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Chemistry

preparing students for exams

Ana Oliveira | January, 2026

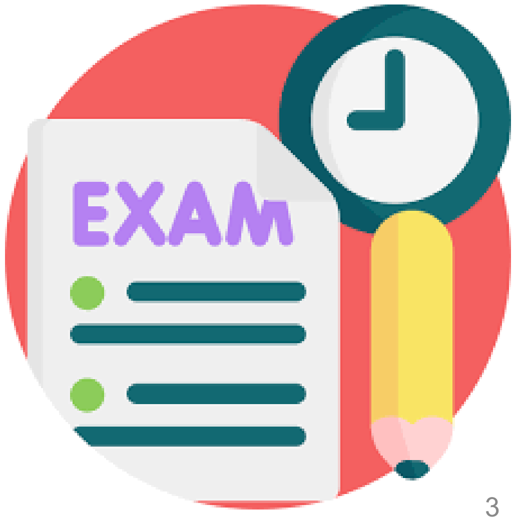
Integrated Masters in Medicine
Model Exam | Access for International Students | 2026/2027

General instructions:

- The exam is evaluated from 0 to 200 points
- The exam is based on 20 questions, 15 multiple-choice and 5 essay questions
- Each multiple-choice question is marked out of 10.0 points and each essay question is also marked out of 10.0 points
- Only a blue or black pen may be used
- The use of a broker is not allowed
- All questions must be answered on the exam sheet
- The use of a scientific calculator is allowed
- The exam lasts 90 minutes

Exam structure:

Type of knowledge and skills		Quote	
Chemistry	Atomic structure, chemical bonding and Lewis's notation	40.0 points	200.0 points
	Solutions and solution preparation	30.0 points	
	Chemical reactions, writing and correcting reactions	30.0 points	
	Chemical equilibrium	40.0 points	
	Acid-base equilibrium	40.0 points	
	Oxidation-reduction equilibrium	20.0 points	



Model Exam resolution

Model Exam resolution

Group I

(15 multiple-choice questions)

1. In a laboratory, a group of students titrate 25.0 cm^3 of aqueous sodium hydroxide, with a concentration of 2.0 mol dm^{-3}, with 50.0 cm^3 of dilute sulfuric acid.

BASE STRONG

ACID STRONG

The equation for the reaction is: $2NaOH\ (aq) + H_2SO_4\ (aq) \longrightarrow Na_2SO4\ (aq) + 2H_2O\ (l)$

1.1. What is the concentration of the dilute sulfuric acid in mol dm^{-3}?

(A) 0.50 mol dm^{-3}

(B) 1.0 mol dm^{-3}

(C) 2.0 mol dm^{-3}

(D) 4.0 mol dm^{-3}

$C_b = 2.0\ mol\ dm^{-3}$

$V_b = 25.0\ cm^3$

$V_a = 50.0\ cm^3$

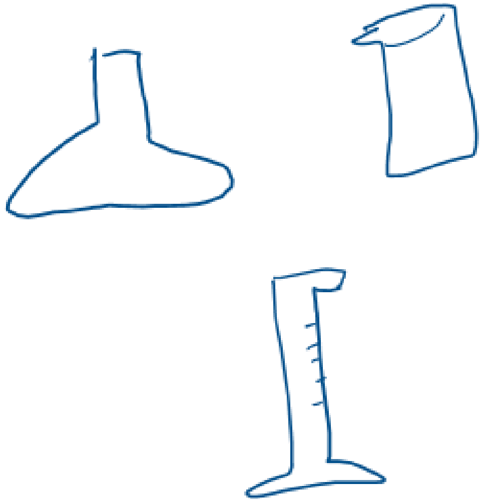
$$\frac{C_a \cdot V_a}{n_b} = \frac{C_b \cdot V_b}{n_a}$$

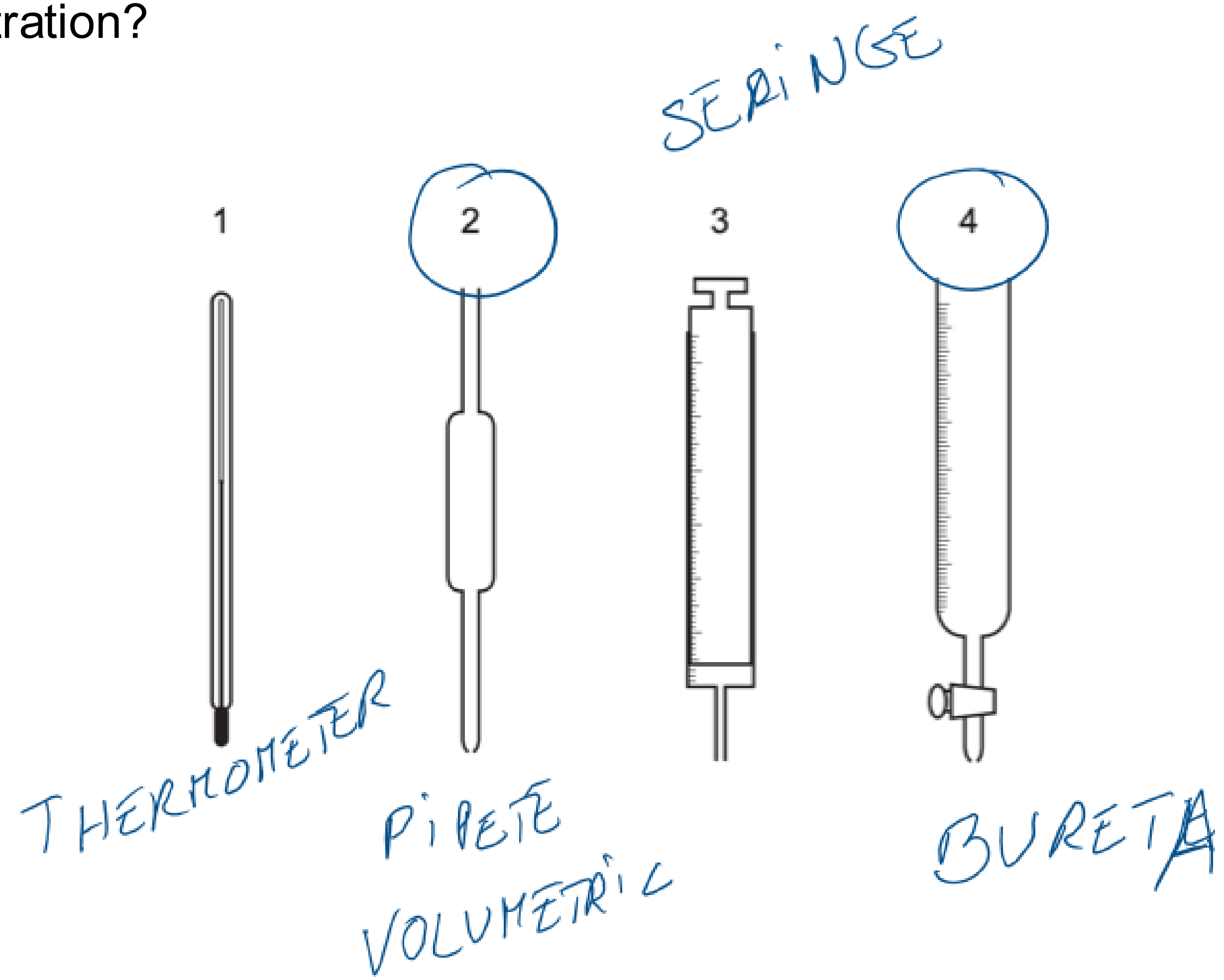
$$\frac{C_a \times 50.0}{1} = \frac{2.0 \times 25.0}{2} \Leftrightarrow C_a = 0.50\ mol\ dm^{-3}$$

1.2. The concentration of acids and alkalis can be determined by titration.

Which pieces of equipment are needed to perform a titration?

- **(A)** 1 and 2
- **(B)** 1 and 3
- **(C)** 2 and 4
- **(D)** 3 and 4





2. Four redox equations and statements about the equations are shown.

	Reaction	Statement
1	$C + O_2 \rightarrow CO_2$	Carbon is oxidised
2	$C + CO_2 \rightarrow 2CO$	Carbon dioxide is oxidised
3	$C + CO_2 \rightarrow 2CO$	Carbon is oxidised
4	$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$	Iron(III) oxide is oxidised

Which statements about the equations are correct?

