وزارة التعليم العالي والبحث العلمي
كلية الرشيد الجامعة
قسم هندسة الاجهزة الطبية

Ministry of Higher Education & Scientific Research
Al-Rasheed University College
Department of Medical Instrumentation Engineering

قسم هندسة الاجهزة الطبية
حقيبة تعليمية

بعنوان:

الكيمياء الطبية

إعداد

م.م فادية فالح محمد

2023 - 2022

المقدمة

يتسم البرنامج التعليمي لمقرر الكيمياء الطبية بالتدريس باللغة الانكليزية لمدة ثلاثون اسبوعا بواقع ساعتين اسبوعيا حيث يتم تدريس الطلبة بأساسيات ومختلف التقنيات المتعلقة بالكيمياء الحياتية الطبية ضمن منهج متكامل ويتدرب الطالب خلال هذه الفترة على إكتساب المعلومات والمهارات اليدوية المهمة وعلى فهم دور الكيمياء الحياتية الطبية في الحياة اليومية عامة و الاجهزة الطبية خاصةو تفسير نتائج تحاليل الكيمياءالطبية.

فهرس المحتويات

وصف المقرر الدراسى

وصف المقرر

يوفر وصف المقرر هذا إيجازاً مقتضياً لأهم خصائص المقرر ومخرجات التعلم المتوقعة من الطالب تحقيقها مبرهناً عما إذا كان قد حقق الاستفادة القصوى من فرص التعلم المتاحة. ولابد من الربط بينها وبين وصف البرنامج.؛

1. المؤسسة التعليمية	
2. القسم العلمي / المركز	هندسة تقنيات الأجهزة الطبية
3. اسم / رمز المقرر	كيمياء طبية
4. أشكال الحضور المتاحة	اسبوعي) نظري + عملي (
5. الفصل / السنة	2021 - 2020
6. عدد الساعات الدراسية)الكلي(	120 ساعة
7. تاريخ إعداد هذا الوصف	2021 / 7 / 1
8. أهداف المقرر دراسة المواد الكيميائية و كيفية الاستفادة منها و كذلك معرفة مخاطرها على جسم الأنسان و التفاعلات التي تدخل فيها	

11. مخرجات المقرر وطرائق التعليم والتعلم والتقييم

أ- الأهداف المعربيية

أ1- التعرف على المواد الكيميائية و كيفية الأستفادة منها.

أ2- التعرف على خصائص المواد الكيميائية.

أ3- التعرف على مخاطر المواد الكيميائية على جسم الانسان.

أ4- التعرف على أنواع التفاعلات الكيميائية.

ب - الأهداف المهاراتية الخاصة بالمقرر.
ب1 –يستخدم الطالب المحاليل الكيميائية ب2 –يستخدم الطالب الاجهزة المختبرية
ب3 –يقيس الطالب نسب العناصر يي المركبات

طرائق التعليم والتعلم

محاضرات نظرية و القيام بالتجارب الكيميائية

طرائق التقييم

اختبارات يومية – اختبارات فصلية – اختبارات سنوية – اسئلة سريعة

ج- الأهداف الوجدانية والقيمية
ج1-أن يصغي الطالب الى شرح الاستاذ
ج2-أن يتعرف الطالب على اهمية المواد الكيميائية يي الحياة ج3-أن يهتم الطالب بالهدوء و نظام الصف
ج4-أن يصف الطالب أهمية تعلم مادة الكيمياء الطبية

طرائق التعليم والتعلم

المناقشة و الحوار مع الطلبة
طرائق التقييم
أسئلة
د ـ المهارات العامة والتأهيلية المنقولة) المهارات الأخرى المتعلقة بقابلية التوظيف والتطور الشخصي.(د1-قابلية الطالب على البحث العلمي د2-قابلية الطالب على المشاركة يي الانشطة اللاصفية د3- المهارات المكتبية

