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CHEM · CHEMISTRY

10. Electrochemistry

Official PMDC Solved Past Paper Topical Booklet · High-Yield Examination Series

73 Solved Questions

2010 to 2024 Archive

Boards: BUMHS, DUHS, KMU, MDCAT, NUMS, PMDC

Weightage: 27% of MDCAT (54 MCQs)

Curated by Ibrahim for fellow bees. Every question in this chapter has been verified against official UHS, NUMS, SZABMU, DUHS, and KMU answer keys. Propolis cognitive autopsies are provided at the end of this booklet to explain core concepts and break down common distractor traps.

OFFICIAL SOLVED EDITION**Q1.**

UHS 2024

Oxidation number of 'Mn' in $KMnO_4$ is: **[UHS 2024]**

- (A) 0
- (B) 1
- (C) -7
- (D) 7

Q2.

UHS 2024

Which step is irrelevant with respect to balancing of redox equations by oxidation number method? **[UHS 2024]**

- (A) Split the reaction into two half reactions
- (B) Assign oxidation number to all the atoms involved in the equation
- (C) Identify the element undergoing a change in oxidation number
- (D) Equalize the number of electrons lost and gained

Q3.

UHS 2024

Which of the following is NOT a correct feature of electrolytic cells? **[UHS 2024]**

- (A) Reduction occurs at cathode
- (B) Oxidation occurs at anode
- (C) Alternating current source is connected to electrodes
- (D) Electrochemical reaction takes place

Q4.

SZABMU 2024

Which type of redox reaction takes place at cathode of the electrochemical cell? **[SZABMU-RC 2024]**

- (A) Decomposition
- (B) Dissociation
- (C) Oxidation
- (D) Reduction

Q5.

SZABMU 2024

During electrolysis of concentrated aqueous solution of NaCl, Which ion is NOT discharged at cathode? **[SZABMU-RC 2024]**

- (A) Na^+
- (B) Cl^-
- (C) H^+
- (D) OH^-

Q6.

SZABMU 2024

Oxidation number of an element in free state is: **[SZABMU-RC 2024]**

- (A) Negative
- (B) Positive
- (C) Zero
- (D) 1

Q7.

SZABMU 2024

The oxidation number of oxygen in Na_2O_2 is:
[SZABMU-RC 2024]

- (A) -1
- (B) 2
- (C) -2
- (D) 1

Q8.

KMU 2024

Which one of the following is a strong electrolyte in solution? [ETEA 2024]

- (A) Acetic acid
- (B) Ammonium hydroxide
- (C) Carbonic acid
- (D) Potassium iodide

Q9.

KMU 2024

The electrode potential of the standard hydrogen electrode is chosen as: [ETEA 2024]

- (A) -1V
- (B) 0V
- (C) 1V
- (D) 2V

Q10.

KMU 2024

760 torr are equal to Pascal: [ETEA 2024]

- (A) 1
- (B) 76
- (C) 760
- (D) 101325

Q11.

DUHS 2024

Fuel cell is a typical galvanic cell which is based on reaction between: [DUHS 2024]

- (A) Hydrogen and copper
- (B) Methane and oxygen
- (C) Hydrogen and oxygen
- (D) Nitrogen and oxygen

Q12.

BUMHS 2024

Oxidation number of "Mn" in $KMnO_4$ is: [BMU 2024]

- (A) +4
- (B) +5
- (C) +6
- (D) +7

Q13.

BUMHS 2024

Electric current in solutions is carried by: [BMU 2024]

- (A) Ions
- (B) Canal rays
- (C) Free protons
- (D) Free electrons

Q14.

BUMHS 2024

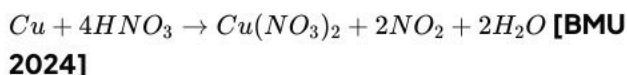
Which of the following is used for galvanizing iron sheet? [BMU 2024]

- (A) Tin
- (B) Zinc
- (C) Aluminum
- (D) Copper

Q15.

BUMHS 2024

What change in oxidation number of Cu takes place in the following reaction?



- (A) 0 to -1
- (B) 0 to +2
- (C) 0 to -2
- (D) 0 to +1

Q16.

BUMHS 2024

Water is ____ electrolyte. [BMU 2024]

- (A) Weak electrolyte
- (B) Strong electrolyte
- (C) Very strong electrolyte
- (D) Moderate electrolyte

Q17.

NUMS 2024

Zn rod acts as cathode when coupled with magnesium electrode. This is because the reduction potential of: [NUMS 2024]

- (A) $Zn > Mg$
- (B) Fe is precipitated out
- (C) Cu and Fe both dissolve
- (D) No reaction taken place

Q18.

NUMS 2024

Placing a rod of iron metal in a solution of CuSO_4 :
[NUMS 2024]

- (A) Cu will be deposited
- (B) Fe is precipitated out
- (C) Cu and Fe both dissolve
- (D) No reaction taken place

Q19.

KMU 2023

In redox reaction of SO_2 with KMnO_4 in acidic medium: [ETEA 2023]

- (A) SO_2 oxidizes KMnO_4
- (B) SO_2 reduces KMnO_4
- (C) KMnO_4 is inert in acidic medium
- (D) SO_2 can't undergo redox reaction

Q20.

KMU 2023

Zinc displaces copper from its solution because:
[ETEA 2023]

- (A) Atomic no. of zinc is higher than that of copper
- (B) Zinc has higher reduction potential than copper
- (C) Zinc is more soluble
- (D) Zinc has smaller reduction potential than copper

Q21.

DUHS 2023

In electrochemical series, what is the electrode potential of all metals above Hydrogen? [DUHS 2023]

- (A) Zero
- (B) Negative
- (C) Positive
- (D) Greater than zero

Q22.

BUMHS 2023

When aqueous solution of NaCl is electrolyzed;
[BUMHS 2023]

- (A) Cl_2 is evolved at the cathode
- (B) H_2 is evolved at cathode
- (C) Na is deposited at the cathode
- (D) Na appears at the anode

Q23.

NUMS 2023

During electrolysis, reduction always occurs at the:
[NUMS 2023]

- (A) Anode
- (B) Cathode
- (C) SHE
- (D) Salt bridge

Q24.

SZABMU 2023

In the reaction $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$

How many electrons are gained or lost by chromium atom? [SZABMU 2023, 2024]

- (A) $+12\text{e}^-$
- (B) $+3\text{e}^-$
- (C) $+6\text{e}^-$
- (D) -6e^-

Q25.

UHS 2022

An electrochemical cell is based upon which type of reaction? [UHS 2022]

- (A) Acid-base reaction
- (B) Nuclear reaction
- (C) Redox reaction
- (D) Neutralization reaction

Q26.

UHS 2022

In which of the following, Oxygen shows fractional oxidation number? [UHS 2022]

- (A) OF_2
- (B) KO_2
- (C) Na_2O_2
- (D) Cl_2O_7

Q27.

SZABMU 2022

Which statement correctly describes the term Standard Electrode potential? [SZABMU 2022]

- (A) It is the electrode potential determined at room temperature and pressure
- (B) It is the electrode potential determined under standard condition using Hydrogen Electrode as the other electrode
- (C) It is the electrode potential of an element and its solution compare to zinc electrode
- (D) It is the potential which is measured when two half cells are connected

Q28.

SZABMU 2022

Oxidation number of an element in free state is:
[SZABMU 2022]

- (A) Negative
- (B) Positive
- (C) Zero
- (D) ± 1

Q29.

SZABMU 2022

The branch of science which deals with the conversion of electrical energy into chemical energy and vice versa is called: [SZABMU 2022]

- (A) Electrochemistry
- (B) Thermochemistry
- (C) Stereochemistry
- (D) Biochemistry

Q30.

KMU 2022

A cathode has the reduction potential: [ETEA 2022]

- (A) Less than the anode
- (B) More than the anode
- (C) Same as that of anode
- (D) Zero

Q31.

KMU 2022

The stronger the reduction potential, the more difficult it is to: [ETEA 2022]

- (A) Reduce the compound
- (B) Oxidize the compound
- (C) Electrolyze the compound
- (D) Neither reduce oxides the compound

Q32.

DUHS 2022

The electrolysis of dilute acid solution gives: [DUHS 2022]

- (A) Cl_2 at cathode & H_2 at anode
- (B) H_2 at cathode & Cl_2 at anode
- (C) H_2 at cathode & O_2 at anode
- (D) H_2 at anode & Na at cathode

Q33.

DUHS 2022

A strong electrolyte is one that _____ Completely in solution. [DUHS 2022]

- (A) Reacts
- (B) Decomposes
- (C) Disappears
- (D) Ionizes

Q34.

DUHS 2022

Down cell is used for the: [DUHS 2022]

- (A) Metallurgy of Na
- (B) Metallurgy of Mg
- (C) Metallurgy of Al
- (D) Metallurgy of Fe

Q35.

BUMHS 2022

What is the oxidation number of Cl_2 ? [BMU 2022]

- (A) 0
- (B) +1
- (C) -1
- (D) -2

Q36.

BUMHS 2022

Which species has greater reduction potential? [BMU 2022]

- (A) Barium ion
- (B) Calcium ion
- (C) Magnesium ion
- (D) Aluminum ion

Q37.

NUMS 2022

Potential of standard hydrogen electrode (SHE) is arbitrarily taken as: [NUMS 2022]

- (A) 10
- (B) -1
- (C) +1
- (D) Zero

Q38.

NUMS 2022

During electrolysis, reduction always occurs at: [NUMS 2022]

- (A) Anode
- (B) SHE
- (C) Cathode
- (D) Salt bridge

Q39.

PMDC 2021

The least reactive transition metal: [PMC 2021]

- (A) Zn
- (B) Sc
- (C) Cu
- (D) Au

Q40.

PMDC 2021

Which of the following is strong reducing agent? [PMC 2021]

- (A) Li
- (B) F
- (C) Na
- (D) Mg

Q41.

PMDC 2021

Electrolysis of a dilute solution of NaCl results at the anode: [PMC 2021]

- (A) Sodium
- (B) Chlorine
- (C) Hydrogen
- (D) Oxygen

Q42.

PMDC 2021

Which of the following is feasible reaction? [PMC 2021]

- (A) $Pb + SnO \rightarrow PbO + Sn$
- (B) $Pb + Zn \rightarrow PbO + Zn$
- (C) $Zn + HCl \rightarrow ZnCl_2 + H_2$
- (D) $2Ag + 2HCl \rightarrow 2AgCl + H_2$

Q43.

PMDC 2020

The oxidation state of "S" in the $S_2O_3^{2-}$ is: [NMDCAT 2020]

- (A) +4
- (B) +6
- (C) -2
- (D) +2

Q44.

PMDC 2020

The common oxidation number of halogens is: [NMDCAT 2020]

- (A) -1
- (B) +1
- (C) -2
- (D) 0

Q45.

PMDC 2020

During oxidation process, oxidation number of an element: [NMDCAT 2020]

- (A) Decreases
- (B) Increases
- (C) Remains constant
- (D) Both "A" and "B"

Q46.

