EmSAT Achieve Chemistry

Public Test Specification

Test Description: EmSAT Achieve Chemistry assesses the extent to which the test taker is ready to study chemistry at the college or university level. It is a computer-based exam where test sections, questions, and options are randomized. The exam is adaptive. Exam content and difficulty is customized to the individual test taker. When a test taker answers a question correctly, they will be given more difficult content; when they answer a question incorrectly, they will be given easier content. This process of continuous adjustment delivers optimized content for each test taker throughout the exam, maximizing their opportunity to perform at their best and providing a more accurate measure of their ability. Test takers should do their best to answer each question correctly; once a question is answered, they will not be able to go back and change the answer.

Test Duration:	120 minutes
Questions:	50 questions
Content Areas:	Matter, Bonding, Stoichiometry, Chemical Reactions, Thermodynamics, Equilibrium, Hydrocarbons, and its Derivatives, Analytical and Nuclear Chemistry.
Task Types:	Multiple Choice, Multi-select, Fill-in the-Blank, and Drag and Drop

EmSAT Achieve Chemistry	
Score	**Score Descriptors**
1500 - 2000	**High Proficiency:** students at this level are well-prepared for first-year chemistry courses at the university level.
1100-1475	**Proficient:** students at this level are at a satisfactory level of preparation to begin first-year chemistry courses at the university level.
900-1075	**Borderline Proficient:** students at this level are minimally prepared for first-year chemistry courses at the university level and may need additional support in some areas.
700-875	**Basic:** students at this level do not have sufficient mastery of prerequisite knowledge for first-year courses in chemistry at the university level and will likely need some additional support in some chemistry's topics.
500-675	**Needs Improvement:** students at this level need additional instructional support in basic chemical concepts and skills before beginning any first-year chemistry courses.
< 500	**Little knowledge of basic science:** students at this level lack knowledge and skills of basic science concepts.

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Appendix 1: Content Areas

Content Area 1: Chemical Foundation. (5%)

- Steps of Scientific Process.
- Conversion of S.I. Units.
- Temperature Scales and Conversions.
- Density Calculations.
- Scientific Notation.
- Significant Figures.
- Accuracy and Precision.
- Dimensional Analysis.

Content Area 2: Inorganic Chemistry. (35%)

- Elements, Compounds, and Mixtures.
- Properties and Interconversions of Solids, Liquids and Gases.
- Physical and Chemical Changes and Properties of Matter.
- Laws of Definite Proportion and Conservation of mass.
- Development of Modern Atomic Theory.
- Protons, Neutrons, and Electrons.
- Atomic Number, Mass Number, And Isotopes.
- Properties of Waves.
- Electromagnetic Radiation.
- Planck's Quantum Theory.
- The Photoelectric Effect.
- Emission Spectra.
- Distribution of Electrons.
- The Pauli Exclusion Principle.
- Hund's Rule.
- The Aufbau Principle.
- Periodic Classification of Elements.
- Periodicity (Atomic and Ionic Radius, Ionization Energy, Electron Affinity, an Electronegativity.
- Ionic Bond.
- Formulae of Ionic Compounds.
- Properties of Ionic Compounds
- Covalent Bond.
- Electronegativity Values and Type of Bond.
- Lewis Structures for Atoms, Ions and Molecules
- Molecular Geometry.
- Properties of Covalent Compounds.
- Intermolecular Forces.
- Properties of intermolecular Forces such as Surface Tension, Viscosity, Vapor Pressure, ar Molar Heat of Vaporization.
- Interpretation of Heating and Cooling Curves.
- Stoichiometry.
- Electrolytic Properties of Aqueous Solutions
- Factors Affecting Solubility.
- Molecular, Ionic and Net Ionic Equations.
- Properties of Acids and Bases.
- Arrhenius, Bronsted-Lowry, and Lewis Definitions of Acids and Bases.
- Acid-Base Equilibria
- Acid-Base Titrations
- Oxidation and Reduction.
- Redox Reactions.
- Corrosion Formation and Protection
- Redox Titrations and Calculations.
- Electrolysis of water, molten and Aqueous Solutions
- Gravimetric Analysis

Content Area 3: Physical Chemistry. (25%)