11. بنية المقرر

الأسبوع	الساعات	مخرجات التعلم المطلوبة	اسم الوحدة / أو الموضوع	طريقة التعليم	طريقة التقييم
الأول	2 ن + 2 ع	الطالب يفهم الدرس	Introduction to analytical chemistry	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الثاني	2 ن + 2 ع	الطالب يفهم الدرس	Qualitative analytical chemistry	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الثالث	2 ن + 2 ع	الطالب يفهم الدرس	Quantitative analytical chemistry	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الرابع	2 ن + 2 ع	الطالب يفهم الدرس	Applications of quantitative analysis	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الخامس	2 ن + 2 ع	الطالب يفهم الدرس	First steps in making analysis	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة

السادس و السابع	4 ن + 4 ع	الطالب يفهم الدرس	Methods of expressing analytical concentrations: normality, Formality	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الثامن و التاسع	4 ن + 4ع	الطالب يفهم الدرس	Methods of expressing analytical concentrations: molarity, mole fraction, mill equivalent	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة

العاشر و الحادي عشر	4 ن + 4ع	الطالب يفهم الدرس	Volumetric analysis: principles, standard, solution	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الثاني عشر و الثالث عشر	4 ن + 4 ع	الطالب يفهم الدرس	Classification of volumetric method	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الرابع عشر	2 ن + 2 ع	الطالب يفهم الدرس	Acid-base indicators	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الخامس عشر	2 ن + 2 ع	الطالب يفهم الدرس	Buffer solution	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة

					سريعة
السادس عشر	2 ن + 2 ع	الطالب يفهم الدرس	Precipitation reaction	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
السابع عشر	2 ن + 2 ع	الطالب يفهم الدرس	The PH-scale	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الثامن عشر	2 ن + 2 ع	الطالب يفهم الدرس	Gravimetric analysis	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
التاسع عشر	2 ن + 2 ع	الطالب يفهم الدرس	Calculations	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
العشرون	2 ن + 2 ع	الطالب يفهم الدرس	Solubility of precipitations	محاضرة نظرية و عملية	اختبارات يومية و فصلية و
					سنوية و اسئلة سريعة

الحادي و العشرون و الثاني و العشرون	4 ن + 4ع	الطالب يفهم الدرس	The ideal gas law	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الثالث و العشرون	2 ن + 2 ع	الطالب يفهم الدرس	Thermodynamic: zero law of thermodynamic	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الرابع و العشرون	2 ن + 2 ع	الطالب يفهم الدرس	Types of systems	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الخامس و العشرون	2 ن + 2 ع	الطالب يفهم الدرس	first law of thermodynamic	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
السادس و العشرون و السابع و العشرون	4 ن + 4ع	الطالب يفهم الدرس	Reversible and irreversible expansion	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة
الثامن والعشرون	2 ن + 2 ع	الطالب يفهم الدرس	Heat capacities	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة

التاسع و العشرون و الثلاثون	4 ن + 4ع	الطالب يفهم الدرس	Adiabatic expansion	محاضرة نظرية و عملية	اختبارات يومية و فصلية و سنوية و اسئلة سريعة

.12 البنية التحتية	
1- الكتب المقررة المطلوبة	1-كتاب مبادئ الثرموداينمك, الأستاذ الدكتور فلاح حسن حسين, الطبعة الثانية, 2112 2-كتاب الأساسيات النظري, الدكتور هادي كاظم عوض, صالح محمد سعيد, 1981
2- المراجع الرئيسية)المصادر(	محاضرات عن الكيمياء التحليلية و الفيزيائية
ا- الكتب والمراجع التي يوصى بها) المجلات العلمية , التقارير ...., (	1-كتاب الكيمياء التحليلية 2-كتاب الكيمياء الفيزيائية
ب - المراجع الالكترونية, مواقع الانترني	Chemistry Study Guide

.13 خطة تطوير المقرر الدراسي
1-توبير بعض الأجهزة الكيميائية 2-توبير بعض المواد الكيميائية 3-اضاية تجارب كيميائية اخرى

TEMPLATE FOR COURSE SPECIFICATION

HIGHER EDUCATION PERFORMANCE REVIEW: PROGRAMME REVIEW

COURSE SPECIFICATION

This Course Specification provides a concise summary of the main features of the course and the learning outcomes that a typical student might reasonably be expected to achieve and demonstrate if he/she takes full advantage of the learning opportunities that are provided. It should be cross-referenced with the programme specification.