NUMS 2019

The oxidation state of carbon in $C_2O_4^{2-}$ is: [NUMS 2019]

- (A) +4
- (B) -4
- (C) +3
- (D) +2

Q47.

SET 2019

The value of oxidation number of chlorine in $HClO_3$ is: [SET 2019]

- (A) +7
- (B) +5
- (C) -1
- (D) +3

Q48.

NUMS 2019

Stronger is the oxidizing agent, stronger is the: [NUMS 2019]

- (A) emf of cell
- (B) Oxidation potential
- (C) Reduction potential
- (D) Redox potential

Q49.

NUMS 2019

Which of the following metal does not liberate hydrogen on reaction with acid? [NUMS 2019]

- (A) Mg
- (B) Pt
- (C) Zn
- (D) Ca

Q50.

SET 2019

Which one of the following elements is the strongest reducing agent? [SET 2019]

- (A) Chlorine
- (B) Sodium
- (C) Magnesium
- (D) Aluminium

Q51.

SET 2019

Rusting of iron metal Fe occurs when Fe gets converted into Fe_2O_3 . What happened with Fe? [SET 2019]

- (A) Fe is neutralized
- (B) Fe is sublimed
- (C) Fe is reduced
- (D) Fe is oxidized

Q52.

NUMS 2019

The electrolyte used in fuel cell is: [NUMS 2019]

- (A) KOH
- (B) $NaCl(aq)$
- (C) $NaNO_3$
- (D) Molten NaCl

Q53.

KMU 2019

When zinc electrode is coupled with copper electrode in a galvanic cell: [ETEA 2019]

- (A) Reduction takes place at zinc electrode
- (B) Oxidation takes place at copper electrode
- (C) Reduction takes place at copper electrode
- (D) Both A and B

Q54.

KMU 2019

The oxidation state of nitrogen in NH_4NO_3 are: [ETEA 2019]

- (A) -3 and 5
- (B) +5 and 3
- (C) -3 and -3
- (D) Zero

Q55.

MDCAT 2019

Aqueous solutions of Iodine and Sodium hydroxide were mixed in a round bottom flask at 70°C . Following chemical reaction was carried out:

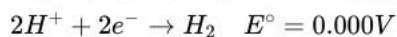
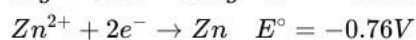


This reaction is termed as: [MDCAT 2019]

- (A) Free radical reaction
- (B) Precipitation reaction
- (C) Substitution reaction
- (D) Redox reaction

Q56.

MDCAT 2019



Keeping in view the values of standard reduction potential given above, which one of the following would you select as a feasible redox chemical reaction? [MDCAT 2019]

- (A) $2Au + 6H^+ \rightarrow 2Au^{3+} + 3H_2$
- (B) $2Cl^- + I_2 \rightarrow Cl_2 + 2I^-$
- (C) $Mg + 2H^+ \rightarrow Mg^{2+} + H_2$
- (D) $Cu + Zn^{2+} \rightarrow Cu^{2+} + Zn$

Q57.

MDCAT 2018

The potential difference of an electrochemical cell is measured by: [MDCAT 2018]

- (A) Galvanometer
- (B) Calorimeter
- (C) Voltmeter
- (D) Ammeter

Q58.

MDCAT 2018

The standard electrode potential of hydrogen is arbitrarily taken at 298K is _____. [MDCAT 2018]

- (A) 1.00 volt
- (B) 0.10 volt
- (C) 0.00 volt
- (D) 10.0 volt

Q59.

MDCAT 2017

In NO_3^- , the oxidation number of "N" is: [MDCAT 2017]

- (A) +5
- (B) +3
- (C) +2
- (D) -3

Q60.

MDCAT 2017

The E° value of standard copper half-cell is +0.34V, measured when it is connected with SHE i.e. Standard hydrogen electrode. In this case the half reaction taking place at SHE is: [MDCAT 2017]

- (A) $2H_{(aq)}^+ + 2e^- \rightarrow H_{2(g)}$
- (B) $H_{2(g)} \rightarrow 2H_{(aq)}^+ + 2e^-$
- (C) $2H_{(aq)}^+ + 2e^- \rightarrow 2H_{2(g)}$
- (D) $H_{2(g)} \rightarrow 2H_{(g)} + 2e^-$

Q61.

MDCAT 2017

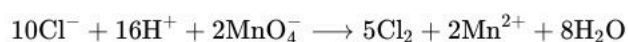
During space flights, astronauts obtained water from: [MDCAT 2017]

- (A) Nickel cadmium cells
- (B) Lead accumulator
- (C) Fuel Cell
- (D) Alkaline battery

Q62.

MDCAT 2016

Study the following redox reaction:



Which statement is true about this reaction?

- (A) Manganese is oxidized from +7 to +2.
- (B) Chlorine is reduced from zero to -1.
- (C) Chloride ions are reduced from -1 to zero.
- (D) Manganese is reduced from +7 to +2.

Q63.

MDCAT 2016

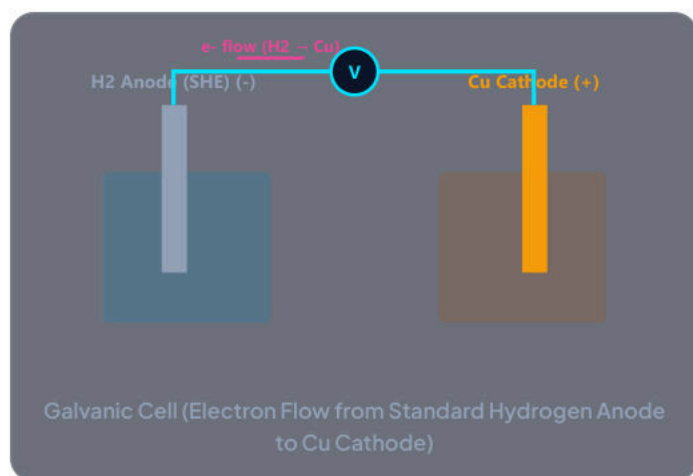
Coinage metals Cu, Ag and Au are the least reactive because they have: [MDCAT 2016]

- (A) Negative reduction potential
- (B) Negative oxidation potential
- (C) Positive reduction potential
- (D) Positive oxidation potential

Q64.

MDCAT 2016

The diagram shows a galvanic cell. The current will flow from:



[MDCAT 2016]

- (A) Hydrogen electrode to copper electrode
- (B) Copper electrode to hydrogen electrode
- (C) Hydrogen electrode to HCl solution
- (D) CuSO₄ solution to hydrogen electrode

Q65.

KMU 2016

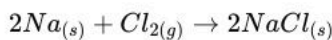
In which of the following reaction hydrogen acts as oxidizing agent. [ETEA 2016]

- (A) $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$
- (B) $\text{C}_2\text{H}_4 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6$
- (C) $2\text{Na} + \text{H}_2 \rightarrow 2\text{NaH}$
- (D) $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$

Q66.

KMU 2016

Choose the true statement regarding the reaction given below:



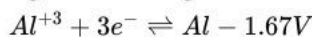
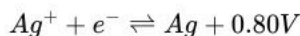
[ETEA 2016]

- (A) Chloride is oxidized and sodium is reduced
- (B) Chlorine acts as an oxidizing agent and sodium as reducing agent
- (C) Chloride acts as a reducing agent and sodium as reducing agent
- (D) None of the above

Q67.

KMU 2016

A cell is constructed of the following two half cells. What is Emf of the cell?



[ETEA 2016]

- (A) 2.47V
- (B) 0.087
- (C) -0.87V
- (D) 5.81V

Q68.

KMU 2016

Which of the following is spontaneous reactions?

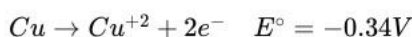
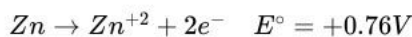
[ETEA 2016]

- (A) $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$
- (B) $2\text{NaCl}_{(l)} \rightarrow 2\text{Na}_{(s)} + \text{Cl}_{2(g)}$
- (C) $\text{Zn}^{2+} + \text{Cu} \rightarrow \text{Zn} + \text{Cu}^{2+}$
- (D) $2\text{Fe}(\text{OH})_3 \rightarrow 2\text{Fe} + 3\text{O}_2 + 3\text{H}_2$

Q69.

MDCAT 2015

Study the following facts, which of the following is correct:



[MDCAT 2015]

- (A) $\text{Cu} + \text{Zn}^{+2} \rightarrow \text{Cu}^{+2} + \text{Zn}$
- (B) $\text{Cu}^{+2} + \text{Zn} \rightarrow \text{Cu} + \text{Zn}^{+2}$
- (C) $\text{Cu}^{+2} + \text{Zn}^{+2} \rightarrow \text{Cu} + \text{Zn}$
- (D) $\text{Cu}^{+2} + \text{Zn}^{+2} \rightarrow \text{Cu} + \text{Zn}^{-2}$

Q70.

MDCAT 2015

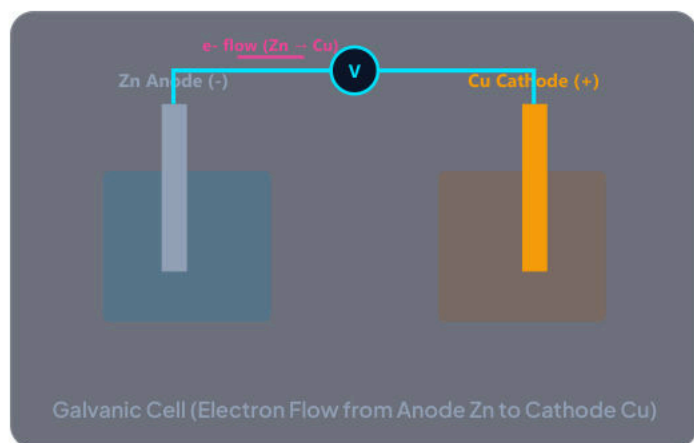
Keeping in mind the electrode potential, which one of the following reactions is feasible? [MDCAT 2015]

- (A) $Zn^{+2} + Cu \rightarrow Cu^{+2} + Zn$
- (B) $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$
- (C) $Zn + MgSO_4 \rightarrow ZnSO_4 + Mg$
- (D) $Cd + MgSO_4 \rightarrow CdSO_4 + Mg$

Q71.

MDCAT 2013

In the figure given below, the electron flow in external circuit is from:

**[MDCAT 2013]**

- (A) Zinc to copper electrode
- (B) Right to left
- (C) Copper to zinc electrode
- (D) porous partition to zinc electrode

Q72.

MDCAT 2011

In voltaic cell a salt bridge is used in order to: [MDCAT 2011]

- (A) Pass the electric current
- (B) Prevent the flow of ions
- (C) Mix solutions of two half cells
- (D) Allow movement of ions between two cells

Q73.

