essay Questions		
1	How is the change in oxidation number related to redox processes?	Oxidation: a process in which the oxidation number increases. Reduction: a process in which the oxidation number decreases.
2	Why is it important to know the medium in which the redox reaction occurs in an aqueous solution when balancing the equation?	Balancing is done with H^+ in acidic solution, balancing is done with OH^- in basic solution.
3	What does the oxidation half-reaction and reduction half-reaction explain?	Oxidation half-reaction: in which the oxidation number increases. Reduction half-reaction: in which the oxidation number decreases.
4	Why is the use of hydrogen ions H^+ in redox reactions considered a simplification of reality?	In an acidic solution, H^+ ions combine with water to form hydronium ions, H_3O^+
5	Describe what happens to the electrons in each half-reaction of the redox process.	Oxidation: The process of losing electrons. Reduction: The process of gaining electrons.
6	When solid copper is placed in a silver nitrate solution, silver metal appears, and a blue-colored copper II nitrate solution is formed. Write both halves of the reaction equation and determine which is oxidation and which is reduction. Write the balanced equation for this reaction.	Oxidation: $Cu \rightarrow Cu^{2+} + 2e^-$, Reduction: $Ag^+ + e^- \rightarrow Ag$ Overall reaction: $Cu + 2Ag^+ \rightarrow 2Ag + Cu^{2+}$ 

Multiple choice questions

1) **What are the two (unbalanced) redox half-reactions of the following unbalanced redox reaction?** $PbO_{(s)} + NH_{3(g)} \rightarrow N_{2(g)} + H_2O_{(l)} + Pb_{(s)}$

choice	Oxidation half-reaction	Oxidation half-reaction
a.	$PbO \rightarrow Pb$	$NH_3 \rightarrow N_2$
b.	$NH_3 \rightarrow N_2$	$PbO \rightarrow Pb$
c.	$Pb \rightarrow PbO$	$N_2 \rightarrow NH_3$
d.	$N_2 \rightarrow NH_3$	$Pb \rightarrow PbO$

2) **What are the two (unbalanced) redox half-reactions of the following unbalanced redox reaction?** $I_{2(s)} + Na_2S_2O_{3(aq)} \rightarrow Na_2S_4O_{6(aq)} + NaI_{(aq)}$

choice	Oxidation half-reaction	Oxidation half-reaction
a.	$NaI \rightarrow I_2$	$Na_2S_4O_4 \rightarrow Na_2S_2O_3$
b.	$Na_2S_4O_4 \rightarrow Na_2S_2O_3$	$NaI \rightarrow I_2$
c.	$I_2 \rightarrow NaI$	$Na_2S_2O_3 \rightarrow Na_2S_4O_6$
d.	$Na_2S_2O_3 \rightarrow Na_2S_4O_6$	$I_2 \rightarrow NaI$

3) **What are the two (unbalanced) redox half-reactions of the following unbalanced redox reaction?** $Sn_{(s)} + HCl_{(aq)} \rightarrow SnCl_{2(aq)} + H_{2(g)}$

choice	Oxidation half-reaction	Oxidation half-reaction
a.	$Sn \rightarrow SnCl_2$	$H^+ \rightarrow H_2$
b.	$H^+ \rightarrow H_2$	$Sn \rightarrow SnCl_2$
c.	$SnCl_2 \rightarrow Sn$	$H_2 \rightarrow H^+$
d.	$H_2 \rightarrow H^+$	$SnCl_2 \rightarrow Sn$

4) **What is the (unbalanced) oxidation half-reaction of the following redox equation?**

$$Pb_{(s)} + Pd(NO_3)_{2(aq)} \rightarrow Pb(NO_3)_{2(aq)} + Pd_{(s)}$$

a. $Pb_{(s)} \rightarrow Pb(NO_3)_{2(aq)}$

b. $Pd(NO_3)_{2(aq)} \rightarrow Pb(NO_3)_{2(aq)}$

c. $Pb_{(s)} \rightarrow Pd_{(s)}$

d. $Pd(NO_3)_{2(aq)} \rightarrow Pd_{(s)}$

5) **Which of the following reactions represents an oxidation half-reaction?**

a. $F_{2(g)} + 2e^- \rightarrow 2F^-_{(aq)}$

b. $2H^+_{(aq)} + 2e^- \rightarrow H_{2(g)}$

c. $Fe^{2+}_{(aq)} \rightarrow Fe^{3+}_{(aq)} + e^-$

d. $MnO_4^-{}_{(aq)} + 5e^- + 8H^+_{(aq)} \rightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}$

6) **Which of the following shows the balanced oxidation half-reaction of a chemical reaction?** $Fe + F_2 \rightarrow FeF_3$

a. $Fe \rightarrow Fe^{3+} + 3e^-$

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

c. $F_2 + 2e^- \rightarrow 2F^-$

d. $F_2 \rightarrow 2F^+ + 2e^-$

7) **In the half-reaction:** $NO_3^- \rightarrow NH_4^+$**, how many electrons must be added to balance the charge?**

a. $NO_3^- + 3e^- \rightarrow NH_4^+$

b. $NO_3^- + 8e^- \rightarrow NH_4^+$

c. $NO_3^- \rightarrow NH_4^+ + 5e^-$

d. $NO_3^- \rightarrow NH_4^+ + 8e^-$

8) Which of the following makes the following oxidation-reduction equation balanced?

$$Fe_{(s)} + Ag^{+} \rightarrow Fe^{2+} + Ag$$

a. $Fe_{(s)} + Ag^{+} \rightarrow Fe^{2+} + 2Ag$

b. $Fe_{(s)} + 2Ag^{+} \rightarrow Fe^{2+} + Ag$

c. $2Fe_{(s)} + Ag^{+} \rightarrow 2Fe^{2+} + Ag$

d. $Fe_{(s)} + 2Ag^{+} \rightarrow Fe^{2+} + 2Ag$

9) If the oxidation reaction is: $Sn^{2+} \rightarrow Sn^{4+} + 2e^{-}$, and the reduction reaction: $Au^{3+} + 3e^{-} \rightarrow Au$, what is the minimum amount of tin ions Sn^{2+} and gold ions Au^{3+} that can react so that no electrons remain?

a. $3Au^{3+}, 2Sn^{2+}$

b. Au^{3+}, Sn^{2+}

c. $2Au^{3+}, 3Sn^{2+}$

d. $3Au^{3+}, Sn^{2+}$

10) What is the balanced redox equation that has the following redox half-reactions?