1. Teaching Institution	Al-Rasheed university college
2. University Department/Centre	Medical instrumentation engineering
3. Course title/code	Medical chemistry/ MeCh120
4. Programme(s) to which it contributes	
5. Modes of Attendance offered	Attendance class . electronic
6. Semester/Year	First year
7. Number of hours tuition (total)	60 hours theory and 60 hours practical
8. Date of production/revision of this specification	
9. Aims of the Cours	
1-training of student how to deal with chemical materials and knowing they are dangerous ,and how he can use chemicals in laboratory.	
2- qualify an engineering know how to deal with lab. Systems and apparatuses and fixing of them ,also he can compare between systemic results and classical manual results	
3- qualify an engineering can develop his knowledge in chemical materials and systems	
4- training of engineering on making experiments by classical manual ways	
5- earn the students theoretical and practical experiences	
6- he can develop the lab and his stuff.	

10· Learning Outcomes, Teaching ,Learning and Assessment Methode
A- Knowledge and Understanding A1. Make a knowledge base in chemical laboratory work . A2.put the theoretical knowledge base about systems work A3.sharing in samples analysis A4.can suggest alternative systems A5. A6 .
B. Subject-specific skills B1.accept laboratory work skills B2. Training of engineering and technician about laboratory systems B3.set up , fix and use laboratory systems
Teaching and Learning Methods
Lectures -scientific laboratories – vido lectures and discussion of previous lecture
Assessment methods
Daily assessments (quizzes) , term exams, evaluation of practical work ,final exam. And the attendance degree.
C. Thinking Skills C1.making the student oriented about theoretical base of the chemistry and many lab. Systems like PH meter, Oxy meter and Spectrophotometer C2. Putting plans for future lab. Work C3. C4.
Teaching and Learning Methods
Assessment methods

D. General and Transferable Skills (other skills relevant to employability and personal development)

D1. Athletics activities .
D2. Art works
D3.literary activities
D4.

13 14	2 2		Errors and statistical treatment of analysis data , sources of errors ,types of errors ,treatment of systematic errors ,confidence limit ,,variance ,median ,average mode ,range ,relative standard deviation ,accuracy .precision, detection limits, Gausian distribution, repeatability , reducibility	Theoretical lecture	Before and after questions
15 16 17 and 18	2 2 2 +2		Absolute error ,relative error ,rejecting of experimental result Thermodynamics : zero and first law of thermodynamics Heat capacities , adiabatic and isothermal process	Theoretical lecture	Before and after questions
19+20+ 21 22 23+24 25 26	2+2+2 2 2+2 2 2		Second law of thermodynamic : spontaneous processes Entropy Electrochemistry : electrochemical cells , types of electrodes ,electrolytes Electromotive force Redox reaction and balancing chemical equation ,Nernst equation ,cell potential		Theoretical lecture
				Theoretical lecture	Before and after questions

11. Course Structure

Week	Hours	ILOs	Unit/Module or Topic Title	Teaching Method	Assessment Method
1	2		Introduction to analytical chemistry ,system of units and units conversion Introduction to lab. Of qualitative analysis Precipitation reaction , the Ph scale . Gravimetric analysis Calculations solubility of product constant of precipitation .	Theoretical lecture	Before and after questions
2	2				
3	2				
4	2				
5	2				
6	2				
7	2		Methods of expressing analytical concentrations Normality, formality ,Molarity, Mole ratio .ppm ,ppb ,wt. and volume percent ratio . Mol fraction ,Mill equivalent Volumetric analysis :principle ,standard solution Classification of volumetric method Acid- base indicators .buffer solutions .	Theoretical lecture	Before and after questions
8	2				
9	2				
10	2				
11	2				
12	2				

27 +28 +29	2+2+2		Photochemistry (spectrophotometer analysis),regions of electromagnetic spectrum , absorption and emission of electromagnetic spectrum ,beer - lambert law instrumentation , component of spectrophotometer, ,analysis ,IR ,HNMR , and Mass analysis	Theoretical lecture	Before and after questions
30	2		Nuclear chemistry in diagnosis and treatment of diseas	Theoretical lecture	Before and after question