MDCAT 2010

In an electrochemical series, elements are arranged on the basis of: [MDCAT 2010]

- (A) pH scale
- (B) pKa scale
- (C) pOH scale
- (D) Hydrogen scale

RAPID 5–COLUMN ANSWER KEY

Official PMDC verified answer keys for 10. Electrochemistry.

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Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD
1	D	UHS 2024	16	A	BUMHS 2024	31	B	KMU 2022	46	C	NUMS 2019	61	C	MDCAT 2017
2	A	UHS 2024	17	A	NUMS 2024	32	C	DUHS 2022	47	B	SET 2019	62	D	MDCAT 2016
3	C	UHS 2024	18	A	NUMS 2024	33	D	DUHS 2022	48	C	NUMS 2019	63	C	MDCAT 2016
4	D	SZABMU 2024	19	B	KMU 2023	34	A	DUHS 2022	49	B	NUMS 2019	64	A	MDCAT 2016
5	A	SZABMU 2024	20	D	KMU 2023	35	A	BUMHS 2022	50	B	SET 2019	65	C	KMU 2016
6	C	SZABMU 2024	21	B	DUHS 2023	36	D	BUMHS 2022	51	D	SET 2019	66	B	KMU 2016
7	A	SZABMU 2024	22	B	BUMHS 2023	37	D	NUMS 2022	52	A	NUMS 2019	67	A	KMU 2016
8	D	KMU 2024	23	B	NUMS 2023	38	C	NUMS 2022	53	C	KMU 2019	68	A	KMU 2016
9	B	KMU 2024	24	B	SZABMU 2023	39	D	PMDC 2021	54	A	KMU 2019	69	B	MDCAT 2015
10	D	KMU 2024	25	C	UHS 2022	40	A	PMDC 2021	55	D	MDCAT 2019	70	B	MDCAT 2015
11	C	DUHS 2024	26	B	UHS 2022	41	D	PMDC 2021	56	C	MDCAT 2019	71	A	MDCAT 2013
12	D	BUMHS 2024	27	B	SZABMU 2022	42	C	PMDC 2021	57	C	MDCAT 2018	72	D	MDCAT 2011
13	A	BUMHS 2024	28	C	SZABMU 2022	43	D	PMDC 2020	58	C	MDCAT 2018	73	D	MDCAT 2010
14	B	BUMHS 2024	29	A	SZABMU 2022	44	A	PMDC 2020	59	A	MDCAT 2017			
15	B	BUMHS 2024	30	B	KMU 2022	45	B	PMDC 2020	60	B	MDCAT 2017			

TOTAL
MCQS

73

CORRECT

INCORRECT

BLANK

ACCURACY

%

Scan the booklet QR code to enter answers in
BeambePrep Grind Mode for automated error
 autopsies.

PROPOLIS COGNITIVE ERROR AUTOPSIES

Step-by-step conceptual derivations, formula working, and distractor autopsies for every question.

Question #1 Key: (D)

UHS 2024

Oxidation number of 'Mn' in [Formula] is: [UHS 2024]

CORE CONCEPT AND DERIVATION

For a neutral chemical compound, the algebraic sum of all the individual oxidation numbers must equal zero.

Formula:

$$+1 + x + 4(-2) = 0$$

Solution:

- Potassium (K) is a Group 1 metal and always has an oxidation state of +1.
- Oxygen (O) typically has an oxidation state of -2.
- Let x be the oxidation state of Manganese (Mn).
- Set up the equation: $1 + x - 8 = 0$.
- Solve for x : $x - 7 = 0 \implies x = +7$.

Why other options are incorrect:

Manganese can exist in +2, +3, +4, +6 states, but in the highly oxidized permanganate ion, it is stripped of 7 valence electrons, resting at +7.

Question #2 Key: (A)

UHS 2024

Which step is irrelevant with respect to balancing of redox equations by oxidation number method? [UHS 2024]

CORE CONCEPT AND DERIVATION

There are two distinct methodologies for balancing redox equations: the Oxidation Number Method and the Ion-Electron (Half-Reaction) Method.

Solution:

- In the **Oxidation Number Method**, the entire skeleton equation is kept intact. You identify the changes in oxidation states and cross-multiply coefficients directly within the single equation to balance the total electron transfer.
- Splitting the equation into two physically separate equations (an oxidation half and a reduction half) is the defining, exclusive first step of the **Ion-Electron Method**.
- Therefore, splitting is entirely irrelevant to the oxidation number method.

Why other options are incorrect:

Options B, C, and D are mandatory, foundational steps for executing the oxidation number method.

Question #3 Key: (C)

UHS 2024

Which of the following is NOT a correct feature of electrolytic cells? [UHS 2024]

CORE CONCEPT AND DERIVATION

An electrolytic cell uses an external power supply to drive a non-spontaneous chemical reaction by forcing electrons in a single, specific direction.

Solution:

- Because specific half-reactions must occur at designated electrodes (oxidation at the anode, reduction at the cathode), the polarity of the electrodes must remain strictly constant.
- This requires a Direct Current (DC) source, like a standard battery.
- If an Alternating Current (AC) source were used, the polarity of the electrodes would rapidly switch back and forth (e.g., 50 times a second), causing the redox reactions to constantly reverse themselves and resulting in zero net electrolysis.

Why other options are incorrect:

Options A, B, and D are fundamental, true characteristics of all electrochemical cells.

Question #4 Key: (D)

SZABMU 2024

Which type of redox reaction takes place at cathode of the electrochemical cell? [SZABMU-RC 2024]

CORE CONCEPT AND DERIVATION

Electrodes are fundamentally defined by the redox process that occurs upon them.

Solution:

- By universal IUPAC definition, the cathode is the electrode where species acquire electrons.
- The acquisition of electrons is called **reduction** (since the oxidation state is mathematically reduced).
- Remember the mnemonic RED CAT (Reduction = Cathode) and AN OX (Anode = Oxidation).

Why other options are incorrect:

Oxidation always occurs at the anode. Decomposition and dissociation are generic reaction types, not specific electrode half-reactions.

Question #5 Key: (A)

SZABMU 2024

During electrolysis of concentrated aqueous solution of NaCl, Which ion is NOT discharged at cathode? [SZABMU-...

CORE CONCEPT AND DERIVATION

During the electrolysis of aqueous salts, multiple ions compete. At the cathode, the cation with the higher standard reduction potential wins the competition and is discharged.

Solution:

- In an aqueous NaCl solution, two cations migrate to the cathode: Na^+ (from the salt) and H^+ (from the water).
- H^+ has a much higher reduction potential than Na^+ .
- Consequently, H^+ is successfully reduced and discharged as H_2 gas.
- Na^+ fails to reduce and remains dissolved in the solution as a spectator ion.

Why other options are incorrect:

While Cl^- and OH^- are technically not discharged at the cathode (they migrate to the anode), the question targets the specific competing cation that fails to discharge. Therefore, Na^+ is the intended chemical answer.

Question #6 Key: (C)

SZABMU 2024

Oxidation number of an element in free state is: [SZABMU-RC 2024]

CORE CONCEPT AND DERIVATION

Oxidation numbers track the shift of electron density caused by bonding between atoms of different electronegativities.

Solution:

- When an element is in its free, uncombined elemental state (e.g., $Fe_{(s)}$, $O_{2(g)}$, $S_{8(s)}$), all atoms in the structure are identical.
- Because they have identical electronegativity, no atom can pull electrons away from another.
- With zero net charge transfer, the IUPAC assigned oxidation number is exactly Zero.

Why other options are incorrect:

Positive and negative oxidation states only exist when an element forms compounds with other elements.

Question #7 Key: (A)

SZABMU 2024

The oxidation number of oxygen in [Formula] is: [SZABMU-RC 2024]

CORE CONCEPT AND DERIVATION

While Oxygen is overwhelmingly found in the -2 oxidation state, its state changes when it bonds to itself in peroxides (O_2^{-2}).

Formula:

$$2(+1) + 2x = 0$$

Solution:

- Sodium (Na) is an alkali metal and unconditionally takes a $+1$ oxidation state in its compounds.
- Set up the equation for Sodium peroxide (Na_2O_2): $2(+1) + 2x = 0$.
- Solve for x : $2 + 2x = 0 \implies 2x = -2 \implies x = -1$.

Why other options are incorrect:

Oxygen is -2 in standard oxides (like Na_2O), $-1/2$ in superoxides, and only positive when bonded to Fluorine.

Question #8 Key: (D)

KMU 2024

Which one of the following is a strong electrolyte in solution? [ETEA 2024]

CORE CONCEPT AND DERIVATION

A strong electrolyte is a substance that dissociates nearly 100% into free, mobile ions when dissolved in water.

Solution:

- Potassium Iodide (KI) is an ionic salt.
- Because it is highly soluble, it completely shatters its crystal lattice in water to yield independent K^+ and I^- ions.
- This massive presence of free ions allows the solution to conduct electricity extremely well, categorizing it as a strong electrolyte.

Why other options are incorrect:

Acetic acid and carbonic acid are weak covalent acids that only partially ionize. Ammonium hydroxide is a weak base that also only partially dissociates.

Question #9 Key: (B)

KMU 2024

The electrode potential of the standard hydrogen electrode is chosen as: [ETEA 2024]

CORE CONCEPT AND DERIVATION

To measure the absolute potential of a single half-cell, it must be compared against a universal thermodynamic baseline.

Solution:

- The global scientific community universally agreed to use the Standard Hydrogen Electrode (SHE) as this baseline.
- By IUPAC convention, the Standard Electrode Potential (E°) of the SHE is arbitrarily assigned an exact value of 0.00 V at all temperatures.
- All other standard reduction potentials on the electrochemical series are measured relative to this zero point.

Why other options are incorrect:

Using non-zero integers like 1 V or -1 V would needlessly complicate the mathematics of cell potential calculation.

Question #10 Key: (D)

KMU 2024

760 torr are equal to Pascal: [ETEA 2024]

CORE CONCEPT AND DERIVATION

Standard atmospheric pressure at sea level is a constant physical property that can be expressed in various equivalent units.

Solution:

- By definition, 1 atmosphere (atm) is exactly equivalent to 760 torr (or 760 mmHg).
- In the International System of Units (SI), pressure is measured in Pascals (Pa).
- The conversion factor dictates that $1 \text{ atm} = 101,325 \text{ Pa}$.
- Therefore, $760 \text{ torr} = 101,325 \text{ Pa}$.

Why other options are incorrect:

1 is the value in atm. 76 is the value in cmHg. 760 is the value in mmHg. Only 101325 represents Pascals.

Question #11 Key: (C)

DUHS 2024

Fuel cell is a typical galvanic cell which is based on reaction between: [DUHS 2024]

CORE CONCEPT AND DERIVATION

A fuel cell continuously converts the chemical energy of a fuel and an oxidizing agent directly into electricity, without combustion.

Solution:

- The most prevalent, highly efficient, and historically significant type of fuel cell (used extensively in aerospace missions like Apollo) is the Alkaline Fuel Cell (AFC).
- This specific cell operates on the continuous redox reaction between **Hydrogen** gas (the fuel, oxidized at the anode) and **Oxygen** gas (the oxidant, reduced at the cathode).
- The only exhaust byproduct is pure water.