$$Fe \rightarrow Fe^{2+} + 2e^{-}, \quad Te^{2+} + 2e^{-} \rightarrow Te$$

a. $Fe + Fe^{2+} \rightarrow Te^{2+} + Te$

b. $Te^{2+} + Te \rightarrow Fe + Fe^{2+}$

c. $Fe + Te^{2+} \rightarrow Fe^{2+} + Te$

d. $Fe^{2+} + Te \rightarrow Fe + Te^{2+}$

11) What is the balanced redox equation that has the following redox half-reactions?

$$Fe^{2+} \rightarrow Fe^{3+} + e^{-}, \quad 5e^{-} + MnO_4^{-} \rightarrow Mn^{2+}$$

a. $Fe^{2+} + MnO_4^{-} + 2H^{+} \rightarrow Fe^{3+} + Mn^{2+} + H_2O$

b. $5Fe^{2+} + MnO_4^{-} + 2H^{+} \rightarrow 5Fe^{3+} + Mn^{2+} + H_2O$

c. $Fe^{2+} + MnO_4^{-} + 8H^{+} \rightarrow Fe^{3+} + Mn^{2+} + 4H_2O$

d. $5Fe^{2+} + MnO_4^{-} + 8H^{+} \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$

12) The permanganate ion oxidizes chloride ions to chlorine gas and produces Mn^{2+}. What is the balanced equation for the redox reaction, given that the reaction occurs in an acidic solution? $MnO_4^- + Cl^- \rightarrow Mn^{2+} + Cl_2$

a. $2MnO_4^- + 10Cl^- + 16H^+ \rightarrow 2Mn^{2+} + 5Cl_2 + 8H_2O$

b. $MnO_4^- + 10Cl^- + 8H^+ \rightarrow Mn^{2+} + 5Cl_2 + 4H_2O$

c. $2MnO_4^- + 2Cl^- + 16H^+ \rightarrow 2Mn^{2+} + Cl_2 + 8H_2O$

d. $2MnO_4^- + 10Cl^- \rightarrow 2Mn^{2+} + 5Cl_2$

13) The redox reaction between $Cr_2O_7^{2-}$ ions and I^- ions in the acidic solution is shown in the corresponding figure. Use the half-reaction method to balance the redox equation, noting that the reaction products are Cr^{3+} and I_2.

$I^- + Cr_2O_7^{2-} \rightarrow Cr^{3+} + I_2$



a. $2I^- + Cr_2O_7^{2-} + 14H^+ \rightarrow 2Cr^{3+} + I_2 + 7H_2O$

b. $6I^- + Cr_2O_7^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$

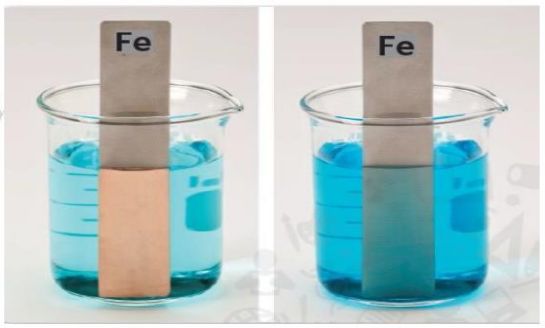
c. $6I^- + Cr_2O_7^{2-} + 2H^+ \rightarrow Cr^{3+} + 3I_2 + H_2O$

d. $6I^- + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 3I_2$

14) Which of the following statements is correct for the following redox reaction.

$Fe_{(s)} + CuSO_{4(aq)} \rightarrow FeSO_{4(aq)} + Cu_{(s)}$

Using the corresponding figure?



a. Oxidation reaction: $Cu \rightarrow Cu^{2+} + 2e^-$

b. Reduction reaction: $Fe^{2+} + 2e^- \rightarrow Fe$

c. 2 electrons are transferred from Fe to Cu^{2+}

d. 2 electrons are transferred from Cu to Fe^{2+}

15) What is the value of X in the following half-reaction equation so that the equation becomes balanced? $MnO_4^-{}_{(aq)} + 8H^+{}_{(aq)} + Xe^- \rightarrow Mn^{2+}{}_{(aq)} + 4H_2O_{(l)}$

a. 5

b. 1

c. 2

d. 10

16) What must be added to the redox equation that occurs in an acidic medium for it to be balanced?

a. H_2O, OH^-

b. H_2O, H^+

c. OH^- only

d. H_2O only

17) Corundum consists of aluminum oxide Al_2O_3 and is gray in color. Rubies are mostly aluminum oxide but contain small amounts of Fe^{2+} and Ti^{4+}. The color of rubies results from the process of electron transfer from Fe^{2+} to Ti^{4+}. Based on the corresponding figure when the mineral on the right is formed, what is an oxidation half-reaction and a reduction half-reaction?





choice	Oxidation half-reaction	Oxidation half-reaction
a.	$Ti^{3+} \rightarrow Ti^{4+} + e^-$	$Fe^{3+} + e^- \rightarrow Fe^{2+}$
b.	$Fe^{3+} + e^- \rightarrow Fe^{2+}$	$Ti^{3+} \rightarrow Ti^{4+} + e^-$
c.	$Ti^{4+} + e^- \rightarrow Ti^{3+}$	$Fe^{2+} \rightarrow Fe^{3+} + e^-$
d.	$Fe^{2+} \rightarrow Fe^{3+} + e^-$	$Ti^{4+} + e^- \rightarrow Ti^{3+}$

18) What is the balanced equation for the following half-reactions? (in acidic solution)

$Al \rightarrow Al^{3+} + 3e^-$, $IO_4^- + 2e^- \rightarrow IO_3^-$

a. $2Al + 3IO_4^- \rightarrow 2Al^{3+} + 3IO_3^-$

b. $Al + IO_4^- + 6H^+ \rightarrow Al^{3+} + IO_3^- + 3H_2O$

c. $2Al + 3IO_4^- + 2H^+ \rightarrow 2Al^{3+} + 3IO_3^- + H_2O$

d. $2Al + 3IO_4^- + 6H^+ \rightarrow 2Al^{3+} + 3IO_3^- + 3H_2O$

19) What is the balanced equation for the following half-reactions? (in acidic solution)

$N_2O \rightarrow 2NO_3^- + 8e^-$, $I_2 + 2e^- \rightarrow 2I^-$

a. $N_2O + I_2 \rightarrow 2NO_3^- + 2I^-$

b. $N_2O + I_2 + 5H_2O \rightarrow 2NO_3^- + 2I^- + 10H^+$

c. $N_2O + 4I_2 + 5H_2O \rightarrow 2NO_3^- + 8I^- + 10H^+$

d. $N_2O + 5I_2 + 5H_2O \rightarrow 2NO_3^- + 10I^- + 10H^+$

20) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $S^{2-}_{(g)} + NO_3^-{}_{(aq)} \rightarrow S_{(s)} + NO_{(g)}$

a. $S^{2-} + NO_3^- \rightarrow S + NO$

b. $S^{2-} + 2NO_3^- + 8H^+ \rightarrow S + 2NO + 4H_2O$

c. $3S^{2-} + 2NO_3^- + 8H^+ \rightarrow 3S + 2NO + 4H_2O$

d. $3S^{2-} + NO_3^- + 2H^+ \rightarrow 3S + NO + H_2O$

21) What is the balanced equation for the following redox equation?