- Equipment and Units to Measure Gas Quantities
- Molar Volume
- Kinetic Molecular Theory
- Total Pressure and Partial Pressures
- The Gas Laws and Problems Involving T, V, P, and n
- Pressure of a Gas Collected over Water.
- Reaction Rate.
- Factors that affect Reaction Rates
- Diffusion Rates of Gases.
- The Rate Law.
- Stoichiometry of Gases.
- Heterogeneous and Homogeneous Catalysis.
- Collision Theory of Chemical Kinetics.
- Concept of Equilibrium.
- Factors that affect Equilibrium.
- The First Law of Thermodynamics.
- Enthalpy Changes ΔH.
- Enthalpy of Chemical Reactions.
- Calorimetry.
- Thermochemical Equations
- Standard Enthalpy of Formation and Reaction.
- Second and Third Laws of Thermodynamics.
- Entropy Changes (ΔS).
- Gibbs Free Energy Changes ΔG.
- Factors Affecting Gibbs Free Energy ΔG.

Content Area 4: Organic Chemistry (20%)

- Chemical and Physical Properties of Organic Compounds.
- Hydrocarbon Types and Nomenclature.
- Saturated Hydrocarbons: Alkanes and Cycloalkanes.
- Unsaturated Hydrocarbons: Alkenes and Alkynes.
- Isomerism.
- Combustion, Addition, and Substitution Reactions.
- Aromatic Compounds Nomenclature.
- Reactions of Aromatic Compounds.
- Alcohols Nomenclature.
- Production of Alcohols by Fermentation and in Industry.
- Reactions of Alcohols.
- Aldehydes and Ketones Nomenclature and Formation.
- Carboxylic Acids and Esters. Nomenclature and Formation.
- Amine Types and Nomenclature.
- Addition and Condensation of Polymers

Content Area 5: Analytical Chemistry (10%)

- Experimental Measurements
- Qualitative Analysis of Inorganic Ions
- Chemical Hazards
- Safety Principles
- Determination of Physical Properties
- Criteria of Purity
- Instrumental Techniques

Content Area 6: Nuclear Chemistry (5%)

- Radioactive Decay.
- Nuclear Transformations.
- Nuclear Fission.
- Nuclear Fusion.
- Half-Life.
- Uses and Risks of Radioactivity.

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Appendix 2: Sample Items

1. Compared to the charge of a proton, the electron charge is

مقارنة بشحنة البروتون، فإن شحنة الإلكترون تكون

A. equal and of opposite sign — مساوية وذات إشارة معاكسة

B. smaller and of opposite sign — أصغر وذات إشارة معاكسة

C. greater and of the same sign — أكبر ولها نفس الإشارة

D. equal and of the same sign — مساوية ولها نفس الإشارة

2. Chlorine atom is in an excited state. When an electron in this atom jumps from the fourth to the third shell, energy is _____ .

ذرة كلور في حالة مستثارة. عندما يتحرك إلكترون في هذه الذرة من مستوى الطاقة الرابع إلى مستوى الطاقة الثالث، فإن الطاقة تكون قد _____ .

A. released — انبعثت

B. absorbed — امتصت

C. disappeared — اختفت

D. converted to electricity — تحولت إلى كهرباء

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Appendix 2: Sample Items

3. One of the most important properties of mixtures is that they _____ .

واحدة من أهم خصائص المخاليط _____.

A. may have different proportions of their components — يمكن أن يكون لديها نسب مختلفة من مكونتها

B. have fixed proportions of their components — ذات نسب تركيب ثابتة

C. can be separated only by chemical means — لا يمكن فصلها إلا بالوسائل الكيميائية

D. are very reactive and unstable — تكون نشطة وغير مستقرة

4. The statements below explain why magnesium is preferred over zinc to protect underground iron pipes in terms of reactivity **except** for _____ .

توضح العبارات أدناه لماذا يفضل المغنيسيوم على الزنك لحماية أنابيب الحديد تحت الأرض من حيث التفاعلية **باستثناء** العبارة _____.

A. Zinc is more active than magnesium — الزنك هو أكثر نشاطا من المغنيسيوم

B. Magnesium atoms lose electrons more easily than zinc atoms — تفقد ذرات المغنيسيوم الإلكترونات بسهولة أكبر من ذرات الزنك

C. Magnesium oxidized more readily than zinc — المغنيسيوم يتأكسد بسهولة أكبر من الزنك

D. Magnesium is more active than zinc — المغنيسيوم هو أكثر نشاطا من الزنك

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Appendix 2: Sample Items

5. Calculate the mass percent of aluminum in the compound below.

(Round your answer to the nearest whole number)

ما نسبة الكتلة المئوية للألمنيوم في المركب أدناه.