Why other options are incorrect:

While methane can be used in Solid Oxide Fuel Cells, basic textbook fuel cells fundamentally teach the Hydrogen-Oxygen reaction. Copper and Nitrogen are not standard fuel cell reagents.

Question #12 Key: (D)

BUMHS 2024

Oxidation number of "Mn" in [Formula] is: [BMU 2024]

CORE CONCEPT AND DERIVATION

The oxidation states of all atoms in a neutral molecule must sum to zero.

Formula:

$$+1 + x + 4(-2) = 0$$

Solution:

- Potassium (K) is always +1. Oxygen (O) is -2.
- Let x be the oxidation state of Manganese (Mn).
- $1 + x - 8 = 0 \implies x - 7 = 0 \implies x = +7$.

Why other options are incorrect:

If one forgot the Potassium atom, they might calculate +8. If they miscalculated Oxygen, they might guess +4 or +6. +7 is mathematically precise.

Question #13 Key: (A)

BUMHS 2024

Electric current in solutions is carried by: [BMU 2024]

CORE CONCEPT AND DERIVATION

Electrical conductivity requires physical charge carriers that are free to move under the influence of an electric field.

Solution:

- In metallic wires, electric current is carried by a "sea" of delocalized, free electrons.
- However, in electrolytic or aqueous solutions, free electrons cannot exist in the solvent.
- Instead, the current is exclusively carried by the physical migration of hydrated **ions** (positive cations moving toward the cathode, and negative anions moving toward the anode).

Why other options are incorrect:

Canal rays are beams of positive ions generated in a vacuum tube. Free protons do not carry bulk current. Free electrons only carry current in solids, not solutions.

Question #14 Key: (B)

BUMHS 2024

Which of the following is used for galvanizing iron sheet? [BMU 2024]

CORE CONCEPT AND DERIVATION

Galvanization is a specific industrial process designed to protect iron and steel from rusting by providing both a physical barrier and cathodic protection.

Solution:

- In galvanization, iron is coated with a thin layer of **Zinc**.
- Because Zinc has a lower (more negative) standard reduction potential than Iron, it acts as a more reactive, stronger reducing agent.
- If the coating is scratched, the Zinc acts as a "sacrificial anode," corroding preferentially and supplying electrons to the Iron, thus completely preventing the Iron from oxidizing (rusting).

Why other options are incorrect:

Coating with Tin is called tin-plating, not galvanizing. Tin is less reactive than Iron, so if a tin coat is scratched, the Iron corrodes even faster. Copper and Aluminum are not used for this specific cathodic protection technique.

Question #15 Key: (B)

BUMHS 2024

What change in oxidation number of Cu takes place in the following reaction? [Formula] [BMU 2024]

CORE CONCEPT AND DERIVATION

Track the oxidation state of the metal as it transitions from a free element into an ionic compound.

Solution:

- On the reactant side, Copper (Cu) is in its elemental, uncombined state. By rule, its oxidation number is 0.
- On the product side, Copper is part of the ionic compound Copper(II) nitrate, $Cu(NO_3)_2$.
- The nitrate polyatomic ion (NO_3^-) carries a fixed charge of -1 .
- To balance two nitrate ions (a total of -2 charge), the single Copper atom must carry an oxidation state of $+2$.
- Therefore, the oxidation number changes from 0 to $+2$.

Why other options are incorrect:

Copper very rarely exhibits a -1 or -2 state (it is a metal and prefers to lose electrons). While $+1$ is possible (Cu_2O), the formula here demands $+2$.

Question #16 Key: (A)

BUMHS 2024

Water is ____ electrolyte. [BMU 2024]

CORE CONCEPT AND DERIVATION

The strength of an electrolyte depends entirely on its ability to auto-ionize or dissociate into free charge carriers in solution.

Solution:

- Pure water does undergo autoionization: $H_2O \rightleftharpoons H^+ + OH^-$.
- However, this equilibrium lies overwhelmingly to the left. At room temperature, the ion product constant of water (K_w) is tiny: 1.0×10^{-14} .
- Because only about 1 in 10 million water molecules is ionized at any given moment, there are very few ions available to conduct electricity.
- Thus, water is an extremely weak electrolyte.

Why other options are incorrect:

Strong electrolytes (like NaCl or HCl) dissociate nearly 100%. Water doesn't come close.

Question #17 Key: (A)

NUMS 2024

Zn rod acts as cathode when coupled with magnesium electrode. This is because the reduction potential of: [NUM...]

CORE CONCEPT AND DERIVATION

In a galvanic cell, the electrode composed of the metal with the higher (more positive/less negative) standard reduction potential acts as the cathode.

Solution:

- The standard reduction potential of Zinc (Zn) is -0.76 V .
- The standard reduction potential of Magnesium (Mg) is -2.37 V .
- Because -0.76 V is mathematically greater than -2.37 V ($Zn > Mg$), Zinc has a stronger thermodynamic pull on electrons.
- Zinc forces Magnesium to oxidize (act as the anode), while Zinc undergoes reduction (acts as the cathode).

Why other options are incorrect:

Note: Options B, C, and D are physical misprints in the original source book, accidentally copied from the subsequent question. The only chemically relevant and correct answer is A.

Question #18 Key: (A)

NUMS 2024

Placing a rod of iron metal in a solution of [Formula]: [NUMS 2024]

CORE CONCEPT AND DERIVATION

A single displacement redox reaction occurs when a more reactive solid metal is placed into a solution containing ions of a less reactive metal.

Solution:

- Look at the electrochemical series. Iron (Fe) has a reduction potential of -0.44 V , while Copper (Cu) has a reduction potential of $+0.34\text{ V}$.
- Because Iron is higher in the reactivity series (it is a stronger reducing agent), it wants to lose its electrons to the Copper ions.
- The Iron rod will begin to dissolve (oxidize) into Fe^{+2} ions:
 $Fe \rightarrow Fe^{+2} + 2e^{-}$.
- The Cu^{+2} ions in the blue sulfate solution will accept those electrons and reduce into solid Copper metal: $Cu^{+2} + 2e^{-} \rightarrow Cu$.
- This solid Copper will be deposited on the iron rod and at the bottom of the beaker.

Why other options are incorrect:

Iron does not precipitate; it actively dissolves. Copper does not dissolve; it precipitates out of solution. The reaction is highly spontaneous, so "no reaction" is false.

Question #19 Key: (B)

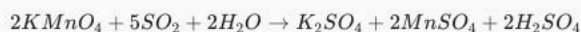
KMU 2023

In redox reaction of [Formula] with [Formula] in acidic medium:
[ETEA 2023]

CORE CONCEPT AND DERIVATION

Potassium Permanganate ($KMnO_4$) is a famous, incredibly strong oxidizing agent, especially in acidic environments. Sulfur dioxide (SO_2) often acts as a reducing agent.

Formula:



Solution:

- In $KMnO_4$, Manganese is in a highly unstable +7 oxidation state and desperately wants to acquire electrons.
- In SO_2 , Sulfur is in a +4 state, but can easily be oxidized to the +6 state (sulfate).
- SO_2 provides the electrons to $KMnO_4$, causing Manganese to be reduced from +7 to +2 (evidenced by the deep purple solution turning colorless).
- Because SO_2 forces $KMnO_4$ to gain electrons, SO_2 acts as the reducing agent.

Why other options are incorrect:

SO_2 does not oxidize $KMnO_4$; it does the exact opposite. $KMnO_4$ is highly active in acidic media, not inert.

Question #20 Key: (D)

KMU 2023

Zinc displaces copper from its solution because: [ETEA 2023]

CORE CONCEPT AND DERIVATION

A metal can spontaneously displace another metal from its aqueous salt solution if it acts as a stronger reducing agent.

Solution:

- The strength of a reducing agent is inversely proportional to its reduction potential. A smaller (more negative) reduction potential means a higher tendency to lose electrons (oxidize).
- Zinc has a standard reduction potential of -0.76 V .
- Copper has a standard reduction potential of $+0.34\text{ V}$.
- Because Zinc has a smaller reduction potential than Copper, solid Zinc will naturally oxidize, forcing the Copper ions in solution to reduce and precipitate out.

Why other options are incorrect:

Option B is factually inverted (Zinc's potential is lower, not higher). Atomic number and general solubility are not the primary thermodynamic drivers for redox displacement.

Question #21 Key: (B)

DUHS 2023

In electrochemical series, what is the electrode potential of all metals above Hydrogen? [DUHS 2023]

CORE CONCEPT AND DERIVATION

The standard electrochemical series is anchored around the Standard Hydrogen Electrode (SHE).

Solution:

- The SHE is assigned a standard reduction potential of exactly 0.00 V.
- Metals placed "above" hydrogen in the series (like Lithium, Zinc, Iron) are stronger reducing agents than Hydrogen gas.
- Because they have a greater tendency to undergo oxidation rather than reduction compared to Hydrogen, their standard reduction potentials are negative (less than zero).

Why other options are incorrect:

Only Hydrogen has a potential of exactly zero. Metals below Hydrogen (like Copper, Silver, Gold) have positive (greater than zero) reduction potentials.

Question #22 Key: (B)

BUMHS 2023

When aqueous solution of NaCl is electrolyzed; [BUMHS 2023]

CORE CONCEPT AND DERIVATION

During the electrolysis of an aqueous solution, multiple cations migrate to the cathode. The cation with the higher (less negative) reduction potential is preferentially reduced.

Solution:

- An aqueous solution of NaCl contains Na^+ ions from the salt and H^+ ions from the autoionization of water.
- The standard reduction potential of Na^+ to Na is -2.71 V.
- The reduction potential for the formation of H_2 gas from water is roughly -0.83 V.
- Because -0.83 V is much higher than -2.71 V, the Hydrogen ions are preferentially reduced, and H_2 gas rapidly evolves at the cathode.

Why other options are incorrect:

Sodium metal is too reactive to exist in water; it would immediately react even if it did form. Chlorine gas (Cl_2) evolves at the anode, not the cathode.

Question #23 Key: (B)

NUMS 2023

During electrolysis, reduction always occurs at the: [NUMS 2023]

CORE CONCEPT AND DERIVATION

The nomenclature for electrochemical electrodes is strictly tied to the type of chemical reaction occurring at their surface.

Solution:

- By universal IUPAC definition, the **cathode** is the electrode where reduction (gain of electrons) takes place.
- The **anode** is the electrode where oxidation (loss of electrons) takes place.
- This holds true whether the cell is galvanic (spontaneous) or electrolytic (forced via an external power source). The mnemonic "RED CAT" (Reduction at Cathode) is always reliable.

Why other options are incorrect:

Oxidation occurs at the anode. The salt bridge is a pathway for spectator ions, not a site of electron transfer.