(using half-reaction method, in basic solution) $Cr_2O_7^{2-} + SO_2 \rightarrow Cr^{3+} + HSO_4^-$

a. $4H_2O + Cr_2O_7^{2-} + 3SO_2 \rightarrow 2Cr^{3+} + 3HSO_4^- + 5OH^-$

b. $2H_2O + Cr_2O_7^{2-} + 3SO_2 \rightarrow 2Cr^{3+} + 3HSO_4^- + 2OH^-$

c. $3H_2O + Cr_2O_7^{2-} + 3SO_2 \rightarrow 2Cr^{3+} + 3HSO_4^- + 3H^+$

d. $H^+ + Cr_2O_7^{2-} + 3SO_2 \rightarrow 2Cr^{3+} + 3HSO_4^- + 3H_2O$

22) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $MnO_4^- + As_2O_3 \rightarrow Mn^{2+} + AsO_4^-$

a. $14H^+ + 4MnO_4^- + 5As_2O_3 \rightarrow 4Mn^{2+} + 10AsO_4^- + 7H_2O$

b. $14H^+ + 8MnO_4^- + 5As_2O_3 \rightarrow 8Mn^{2+} + 10AsO_4^- + 7H_2O$

c. $2H^+ + 8MnO_4^- + 5As_2O_3 \rightarrow 8Mn^{2+} + 10AsO_4^- + H_2O$

d. $2H^+ + 8MnO_4^- + As_2O_3 \rightarrow 8Mn^{2+} + 2AsO_4^- + H_2O$

23) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $NO_3^- + H_2S \rightarrow NO + S$

a. $2H^+ + 2NO_3^- + 4H_2S \rightarrow 2NO + 3S + 5H_2O$

b. $2H^+ + 2NO_3^- + H_2S \rightarrow 2NO + S + 4H_2O$

c. $2H^+ + 2NO_3^- + 2H_2S \rightarrow 2NO + 3S + 2H_2O$

d. $2H^+ + 2NO_3^- + 3H_2S \rightarrow 2NO + 3S + 4H_2O$

24) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $Bi^{3+} + SnO_2^{2-} \rightarrow Bi + SnO_3^{2-}$

a. $H_2O + 2Bi^{3+} + SnO_2^{2-} \rightarrow 2Bi + SnO_3^{2-} + 2H^+$

b. $3H_2O + 2Bi^{3+} + 3SnO_2^{2-} \rightarrow 2Bi + 3SnO_3^{2-} + 6H^+$

c. $2H_2O + 2Bi^{3+} + 3SnO_2^{2-} \rightarrow 2Bi + 3SnO_3^{2-} + 4H^+$

d. $4H_2O + 2Bi^{3+} + 3SnO_2^{2-} \rightarrow 2Bi + 3SnO_3^{2-} + 8H^+$

25) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+}$

a. $8H^+ + 5Fe^{2+} + MnO_4^- \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$

b. $4H^+ + 5Fe^{2+} + MnO_4^- \rightarrow 5Fe^{3+} + Mn^{2+} + 2H_2O$

c. $6H^+ + Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+} + 3H_2O$

d. $2H^+ + 6Fe^{2+} + MnO_4^- \rightarrow 6Fe^{3+} + Mn^{2+} + H_2O$

26) What is the balanced equation for the following redox equation? (using half-reaction method, in acidic solution) $Mn^{2+}_{(aq)} + BiO_3^-{}_{(aq)} \rightarrow MnO_4^-{}_{(aq)} + Bi^{3+}_{(aq)}$

a. $12H^+ + Mn^{2+} + 5BiO_3^- \rightarrow MnO_4^- + 5Bi^{3+} + 6H_2O$

b. $2H^+ + 2Mn^{2+} + 5BiO_3^- \rightarrow 2MnO_4^- + 5Bi^{3+} + H_2O$

c. $14H^+ + 2Mn^{2+} + 5BiO_3^- \rightarrow 2MnO_4^- + 5Bi^{3+} + 7H_2O$

d. $10H^+ + 2Mn^{2+} + BiO_3^- \rightarrow 2MnO_4^- + Bi^{3+} + 5H_2O$

27) What is the balanced equation for the following redox equation? (using half-reaction method, in acidic solution) $MnO_2 + Cl^- \rightarrow Mn^{2+} + Cl_2$

a. $8H^+ + MnO_2 + 4Cl^- \rightarrow Mn^{2+} + 2Cl_2 + 4H_2O$

b. $2H^+ + MnO_2 + 2Cl^- \rightarrow Mn^{2+} + Cl_2 + H_2O$

c. $6H^+ + MnO_2 + 2Cl^- \rightarrow Mn^{2+} + Cl_2 + 3H_2O$

d. $4H^+ + MnO_2 + 2Cl^- \rightarrow Mn^{2+} + Cl_2 + 2H_2O$

28) What is the balanced equation for the following redox equation? (using half-reaction method, in acidic solution) $C_2O_4^{2-} + CrO_4^{2-} \rightarrow Cr^{3+} + CO_2$

a. $16H^+ + 3C_2O_4^{2-} + 2CrO_4^{2-} \rightarrow 2Cr^{3+} + 6CO_2 + 8H_2O$

b. $8H^+ + 3C_2O_4^{2-} + 2CrO_4^{2-} \rightarrow 2Cr^{3+} + 6CO_2 + 4H_2O$

c. $16H^+ + 3C_2O_4^{2-} + CrO_4^{2-} \rightarrow Cr^{3+} + 6CO_2 + 8H_2O$

d. $10H^+ + C_2O_4^{2-} + 2CrO_4^{2-} \rightarrow 2Cr^{3+} + 2CO_2 + 5H_2O$

29) What is the balanced equation for the following redox equation? (using half-reaction method, in acidic solution) $MnO_4^- + Al \rightarrow Al^{3+} + Mn^{2+}$