(A) 1 and 2

(B) 1 and 3

(C) 2 and 4

(D) 3 and 4

$C + O_2 \rightarrow CO_2$

?

0 0

$x + (-2) \times 2 = 0$

$x - 4 = 0$

$x = 4$

OXIDATION

$O \rightarrow nox = -2$

$H \rightarrow nox = +1$

$C + O_2 \rightarrow CO_2$
$C + CO_2 \rightarrow 2CO$
$C + CO_2 \rightarrow 2CO$
$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

$C + CO_2 \rightarrow 2CO$

0 2

OXIDATION

$C + CO_2 \rightarrow 2CO$

4

$x - 2 = 0$

$x = 2$

REDUCTION

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

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

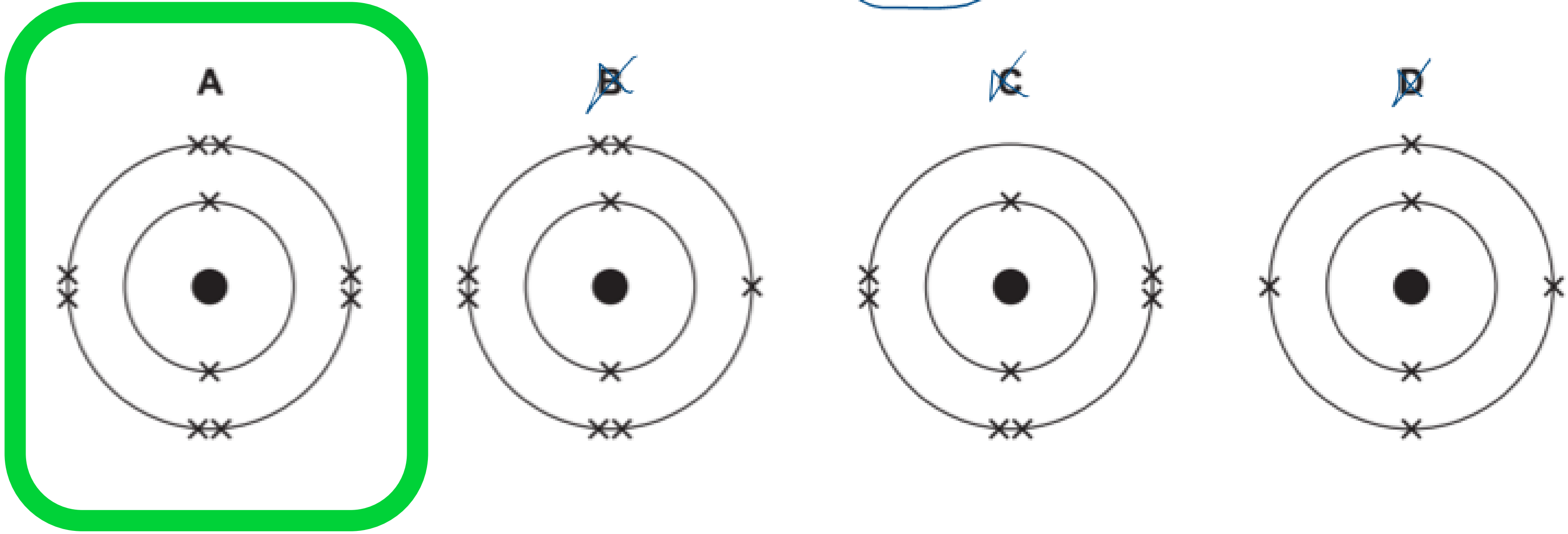
$2x - 6 = 0$

$x = 3$

0

REDUCTION

3. Which diagram shows the electronic structure of a noble gas?



$ns^2 \; 2p^6$ → 8 ELECTRONS

BOHR

HELIUM (He)

2 ELECTRONS

$1s^2 \; 2s^2 \; 2p_x^2 \; 2p_y^2 \; 2p_z^2$ ....

Ne Kr ... (LAST GROUP OF PERIODIC TABLE)

To know

- Noble gases (like helium, neon, argon, krypton, xenon, and radon) are chemically stable because their outermost energy levels (electron shells) are completely filled with electrons
- For most noble gases (like Ne, Ar, etc.), this means having 8 electrons in their outer shell – a condition known as the octet
- For helium (He), the outer shell only needs 2 electrons to be full, and helium has exactly 2 electrons

Learn more

Electron Configuration of the Noble Gases – YouTube
This video walks through the electron configurations of each noble gas, highlighting their complete outer shells

Noble Gases – YouTube
This tutorial provides an overview of the noble gases, their electron configurations, and why they are unreactive

Learn more about the periodic table

Periodic Table Song

Periodic Table of Elements | Groups, Periods, Chemistry
This video provides a comprehensive overview of the periodic table, detailing the arrangement of elements into groups and periods, and explaining the significance of each

Groups of the Periodic Table
This video focuses on the different groups within the periodic table, such as alkali metals, alkaline earth metals, halogens, and noble gases, highlighting their unique properties

Atomic Radius, Ionization Energy, and Electronegativity
This video explains key periodic trends such as atomic radius, ionization energy, and electronegativity, and how they vary across the periodic table

How Does The Periodic Table Work | Properties of Matter
This video provides a basic understanding of how the periodic table functions and how it relates to the properties of matter

To know

Electron configuration refers to the arrangement of electrons in an atom's energy levels, sublevels, and orbitals. Electrons occupy orbitals in a manner that minimizes the atom's energy, following specific principles:

1. **Aufbau Principle**: Electrons fill orbitals starting from the lowest energy level to higher ones
2. **Pauli Exclusion Principle**: An orbital can hold a maximum of two electrons with opposite spins
3. **Hund's Rule**: Electrons will singly occupy degenerate orbitals (orbitals of the same energy) before pairing up

Learn more

- **Electron Configuration - Basic Introduction**
This video provides a foundational overview of electron configurations, including practice problems to reinforce learning

- **Electron Configuration Diagrams | Properties of Matter | FuseSchool**
An animated explanation focusing on electron configuration diagrams, ideal for visual learners

- **Introduction to Electron Configurations | Khan Academy**
A comprehensive tutorial that delves into the principles governing electron configurations

- **Electron Configurations with the Periodic Table | Khan Academy**
This video demonstrates how to use the periodic table as a tool to determine electron configurations

4. In an aqueous solution of sodium hydroxide (NaOH) at 25°C, the pH of the solution is 10.2. Considering complete base ionization, the concentration of NaOH is

- **(A)** 1.6×10^{-13} mol dm^{-3}
- **(B)** 3.2×10^{-3} mol dm^{-3}
- **(C)** 1.6×10^{-4} mol L^{-1}
- **(D)** 6.3×10^{-11} mol L^{-1}

BASE

$pH = 10.2$

$NaOH \rightarrow Na^{+} + OH^{-}$

$[NaOH] = [OH^{-}]$

$pH + pOH = 14$ (25°C)

$pOH = -\log[OH^{-}]$

$pOH = 14 - pH = 14 - 10.2$

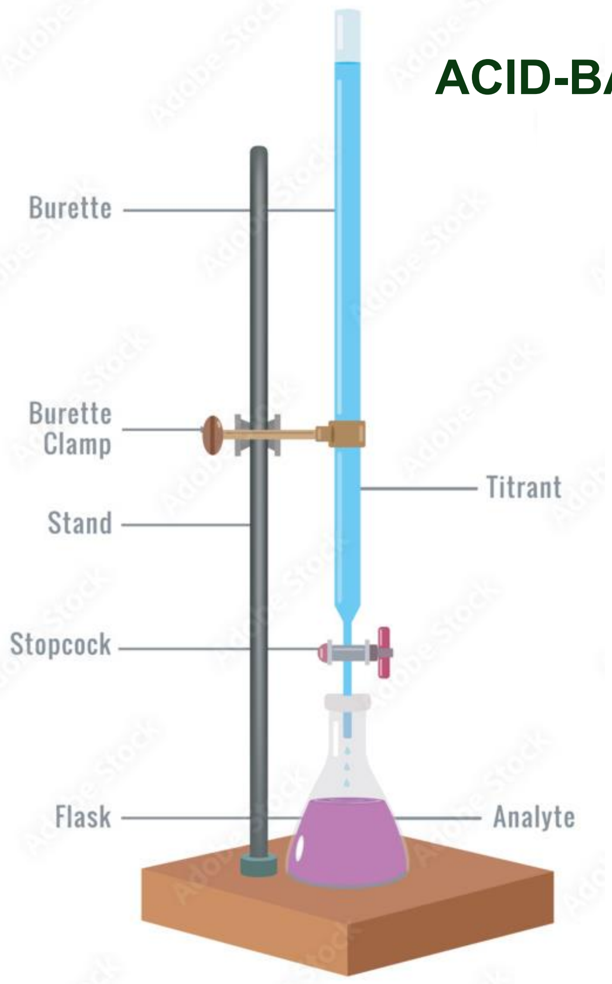
$pOH = 3.8$

$[OH^{-}] = 10^{-pOH}$

$[OH^{-}] = 10^{-3.8} = 1.6 \times 10^{-4}$ mol dm^{-3}

To know

ACID-BASE TITRATION



$$\frac{C_a \times V_a}{n_b} = \frac{C_b \times V_b}{n_a}$$

at equilibrium:

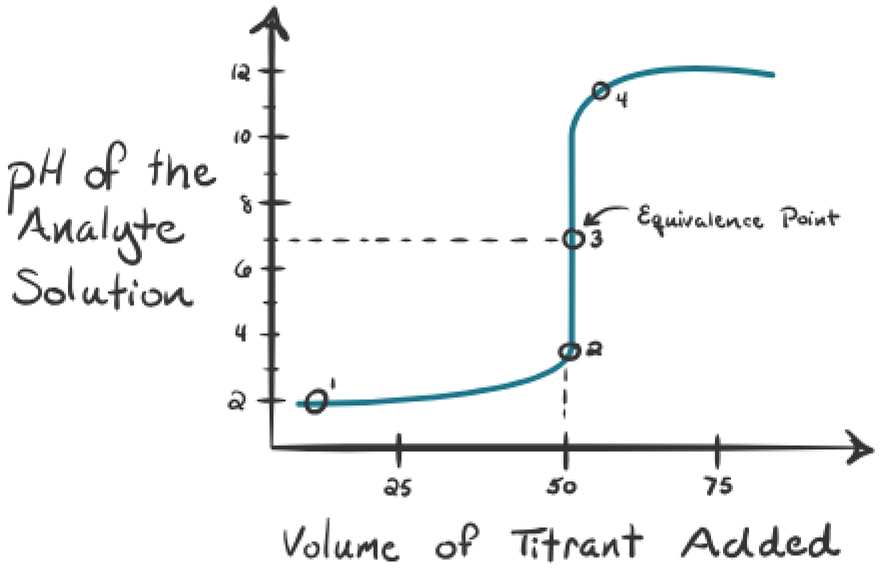
$$\frac{[acid] \times V_a}{n_b} = \frac{[base] \times V_b}{n_a}$$

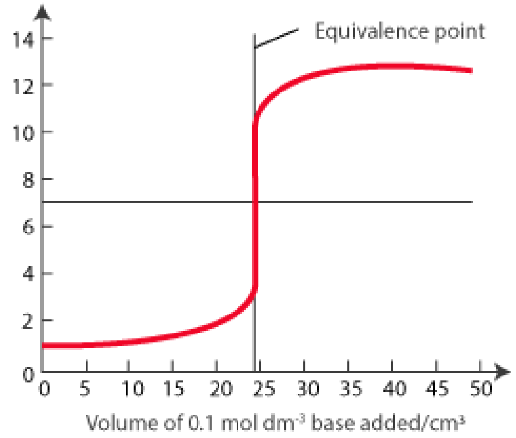
n = number of moles from the balanced equation

To know

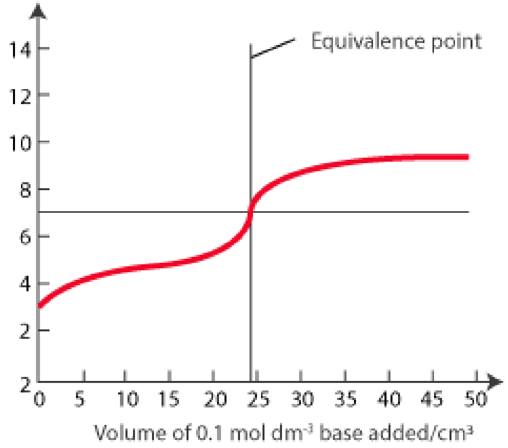
TITRATION CURVE

Typical Titration Curve

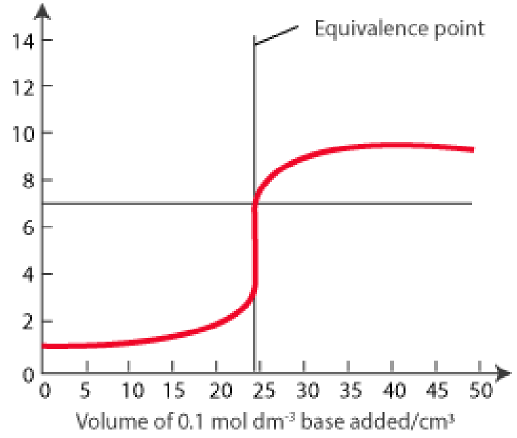




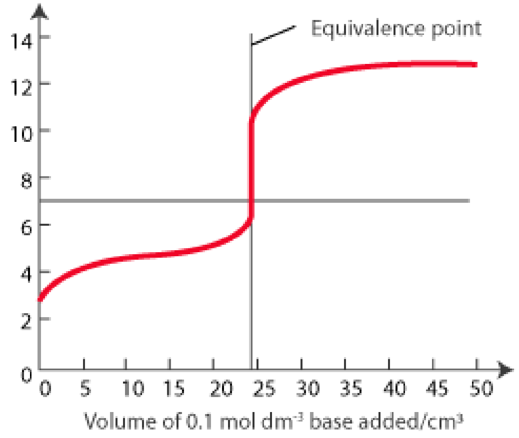
(Strong acid and strong base)



(Strong acid and weak base)



(Weak acid and weak base)



(Weak acid and strong base)

Learn more

Acid Base Titration with Sulfuric Acid and Sodium Hydroxide - YouTube

Step-by-step titration example with H_2SO_4 and NaOH

Titration Calculations Made Easy - YouTube

A basic tutorial with calculation examples

Khan Academy: Titration example with strong acid and base

Focuses on strong acid–strong base titration logic

Acid Base Titration Problems, Basic Introduction, Calculations

This video provides a basic introduction to acid-base titrations, including step-by-step calculations

How To Do Titration Calculations | Chemistry | FuseSchool

An educational video explaining how to perform titration calculations in chemistry

Determining Solute Concentration by Acid–Base Titration | Khan Academy

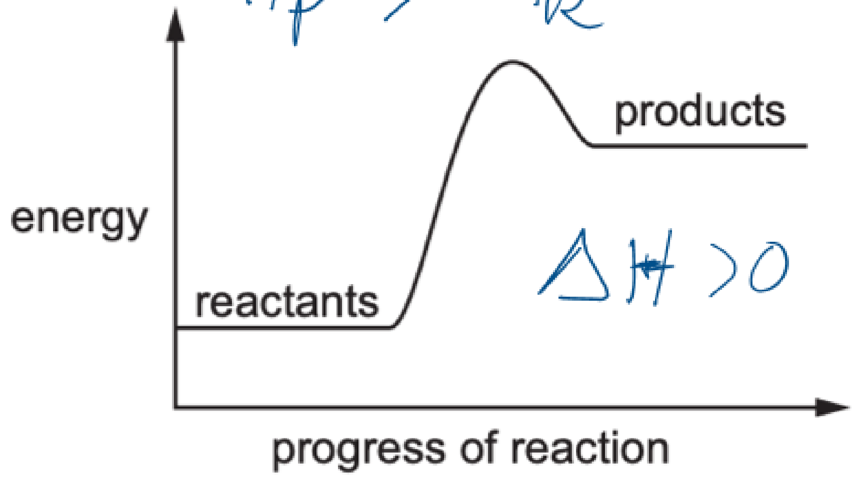
A tutorial on determining solute concentration through acid-base titration

5. A reaction pathway diagram is shown.

Which statement about this reaction is correct?

- **(A)** The reaction rate increases during the reaction.
- **(B)** The temperature of the surroundings increases.
- **(C)** The reaction transfers thermal energy to the surroundings.
- **(D)** The reaction is endothermic.