Question #24 Key: (B)

SZABMU 2023

In the reaction [Formula] How many electrons are gained or lost by chromium atom? [SZABMU 2023, 2024]

CORE CONCEPT AND DERIVATION

To determine electron transfer per atom, calculate the change in the oxidation state of that specific element from reactant to product.

Solution:

- First, find the oxidation state of Chromium (Cr) in the dichromate ion ($\text{Cr}_2\text{O}_7^{2-}$):
 $2x + 7(-2) = -2 \implies 2x - 14 = -2 \implies 2x = +12 \implies x = +6$.
- On the product side, Chromium is Cr^{+3} , so its oxidation state is +3.
- The oxidation state of a single Chromium atom goes from +6 down to +3.
- This mathematical reduction of 3 indicates a gain of 3 electrons ($+3e^-$) per Chromium atom.

Why other options are incorrect:

The entire dichromate molecule (which contains two Cr atoms) gains a total of 6 electrons. However, the question specifically asks for the transfer "by chromium atom" (singular), which is 3.

Question #25 Key: (C)

UHS 2022

An electrochemical cell is based upon which type of reaction? [UHS 2022]

CORE CONCEPT AND DERIVATION

Electrochemistry is the study of electricity relating to chemical reactions, specifically relying on the physical transfer of electrons between chemical species.

Solution:

- The entire foundation of both Galvanic (voltaic) and Electrolytic cells is the spatial separation of electron loss (oxidation) and electron gain (reduction).
- Because these cells operate strictly via oxidation and reduction half-reactions, the fundamental underlying mechanism is a Reduction-Oxidation (Redox) reaction.

Why other options are incorrect:

Acid-base (neutralization) reactions involve the transfer of protons (H^+), not electrons, and do not inherently generate electric current. Nuclear reactions involve changes to the atomic nucleus, not valence shell electrons.

Question #26 Key: (B)

UHS 2022

In which of the following, Oxygen shows fractional oxidation number? [UHS 2022]

CORE CONCEPT AND DERIVATION

While Oxygen usually has an oxidation state of -2 , its state changes when bonded to more electronegative halogens, or when forming peroxides and superoxides.

Solution:

- Let's determine the oxidation state of O in Potassium superoxide, KO_2 .
- Potassium (K) is a Group 1 alkali metal and strictly holds a +1 oxidation state.
- Set up the equation: $+1 + 2x = 0 \implies 2x = -1 \implies x = -1/2$.
- The fractional oxidation state of Oxygen in a superoxide is $-1/2$.

Why other options are incorrect:

In OF_2 , Oxygen is +2 (since Fluorine is always -1). In Sodium peroxide (Na_2O_2), Oxygen is -1 . In Dichlorine heptoxide (Cl_2O_7), Oxygen is its normal -2 .

Question #27 Key: (B)

SZABMU 2022

Which statement correctly describes the term Standard Electrode potential? [SZABMU 2022]

CORE CONCEPT AND DERIVATION

Single electrode potentials cannot be measured in isolation; they must be measured as a potential difference against a universally agreed-upon standard reference.

Solution:

- The scientific community defines the Standard Hydrogen Electrode (SHE) as the ultimate reference point (assigned 0.00 V).
- The term "Standard Electrode Potential" (E°) specifically means coupling the target half-cell (at standard conditions: 1 M concentration, 1 atm pressure, 298 K) against the SHE and recording the voltage on a voltmeter.

Why other options are incorrect:

Option A mentions temperature and pressure but neglects the critical requirement of a reference electrode. Option C incorrectly suggests Zinc is the universal reference. Option D is simply the definition of cell potential, not a *standard* single electrode potential.

Question #28 Key: (C)

SZABMU 2022

Oxidation number of an element in free state is: [SZABMU 2022]

CORE CONCEPT AND DERIVATION

Oxidation numbers keep track of electron distribution in compounds. If an element has not formed bonds with any other unique element, there has been no electron transfer.

Solution:

- By fundamental IUPAC definition, any element existing in its uncombined, pure, free state (whether monoatomic like He , diatomic like O_2 , or polyatomic like S_8) has not gained or lost any electrons relative to its neutral atomic state.
- Therefore, its assigned oxidation number is exactly Zero.

Why other options are incorrect:

Positive and negative oxidation states only arise when an atom forms bonds with an atom of a different element with differing electronegativity.

Question #29 Key: (A)

SZABMU 2022

The branch of science which deals with the conversion of electrical energy into chemical energy and vice versa...

CORE CONCEPT AND DERIVATION

The interaction between electrical current and chemical reactions is a massive, dedicated subset of physical chemistry.

Solution:

- **Electrochemistry** encompasses two main phenomena:
 1. Galvanic/Voltaic processes: Spontaneous chemical reactions generating electrical energy (e.g., batteries).
 2. Electrolytic processes: Using external electrical energy to force non-spontaneous chemical reactions to occur (e.g., electroplating).

Why other options are incorrect:

Thermochemistry studies heat/energy changes in reactions. Stereochemistry studies the 3D spatial arrangement of atoms. Biochemistry studies chemical processes within living organisms.

Question #30 Key: (B)

KMU 2022

A cathode has the reduction potential: [ETEA 2022]

CORE CONCEPT AND DERIVATION

In any standard electrochemical cell, the half-cell with the stronger "pull" on electrons will force the other half-cell to give them up.

Solution:

- Reduction potential is literally a measure of a species' tendency to acquire electrons and undergo reduction.
- The cathode is defined strictly as the electrode where reduction occurs.
- Therefore, to spontaneously drive electrons from the anode to the cathode, the cathode *must* possess a higher (more positive) reduction potential than the anode.

Why other options are incorrect:

If the cathode had a lesser reduction potential, it would act as the anode instead. If they were the same, no potential difference would exist and the cell voltage would be zero.

Question #31 Key: (B)

KMU 2022

The stronger the reduction potential, the more difficult it is to: [ETEA 2022]

CORE CONCEPT AND DERIVATION

Reduction potential and oxidation potential are mathematically equal but opposite in sign. $E_{red}^{\circ} = -E_{ox}^{\circ}$.

Solution:

- A high, strong (very positive) reduction potential means a species desperately wants to gain electrons (it wants to be reduced).
- Because it holds onto its electrons tightly, it strongly resists giving them away.
- Giving away electrons is the definition of oxidation. Therefore, a high reduction potential makes the species highly resistant and difficult to oxidize.

Why other options are incorrect:

A strong reduction potential makes it mathematically very easy to reduce the compound, not difficult.

Question #32 Key: (C)

DUHS 2022

The electrolysis of dilute acid solution gives: [DUHS 2022]

CORE CONCEPT AND DERIVATION

Electrolysis of a dilute acid (such as dilute H_2SO_4) is essentially the electrolysis of water, facilitated by the acid's ions which increase electrical conductivity.

Solution:

- At the cathode (reduction site): The abundant H^+ ions from the acid are easily reduced to form Hydrogen gas.
 $2H^+ + 2e^- \rightarrow H_2$.
- At the anode (oxidation site): Water molecules (or OH^- ions) are oxidized because the counter anions (like SO_4^{2-}) are highly stable and very difficult to oxidize compared to water.
 $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$.
- Therefore, H_2 evolves at the cathode, and O_2 evolves at the anode.

Why other options are incorrect:

Chlorine gas would only evolve if you electrolyzed concentrated hydrochloric acid or brine, not a generic dilute acid. Hydrogen always evolves at the cathode (since it is a positive ion), never the anode.

Question #33 Key: (D)

DUHS 2022

A strong electrolyte is one that ____ Completely in solution. [DUHS 2022]

CORE CONCEPT AND DERIVATION

Electrolytes are substances that produce an electrically conducting solution when dissolved in a polar solvent, such as water.

Solution:

- The strength of an electrolyte is strictly defined by the extent to which it dissociates into independent, mobile ions.
- A strong electrolyte (such as $NaCl$ or HCl) breaks apart practically 100% into its constituent cations and anions when placed in water.
- This process of forming ions is called ionization or dissociation.

Why other options are incorrect:

Decomposition implies the permanent breakdown of chemical bonds into entirely different elemental substances. "Disappears" is non-scientific. Ionization accurately describes the physical separation into charged particles.

Question #34 Key: (A)

DUHS 2022

Down cell is used for the: [DUHS 2022]

CORE CONCEPT AND DERIVATION

Highly reactive alkali metals cannot be extracted from aqueous solutions via electrolysis because water would be reduced instead of the metal ions.

Solution:

- To extract pure metallic Sodium, industrial chemists use a specialized electrolytic apparatus known as the Downs cell.
- In the Downs cell, molten Sodium Chloride ($NaCl$, mixed with $CaCl_2$ to lower the melting point) is electrolyzed.
- Sodium ions (Na^+) are reduced at the iron cathode to form liquid metallic Sodium, while Chloride ions (Cl^-) are oxidized at the carbon anode to form Chlorine gas.

Why other options are incorrect:

Magnesium is typically extracted using a Dow cell (similar, but specifically for $MgCl_2$). Aluminum uses the Hall-Héroult process. Iron is extracted via pyrometallurgy in a blast furnace.

Question #35 Key: (A)

BUMHS 2022

What is the oxidation number of [Formula] ? [BMU 2022]

CORE CONCEPT AND DERIVATION

The oxidation number indicates the degree of oxidation (electron loss/gain). In a homonuclear diatomic molecule, bonding electrons are shared perfectly equally.

Solution:

- Chlorine gas (Cl_2) consists of two identical Chlorine atoms covalently bonded together.
- Because both atoms possess the exact same electronegativity, neither atom can pull electron density away from the other.
- Consequently, there is zero net charge transfer. By universal IUPAC convention, any element in its free elemental state is assigned an oxidation number of 0.

Why other options are incorrect:

Chlorine only exhibits -1 when it successfully bonds with a less electronegative element (like Na) to form an ionic or polar covalent bond.

Question #36 Key: (D)

BUMHS 2022

Which species has greater reduction potential? [BMU 2022]

CORE CONCEPT AND DERIVATION

Reduction potential indicates how eagerly an ion wishes to gain electrons to return to its neutral metallic state.

Solution:

- According to the electrochemical series, reduction potential generally increases (becomes less negative/more positive) as you move "down" the series towards less reactive metals.
- Alkali and heavier alkaline earth metals (Barium, Calcium, Magnesium) are extremely reactive; they desperately want to stay as ions. Thus, they have highly negative reduction potentials.
- Aluminum (Al) is less reactive than Group 2 elements. Its standard reduction potential (-1.66 V) is algebraically greater (less negative) than Magnesium (-2.37 V), Calcium (-2.87 V), and Barium (-2.90 V).

Why other options are incorrect:

Barium, Calcium, and Magnesium are all more electropositive than Aluminum, meaning their ionic forms are much harder to reduce.

Question #37 Key: (D)

NUMS 2022

Potential of standard hydrogen electrode (SHE) is arbitrarily taken as: [NUMS 2022]

CORE CONCEPT AND DERIVATION

Just as sea level is assigned an arbitrary altitude of 0 meters to measure the height of mountains, electrochemistry requires a "sea level" to measure standard voltages.