a. $12H^+ + 3MnO_4^- + Al \rightarrow Al^{3+} + 3Mn^{2+} + 6H_2O$

b. $24H^+ + 3MnO_4^- + 5Al \rightarrow 5Al^{3+} + 3Mn^{2+} + 12H_2O$

c. $24H^+ + MnO_4^- + Al \rightarrow Al^{3+} + Mn^{2+} + 12H_2O$

d. $12H^+ + MnO_4^- + 5Al \rightarrow 5Al^{3+} + Mn^{2+} + 12H_2O$

30) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $Cl_2 \rightarrow ClO^- + Cl^-$

a. $2H_2O + 2Cl_2 \rightarrow 2ClO^- + 2Cl^- + 4H^+$

b. $4H_2O + 3Cl_2 \rightarrow ClO^- + 2Cl^- + 8H^+$

c. $2H_2O + 3Cl_2 \rightarrow 2ClO^- + 4Cl^- + 4H^+$

d. $6H_2O + 2Cl_2 \rightarrow 2ClO^- + Cl^- + 12H^+$

31) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $ClO^- \rightarrow Cl_2 + ClO_3^-$

a. $4H^+ + 6ClO^- \rightarrow 2Cl_2 + 2ClO_3^- + 3H_2O$

b. $6H^+ + 5ClO^- \rightarrow Cl_2 + 3ClO_3^- + 3H_2O$

c. $4H^+ + 5ClO^- \rightarrow 2Cl_2 + ClO_3^- + 2H_2O$

d. $6H^+ + 3ClO^- \rightarrow 2Cl_2 + ClO_3^- + 3H_2O$

32) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $MnO_4^- + Cl^- \rightarrow MnO_2 + Cl_2$

a. $4H^+ + MnO_4^- + 6Cl^- \rightarrow MnO_2 + 3Cl_2 + 2H_2O$

b. $10H^+ + MnO_4^- + 6Cl^- \rightarrow MnO_2 + 3Cl_2 + 5H_2O$

c. $4H^+ + 2MnO_4^- + 2Cl^- \rightarrow 2MnO_2 + Cl_2 + 2H_2O$

d. $8H^+ + 2MnO_4^- + 6Cl^- \rightarrow 2MnO_2 + 3Cl_2 + 4H_2O$

33) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $Cr_2O_7^{2-} + ClO^- \rightarrow ClO_2^- + Cr_2O_3$

a. $4H^+ + Cr_2O_7^{2-} + 4ClO^- \rightarrow 3ClO_2^- + Cr_2O_3 + 2H_2O$

b. $2H^+ + Cr_2O_7^{2-} + 3ClO^- \rightarrow 3ClO_2^- + Cr_2O_3 + H_2O$

c. $2H^+ + Cr_2O_7^{2-} + 4ClO^- \rightarrow 2ClO_2^- + Cr_2O_3 + 2H_2O$

d. $4H^+ + Cr_2O_7^{2-} + 3ClO^- \rightarrow 3ClO_2^- + Cr_2O_3 + 2H_2O$

34) What is the balanced equation for the following redox equation?

(using half-reaction method, in basic solution) $MnO_2 + S^{2-} \rightarrow Mn_2O_3 + S_2O_3^{2-}$

a. $2H_2O + 8MnO_2 + S^{2-} \rightarrow 2Mn_2O_3 + S_2O_3^{2-} + 4OH^-$

b. $H_2O + 8MnO_2 + 2S^{2-} \rightarrow 4Mn_2O_3 + S_2O_3^{2-} + 2OH^-$

c. $2H_2O + 4MnO_2 + 2S^{2-} \rightarrow 2Mn_2O_3 + S_2O_3^{2-} + 2OH^-$

d. $H_2O + 4MnO_2 + S^{2-} \rightarrow 4Mn_2O_3 + S_2O_3^{2-} + 4OH^-$

35) What is the balanced equation for the following redox equation?

(using half-reaction method, in basic solution) $IO_3^- + MnO_4^- \rightarrow MnO_2 + IO_4^-$

a. $2H_2O + 3IO_3^- + 2MnO_4^- \rightarrow MnO_2 + 3IO_4^- + 2OH^-$

b. $4H_2O + IO_3^- + 2MnO_4^- \rightarrow 3MnO_2 + IO_4^- + 2OH^-$

c. $H_2O + 3IO_3^- + 2MnO_4^- \rightarrow 2MnO_2 + 3IO_4^- + 2OH^-$

d. $H_2O + IO_3^- + 4MnO_4^- \rightarrow 4MnO_2 + IO_4^- + 2OH^-$

36) What is the balanced equation for the following redox equation?

(using half-reaction method, in basic solution) $MnO_4^{2-} \rightarrow MnO_2 + MnO_4^-$

a. $H_2O + 2MnO_4^{2-} \rightarrow MnO_2 + MnO_4^- + 2OH^-$

b. $2H_2O + 2MnO_4^{2-} \rightarrow MnO_2 + MnO_4^- + 4OH^-$

c. $H_2O + 3MnO_4^{2-} \rightarrow MnO_2 + 2MnO_4^- + 2OH^-$

d. $2H_2O + 3MnO_4^{2-} \rightarrow MnO_2 + 2MnO_4^- + 4OH^-$

37) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $ClO_3^-{}_{(aq)} \rightarrow ClO_{2(g)} + ClO_4^-{}_{(aq)}$

a. $2H^+ + 3ClO_3^- \rightarrow 2ClO_2 + ClO_4^- + H_2O$

b. $4H^+ + 2ClO_3^- \rightarrow ClO_2 + ClO_4^- + 2H_2O$

c. $4H^+ + 3ClO_3^- \rightarrow 2ClO_2 + ClO_4^- + 2H_2O$

d. $6H^+ + 2ClO_3^- \rightarrow ClO_2 + ClO_4^- + 3H_2O$

38) What is the balanced equation for the following redox equation? (using half-reaction method, in acidic solution) $MnO_4^-{}_{(aq)} + SO_{2(g)} \rightarrow Mn^{2+}{}_{(aq)} + SO_4^{2-}{}_{(aq)}$

a. $H_2O + 2MnO_4^- + 3SO_2 \rightarrow 2Mn^{2+} + 3SO_4^{2-} + H^+$

b. $H_2O + MnO_4^- + 5SO_2 \rightarrow Mn^{2+} + 5SO_4^{2-} + H^+$

c. $2H_2O + 2MnO_4^- + 5SO_2 \rightarrow 2Mn^{2+} + 5SO_4^{2-} + 4H^+$

d. $2H_2O + MnO_4^- + 4SO_2 \rightarrow Mn^{2+} + 4SO_4^{2-} + 4H^+$

39) What is the balanced equation for the following redox equation? (using half-reaction method, in acidic solution) $SeO_3^{2-}{}_{(aq)} + ClO_3^-{}_{(aq)} \rightarrow SeO_4^{2-}{}_{(aq)} + Cl_{2(g)}$

a. $2H^+ + SeO_3^{2-} + 2ClO_3^- \rightarrow SeO_4^{2-} + Cl_2 + H_2O$

b. $8H^+ + 5SeO_3^{2-} + 4ClO_3^- \rightarrow 5SeO_4^{2-} + 2Cl_2 + 4H_2O$

c. $2H^+ + 3SeO_3^{2-} + 4ClO_3^- \rightarrow 3SeO_4^{2-} + 2Cl_2 + H_2O$

d. $2H^+ + 5SeO_3^{2-} + 2ClO_3^- \rightarrow 5SeO_4^{2-} + Cl_2 + H_2O$

40) What is the balanced equation for the following redox equation? (using half-reaction method, in acidic solution) $Cr_2O_7^{2-}{}_{(aq)} + Fe^{2+}{}_{(aq)} \rightarrow Cr^{3+}{}_{(aq)} + Fe^{3+}{}_{(aq)}$