12. Infrastructure	
Required reading: · CORE TEXTS · COURSE MATERIALS · OTHER	Chemical principles -Zumdahl-4th edition essentials of general chemistry -edding ,Gammon and Ragsdale
Special requirements (include for example workshops, periodicals, IT software, websites)	
Community-based facilities (include for example, guest Lectures , internship , field studies)	

13. Admissions	
Pre-requisites	
Minimum number of students	
Maximum number of students	

إرشادات للطلبة

- الرغبة والحماس للتعليم
- كن مشاركاً في جميع الأنشطة
- احترم أفكار المدرس والزملاء
- أنقد أفكار المدرس والزملاء بأدب إن كانت هناك حاجة.
- احرص على استثمار الوقت
- تقبل الدور الذي يسند إليك في المجموعة
- حفز أفراد مجموعتك في المشاركة في النشاطات
- احرص على بناء علاقات طيبة مع المدرس والزملاء أثناء المحاضرة
- احرص على ما تعلمته في المحاضرة وطبقه في الميدان .
- ركز ذهنك بالتعليم واحرص على التطبيق المباشر
- تغلق الموبايل قبل الشروع بالمحاضرة

ملاحظة: موحدة تعتمد لجميع الاقسام

أهداف المحاضرة الاولى:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **معرفة ما المقصود بالكيمياء التحليلية و اهميتها**
2. **معرفقة ما المقصود الكيمياء التحليلية النوعية و الكمية و التميز بينهما**

موضوعات المحاضرة الاولى:

مقدمة في الكيمياء التحليلية
الكيمياء التحليلية النوعية
الكيمياء التحليلية الكمية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
1	● نشاط التعارف (1/1/1) ● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

ملاحظة: للتدريسي حرية في تغيير الاساليب والانشطة والوسائل حسب ما يراه مناسبا

خطة إجراءات تنفيذ المحاضرة الاولى

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الأولى	الأولى	الترحيب بالطلبة والتعارف معهم	90 دقيقة
		التعريف بالبرنامج وأهدافه وأهميته	
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

ملاحظات:

1. **المدرس يقدم النشاط على المادة العلمية إذا كانت هناك خبرات سابقة لدى الطلبة.**
2. **قد تحتاج لأكثر من نشاط في المحاضرة الواحدة.**

المادة العلمية:

Analytical Chemistry:

Is a branch of chemistry that deals with the analysis of substances (analytes) present in the sample **qualitatively** and **quantitatively**. In order to accomplish this analysis we must know the physical and chemical properties of these substances. In other words analytical chemistry deals with the separation, Identification and determination of substances in a sample. It also includes coverage of chemical equilibrium and statistical treatment of data.

Definitions:-

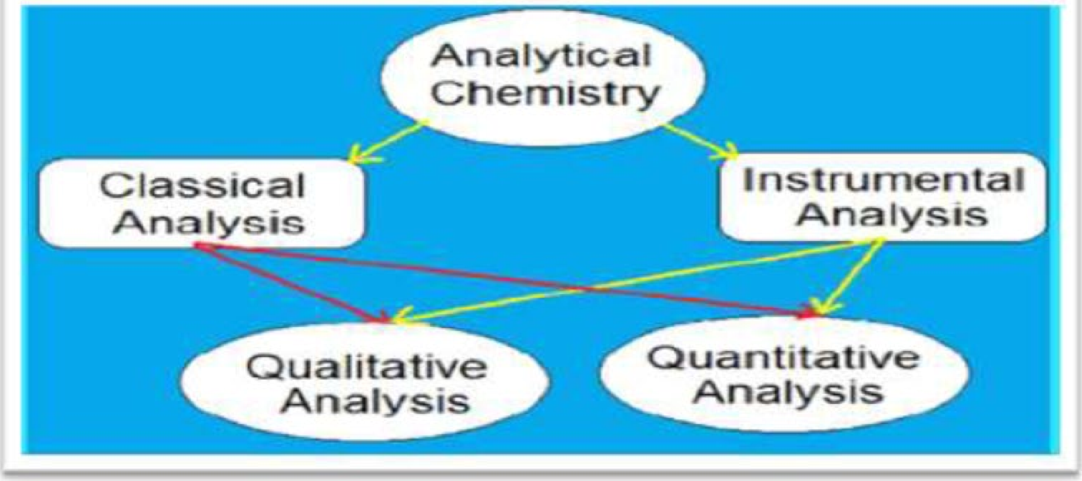
Sample is anything that comes to mind in the air, water, soil, food and living organisms such as a piece of rock or a piece of meat or some water from the tank of the house or from a river or a lack or a sea or some tissue or blood from humans or animals or some vegetables .... etc. The sample is taken to the laboratory and analyzed for its substances (analytes) after pretreatment and the final step is the calculations of the percentage of each substance in the sample. An **analyte** is a constituent of a sample that is analyzed for, and its concentration is determined.