Solution:

- The Standard Hydrogen Electrode (SHE) consists of platinum submerged in $1\text{ M }H^+$ solution, with H_2 gas bubbled at 1 atm.
- By universal international convention, the thermodynamic value for the reduction potential (and oxidation potential) of this specific half-cell is set exactly to Zero Volts (0.00 V) at all temperatures.

Why other options are incorrect:

Values like $+1$ or -1 are not used. A baseline of exactly zero allows for a mathematically simple reference scale featuring positive and negative values.

Question #38 Key: (C)

NUMS 2022

During electrolysis, reduction always occurs at: [NUMS 2022]

CORE CONCEPT AND DERIVATION

The definitions of the electrodes are tied strictly to the chemical processes that occur at their surfaces, regardless of whether the cell is galvanic or electrolytic.

Solution:

- A universal mnemonic in electrochemistry is **RED CAT** (Reduction occurs at the Cathode) and **AN OX** (Oxidation occurs at the Anode).
- In an electrolytic cell, the battery pumps electrons into the cathode. Positive ions (cations) migrate to the cathode to gain these electrons, completing the process of reduction.

Why other options are incorrect:

Oxidation occurs at the anode. A salt bridge is an internal pathway for ion exchange, not a site for redox reactions.

Question #39 Key: (D)

PMDC 2021

The least reactive transition metal: [PMC 2021]

CORE CONCEPT AND DERIVATION

The chemical reactivity of a metal is tied to its willingness to lose electrons (oxidation potential). Metals with very high positive reduction potentials are extremely resistant to oxidation.

Solution:

- Gold (Au) sits at the very bottom of the standard electrochemical series.
- It has an exceptionally high standard reduction potential ($Au^{+3}/Au \approx +1.50$ V).
- This implies that Gold has virtually zero tendency to spontaneously lose electrons to the environment, making it a highly inert, noble metal.

Why other options are incorrect:

Scandium and Zinc have highly negative reduction potentials, making them very reactive. Copper is less reactive than Zn but far more reactive than Gold.

Question #40 Key: (A)

PMDC 2021

Which of the following is strong reducing agent? [PMC 2021]

CORE CONCEPT AND DERIVATION

A reducing agent donates electrons. The strongest reducing agents are elements that most desperately want to lose an electron, which translates to having the most negative standard reduction potential.

Solution:

- Lithium (Li) sits at the absolute top of the standard electrochemical series.
- It has the lowest (most negative) standard reduction potential of all elements (-3.05 V).
- Because its oxidation potential is incredibly high, solid Lithium is the strongest reducing agent in aqueous conditions.

Why other options are incorrect:

Fluorine (F) sits at the absolute bottom of the series and is the strongest oxidizing agent. While Sodium (Na) and Magnesium (Mg) are strong reducing agents, they are thermodynamically weaker than Lithium.

Question #41 Key: (D)

PMDC 2021

Electrolysis of a dilute solution of NaCl results at the anode: [PMC 2021]

CORE CONCEPT AND DERIVATION

In the electrolysis of aqueous solutions, competition occurs at the electrodes between the ions from the salt and the water molecules themselves.

Solution:

- In a **dilute** aqueous solution of NaCl, the concentration of Cl^- ions is very low compared to water molecules.
- At the anode (where oxidation occurs), two reactions compete: the oxidation of Cl^- to Cl_2 gas, and the oxidation of H_2O (or OH^-) to O_2 gas.
- Thermodynamically, the oxidation of water (requiring +1.23 V) is easier than the oxidation of chloride ions (requiring +1.36 V).
- Because the solution is dilute, the overpotential effect that usually favors Chlorine gas in concentrated brine is negligible. Thus, Oxygen gas is evolved at the anode.

Why other options are incorrect:

Chlorine gas is only evolved if the NaCl solution is highly concentrated (brine). Hydrogen is evolved at the cathode, not the anode.

Question #42 Key: (C)

PMDC 2021

Which of the following is feasible reaction? [PMC 2021]

CORE CONCEPT AND DERIVATION

A single displacement reaction between a metal and an acid is feasible if the metal has a negative standard reduction potential (placing it above Hydrogen in the electrochemical series).

Solution:

- Zinc (Zn) has a standard reduction potential of -0.76 V.
- Because it is "above" Hydrogen (0.00 V), it acts as a stronger reducing agent.
- Zinc will spontaneously donate electrons to the H^+ ions in Hydrochloric Acid, dissolving into $ZnCl_2$ and liberating H_2 gas. This makes option C highly feasible.

Why other options are incorrect:

Silver (Ag) in option D is a coinage metal situated below Hydrogen (positive reduction potential); it cannot displace Hydrogen from acids. Options A and B are thermodynamically non-spontaneous based on their relative reduction potentials.

Question #43 Key: (D)

PMDC 2020

The oxidation state of "S" in the [Formula] is: [NMDCAT 2020]

CORE CONCEPT AND DERIVATION

The average oxidation state of an element in a polyatomic ion is calculated by ensuring the sum of all oxidation states equals the net ionic charge.

Formula:

$$2x + 3(-2) = -2$$

Solution:

- Let x be the average oxidation state of Sulfur (S) in the thiosulfate ion ($S_2O_3^{2-}$).
- The oxidation state of Oxygen (O) is -2 .
- Set up the algebraic equation: $2x + 3(-2) = -2$.
- Solve for x : $2x - 6 = -2 \implies 2x = +4 \implies x = +2$.

Why other options are incorrect:

Sulfur has an oxidation state of $+6$ in sulfates (SO_4^{2-}) and $+4$ in sulfites (SO_3^{2-}). Thiosulfate specifically yields an average of $+2$.

Question #44 Key: (A)

PMDC 2020

The common oxidation number of halogens is: [NMDCAT 2020]

CORE CONCEPT AND DERIVATION

Halogens are Group 17 elements (Fluorine, Chlorine, Bromine, Iodine) possessing seven valence electrons.

Solution:

- To achieve a stable noble gas electron configuration (an octet), a halogen atom requires only one additional electron.
- Due to their high electronegativity, they readily pull one electron from metals or less electronegative non-metals.
- By gaining one electron, they predominantly form halide ions (e.g., F^- , Cl^- , Br^-) with an oxidation state of -1 .

Why other options are incorrect:

While halogens (except Fluorine) can exhibit positive oxidation states (like $+1$, $+3$, $+5$, $+7$) when bonded to more electronegative oxygen, the most common and dominant state across all halogens is -1 .

Question #45 Key: (B)

PMDC 2020

During oxidation process, oxidation number of an element: [NMDCAT 2020]

CORE CONCEPT AND DERIVATION

Oxidation is fundamentally defined as the loss of electrons from an atom, ion, or molecule.

Solution:

- Because electrons carry a negative electrical charge, removing them causes the chemical species to become more mathematically positive.
- For example, when solid Zinc oxidizes, it loses two electrons: $Zn \rightarrow Zn^{+2} + 2e^-$.
- The oxidation number moves from 0 to $+2$, which is a numerical increase.

Why other options are incorrect:

A decrease in oxidation number corresponds to the gain of electrons, which is strictly defined as reduction.

Question #46 Key: (C)

NUMS 2019

The oxidation state of carbon in [Formula] is: [NUMS 2019]

CORE CONCEPT AND DERIVATION

In polyatomic ions, the algebraic sum of the oxidation numbers of all atoms equates to the overall charge of the ion.

Formula:

$$2x + 4(-2) = -2$$

Solution:

- Let x be the oxidation state of a single Carbon (C) atom.
- The oxidation state of Oxygen (O) is -2 .
- Set up the equation for the oxalate ion ($C_2O_4^{2-}$): $2x + 4(-2) = -2$.
- Solve for x : $2x - 8 = -2 \implies 2x = +6 \implies x = +3$.

Why other options are incorrect:

Carbon has an oxidation state of $+4$ in carbon dioxide (CO_2) and carbonates, not in oxalates. -4 is for methane (CH_4).

Question #47 Key: (B)

SET 2019

The value of oxidation number of chlorine in [Formula] is: [SET 2019]

CORE CONCEPT AND DERIVATION

For a neutral molecule, the sum of the oxidation states of all the constituent atoms must equal exactly zero.

Formula:

$$(+1) + x + 3(-2) = 0$$

Solution:

- Hydrogen (H) generally has an oxidation state of $+1$.
- Oxygen (O) is -2 .
- Let x be the oxidation state of Chlorine (Cl).
- Set up the equation: $1 + x - 6 = 0$.
- Solve for x : $x - 5 = 0 \implies x = +5$.

Why other options are incorrect:

Chlorine shows -1 in hydrochloric acid (HCl), $+3$ in chlorous acid ($HClO_2$), and $+7$ in perchloric acid ($HClO_4$).

Question #48 Key: (C)

NUMS 2019

Stronger is the oxidizing agent, stronger is the: [NUMS 2019]

CORE CONCEPT AND DERIVATION

An oxidizing agent causes another substance to be oxidized while it itself is reduced.

Solution:

- The strength of an oxidizing agent is directly proportional to its tendency to gain electrons.
- The thermodynamic measure of the tendency to gain electrons is the Standard Reduction Potential (E_{red}°).
- Therefore, the stronger the oxidizing power of a chemical species, the more positive and higher its standard reduction potential.

Why other options are incorrect:

A strong oxidation potential indicates a strong *reducing* agent, not an oxidizing agent. EMF refers to the total voltage of a complete cell, not a single species. Redox potential is a generic term.

Question #49 Key: (B)

NUMS 2019

Which of the following metal does not liberate hydrogen on reaction with acid? [NUMS 2019]

CORE CONCEPT AND DERIVATION

Metals located above Hydrogen in the electrochemical series (negative reduction potentials) are reactive enough to displace H^+ ions from dilute acids, generating H_2 gas.

Solution:

- Platinum (Pt) is a highly unreactive, noble metal situated far below Hydrogen in the electrochemical series.
- It has a high positive reduction potential (+1.20 V).
- Because its oxidation potential is negative relative to Hydrogen, it cannot spontaneously reduce H^+ ions into H_2 gas.

Why other options are incorrect:

Magnesium, Zinc, and Calcium all have negative reduction potentials (they lie above Hydrogen) and act as strong reducing agents, eagerly dissolving in acids to liberate hydrogen gas.

Question #50 Key: (B)

SET 2019

Which one of the following elements is the strongest reducing agent? [SET 2019]

CORE CONCEPT AND DERIVATION

A reducing agent donates electrons to another species, meaning it undergoes oxidation itself.

Solution:

- The strength of a reducing agent is inversely proportional to its standard reduction potential (and directly proportional to its oxidation potential).
- Alkali metals (Group 1), such as Sodium (Na), have extremely low (highly negative) reduction potentials because they eagerly want to lose their single valence electron to achieve a noble gas configuration.
- Among the given options, Sodium has the most negative reduction potential, making it the strongest reducing agent.