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

b. $Cr_2O_7^{2-} + 4Fe^{2+} + 12H^+ \rightarrow 2Cr^{3+} + 4Fe^{3+} + 6H_2O$

c. $2Cr_2O_7^{2-} + 4Fe^{2+} + 14H^+ \rightarrow 4Cr^{3+} + 4Fe^{3+} + 7H_2O$

d. $2Cr_2O_7^{2-} + 6Fe^{2+} + 12H^+ \rightarrow 4Cr^{3+} + 6Fe^{3+} + 6H_2O$

41) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $Br_{2(l)} \rightarrow Br^-{}_{(aq)} + BrO_3^-{}_{(aq)}$

a. $3Br_2 + 6H_2O \rightarrow 6Br^- + 2BrO_3^- + 12H^+$

b. $6Br_2 + 6H_2O \rightarrow 10Br^- + 2BrO_3^- + 12H^+$

c. $3Br_2 + 3H_2O \rightarrow 6Br^- + 2BrO_3^- + 6H^+$

d. $6Br_2 + 3H_2O \rightarrow 10Br^- + 2BrO_3^- + 6H^+$

42) What is the balanced equation for the following redox equation? (using half-reaction method, in acidic solution) $Cl^-_{(aq)} + NO_3^-{}_{(aq)} \rightarrow ClO^-_{(aq)} + NO_{(g)}$

a. $4Cl^- + 2NO_3^- + 2H^+ \rightarrow 4ClO^- + 2NO + H_2O$

b. $3Cl^- + 2NO_3^- + 2H^+ \rightarrow 3ClO^- + 2NO + H_2O$

c. $3Cl^- + 2NO_3^- + 4H^+ \rightarrow 3ClO^- + 2NO + 2H_2O$

d. $Cl^- + 2NO_3^- + 2H^+ \rightarrow ClO^- + 2NO + H_2O$

43) What is the balanced equation for the following redox equation? (using half-reaction method, in acidic solution) $IO_3^-{}_{(aq)} + Br^-_{(aq)} \rightarrow Br_{2(l)} + I^-_{(s)}$

a. $IO_3^- + 6Br^- + 6H^+ \rightarrow 3Br_2 + I^- + 3H_2O$

b. $3IO_3^- + 2Br^- + 6H^+ \rightarrow 2Br_2 + 3I^- + 3H_2O$

c. $IO_3^- + 6Br^- + 2H^+ \rightarrow 3Br_2 + I^- + H_2O$

d. $2IO_3^- + 2Br^- + 6H^+ \rightarrow Br_2 + 2I^- + 3H_2O$

44) What is the balanced equation for the following redox equation? (using half-reaction method, in acidic solution) $I_{2(s)} + S_2O_3^{2-}{}_{(aq)} \rightarrow S_4O_6^{2-}{}_{(aq)} + I^-_{(aq)}$

a. $I_2 + 2S_2O_3^{2-} + 2H^+ \rightarrow S_4O_6^{2-} + 2I^- + H_2O$

b. $I_2 + 4S_2O_3^{2-} \rightarrow 2S_4O_6^{2-} + 2I^-$

c. $I_2 + 2S_2O_3^{2-} + 6H^+ \rightarrow S_4O_6^{2-} + 2I^- + 3H_2O$

d. $I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$

45) What is the balanced equation for the following redox equation? (using half-reaction method, in acidic solution) $Sb^{3+} + MnO_4^- \rightarrow SbO_4^{3-} + Mn^{2+}$

a. $5Sb^{3+} + 2MnO_4^- + 6H_2O \rightarrow 5SbO_4^{3-} + 2Mn^{2+} + 12H^+$

b. $Sb^{3+} + 2MnO_4^- + 12H_2O \rightarrow SbO_4^{3-} + 2Mn^{2+} + 24H^+$

c. $5Sb^{3+} + 2MnO_4^- + 12H_2O \rightarrow 5SbO_4^{3-} + 2Mn^{2+} + 24H^+$

d. $2Sb^{3+} + MnO_4^- + 6H_2O \rightarrow 2SbO_4^{3-} + Mn^{2+} + 12H^+$

46) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $ClO_3^- + SO_2 \rightarrow Cl^- + SO_4^{2-}$

a. $ClO_3^- + 3SO_2 + 3H_2O \rightarrow 3SO_4^{2-} + Cl^- + 6H^+$

b. $ClO_3^- + SO_2 + 3H_2O \rightarrow SO_4^{2-} + Cl^- + 6H^+$

c. $2ClO_3^- + SO_2 + 6H_2O \rightarrow SO_4^{2-} + 2Cl^- + 12H^+$

d. $ClO_3^- + 3SO_2 + 6H_2O \rightarrow 3SO_4^{2-} + Cl^- + 12H^+$

47) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $P + NO_3^- \rightarrow PO_4^{3-} + NO$

a. $3P + 4NO_3^- + 2H_2O \rightarrow 3PO_4^{3-} + 4NO + 4H^+$

b. $4P + 5NO_3^- + 2H_2O \rightarrow 4PO_4^{3-} + 5NO + 4H^+$

c. $3P + 5NO_3^- + 2H_2O \rightarrow 3PO_4^{3-} + 5NO + 4H^+$

d. $P + 4NO_3^- + 2H_2O \rightarrow PO_4^{3-} + 4NO + 4H^+$

48) What is the balanced equation for the following redox equation?