(قرب إجابتك إلى أقرب عدد صحيح)

$$Al_2(SO_4)_3$$

Answer = _____ % = الإجابة

6. Which of the following equations represents sublimation?

ما المعادلة التي تمثل عملية التسامي؟

A. $CO_2(s) \rightarrow CO_2(g)$

B. $Hg(l) \rightarrow Hg(s)$

C. $CH_3OH(g) \rightarrow CH_3OH(l)$

D. $CH_4(l) \rightarrow CH_4(g)$

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Appendix 2: Sample Items

7. Given the equation representing a nuclear reaction in which X represents a nuclide:

بالنظر إلى معادلة التفاعل النووي الذي تمثل فيه X نواه لعنصرٍما:

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow X$$

Which nuclide is represented by X?

ما هي النواة X؟

A. $^{236}_{92}U$

B. $^{234}_{92}U$

C. $^{235}_{93}Np$

D. $^{236}_{92}Np$

8. Which of the following terms used as a measure of the average kinetic energy of the particles in a sample?

أي من المصطلحات التالية يُستخدم كمقياس لمتوسط الطاقة الحركية للجسيمات في عينةٍ ما ؟

A. temperature — درجة الحرارة

B. pressure — الضغط

C. volume — الحجم

D. chemical energy — الطاقة الكيميائية

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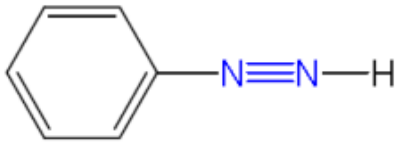
Appendix 2: Sample Items

9. What is the total number of electrons shared in the bonds between the two nitrogen atoms in the following molecule

ما عدد الإلكترونات المشتركة في الروابط بين ذرتي النيتروجين في المركب أدناه



A. 6

B. 2

C. 3

D. 8

10. An elevator at shopping mall has a maximum load of 1600 *lb*.

How many 75 *kg* persons can use the elevator at the same time?
(1 *lb* = 0.45359237)

مصعد في مركز للتسوق حمولته القصوى تبلغ 1600 *lb*

كم عدد الأشخاص الذين يمكنهم استخدام المصعد في آن واحد إذا افترضنا أن متوسط كتلة الشخص هي 75 *kg* ؟
(1 *lb* = 0.45359237)

Answer = [ ] = الإجابة

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Appendix 2: Sample Items

11. The gold foil experiment led to the discovery of the _____ .

أدت تجربة رقاقة الذهب إلى اكتشاف _____.