Why other options are incorrect:

Chlorine is a non-metal and acts as a strong oxidizing agent. Magnesium and Aluminium are good reducing agents, but they are less reactive (less electropositive) than Sodium.

Question #51 Key: (D)

SET 2019

Rusting of iron metal Fe occurs when Fe gets converted into Fe_2O_3 . What happened with Fe? [SET 2019]

CORE CONCEPT AND DERIVATION

Corrosion (rusting) is fundamentally a spontaneous electrochemical redox process where a refined metal reverts to a more stable oxide form.

Solution:

- In its elemental state, iron (Fe) has an oxidation number of 0.
- In rust (iron(III) oxide, Fe_2O_3), the oxidation state of iron is +3.
- Because the oxidation state increases from 0 to +3, Iron has lost electrons.
- The loss of electrons is strictly defined as oxidation.

Why other options are incorrect:

Reduction would mean gaining electrons (which happens to ambient Oxygen in this reaction, not Iron). Neutralization is an acid-base reaction. Sublimation is a physical phase change from solid to gas.

Question #52 Key: (A)

NUMS 2019

The electrolyte used in fuel cell is: [NUMS 2019]

CORE CONCEPT AND DERIVATION

Fuel cells require an electrolyte to facilitate the internal transport of ions between the anode and the cathode while acting as an electrical insulator to force electrons through the external circuit.

Solution:

- The traditional alkaline fuel cell (AFC), famous for its use in the Apollo space missions, utilizes an aqueous solution of Potassium Hydroxide (KOH).
- The KOH solution allows for the rapid mobility of hydroxide (OH^-) ions from the cathode to the anode, which is necessary to sustain the redox reactions.

Why other options are incorrect:

Sodium chloride and sodium nitrate are not used because they do not provide the necessary OH^- ions or H^+ ions required for the standard hydrogen-oxygen half-reactions.

Question #53 Key: (C)

KMU 2019

When zinc electrode is coupled with copper electrode in a galvanic cell: [ETEA 2019]

CORE CONCEPT AND DERIVATION

In a galvanic cell, oxidation always occurs at the anode and reduction always occurs at the cathode.

Solution:

- Zinc has a lower reduction potential (-0.76 V) and therefore a higher tendency to lose electrons compared to Copper.
- Zinc acts as the anode, undergoing oxidation ($\text{Zn} \rightarrow \text{Zn}^{+2} + 2\text{e}^-$).
- Copper has a higher reduction potential ($+0.34 \text{ V}$) and therefore acts as the cathode.
- At the Copper electrode, reduction takes place ($\text{Cu}^{+2} + 2\text{e}^- \rightarrow \text{Cu}$).

Why other options are incorrect:

Reduction does not occur at the Zinc electrode; oxidation does. Oxidation does not occur at the Copper electrode; reduction does.

Question #54 Key: (A)

KMU 2019

The oxidation state of nitrogen in [Formula] are: [ETEA 2019]

CORE CONCEPT AND DERIVATION

Ammonium nitrate is an ionic compound composed of two distinct polyatomic ions: the ammonium cation (NH_4^+) and the nitrate anion (NO_3^-). The nitrogen atoms in these two ions exist in completely different oxidation states.

Solution:

- **For the Ammonium ion (NH_4^+):** Let x be the oxidation state of N.
 $x + 4(+1) = +1 \Rightarrow x = -3$.
- **For the Nitrate ion (NO_3^-):** Let y be the oxidation state of N.
 $y + 3(-2) = -1 \Rightarrow y - 6 = -1 \Rightarrow y = +5$.
- Therefore, the oxidation states of the two nitrogen atoms are -3 and $+5$, respectively.

Why other options are incorrect:

If one erroneously tried to average the nitrogens as $N_2H_4O_3$, they might guess something else, but chemically, the ions are distinct and must be calculated separately.

Question #55 Key: (D)

MDCAT 2019

Aqueous solutions of Iodine and Sodium hydroxide were mixed in a round bottom flask at 70°C . Following chemica...

CORE CONCEPT AND DERIVATION

A disproportionation reaction is a specific type of redox reaction where the exact same element is simultaneously oxidized and reduced.

Solution:

- Look at the oxidation state of Iodine (I) on the reactant side: I_2 is in its elemental state, so its oxidation number is 0.
- On the product side, Iodine exists in two distinct compounds.
- In Sodium Iodate ($NaIO_3$): $+1 + x + 3(-2) = 0 \Rightarrow x = +5$ (Oxidation).
- In Sodium Iodide (NaI): $+1 + x = 0 \Rightarrow x = -1$ (Reduction).
- Because Iodine is both oxidized and reduced simultaneously, this is definitively a redox reaction.

Why other options are incorrect:

There is no insoluble solid formed (so not precipitation). There are no free radicals involved. It is an internal electron transfer, not a simple physical substitution.

Question #56 Key: (C)

MDCAT 2019

[Formula] [Formula] [Formula] [Formula] Keeping in view the values of standard reduction potential given above...

CORE CONCEPT AND DERIVATION

A spontaneous (feasible) redox reaction occurs when a metal with a highly negative reduction potential is oxidized while transferring its electrons to a species with a less negative (or positive) reduction potential.

Solution:

- Let's evaluate Option C: Magnesium solid reacting with Hydrogen ions.
- Magnesium has a very negative reduction potential (-2.37 V), making it an extremely strong reducing agent (it wants to oxidize).
- Hydrogen has a higher reduction potential (0.00 V).
- Therefore, Mg will easily displace Hydrogen from acidic solutions, undergoing oxidation while H^+ is reduced to H_2 gas. The cell potential is vastly positive ($+2.37$ V), making it highly feasible.

Why other options are incorrect:

In option D, Cu ($+0.34$ V) cannot reduce Zn^{2+} (-0.76 V). Options A and B include elements (Au, Cl, I) whose potentials are not even listed, though scientifically Au cannot displace H^+ , and I₂ cannot oxidize Cl^- .

Question #57 Key: (C)

MDCAT 2018

The potential difference of an electrochemical cell is measured by: [MDCAT 2018]

CORE CONCEPT AND DERIVATION

Electrical potential difference, also known as voltage or electromotive force (EMF), is a measure of the driving force pushing electrons through a circuit.

Solution:

- A **Voltmeter** is specifically designed with high internal resistance to measure the potential difference between two points in a circuit without drawing significant current itself.
- In electrochemistry, it connects the anode and cathode to measure the cell's voltage.

Why other options are incorrect:

A galvanometer detects the presence and direction of minute currents. An ammeter measures the magnitude of electrical current (flow of charge), not potential. A calorimeter measures heat changes in thermodynamic reactions.

Question #58 Key: (C)

MDCAT 2018

The standard electrode potential of hydrogen is arbitrarily taken at 298k is _____. [MDCAT 2018]

CORE CONCEPT AND DERIVATION

Standard reduction potentials cannot be measured in absolute terms; they require a baseline reference electrode to calculate relative potential differences.

Solution:

- The scientific community universally agreed to use the Standard Hydrogen Electrode (SHE) as this baseline.
- By IUPAC convention, the standard electrode potential of SHE is assigned an arbitrary, exact value of 0.00 V at all temperatures (including standard 298 K).

Why other options are incorrect:

Values like 1.00 V or 0.10 V are simply random numbers. The entire thermodynamic table of standard potentials revolves around Hydrogen being exactly zero.

Question #59 Key: (A)

MDCAT 2017

In [Formula], the oxidation number of "N" is: [MDCAT 2017]

CORE CONCEPT AND DERIVATION

The sum of the oxidation states of all atoms in a polyatomic ion must equal the net charge of the ion.

Formula:

$$x + 3(-2) = -1$$

Solution:

- Let x be the oxidation state of Nitrogen (N).
- The oxidation state of Oxygen (O) is generally -2 .
- Set up the algebraic equation: $x + 3(-2) = -1$.
- Solve for x : $x - 6 = -1 \Rightarrow x = +5$.

Why other options are incorrect:

A value of -3 would apply to Ammonia (NH_3), not Nitrate. Values of $+3$ or $+2$ correspond to nitrites or nitrogen monoxide, respectively.

Question #60 Key: (B)

MDCAT 2017

The E° value of standard copper half-cell is $+0.34V$, measured when it is connected with SHE i.e. Standard hydr...

CORE CONCEPT AND DERIVATION

When two half-cells are connected, the one with the higher (more positive) standard reduction potential acts as the cathode (undergoes reduction), and the other acts as the anode (undergoes oxidation).

Solution:

- Copper has a standard reduction potential of $+0.34V$, which is greater than that of SHE ($0.00V$).
- Because Copper has a higher reduction potential, it forces the SHE to act as the anode.
- At the anode, oxidation (loss of electrons) occurs.
- The oxidation half-reaction for hydrogen gas is: $H_{2(g)} \rightarrow 2H_{(aq)}^+ + 2e^-$.

Why other options are incorrect:

Option A represents reduction, which would only happen if SHE were connected to a metal with a negative reduction potential (like Zn). Option C is stoichiometrically incorrect. Option D shows the formation of atomic hydrogen gas instead of aqueous H^+ ions.

Question #61 Key: (C)

MDCAT 2017

During space flights, astronauts obtained water from: [MDCAT 2017]

CORE CONCEPT AND DERIVATION

A hydrogen-oxygen fuel cell continuously converts the chemical energy of a fuel (H_2) and an oxidant (O_2) directly into electrical energy.

Solution:

- In a standard Apollo-era fuel cell, Hydrogen is oxidized at the anode and Oxygen is reduced at the cathode.
- The overall highly exothermic cell reaction is: $2H_2 + O_2 \rightarrow 2H_2O$.
- One of the most significant advantages of this specific power source in aerospace engineering is that its only chemical byproduct is pure, perfectly potable liquid water, which astronauts utilize for drinking.

Why other options are incorrect:

Nickel-cadmium, lead-acid accumulators, and alkaline batteries are closed-system storage cells that do not produce harvestable drinking water as a byproduct.

Question #62 Key: (D)

MDCAT 2016

Study the following redox reaction: $10\text{Cl}^- + 16\text{H}^+ + 2\text{MnO}_4^- \rightarrow 5\text{Cl}_2 + 2\text{Mn}^{2+} + 8\text{H}_2\text{O}$

CORE CONCEPT AND DERIVATION

In a redox reaction, **oxidation** corresponds to an increase in oxidation number (loss of electrons), whereas **reduction** corresponds to a decrease in oxidation number (gain of electrons).

Formula / Reaction Analysis:**Solution:**

- **Manganese:** In the permanganate ion (MnO_4^-), let the oxidation number of Mn be x :

$$x + 4(-2) = -1 \implies x = +7$$

In the product Mn^{2+} , the oxidation number is +2.
Since the oxidation state decreases from +7 $\rightarrow$ +2, **Manganese is reduced** (it gains 5 electrons).

- **Chlorine:** Reactant is Cl^- (oxidation state -1) and product is Cl_2 (oxidation state 0).
Since the oxidation state increases from $-1 \rightarrow 0$, **Chloride ions are oxidized** (loss of electrons).