Common Analytical issues

Perhaps the most common analytical problem is a quantitative analysis. Examples of typical quantitative analyses include the elemental analysis of a newly synthesized compound, measuring the concentration of glucose in blood, or determining the difference between the bulk and surface concentrations of Cr in steel. Much of the analytical work in clinical, pharmaceutical, environmental, and industrial labs involves developing new quantitative methods for trace amounts of chemical species in complex samples. Most of the examples in this text are quantitative analyses.

Another important area of analytical chemistry, which receives some attention in this text, is the development of new methods for characterizing physical and chemical properties. Determinations of chemical structure, equilibrium constants, particle size, and surface structure are examples of a characterization analysis.

The purpose of a qualitative, quantitative, or characterization analysis is to solve a problem associated with a particular sample. The purpose of a fundamental analysis, on the other hand, is to improve our understanding of the theory behind an analytical method. Extending and improving the theory on which an analytical method is based, studying an analytical method's limitations, and designing and modifying existing analytical method are examples of fundamental studies in analytical chemistry.



Qualitative Analysis

This analysis detects (identify) the type of all or some of the substances present in the sample (elements or ions or compounds). In other words it gives an answer to the question:

What substances are present in a sample?

These substances can be detected either by a chemical reaction For example, when you add silver nitrate solution to the sample solution a white precipitate formation indicates the presence of chloride ion in the sample.

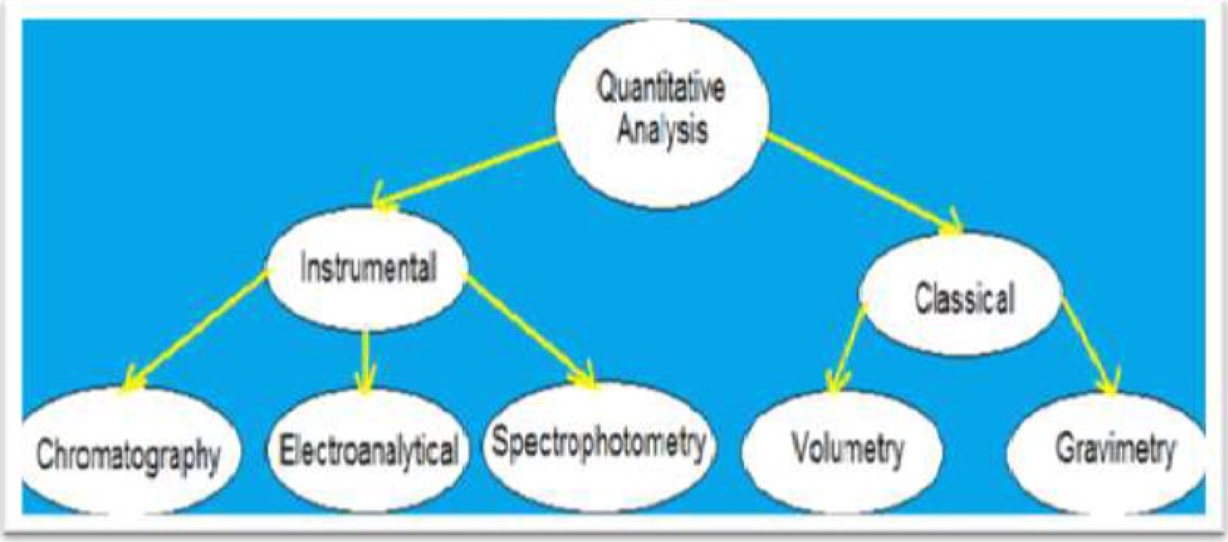
There are also many reagents that give distinctive colors with some of the substances and can be used in the detection of these substances. The flame also can be used for the detection of some common metals.