(using half-reaction method, in basic solution) $N_2O + ClO^- \rightarrow Cl^- + NO_2^-$

a. $N_2O + ClO^- + 2OH^- \rightarrow 2NO_2^- + Cl^- + H_2O$

b. $2N_2O + 2ClO^- + 2OH^- \rightarrow 4NO_2^- + 2Cl^- + H_2O$

c. $N_2O + ClO^- + 4OH^- \rightarrow 2NO_2^- + Cl^- + 2H_2O$

d. $N_2O + 2ClO^- + 2OH^- \rightarrow 2NO_2^- + 2Cl^- + H_2O$

49) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $ClO_3^- + Cl^- \rightarrow Cl_2 + ClO_2$

a. $2H^+ + 2ClO_3^- + 2Cl^- \rightarrow Cl_2 + 2ClO_2 + H_2O$

b. $4H^+ + 2ClO_3^- + 2Cl^- \rightarrow Cl_2 + 2ClO_2 + 2H_2O$

c. $8H^+ + 2ClO_3^- + 2Cl^- \rightarrow Cl_2 + 2ClO_2 + 4H_2O$

d. $6H^+ + 2ClO_3^- + 4Cl^- \rightarrow 2Cl_2 + 2ClO_2 + 3H_2O$

50) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $Zn_{(s)} + NO_3^-{}_{(aq)} \rightarrow Zn^{2+}{}_{(aq)} + NO_{(g)}$

a. $2Zn + 2NO_3^- + 8H^+ \rightarrow 2Zn^{2+} + 2NO + 4H_2O$

b. $3Zn + 2NO_3^- + 8H^+ \rightarrow 3Zn^{2+} + 2NO + 4H_2O$

c. $4Zn + NO_3^- + 4H^+ \rightarrow 4Zn^{2+} + NO + 2H_2O$

d. $5Zn + 2NO_3^- + 4H^+ \rightarrow 5Zn^{2+} + 2NO + 2H_2O$

51) What is the balanced equation for the following redox equation?

(using half-reaction method, in acidic solution) $Cu_{(s)} + NO_3^-{}_{(aq)} \rightarrow Cu^{2+}{}_{(aq)} + NO_{(aq)}$

a. $Cu + 2NO_3^- + 8H^+ \rightarrow Cu^{2+} + 2NO + 4H_2O$

b. $3Cu + 3NO_3^- + 4H^+ \rightarrow 3Cu^{2+} + 3NO + 2H_2O$

c. $Cu + 4NO_3^- + 4H^+ \rightarrow Cu^{2+} + 4NO + 2H_2O$

d. $3Cu + 2NO_3^- + 8H^+ \rightarrow 3Cu^{2+} + 2NO + 4H_2O$

52) What is the balanced equation for the following redox equation?

$Au^{3+}{}_{(aq)} + I^-{}_{(aq)} \rightarrow Au_{(s)} + I_{2(s)}$

a. $2Au^{3+} + 6I^- \rightarrow 2Au + 3I_2$

b. $Au^{3+} + 6I^- \rightarrow Au + 3I_2$

c. $2Au^{3+} + 2I^- \rightarrow 2Au + I_2$

d. $2Au^{3+} + 8I^- \rightarrow 2Au + 4I_2$

Answer Key

1	b	2	d	3	a	4	a	5	c
6	a	7	b	8	d	9	c	10	c
11	d	12	a	13	b	14	c	15	a
16	b	17	d	18	d	19	c	20	c
21	a	22	b	23	d	24	b	25	a
26	c	27	d	28	a	29	b	30	a
31	c	32	d	33	b	34	b	35	c
36	d	37	a	38	c	39	d	40	a
41	b	42	b	43	a	44	d	45	c
46	a	47	c	48	d	49	b	50	b
51	d	52	a						

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Part Three (Exams of last years)

Previous years exam questions with answers at the end of each exam.

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Exam 2021-2022 (12 Advanced)

1) **Which of the following is true for the reaction: $2K_{(s)} + F_{2(g)} \rightarrow 2KF_{(s)}$?**

   a. **The potassium atom K gained an electron, and it is reduced**

   b. **Fluorine F_2 gained electrons and was oxidized**

   c. **The potassium atom K lost an electron and was oxidized**

   d. **Fluorine F_2 lost electrons and was oxidized**

2) **What is the correct ascending order of the following formulas according to the oxidation number of chlorine in each of them?**

   a. **$NaCl \rightarrow Cl_2 \rightarrow KClO \rightarrow KClO_4$**

   $Cl_2 - NaCl - KClO_4 - KClO$

   b. **$Cl_2 \rightarrow NaCl \rightarrow KClO_4 \rightarrow KClO$**

   c. **$KClO_4 \rightarrow KClO \rightarrow Cl_2 \rightarrow NaCl$**

   d. **$KClO_4 \rightarrow NaCl \rightarrow Cl_2 \rightarrow KClO$**

3) **The reaction between nickel and copper (II) chloride shown below, what we describe as redox reactions: $Ni_{(s)} + CuCl_{2(aq)} \rightarrow Cu_{(s)} + NiCl_{2(aq)}$?**

	oxidation half-reaction	reduction half-reaction
A	$Ni \rightarrow Ni^{2+} + 2e^-$	$Cl_2 \rightarrow 2Cl^- + 2e^-$
B	$Ni \rightarrow Ni^{2+} + e^-$	$Cu^+ + e^- \rightarrow Cu$
C	$Ni \rightarrow Ni^{2+} + 2e^-$	$Cu^{2+} + 2e^- \rightarrow Cu$
D	$Cu^+ + e^- \rightarrow Cu$	$Ni \rightarrow Ni^{2+} + 2e^-$

   a. **B**

   b. **D**

   c. **A**

   d. **C**

4) **What is the reducing agent in the following reaction?**

$$H_2S_{(g)} + Cl_{2(g)} \rightarrow S_{(s)} + 2HCl_{(g)}$$

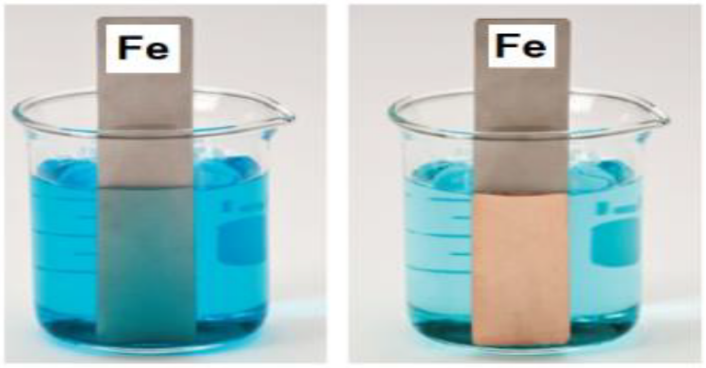
a. S

b. HCl

c. H_2S

d. Cl_2

5) **An iron plate was placed in a solution of copper (II) sulfate as shown in the figure below. Why did the color of iron plate change?**