$H_P > H_R$



$\Delta H = H_{PRODUCTS} - H_{REAGENTS}$

ΔH < 0 ⇒ REACTION is EXOTHERMIC

ΔH > 0 ⇒ REACTION is ENDOTHERMIC

ENTALPY

6. The equation for the reaction between sodium carbonate and excess dilute hydrochloric acid is:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

When 26.5 g of sodium carbonate reacts with excess dilute hydrochloric acid, what is the maximum volume of carbon dioxide produced?

- **(A)** 6 dm^3
- **(B)** 12 dm^3
- **(C)** 18 dm^3
- **(D)** 24 dm^3

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

1 mol Na_2CO_3 — 1 mol CO_2

1) CALCULE NO. MOLES Na_2CO_3

$$M(Na_2CO_3) = 23 \times 2 + 12 + 16 \times 3 = 106 \text{ g mol}^{-1}$$

106 g — 1 mol

26.5 g — x

$$x = \frac{26.5 \times 1}{106} = 0.25 \text{ mol}$$

2) STOICHEMISTRY

1 mol Na_2CO_3 — 1 mol CO_2

0.25 mol — x

$$x = \frac{0.25 \times 1}{1} = 0.25 \text{ mol } CO_2$$

3) CALCULATE THE VOLUME

$V_m = 22.4\ dm^3\ mol^{-1}$ AT 1 atm AND 25°C

$22.4\ dm^3$ — 1 mol

x — 0.25 mol

$$x = \frac{22.4 \times 0.25}{1} = 5.6 \simeq 6\ dm^3$$

7. Which pair of atoms contains the same number of neutrons?

(A) ${}^{59}_{27}Co$ and ${}^{59}_{28}Ni$

(B) ${}^{64}_{29}Cu$ and ${}^{65}_{29}Cu$

(C) ${}^{64}_{29}Cu$ and ${}^{65}_{30}Zn$

(D) ${}^{65}_{29}Cu$ and ${}^{65}_{30}Zn$

${}^{64}_{29}Cu$ → P = 29

→ N = 64 - 29 = 35

${}^{65}_{30}Zn$ → P = 30

→ N = 65 - 30 = 35

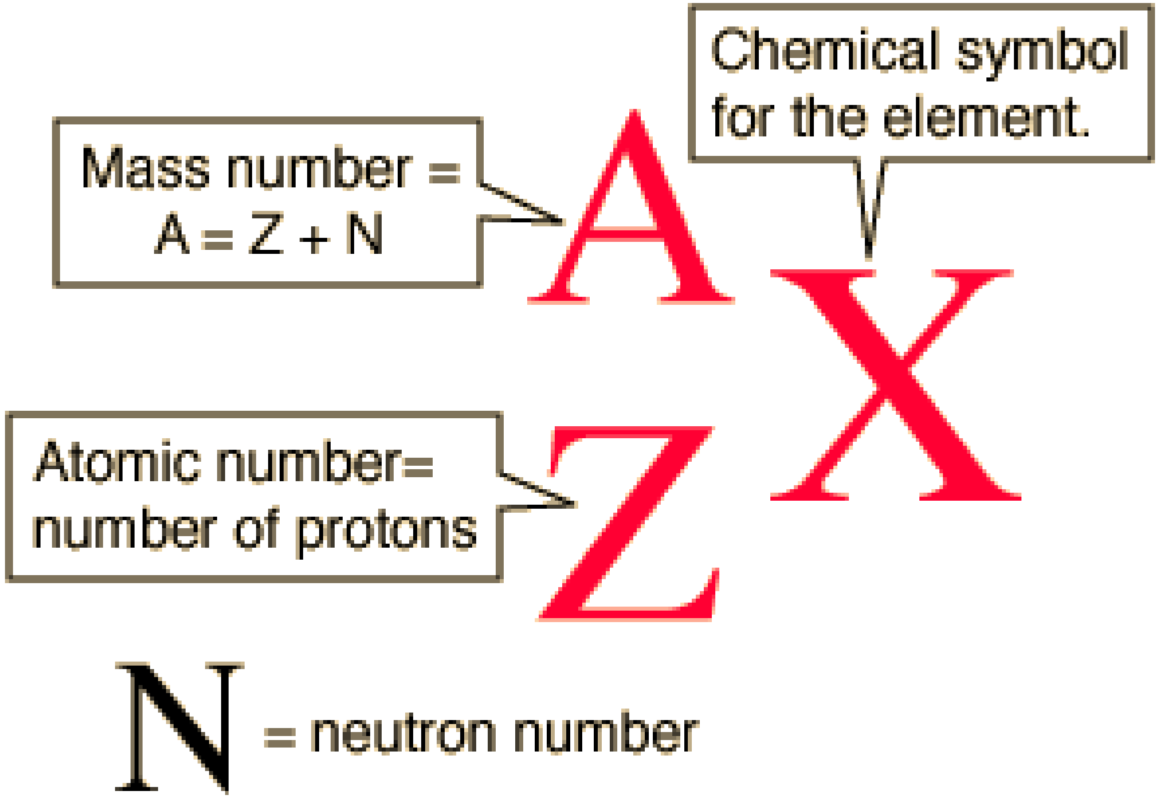
${}^{59}_{27}Co$ → No. PROTONS = 27

→ No. NEUTRONS = 59 - 27 = 32

${}^{59}_{28}Ni$ → No PROTONS = 28

→ No NEUTRONS = 59 - 28 = 33

To know



$^{A}_{Z}X$ $\quad$ $N.º P = N.º E$

X^{-2} $\quad$ $N.º E = N.º P + 2$

X^{+3} $\quad$ $N.º E = N.º P - 3$

Learn more [Atomic Symbols]

8. What is the name of the organic compound represented below, according to the IUPAC (International Union of Pure and Applied Chemistry) nomenclature?