A. nucleus — النواة

B. neutron — النيوترون

C. electron — الإلكترون

D. cathode ray — اشعة المهبط

12. Which particles are found in the nucleus of an atom?

ما المكونات الموجودة في نواة الذرة؟

A. protons and neutrons — البروتونات والنيوترونات

B. protons and electrons — البروتونات والإلكترونات

C. neutrons and electrons — النيوترونات والإلكترونات

D. protons — البروتونات

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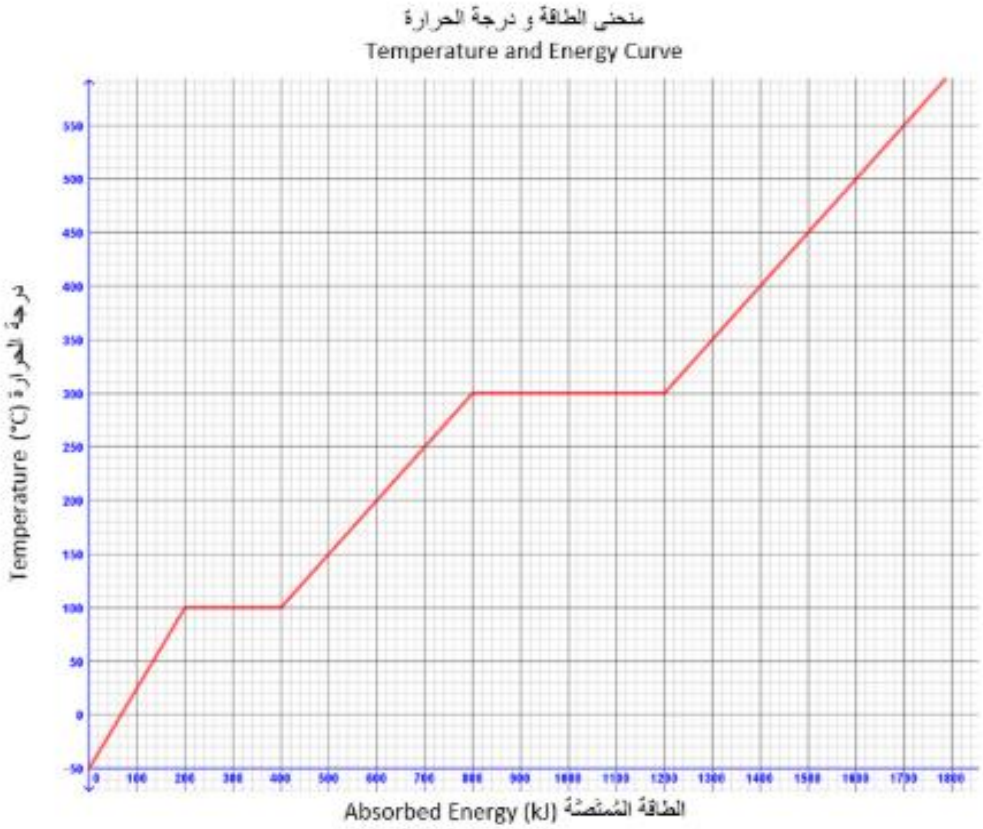
Appendix 2: Sample Items

13.

The below graph for a substance being heated from −50 °C to 600 °C .

الرسم البياني أدناه يمثل عملية تسخين ماده من −50 °C إلى 600 °C



If 600 *kJ* of heat are removed from the substance when it is at 350 °C, what will be the state and temperature of the substance?

تم تبريد الماده عن طريق سحب ما مقداره 600 *kJ* من الحراره عندما كانت درجة حرارتها 350 °C ما حاله الماده الفيزيائية و درجة حرارتُها؟

A. liquid at 250°C — سائله عند 250°C

B. gas at 250 °C — غازيه عند 250 °C

C. solid at 200 °C — صلبة عند 200 °C

D. liquid at 200 °C — سائله عند 200 °C

14. The equilibrium constant *K* for the following reaction is $1.5 \times 10^{+5}$

إذا علمت أن ثابت الإتزان K للتفاعل أدناه يساوي $1.5 \times 10^{+5}$

$$X \rightleftharpoons Y$$

Based on the above information, the reaction at equilibrium will **always** have _____ .

استنادا إلى المعلومات المذكورة أعلاه، التفاعل عند الإتزان سوف يكون **دائماً** لديه _____.

A. large amount of product Y — كمية كبيرة من المادة الناتجة Y

B. large amount of reactant X — كمية كبيرة من المادة المتفاعلة X

C. 75% product of Y and 25% reactant X — 75% من المادة الناتجة Y و25% من المادة المتفاعلة X

D. 50% product of Y and 50% reactant X — 50% من المادة الناتجة Y و50% من المادة المتفاعلة X

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Appendix 2: Sample Items

15. A student conducted a titration by adding 12.0 *mL* of $NaOH(aq)$ of unknown concentration to 16.0 *mL of* 0.15 *M* $HCl(aq)$.

What is the molar concentration of the $NaOH(aq)$?

أجرى طالب عملية المعايرة بإضافة 12.0 *mL* من محلول $NaOH(aq)$ غير معروف التركيز إلى 16.0 *mL* من محلول $HCl(aq)$ الذي تركيزه 0.15 *M*

ما تركيز $NaOH(aq)$؟

A. 0.2 M

B. 2.0 M

C. 0.15 M

D. 2.4 M

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Appendix 2: Sample Items

Item	Key
1	A
2	A
3	A
4	A
5	16
6	A
7	A
8	A
9	A
10	9
11	A
12	A
13	A
14	A
15	A

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Appendix 3: Formulas

Common Units: الوحدات الشائعة

الرمز Symbol	إسم الوحدة Name	الكمية Quantity
m	meter	Length طول
g	gram	Mass كتلة
Pa	Pascal	Pressure ضغط
K	kelvin	Temperature درجة الحرارة
mol	mole	Amount of substance كمية المادة
J	joule	Energy, work, amount of heat طاقة، عمل، كمية الحرارة
s	second	Time زمن
min	minute	Time زمن
h	hour	Time زمن
d	day	Time زمن
y	year	Time زمن
L	liter	Volume حجم
ppm	parts	Parts per million concentration التركيز لكل جزء في المليون
M	molarity	Solution concentration تركيز المحلول