Why other options are incorrect:

- **Opt_A:** Manganese undergoes a decrease in oxidation number ($+7 \rightarrow +2$), which is *reduction*, not oxidation.
- **Opt_B:** Chlorine in the reactants is present as Cl^- (state -1), not zero. The forward reaction oxidizes $-1 \rightarrow 0$.
- **Opt_C:** Going from $-1 \rightarrow 0$ is an algebraic increase in oxidation number (loss of e^-), which defines *oxidation*, not reduction.

Question #63 Key: (C)

MDCAT 2016

Coinage metals Cu, Ag and Au are the least reactive because they have: [MDCAT 2016]

CORE CONCEPT AND DERIVATION

The reactivity of a metal is determined by its tendency to lose electrons (oxidize). Metals with high positive reduction potentials prefer to gain electrons rather than lose them, making them chemically stable or "noble."

Solution:

- In the electrochemical series, elements placed below Hydrogen have positive standard reduction potentials ($E_{red}^{\circ} > 0$).
- Coinage metals (Copper, Silver, Gold) all lie below Hydrogen in the series.
- A positive reduction potential indicates that they are poor reducing agents and very resistant to oxidation (corrosion), which is why they are ideal for making coins and jewelry.

Why other options are incorrect:

Alkali and alkaline earth metals (like Na and Mg) have negative reduction potentials (and thus highly positive oxidation potentials), making them extremely reactive. Coinage metals are the opposite.

Question #64 Key: (A)

MDCAT 2016

The diagram shows a galvanic cell. The current will flow from: H₂ Anode (SHE) (-) Cu Cathode (+) V e⁻ flow (H₂...

CORE CONCEPT AND DERIVATION

In a standard galvanic cell, electrons flow spontaneously from the anode (lower reduction potential) to the cathode (higher reduction potential).

Solution:

- The cell pairs a Standard Hydrogen Electrode (0.00 V) with a Copper half-cell (+0.34 V).
- Because Hydrogen has the lower reduction potential, it undergoes oxidation and acts as the anode.
- Copper acts as the cathode.
- The electron flow (frequently referred to colloquially as "current" in MDCAT nomenclature) originates at the anode and travels through the external wire to the cathode: from the Hydrogen electrode to the Copper electrode.

Why other options are incorrect:

Flowing from Copper to Hydrogen would require a non-spontaneous input of energy (electrolytic cell). Current does not flow from the electrode directly into its own bulk solution in an external circuit context.

Question #65 Key: (C)

KMU 2016

In which of the following reaction hydrogen acts as oxidizing agent.
[ETEA 2016]

CORE CONCEPT AND DERIVATION

An oxidizing agent removes electrons from another substance, meaning the oxidizing agent itself gets reduced (its oxidation state decreases).

Solution:

- We must find the reaction where Hydrogen's oxidation state decreases from 0 to a negative value.
- In option C: $2Na + H_2 \rightarrow 2NaH$.
- Sodium is a highly electropositive Group 1 metal (it desperately wants to lose an electron).
- Elemental Hydrogen (0) is forced to accept an electron from Sodium, becoming the hydride ion (H^-) with an oxidation state of -1 .
- Because Hydrogen gains electrons and is reduced, it acts as the oxidizing agent.

Why other options are incorrect:

In reactions with more electronegative non-metals like Chlorine or Nitrogen, Hydrogen acts as the reducing agent, losing electron density and taking on a $+1$ oxidation state.

Question #66 Key: (B)

KMU 2016

Choose the true statement regarding the reaction given below:
[Formula] [ETEA 2016]

CORE CONCEPT AND DERIVATION

In ionic bond formation between a metal and a non-metal, the metal acts as a reducing agent (loses electrons) and the non-metal acts as an oxidizing agent (gains electrons).

Solution:

- In the reactants, both Sodium (Na) and Chlorine (Cl_2) are in their free elemental states with oxidation numbers of 0.
- In the product ($NaCl$), Na is $+1$ and Cl is -1 .
- Sodium's oxidation state increases ($0 \rightarrow +1$), so it undergoes oxidation. It is the reducing agent.
- Chlorine's oxidation state decreases ($0 \rightarrow -1$), so it undergoes reduction. It is the oxidizing agent.

Why other options are incorrect:

Option A falsely claims Sodium is reduced. Option C is grammatically and scientifically nonsensical. Option B is factually perfect.

Question #67 **Key: (A)**

KMU 2016

A cell is constructed of the following two half cells. What is Emf of the cell? [Formula] [Formula] [ETEA 2016...]

CORE CONCEPT AND DERIVATION

The standard Electromotive Force (EMF) of a cell is calculated by subtracting the reduction potential of the anode from the reduction potential of the cathode.

Formula:

$$E_{cell}^{\circ} = E_{cathode}^{\circ} - E_{anode}^{\circ}$$

Solution:

- First, identify the anode and cathode based on standard reduction potentials.
- Ag has a higher reduction potential (+0.80 V), so it acts as the cathode (reduction).
- Al has a lower reduction potential (−1.67 V), so it acts as the anode (oxidation).
- Apply the formula: $E_{cell}^{\circ} = (+0.80 \text{ V}) - (-1.67 \text{ V})$.
- $E_{cell}^{\circ} = 0.80 + 1.67 = 2.47 \text{ V}$.

Why other options are incorrect:

If one incorrectly subtracted the larger from the smaller, they would get a negative voltage. Standard galvanic cell potentials are always positive.

Question #68 **Key: (A)**

KMU 2016

Which of the following is spontaneous reactions? [ETEA 2016]

CORE CONCEPT AND DERIVATION

A redox reaction is spontaneous if the metal being oxidized sits "higher" (has a more negative reduction potential) in the electrochemical series than the metal ion being reduced.

Solution:

- Zinc (Zn) has a standard reduction potential of −0.76 V.
- Copper (Cu) has a standard reduction potential of +0.34 V.
- Because Zn is a stronger reducing agent than Cu, solid Zinc will naturally oxidize to Zn^{2+} while forcing Cu^{2+} to reduce to solid Cu.
- This is the classic, highly spontaneous reaction that powers the Daniell cell (yielding +1.10 V).

Why other options are incorrect:

Option B is the electrolysis of molten NaCl, requiring massive external energy. Option C is the reverse of the Daniell cell and is non-spontaneous. Option D is an extremely non-spontaneous decomposition.

Question #69 Key: (B)

MDCAT 2015

Study the following facts, which of the following is correct:
[Formula] [Formula] [MDCAT 2015]

CORE CONCEPT AND DERIVATION

A spontaneous redox reaction occurs when a metal with a higher oxidation potential displaces a metal with a lower oxidation potential from its solution.

Solution:

- The given values are standard **oxidation** potentials (notice the reactions show the loss of electrons).
- Zinc has a much higher oxidation potential (+0.76 V) than Copper (−0.34 V).
- Therefore, solid Zinc will spontaneously oxidize into Zn^{+2} , and aqueous Cu^{+2} will be forced to undergo reduction into solid Copper.
- The spontaneous overall reaction is: $Zn_{(s)} + Cu_{(aq)}^{+2} \rightarrow Zn_{(aq)}^{+2} + Cu_{(s)}$.

Why other options are incorrect:

Option A represents the reverse (non-spontaneous) reaction. Options C and D show fundamentally impossible redox stoichiometry where both species undergo reduction.

Note on Signs: Standard reduction potentials are $E_{red}^{\circ}(Zn) = -0.76$ V and $E_{red}^{\circ}(Cu) = +0.34$ V. Because the half-reactions in the question prompt depict electron loss (oxidation), the values given are standard oxidation potentials (+0.76 V and −0.34 V).

Question #70 Key: (B)

MDCAT 2015

Keeping in mind the electrode potential, which one of the following reactions is feasible? [MDCAT 2015]

CORE CONCEPT AND DERIVATION

A metal can displace another metal from its aqueous salt solution only if it sits "higher" (has a more negative reduction potential) in the electrochemical series.

Solution:

- Iron (Fe) has a standard reduction potential of −0.44 V, whereas Copper (Cu) has a potential of +0.34 V.
- Because Fe is a stronger reducing agent than Cu, solid Iron will easily oxidize and displace Copper ions from the sulfate solution.
- The reaction $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$ is highly spontaneous and feasible.

Why other options are incorrect:

In option A, Cu cannot displace Zn. In option C, Zn cannot displace Mg (Mg is highly reactive). In option D, Cd cannot displace Mg.

Question #71 Key: (A)

MDCAT 2013

In the figure given below, the electron flow in external circuit is from: Zn Anode (-) Cu Cathode (+) V e- flo...

CORE CONCEPT AND DERIVATION

In any standard galvanic (voltaic) cell, electrons always flow through the external wire from the anode (site of oxidation) to the cathode (site of reduction).

Solution:

- Zinc (Zn) has a lower standard reduction potential (-0.76 V) compared to Copper ($+0.34\text{ V}$).
- Therefore, Zinc acts as the anode and gets oxidized (loses electrons: $\text{Zn} \rightarrow \text{Zn}^{+2} + 2\text{e}^-$).
- Copper acts as the cathode and gets reduced (gains those electrons).
- The electrons travel from the Zinc electrode, through the external circuit, to the Copper electrode.

Why other options are incorrect:

Electrons never flow from a higher reduction potential (Cu) to a lower one (Zn) spontaneously. The porous partition regulates internal ion flow, not external electron flow.

Question #72 Key: (D)

MDCAT 2011

In voltaic cell a salt bridge is used in order to: [MDCAT 2011]

CORE CONCEPT AND DERIVATION

A salt bridge acts as an electrical connection between two half-cells in a galvanic (voltaic) cell, maintaining electrical neutrality.

Solution:

- During the operation of a voltaic cell, oxidation occurs at the anode (generating positive ions) and reduction at the cathode (depleting positive ions).
- If this charge imbalance is not neutralized, the cell potential quickly drops to zero.
- The salt bridge allows the flow of spectator ions between the two half-cells to balance this charge without allowing the bulk solutions to mix.

Why other options are incorrect:

The salt bridge does not pass electric current (electrons travel through the external wire). It does not prevent ion flow, but rather facilitates it. It specifically exists to **prevent** the physical mixing of the two reactive solutions.

Question #73 Key: (D)

MDCAT 2010

In an electrochemical series, elements are arranged on the basis of: [MDCAT 2010]

CORE CONCEPT AND DERIVATION

The electrochemical series is a systematic arrangement of elements based on their standard electrode potentials.

Solution:

- All standard electrode potentials are measured relative to a universal reference point.
- This reference is the Standard Hydrogen Electrode (SHE), which is arbitrarily assigned a potential of exactly 0.00 V .
- Therefore, the series is fundamentally arranged on the basis of the "Hydrogen scale" (increasing or decreasing standard reduction potential relative to Hydrogen).

Why other options are incorrect:

pH, pOH, and pKa scales are used to measure the acidity, basicity, or dissociation constants of chemical species in solution, not their standard redox potentials.