- **(A)** 2-yne-pentane
- **(B)** 2-butyne
- **(C)** 2-butane
- **(D)** 2-butene

5 CARBONS

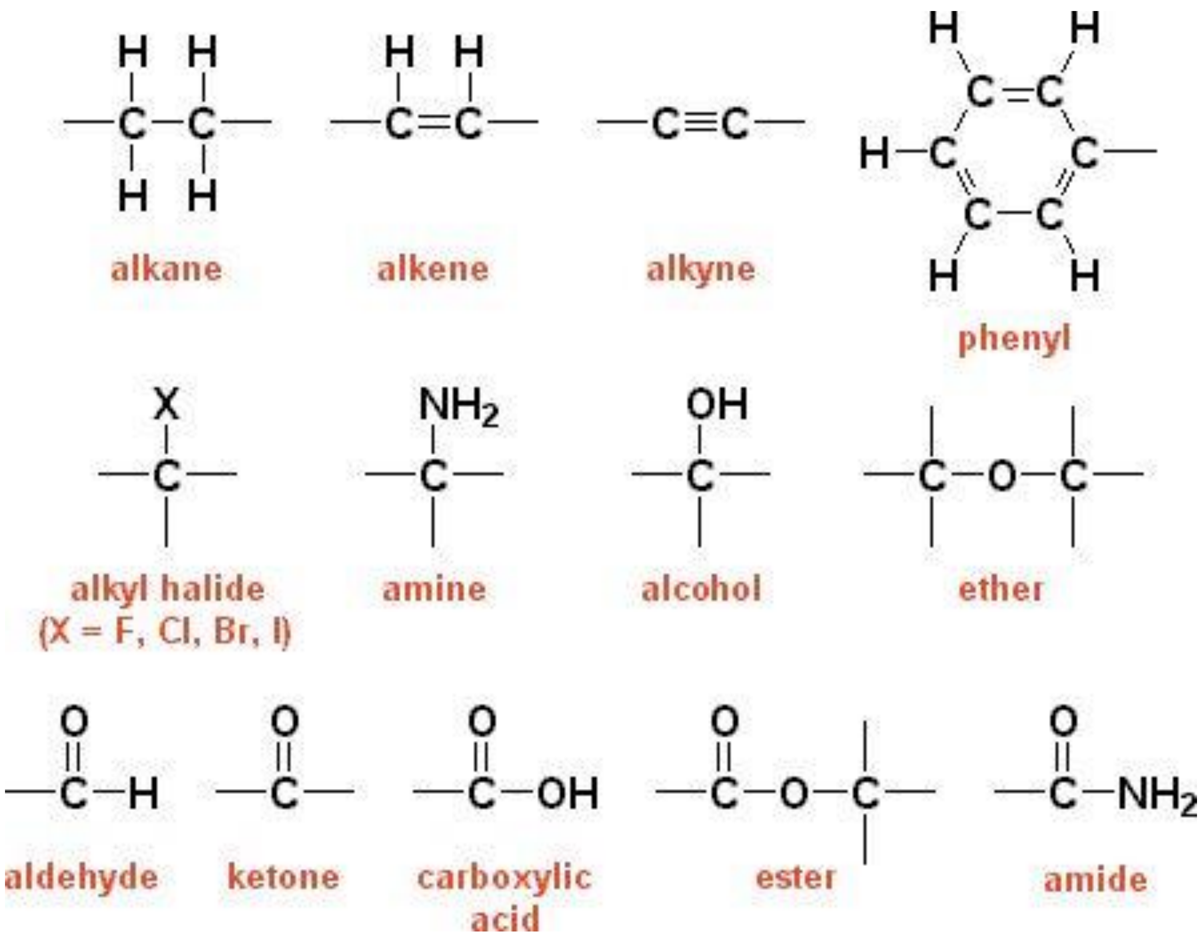
$$CH_3 - C \equiv C - CH_3$$

$CH_3 - CH_2 - CH_2 - CH_3$

$CH_3 - CH = CH - CH_3$

To know

ORGANIC CHEMISTRY families



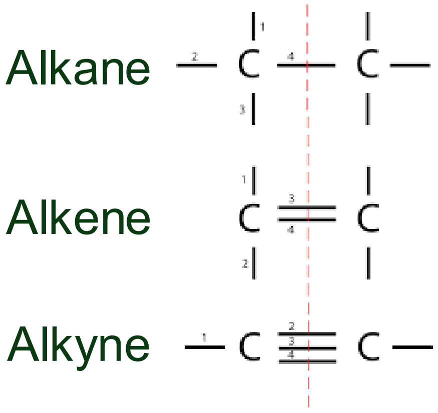
- Amide
- Amine
- Alcohol
- Aldehyde
- Carboxylic acid
- Ether
- Ester
- Hydrocrabons
- Ketone
- Phenyl

To know

HYDROCARBONS families

	Family							
	Alkane	Alkene	Alkyne	Aromatic	Haloalkane	Alcohol	Phenol	Ether
Functional group	C—H and C—C bonds	$>C=C<$	$-C\equiv C-$	Aromatic ring	$-\overset{\mid}{\underset{\mid}{C}}-\ddot{\underset{..}{X}}:$	$-\overset{\mid}{\underset{\mid}{C}}-\ddot{O}H$	OH on benzene ring	$-\overset{\mid}{\underset{\mid}{C}}-\ddot{O}-\overset{\mid}{\underset{\mid}{C}}-$
General formula	RH	$RCH=CH_2$ $RCH=CHR$ $R_2C=CHR$ $R_2C=CR_2$	$RC\equiv CH$ $RC\equiv CR$	ArH	RX	ROH	ArOH	ROR
Specific example	CH_3CH_3	$CH_2=CH_2$	$HC\equiv CH$	(benzene ring)	CH_3CH_2Cl	CH_3CH_2OH	(phenol ring with OH)	CH_3OCH_3
IUPAC name	Ethane	Ethene	Ethyne	Benzene	Chloroethane	Ethanol	Phenol	Methoxymethane
Common name[a]	Ethane	Ethylene	Acetylene	Benzene	Ethyl chloride	Ethyl alcohol	Phenol	Dimethyl ether
	Amine	Aldehyde	Ketone	Carboxylic Acid	Ester	Amide		Nitrile
Functional group	$-\overset{\mid}{\underset{\mid}{C}}-\ddot{N}<$	$\overset{\ddot{O}}{\overset{\|}{C}}-H$	$-\overset{\mid}{\underset{\mid}{C}}-\overset{\ddot{O}}{\overset{\|}{C}}-\overset{\mid}{\underset{\mid}{C}}-$	$\overset{\ddot{O}}{\overset{\|}{C}}-\ddot{O}H$	$\overset{\ddot{O}}{\overset{\|}{C}}-\ddot{O}-\overset{\mid}{\underset{\mid}{C}}-$	$\overset{\ddot{O}}{\overset{\|}{C}}-\ddot{N}<$		$-C\equiv N:$
General formula	RNH_2 R_2NH R_3N	$R\overset{O}{\overset{\|}{C}}H$	$R\overset{O}{\overset{\|}{C}}R'$	$R\overset{O}{\overset{\|}{C}}OH$	$R\overset{O}{\overset{\|}{C}}OR'$	$R\overset{O}{\overset{\|}{C}}NH_2$ $R\overset{O}{\overset{\|}{C}}NHR'$ $R\overset{O}{\overset{\|}{C}}NR'R''$		RCN
Specific example	CH_3NH_2	$CH_3\overset{O}{\overset{\|}{C}}H$	$CH_3\overset{O}{\overset{\|}{C}}CH_3$	$CH_3\overset{O}{\overset{\|}{C}}OH$	$CH_3\overset{O}{\overset{\|}{C}}OCH_3$	$CH_3\overset{O}{\overset{\|}{C}}NH_2$		$CH_3C\equiv N$
IUPAC name	Methanamine	Ethanal	Propanone	Ethanoic acid	Methyl ethanoate	Ethanamide		Ethanenitrile
Common name	Methylamine	Acetaldehyde	Acetone	Acetic acid	Methyl acetate	Acetamide		Acetonitrile

[a] These names are also accepted by the IUPAC.



Hydrocarbons "families":

- **Alkanes** (single bond) C_nH_{2n+2}
- **Alkenes** (double bond) C_nH_{2n}
- **Alkynes** (triple bond) C_nH_{2n-2}

Learn more [IUPAC names and rules]

9. Aqueous iron(III) sulfate and aqueous sodium hydroxide react to give a precipitate of iron(III) hydroxide and a solution of sodium sulfate. What is the balanced symbol equation for this reaction?

(A) $Fe_2(SO_4)_3$ (aq) + 2NaOH (aq) → $Fe(OH)_3$ (s) + Na_2SO_4 (aq) X

(B) $Fe_2(SO_4)_3$ (aq) + 3NaOH (aq) → $Fe(OH)_3$ (s) + $3Na_2SO_4$ (aq) X

(C) $2Fe_2(SO_4)_3$ (aq) + 6NaOH (aq) → $4Fe(OH)_3$ (s) + $6Na_2SO_4$ (aq) X

(D) $Fe_2(SO_4)_3$ (aq) + 6NaOH (aq) → $2Fe(OH)_3$ (s) + $3Na_2SO_4$ (aq)

LAVOISIER PRINCIPLE

10. The diagram shows the result of dropping a purple crystal into water

Which processes take place in this experiment?

	Chemical reaction	Diffusing	Dissolving
(A)	✓	✓	X
(B)	✓	X	X
(C)	X	X	✓
(D)	X	✓	✓

11. Ethanol, CH_3CH_2OH (M = 46.08 g mol^{-1}), can be obtained from sucrose, $C_{12}H_{22}O_{11}$ (M = 342.34 g mol^{-1}), extracted from sugar beet, in a process that can be, globally, translated as:

$$C_{12}H_{22}O_{11}\ (aq) + H_2O\ (l) \rightarrow 4\ CH_3CH_2OH\ (aq) + 4\ CO_2\ (g)$$

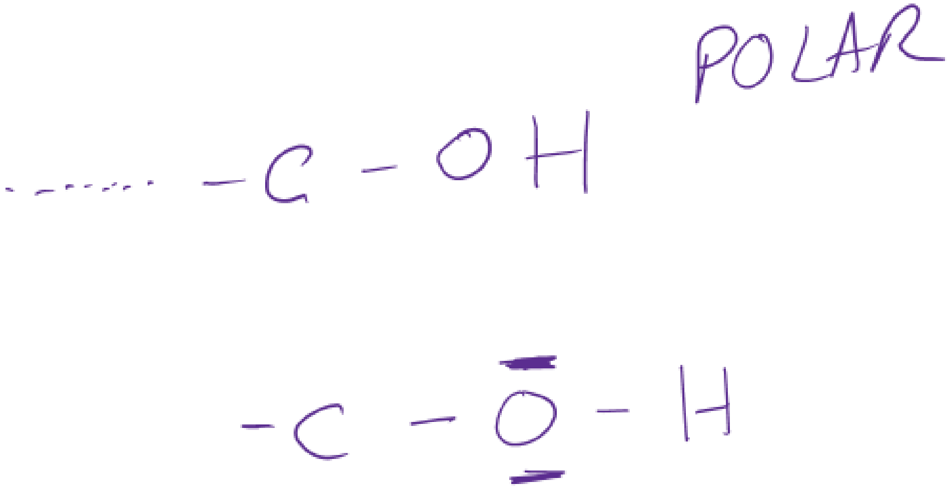
11.1. Ethanol belongs to the _____ functional group. The ethanol molecule is _____ and has, in total, _____ _____valence electrons.