Units Conversion: *التحويل بين الوحدات:*

طول Length	كتلة Mass	حجم Volume	الحرارة و الطاقة Tem. & Energy	الضغط Pressure
1 cm = 10 mm 1 m = 100 cm 1 m = 1000 mm 1 km = 1000 m 1 ft = 12 in 1 yard = 3 ft 1 mile = 5280 ft 1 in = 2.54 cm 1 yd = 0.914 m 1 km = 0.621 miles	1 g = 1000 mg 1 kg = 1000 g 1 mg = 1000 µg 1 lb = 16 oz 1 kg = 2.20 lb 454 g = 1 lb 1 ton = 907.2 kg	1 mL = 1 cm^3 1 dL = 100 mL 1 L = 10 dL 1 L = 1000 mL 1 pint = 2 cups 1 qt = 4 cups 1 gallon = 4 qts 946 mL = 1 qt 1 L = 1.06 qt	K = °C + 273.15 °C = (F - 32) x 5/9 1 cal = 4.184 J	1 psi = 0.068 atm 1 atm = 101.325 kPa 1 atm = 760 mmHg 1 atm = 1.01325 bar 1 mmHg = 1 torr

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Constants: *ثوابت:*

اسم الثابت Name of the constant	قيمة الثابت Value of the constant
Planck's constant (h) ثابت بلانك Speed of light (c) سرعة الضوء Avogadro's number (N_A) عدد أفوجادرو Faraday constant ($\mathcal{F}$) ثابت فارادي Atomic mass unit amu (u) وحدة الكتلة الذرية	6.626×10^{-34} J s 2.998×10^{8} m/s 6.022×10^{23} mol^{-1} 9.65×10^{4} C/mol $1.66053040 \times 10^{-27}$ Kg
Gas constants (R) ثابت الغاز	8.314 J mol^{-1} K^{-1} 62.36 L torr mol^{-1} K^{-1} 0.08206 atm mol^{-1} K^{-1}
STP conditions الظروف المعيارية (القياسية)	1.000 atm 0.00 °C
Boltzmann constant (*k*) ثابت بولتزمان	1.38×10^{-23} JK^{-1}
1 mol of ideal gas at (STP) مول واحد من الغاز عند	22.4 L
Specific Heat of water (l) الحرارة النوعية للماء (سائل)	4.18 J/g°C
Specific Heat of water (g) الحرارة النوعية للماء (غاز)	2.02 J/g°C
Specific Heat of water (s) الحرارة النوعية للماء (صلب)	2.05 J/g°C
Heat of fusion of water حرارة الانصهار للماء	6.01 kJ/mol
Heat of vaporization of water حرارة التبخر للماء	40.7 kJ/mol
Rydberg Constant (R) ثابت ريدبيرج	1.0974×10^{7} m^{-1}

Subatomic Particles : *الجسيمات دون الذرية :*

الإسم Name	الرمز Symbol	الكتلة Mass (kg)	الشحنة Charge (C)
proton	p^+	1.673×10^{-27}	$+1.602 \times 10^{-19}$
electron	e^-	9.109×10^{-31}	-1.602×10^{-19}
neutron	n^0	1.675×10^{-27}	0

SOLUBILITY RULES *قواعد الذائبية*

SOLUBLE ذائب	INSOLUBLE غير ذائب
All Nitrates, Acetates, Ammonium and Group I salts All Chlorides, Bromides, and Iodides, except Silver, Lead, and Mercury (I) All Fluorides except Group II, Lead (II), and Iron (III) All Sulfates except Calcium, Strontium, Barium, Mercury, Lead (II), and Silver	All Carbonates and Phosphates except Group I and Ammonium All Hydroxides except Group I, Strontium, and Barium All Sulfides except Group I, II, and Ammonium All Oxides except Group I