$$2Fe_{(s)} + 3CuSO_{4(aq)} \rightarrow 3Cu_{(s)} + Fe_2(SO_4)_{3(aq)}$$

a. Oxidation of iron (III) ions by losing electrons

b. Reduction of copper (II) ions and deposition of copper on the iron plate

c. Reduction of iron (III) ions by gaining electrons

d. Oxidation of copper atoms to copper (II) ions

6) **Using the half-reaction method to balance redox reactions, what is the correct balanced equation for the following reaction in an acidic solution?**

$$I_{2(s)} + S_2O_3^{2-}{}_{(aq)} \rightarrow S_2O_4^{2-}{}_{(aq)} + I^-_{(aq)}$$

a. $S_2O_3^{2-} + I_2 + 2H^+ \rightarrow S_2O_4^{2-} + H_2O + 2I^-$

b. $S_2O_3^{2-} + H_2O + I_2 \rightarrow S_2O_4^{2-} + 2H^+ + 2I^-$

c. $2S_2O_3^{2-} + 2H_2O + I_2 \rightarrow 2S_2O_4^{2-} + 4H^+ + 2I^-$

d. $S_2O_3^{2-} + H_2O + I_2 \rightarrow S_2O_4^{2-} + 2H^+ + I^-$

Answer Key

1	c	2	a	3	d	4	c	5	b
6	b								

Exam 2022-2023 (12 Advanced)

1) In the reaction represented by the equation below. Which of the following is correct?

$$2F^-_{(aq)} + I_{2(aq)} \rightarrow F_{2(aq)} + 2I^-_{(aq)}$$

a. The iodine receives electrons from the fluoride ions, and it is oxidized

b. The iodine receives electrons from the fluoride ions, and it is reduced

c. The fluoride ions receive electrons from the iodine, and it is oxidized

d. The fluoride ions receive electrons from the iodine, and it is reduced

2) In which of the following formulas does the oxidation number of oxygen differ than in the other formulas?

$NO - NO_2 - H_2O - H_2O_2$

a. NO

b. NO_2

c. H_2O

d. H_2O_2

3) In the general equation below, if you know that the reactant X is a reducing agent. Which of the following describe it correctly?

1	Gains electrons - its oxidation number increases – it is the oxidized
2	Loses electrons - its oxidation number increases - it is the oxidized
3	Gains electrons - its oxidation number decreases - it is the reduced
4	Loses electrons - its oxidation number decreases - it is the reduced

a. 1

b. 2

c. 3

d. 4

4) If given the following two redox half-reactions. What is the minimum numbers of Pb^{2+} and Fe^{3+} would have to react in order to have zero electrons left over?

$Pb^{2+} \longrightarrow Pb^{4+} + 2e^-$	نصف تفاعل الأكسدة Oxidation Half-Reaction
$Fe^{3+} + 3e^- \longrightarrow Fe$	نصف تفاعل الاختزال Reduction Half-Reaction

Fe^{3+}	Pb^{2+}	
2	3	A
3	2	B
2	1	C
1	2	D

a. A

b. B

c. C

d. D

5) Using the half-reaction method. Which of the following is the balanced equation for the reaction below in an acidic solution?

$$SeO_3^{2-}{}_{(aq)} + ClO_3^-{}_{(aq)} \rightarrow SeO_4^{2-}{}_{(aq)} + Cl_{2(g)}$$

a. $5SeO_3^{2-}{}_{(aq)} + 2ClO_3^-{}_{(aq)} + 2H^+ \rightarrow 5SeO_4^{2-}{}_{(aq)} + Cl_{2(g)} + H_2O_{(l)}$

b. $5SeO_3^{2-}{}_{(aq)} + 2ClO_3^-{}_{(aq)} + H_2O_{(l)} \rightarrow 5SeO_4^{2-}{}_{(aq)} + Cl_{2(g)} + 2H^+$

c. $2SeO_3^{2-}{}_{(aq)} + 5ClO_3^-{}_{(aq)} + 2H^+ \rightarrow 2SeO_4^{2-}{}_{(aq)} + 5Cl_{2(g)} + H_2O_{(l)}$

d. $2SeO_3^{2-}{}_{(aq)} + 5ClO_3^-{}_{(aq)} + H_2O_{(l)} \rightarrow 2SeO_4^{2-}{}_{(aq)} + 5Cl_{2(g)} + 2H^+$

Answer Key

1	b	2	d	3	b	4	a	5	a

Exam 2021-2022 (12 General)

1) **What is the number assigned to an atom or ion called to indicate its degree of oxidation or reduction?**

   a. Coefficient

   b. Oxidation number

   c. Equivalent number

   d. Atomic number

2) **What is the redox half-reaction of the net ionic equation shown below?**

   $2Na_{(s)} + Cl_{2(g)} \rightarrow 2Na^{+}_{(aq)} + 2Cl^{-}_{(aq)}$

   a. $Na \rightarrow Na^{+} + e^{-}$

   b. $2Cl^{-} \rightarrow Cl_2 + 2e^{-}$

   c. $Cl_2 + 2e^{-} \rightarrow 2Cl^{-}$

   d. $Na^{+} + e^{-} \rightarrow Na$

3) **Which of the following statements is incorrect regarding the complete chemical equation shown below?** $2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$

   a. No electrons are transferred between atoms

   b. Magnesium atom is changed to positive ion

   c. The reaction is an oxidation-reduction

   d. Electrons are transferred between atoms

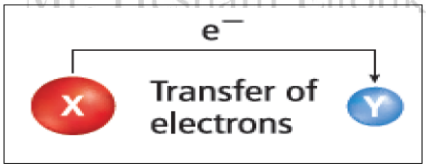
4) **Which of the following statements is incorrect regarding the corresponding figure?**

   a. The oxidation number of X increases

   b. X is the reducing agent and becomes oxidized

   c. X loses electron

   d. X is the oxidizing agent and becomes reduced



5) What substance is oxidized in the following equation?

$$2Br^- + Cl_2 \rightarrow Br_2 + 2Cl^-$$

a. Br_2

b. Cl^-

c. Cl_2

d. Br^-

6) What is the oxidation number of chromium (Cr) in the following ion formula?

$$CrO_4^{2-}$$

a. –6

b. +2

c. +6

d. –2

7) Which of the following is not an example of a half-reaction?

a. $2Fe + 3Cl_2 \rightarrow 2FeCl_3$

b. $Fe \rightarrow Fe^{3+} + 3e^-$

c. $2H^+ + 2e^- \rightarrow H_2$

d. $Cl_2 + 2e^- \rightarrow 2Cl^-$

8) To balance redox reactions equations, the coefficients must be adjusted so that the number of electrons lost in oxidation ..... the number of electrons gained in reduction.