(A) alcohols; nonpolar; eight; ligands

(B) alcohols; polar; eight; non-ligands

(C) alcohols; nonpolar; four; ligands

(D) alcohols; polar; four; non-ligands



$M = \frac{m}{n}$

11.2. The mass of ethanol that can be obtained, at most, from 3.0 tonnes of sugar beet, which have, on average, a sucrose content of 20% (m/m) is calculated as follows:

(A) $m = \frac{3\times10^6\times0.20\times4\times46.08}{342.34}$ g of CH_3CH_2OH

(B) $m = \frac{3\times10^6\times4\times342.34}{0.20\times46.08}$ g of CH_3CH_2OH

(C) $m = \frac{3\times0.20\times46.08}{4\times342.34}$ t of CH_3CH_2OH

(D) $m = \frac{3\times0.20\times4\times342.34}{46.08}$ t of CH_3CH_2OH

$M(\text{SUCROSE}) = 342.34\ g\ mol^{-1}$

$M(CH_3CH_2OH) = 46.08\ g\ mol^{-1}$

$n(\text{SUCROSE}) = \frac{3\times10^6\times0{,}20}{342{,}34}$

$n(CH_3CH_2OH) = \frac{4\times3\times10^6\times0{,}20}{342.34}$

$m(CH_3CH_2OH) = 46.08\times\frac{4\times3\times10^6\times0.20}{342.34}$

$C_{12}H_{22}O_{11}\ (aq) + H_2O\ (l) \rightarrow 4\ CH_3CH_2OH\ (aq) + 4\ CO_2\ (g)$

1 mol SUCROSE → 4 mol ETHANOL

To know

$$Percent\ yield\ of\ a\ reaction\ (\%):\ \ \eta = \frac{actual\ yield}{theoretical\ yield} \times 100$$

Learn more

https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introductory_Chemistry_(CK-12)/12%3A_Stoichiometry/12.09%3A_Theoretical_Yield_and_Percent_Yield

To know

$$Concentration\ (mol\ dm^{-3}):\ \ [X] = \frac{n}{V}$$

$$Molar\ mass\ (g\ mol^{-1}):\ M = \frac{m}{n}$$

$$Density\ (g\ cm^{-3}):\ \ \rho = \frac{m}{V}$$

Learn more

https://chem.libretexts.org/Courses/Prince_Georges_Community_College/CHEM_2000%3A_Chemistry_for_Engineers_(Sinex)/Unit_4%3A_Nomenclature_and_Reactions/Chapter_12%3A_Aqueous_Reactions/Chapter_12.1%3A_Preparing_Solutions

12. The diagram shows an experiment to measure the rate of a chemical reaction.

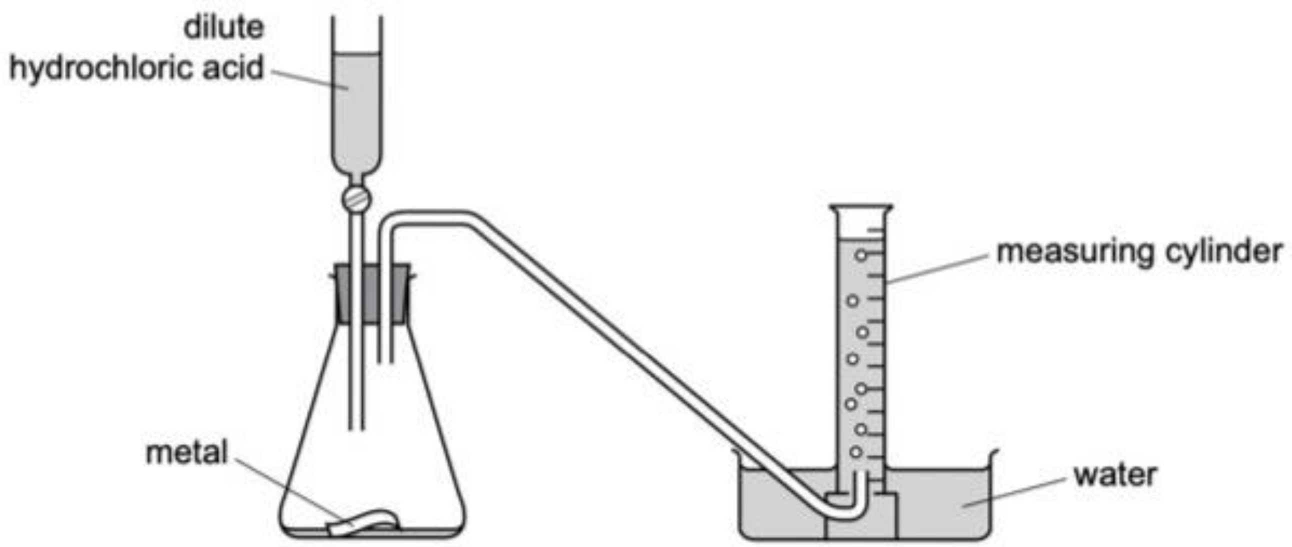
Which change decreases the rate of reaction?

(A) Heating the flask during the reaction.

(B) Adding water to the flask.

(C) Using more concentrated acid.

(D) Using powdered metal.



To know

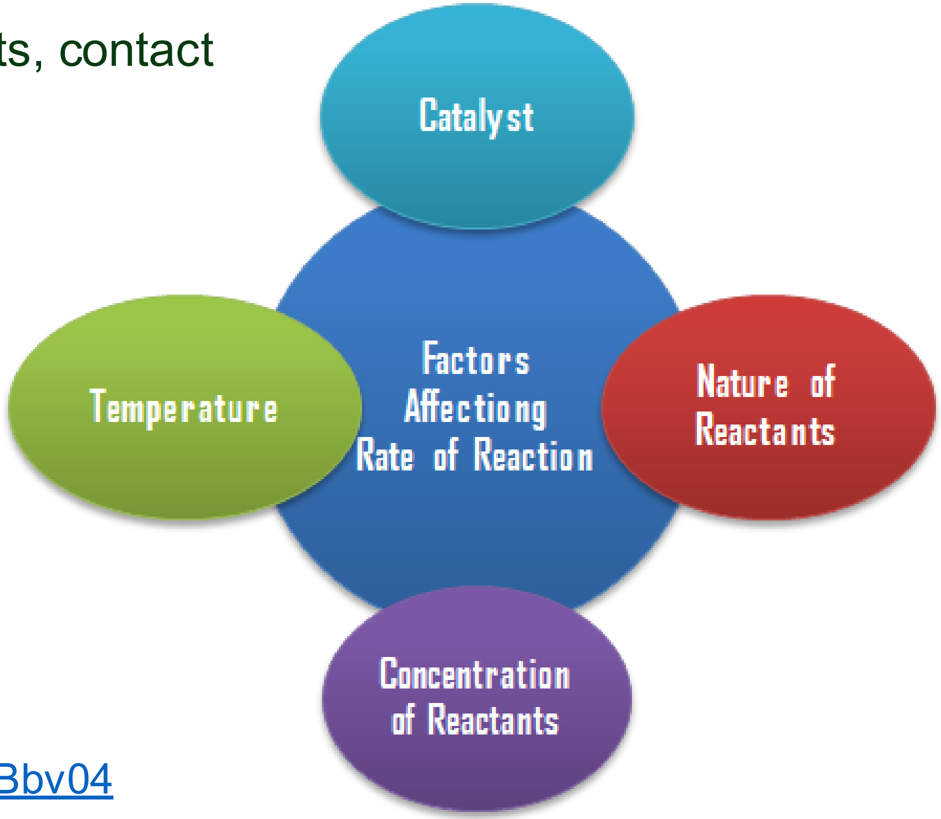
Several factors influence the speed (rate) of a chemical reaction:

1. **Temperature**: Increasing the temperature raises the kinetic energy of molecules, leading to more frequent and energetic collisions, which can increase the reaction rate
2. **Concentration**: Higher concentration of reactants leads to more collisions per unit time, thus potentially increasing the reaction rate
3. **Surface Area**: For reactions involving solids, increasing the surface area (e.g., by grinding into a powder) exposes more particles to react, enhancing the reaction rate
4. **Catalysts**: Catalysts provide an alternative pathway with a lower activation energy, increasing the reaction rate without being consumed in the process
5. **Pressure**: In reactions involving gases, increasing the pressure effectively increases the concentration of gas molecules, leading to a higher reaction rate
6. **Nature of Reactants**: Some substances react more readily than others due to their chemical nature
7. **Light (for photochemical reactions)**: Light can provide energy to reactants, initiating or accelerating certain reactions

To know

REACTIONS RATE

- Factors that influence the rate of reactions: concentration of reactants, contact surface of reactants, temperature and presence of catalyst



Learn more https://www.youtube.com/watch?v=-4HXaUBbv04

13. When chlorine gas dissolves in water a reaction occurs:

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

Which row of the table identifies the oxidation number for chlorine in the chlorine-containing species?

	Cl_2	HCl	HClO
(A)	-1	-1	-1
(B)	0	-1	-1
(C)	-1	+1	+1
(D)	0	-1	+1

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

Cl_2: 0

HCl: H +1, Cl x

$$1 + x = 0$$
$$x = -1$$

HClO: H +1, Cl x, O -2

$$1 + x - 2 = 0$$
$$x = +1$$

Learn more

Redox Equilibria – A Level | CAPE Chemistry Unit 1

This educational video delves into redox equilibria concepts, suitable for advanced high school or early college-level students

Standard Potential, Free Energy, and the Equilibrium Constant – Khan Academy

This video explains the relationship between standard electrode potentials, Gibbs free energy, and equilibrium constants in redox reactions

Find Equilibrium Constant of Redox Reaction

This tutorial walks through the process of calculating the equilibrium constant for a redox reaction, providing practical exemples

Oxidation and Reduction In Terms of Change in Oxidation State

This video explains redox reactions by focusing on changes in oxidation states, a fundamental concept in understanding redox equilibrium

To know

OXIDATION NUMBERS

- The oxidation number is a positive or negative number that is assigned to an atom to indicate its degree of oxidation or reduction
- In oxidation-reduction processes, the driving force for chemical change is in the exchange of electrons between chemical species
- Six rules for determining oxidation numbers:

1) For free elements (uncombined state), each atom has an oxidation number of zero, H_2, Br_2, Na, Be, K, O_2, P_4, all have an oxidation number of 0.

To know

OXIDATION NUMBERS

2) Monatomic ions have oxidation numbers equal to their charge, for exemple, Li^{+}=+1, Ba^{2+}=+2, Fe^{3+}=+3, I^{-}=−1, O^{2-}=−2, etc. Alkali metal oxidation numbers =+1. Alkaline earth oxidation numbers =+2. Aluminum =+3 in all of its compounds. Oxygen's oxidation number =−2 *except* when in hydrogen peroxide (H_2O_2), or a peroxide ion (O_2^{-2}) where it is −1.

3) Hydrogen's oxidation number is +1, except for when bonded to metals as the hydride ion forming binary compounds. In LiH, NaH, and CaH_2, the oxidation number is −1.

4) Fluorine has an oxidation number of −1 in all of its compounds.

To know

Oxidation numbers

5) Halogens (Cl, Br, I) have negative oxidation numbers when they form halide compounds. When combined with oxygen, they have positive numbers. In the chlorate ion (ClO^{-3}), the oxidation number of Cl is +5, and the oxidation number of O is −2.

6) In a neutral atom or molecule, the sum of the oxidation numbers must be 0. In a polyatomic ion, the sum of the oxidation numbers of all the atoms in the ion must be equal to the charge on the ion.

To know

What Happens in an Electrolysis Cell?

In an electrolysis cell, electrical energy is used to drive a chemical reaction

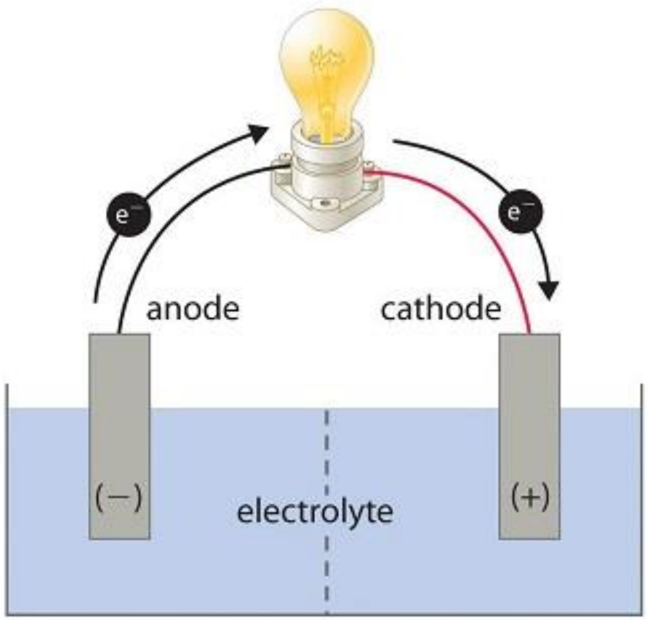
The cell has two electrodes: the **anode** (positive) and the **cathode** (negative), placed in an electrolyte, a liquid that contains **ions**

- **Electrons** are provided by a power source (like a battery) and move through wires from the **anode** to the **cathode**
- **Positive ions** in the electrolyte move **toward the cathode** to gain electrons (this is called **reduction**).
- **Negative ions** move **toward the anode** to lose electrons (this is called **oxidation**)

In sum:

- **Electrons flow** through the wire from anode to cathode
- **Ions move** through the solution: positive ions to the cathode, negative ions to the anode

To know



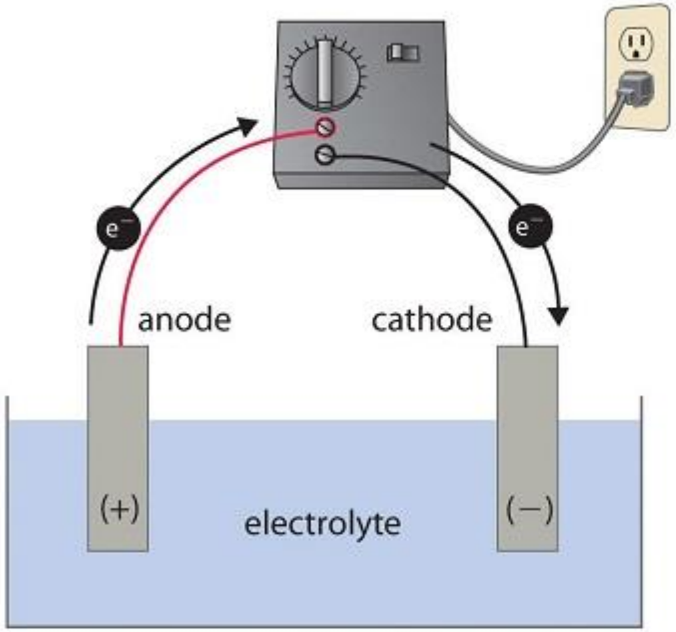
GALVANIC CELL

Energy released by spontaneous redox reaction is converted to electrical energy.

Oxidation half-reaction:
$Y \rightarrow Y^{+} + e^{-}$

Reduction half-reaction:
$Z^{+} + e^{-} \rightarrow Z$

Overall cell reaction:
$Y + Z \rightarrow Y^{+} + Z^{-}$ $(G < 0)$



ELECTROLYTIC CELL

Electrical energy is used to drive nonspontaneous redox reaction.