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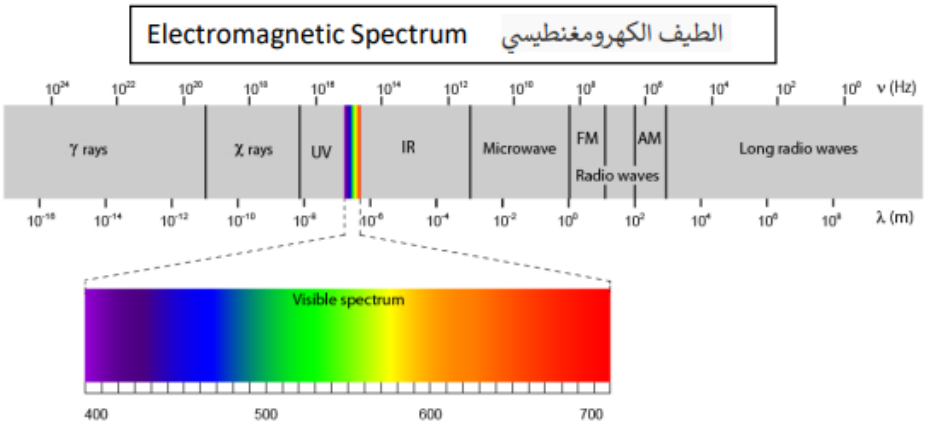
Appendix 3: Formulas

H 2.1																	He
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr 3.0
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe 2.6
Cs 0.7	Ba 0.9	La 1.1	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Ti 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2	Rn 2.4
Fr 0.7	Ra 0.7	Ac 1.1	Unq	Unp	Unh	Uns	Uno	Une									

Electronegativity الكهروسلبية

Ce 1.1	Pr 1.1	Nd 1.1	Pm 1.1	Sm 1.1	Eu 1.1	Gd 1.1	Tb 1.1	Dy 1.1	Ho 1.1	Er 1.1	Tm 1.1	Yb 1.1	Lu 1.2
Th 1.3	Pa 1.5	U 1.7	Np 1.3	Pu 1.3	Am 1.3	Cm 1.3	Bk 1.3	Cf 1.3	Es 1.3	Fm 1.3	Md 1.3	No 1.3	Lr



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Appendix 3: Formulas

Equations: بعض القوانين و المعادلات:

$$PV = nRT$$

$$P_A = P_{\text{total}} \times X_A, \text{ where } X_A = \frac{\text{moles A}}{\text{total moles}}$$

$$P_{total} = P_A + P_B + P_C + \dots$$

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

$$K = °C + 273$$

$$D = \frac{m}{V}$$

$$KE \text{ per molecule} = \frac{1}{2}mv^2$$

$$\frac{Rate_1}{Rate_2} = \sqrt{\frac{M_2}{M_1}}$$

$$q = mc\Delta T$$

$$\Delta S^\circ = \sum S^\circ \text{ products} - \sum S^\circ \text{ reactants}$$

$$\Delta H^\circ = \sum \Delta H_f^\circ \text{ products} - \sum \Delta H_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \sum \Delta G_f^\circ \text{ products} - \sum \Delta G_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$
$$= -RT \ln K$$
$$= -nFE^\circ$$

$$I = \frac{q}{t}$$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}, \text{ where } a\,A + b\,B \rightleftarrows c\,C + d\,D$$

$$K_p = \frac{(P_C)^c(P_D)^d}{(P_A)^a(P_B)^b}$$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$K_b = \frac{[OH^-][HB^+]}{[B]}$$

$$K_w = [H^+][OH^-] = 1.0 \times 10^{-14} \text{ at } 25°C$$
$$= K_a \times K_b$$

$$pH = -\log[H^+],\ pOH = -\log[OH^-]$$

$$14 = pH + pOH$$

$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$

$$pK_a = -\log K_a,\ pK_b = -\log K_b$$

$$\ln[A]_t - \ln[A]_0 = -kt$$

$$\frac{1}{[A]_t} - \frac{1}{[A]_0} = kt$$

$$t_{1/2} = \frac{0.693}{k}$$

$$E = \frac{hc}{\lambda}$$

$$v = {}^{c}/_{\lambda}$$

$$E = R_E\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$F_e = k_e\frac{Q_1 Q_2}{r^2}$$

$$P_{solution} = P_1x_1 + P_2x_2 + \cdots$$

$$\Delta T_{solution} = K_b \cdot m_{solute}$$

$$\Delta T_{solution} = K_f \cdot m_{solute}$$