a. twice of

b. equals

c. more than

d. less than

9) What is the reason for the different colors of copper forms shown below?



a. Particle size variation

b. Oxidation number variation

c. Mass number difference

d. Atomic number difference

10) What is the value of X in the following half-reaction equation so that the equation becomes balanced? $MnO_4^-{}_{(aq)} + 8H^+{}_{(aq)} + Xe^- \rightarrow Mn^{2+}{}_{(aq)} + 4H_2O_{(l)}$

a. 5

b. 1

c. 2

d. 3

11) Which of the following is the correct balanced redox equation for the following reaction using the half-reaction method in an acidic solution?

$$Cr_2O_7^{2-}{}_{(aq)} + Fe^{2+}{}_{(aq)} \rightarrow Cr^{3+}{}_{(aq)} + Fe^{3+}{}_{(aq)}$$

a. $Cr_2O_7^{2-} + H^+ + Fe^{2+} \rightarrow 2Cr^{3+} + Fe^{3+} + H_2O$

b. $Cr_2O_7^{2-} + H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 6Fe^{3+} + H_2O$

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

d. $Cr_2O_7^{2-} + 7H^+ + Fe^{2+} \rightarrow 2Cr^{3+} + Fe^{3+} + 7H_2O$

Answer Key

1	b	2	a	3	a	4	d	5	d
6	c	7	a	8	b	9	b	10	a
11	c								

Exam 2022-2023 (12 General)

1) Regarding the reaction below, which of the following is correct?

$$2KBr_{(aq)} + Cl_{2(aq)} \rightarrow 2KCl_{(aq)} + Br_{2(aq)}$$

a. The oxidation number of bromine changed from –1 to 0

b. The oxidation number of bromine changed from 0 to –1

c. The oxidation number of chlorine changed from +1 to 0

d. The oxidation number of chlorine changed from –2 to 0

2) Which of the following describes oxidation correctly?

a. A reactant loses electrons, and its oxidation number increases

b. A reactant loses electrons, and its oxidation number decreases

c. A reactant gains electrons and its oxidation number increases

d. A reactant gains electrons and its oxidation number decreases

3) What is the oxidation number of the underlined element in the following formula?

a. –4

b. +4

c. –3

d. +3

$\underline{B}_4O_7^{2-}$

4) In which of the following does the oxidation number of sulfur equals –2?

a. SO_2

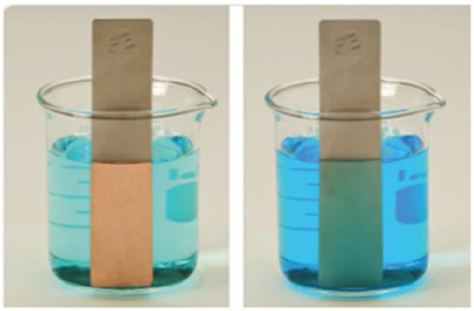
b. SO_3

c. H_2S

d. SO_4^{2-}

$SO_2 - SO_3 - H_2S - SO_4^{2-}$

5) When you put an iron plate into a solution of copper (II) sulphate, as in the figure below, the iron plate color changes. What explains this?



$$Fe_{(s)} + CuSO_{4(aq)} \rightarrow Cu_{(s)} + Fe_2(SO_4)_{3(aq)}$$

a.

Oxidation half-reaction	Reduction half-reaction
$2Fe \rightarrow 2Fe^{3+} + 6e^-$	$3Cu^{2+} + 6e^- \rightarrow 3Cu$

b.

Oxidation half-reaction	Reduction half-reaction
$3Cu^{2+} + 6e^- \rightarrow 3Cu$	$2Fe \rightarrow 2Fe^{3+} + 6e^-$

c. Iron ions are reduced, and copper atoms are oxidized

d. Both iron ions and copper ions are reduced

6) In the reaction below, if you know that the reactant Fe is the reducing agent. Which of the following describes it correctly? $Fe_{(s)} + 2Ag^+_{(aq)} \rightarrow Fe^{2+}_{(aq)} + 2Ag_{(s)}$

1	Gains electrons - its oxidation number increases – it is the oxidized
2	Loses electrons - its oxidation number increases - it is the oxidized
3	Gains electrons - its oxidation number decreases - it is the reduced
4	Loses electrons - its oxidation number decreases - it is the reduced

a. 1

b. 2

c. 3

d. 4

7) When using the half-reaction method to balance the redox equation below in the acidic solution. Which of the following is the correct balanced equation?

$$ClO_3^- + SO_2 \rightarrow Cl^- + SO_4^{2-}$$

a. $3ClO_3^- + 2SO_2 + 6H^+ \rightarrow 3Cl^- + 2SO_4^{2-} + 3H_2O$

b. $ClO_3^- + 3SO_2 + 6H^+ \rightarrow Cl^- + 3SO_4^{2-} + 3H_2O$

c. $ClO_3^- + 3SO_2 + 3H_2O \rightarrow Cl^- + 3SO_4^{2-} + 6H^+$

d. $3ClO_3^- + 2SO_2 + 3H_2O \rightarrow 3Cl^- + 2SO_4^{2-} + 6H^+$

8) If given the following two redox half-reactions. What is the minimum numbers of Sn^{2+} and Au^{3+} would have to react in order to have zero electrons left over?

$Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$	نصف تفاعل الأكسدة Oxidation Half-Reaction
$Au^{3+} + 3e^- \longrightarrow Au$	نصف تفاعل الاختزال Reduction Half-Reaction

a. A

b. B

c. C

d. D

Au^{3+}	Sn^{2+}	
2	3	A
3	2	B
2	1	C
1	2	D

9) When balancing equations for redox reactions in a basic solution. What is done in the last step in the balancing method?

a. Hydrogen ions (H^+) and water molecules are added to either side of the equation

b. Hydroxide ions (OH^-) and water molecules are added to either side of the equation

c. The numbers of atoms only balanced in both sides of the equation

d. Adjusting the coefficients so that the number of electrons lost in oxidation equals the number of electrons gained in reduction

10) What is the correct ascending order of the following formulas according to the oxidation number of hydrogen in each of them?

H_2 – HCl – LiH

a. The smallest is $H_2 \rightarrow LiH \rightarrow HCl$ the greatest

b. The smallest is $H_2 \rightarrow HCl \rightarrow LiH$ the greatest

c. The smallest is $LiH \rightarrow HCl \rightarrow H_2$ the greatest

d. The smallest is $LiH \rightarrow H_2 \rightarrow HCl$ the greatest

Answer Key

1	a	2	a	3	d	4	c	5	a
6	b	7	c	8	a	9	b	10	d