Oxidation half-reaction:
$Z^{-} \rightarrow Z + e^{-}$

Reduction half-reaction:
$Y^{+} + e^{-} \rightarrow Y$

Overall cell reaction:
$Y^{+} + Z^{-} \rightarrow Y + Z$ $(G > 0)$

Learn more

Electrolysis | Reactions | Chemistry | FuseSchool

A clear, student-friendly explanation of electrolysis with animations

Crash Course Chemistry – Electrochemistry

More detailed explanation

Galvanic Cell vs Electrolytic Cell Animation

An animated explanation highlighting the similarities and differences between galvanic and electrolytic cells

Galvanic Cell Vs Electrolytic Cell Differences

This video focuses on the distinctions between galvanic and electrolytic cells

Model Exam resolution

Group II

(5 essay questions)

14. The gas phase reaction between carbon monoxide and water produces dihydrogen and carbon dioxide:

$CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2\,(g)} + H_{2\,(g)}$ $\Delta H < 0$, at T

When in equilibrium at temperature T, the equilibrium constant, Kc, has a value of 1.8.

14.1. Consider that, in a closed and non-deformable reactor, with volume V, maintained at temperature T, there are, at a given instant, 0.2 mol of CO (g), 5.0 mol of H_2O (g), 4.0 mol of CO_2 (g) and 1.0 mol of H_2 (g). Justify in which direction the equilibrium will evolve, presenting all calculations performed.

$[\,] = \frac{n}{V}$

Q → QUOCIENT OF REACTION

$$Q = \frac{[CO_2]\times[H_2]}{[CO]\times[H_2O]} = \frac{\frac{4.0}{V}\times\frac{1.0}{V}}{\frac{0.2}{V}\times\frac{5.0}{V}} = \frac{4.0\times1.0}{0.2\times5.0} = 4$$

$Q > K_c\ (1.8)$ → EQUILIBRIUM WILL EVOLVE IN THE INDIRECT WAY

14.2. From that instant (described in question 14.1), and until chemical equilibrium is reached, all the constituents of the reaction system have changed their quantity by 0.15 mol.

Determine the quantity of CO (g) in the reactor when equilibrium is reached.

Present all calculations performed.

←

$$CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_2{}_{(g)} + H_2{}_{(g)} \qquad \Delta H < 0, \text{ at } T$$

B: 0.2 5.0 4.0 1.0

NEW E.: 0.2+0.15 5.0+0.15 4.0−0.15 1.0−0.15

$[CO] = 0.2 + 0.15 = 0.35 \ mol \ dm^{-3}$

14.3. According to Le Chatelier's Principle, in which direction of the reaction does the system evolve when the temperature increases? Justify.

$$CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2\,(g)} + H_{2\,(g)} \qquad \Delta H < 0, \text{ at } T$$

EXOTHERMIC

$$CO + H_2O \rightleftarrows CO_2 + H_2 \quad + \text{ENERGY}$$

←

SYSTEM EVOLVE IN THE INDIRECT WAY

To know

EQUILIBRIUM

$$aA + bB \rightleftharpoons cC + dD$$

$$K_c = \frac{[C]^c \cdot [D]^d}{[A]^a \cdot [B]^b}$$

Learn more

https://www.youtube.com/watch?v=J4WJCYpTYj8

https://www.youtube.com/watch?v=XsDWeS5nzi0&list=PLCqaWwIFjceo0X3tPf2Mw9yrz8C4rLt3-

https://www.youtube.com/watch?v=1GiZzCzmO5Q

https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Chemistry_for_Allied_Health_(Soult)/08%3A_Properties_of_Solutions/8.02%3A_Chemical_Equilibrium

To know

Factors Affecting Chemical Equilibrium:

1. **Concentration:** Altering the concentration of reactants or products shifts the equilibrium to oppose the change. For example, increasing the concentration of reactants drives the reaction forward, producing more products. Conversely, increasing the concentration of products shifts the equilibrium backward, forming more reactants

2. **Pressure (for gases):** Changing the pressure affects equilibria involving gaseous reactants or products. Increasing pressure shifts the equilibrium toward the side with fewer gas molecules, while decreasing pressure favors the side with more gas molecules

3. **Temperature:** Temperature changes can shift the equilibrium depending on whether the reaction is exothermic or endothermic. Increasing temperature favors the endothermic direction (absorbing heat), while decreasing temperature favors the exothermic direction (releasing heat)

4. **Catalysts:** Catalysts speed up both the forward and reverse reactions equally, thus they do not affect the position of equilibrium but help the system reach equilibrium faster

Learn more

- **Le Chatelier's Principle**

A video tutorial offering a basic introduction to Le Châtelier's Principle of chemical equilibrium

- **Equilibrium: Crash Course Chemistry #28**

An engaging video that discusses chemical equilibrium and its significance in chemistry

- **Le Châtelier's principle | Reaction rates and equilibrium**

This video explains how chemical systems at equilibrium respond to changes in conditions

WEAK ACID

15. Lactic acid is a monoprotic acid that partially ionizes in water, according to the equation → pH = ?

$$CH_3CH(OH)COOH\ (aq) + H_2O\ (l) \rightleftarrows CH_3CH(OH)COO^-\ (aq) + H_3O^+\ (aq)$$

At a temperature of 25°C, the acidity constant, K_a, is 1.38×10^{-4}.

15.1. In a laboratory, there is a flask with a handwritten label: «lactic acid (aq), pH 2.65». To confirm this information, a 50.00 mL sample of the lactic acid solution was taken from the flask and titrated with a standard NaOH solution, with a concentration of 1.00×10^{-2} mol dm^{-3}, using 11.20 mL until reaching the equivalence point. Determine the pH of the lactic acid solution at 25°C, showing that the value shown on the label is incorrect.

STRONG BASE

Present all calculations performed.

1) CALCULATE C_a

$$\frac{C_a V_a}{n_b} = \frac{C_b V_b}{n_a} \Leftrightarrow \frac{C_a \times 50}{1} = \frac{1.00\times10^{-2} \times 11.20}{1}$$

$$C_a = 2.24\times10^{-3}\ mol\ dm^{-3}$$

2) CALCULATE $[H_3O^+]$

$$K_a = \frac{[H_3O^+] \times [CH_3CH(OH)COO^-]}{[CH_3CH(OH)COOH]} \Leftrightarrow 1.38 \times 10^{-4} = \frac{[H_3O^+]^2}{2.24 \times 10^{-3}}$$

$$[H_3O^+] = 4.91 \times 10^{-4} \text{ mol dm}^{-3}$$

3) CALCULATE pH

$$pH = -\log[H_3O^+] = -\log(4.91 \times 10^{-4}) = 3.31$$

LABEL <u>WRONG</u>

15.2. When, at a given temperature, the pH decreases by 0.5, how does the concentration of H_3O^+ vary? Justify.

$pH = -\log[H_3O^+] \Leftrightarrow [H_3O^+] = 10^{-pH}$

$a^{b+c} = a^b \times a^c$

$[H_3O^+] = 10^{-(pH-0.5)} = 10^{-pH+0.5}$

$[H_3O^+] = 10^{-pH} \times 10^{0.5}$

$[H_3O^+] = 10^{-pH} \times 3.16$

$[H_3O^+]$ INCREASES ~ 3

To know

Acid-Base Equilibrium

Acidity constant (K_a)

$$aHA + H_2O \rightleftharpoons bA^- + cH_3O^+$$

$$K_a = \frac{[A^-]^b \cdot [H_3O^+]^c}{[HA]^a}$$

Conjugate acid/base pair

$$K_a \cdot K_b = K_W$$

Basicity constant (K_b)

$$aBOH \rightleftharpoons bB^- + cOH^-$$

$$K_b = \frac{[B^-]^b \cdot [OH^-]^c}{[BOH]^a}$$

Learn more

https://www.youtube.com/watch?v=pkqDTi2K-5g

To know

ACID-BASE EQUILIBRIUM

$$pOH = -log[OH^-] \Leftrightarrow [OH^-] = 10^{-pOH}$$

$$pH = -log[H^+] \Leftrightarrow [H^+] = 10^{-pH}$$

or

$$pH = -log[H_3O^+] \Leftrightarrow [H_3O^+] = 10^{-pH}$$

Learn more

https://www.youtube.com/watch?v=R07zGPMAni0

$$at\ 25°C:\quad pH + pOH = 14 \longrightarrow K_w = [H_3O^+] \cdot [OH^-] = 1 \times 10^{-14}$$

Chemistry Exam

QUESTIONS?