Qualitative Instrumental Analysis:

Currently there are many instruments that are separate and distinguish substances (organic or inorganic) in the sample, such as gas chromatography – mass spectrometry (GC – MS) , High performance liquid chromatography - mass spectrometry (HPLC – MS) , infrared spectra (IR) and induced coupled plasma – mass spectrometry (ICP – MS) or ICP – AES (Atomic Emission Spectrometry).

Figure (2) Qualitative Instrumental Analysis

Quantitative Analysis: This analysis gives knowledge of the amount of all or some of the substances present in the sample and uses two types of analysis depending on the concentration of the substance in the sample, namely **classical chemical analysis** and **instrumental analysis.**



Classical chemical analysis:

Which depends on the chemical reaction, such as volumetric analysis and gravimetric analysis, as we shall see later in lectures. And it uses simple equipment such as burettes, balances, flame, furnace. And is used to estimate high concentrations (more than 0.001 M).

Figure (3) Chemical instruments used in Lab.

Instrumental Analysis:

This type of analysis uses instruments and depends on the physical and physico-chemical properties of the substance being analyzed (analyte) such as absorption or emission of electromagnetic radiation (spectroscopic methods of analysis) or electrical properties of the substance being analyzed such as voltage or current intensity or electrical conductivity ...... etc. (electrochemical methods of analysis) and finally the methods of separation such chromatography.

Figure (4) FTIR Instrumental Analysis

الوحدة الأولى - المحاضرة الثانية - الزمن: 90 دقيقة

أهداف المحاضرة الثانية:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **معرفة تطبيقات الكيمياء التحليلية الكمية**

موضوعات المحاضرة الثانية:

الخطوات الاساسية لاجراء التحليل الكمي و ماهي تطبيقاته العملية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
2	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الثانية

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الأولى	الثانية	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Quantitative analysis applications

Quantitative analysis is a chemical analysis performed to find the amount of each component present in a material. It is done by either a classical or instrumental procedure.

A quantitative investigation means that the amount (quantity) or relative amount of each component present is determined. In a pure substance, the entire **mass**, or 100%, is composed of a single component. In materials composed of two or more substances, a quantitative investigation would determine the mass or relative mass present for each component within the sample. It is not always necessary to find quantitative values for all components that make up a substance. In most cases it is sufficient to analyze the material for one or perhaps more components of interest. The amount of active medicine within an antacid tablet, for example, is significant, whereas the fillers, binders, colorants, and flavoring agents present are of lesser importance.

Method	**Response**
Potentiometry:	Many chemical reactions produce electric energy, a battery for example. The amount of chemical to produce a measured potential is calculated.
Coulometry:	The amount of electrical current and the duration over which it flows is a measure of the amount of chemical substance producing the current.
Conductimetry:	The number of charged chemical components in a solution determine the resistance or conductance of a solution to the passage of electrical current.

Voltammetry:	The magnitude of electric potential necessary to cause the breakdown of a chemical substance and the current resulting from that breakdown are related to the amount of chemical present.
Ultraviolet, visible, infrared, and x-ray spectometry:	The extent to which these rays are absorbed by a sample depends upon the amount of sample present
Thermogravimetry:	The loss in weight of a substance as it decomposes upon heating is proportional to the amount of substance initially present.
Nuclear magnetic resonance:	For chemicals showing magnetic properties the strength of the magnetism is related to the amount of substance present.
Nuclear activation analysis:	The amount of radioactivity produced by a substance is proportional to the amount of material emitting radiation.
Mass spectrometry:	The intensity of each component fraction present as a chemical is broken apart relates to the amount initially present.

The general steps in the analytical processes

1. ***Formulating the question:*** Translate general questions into specific questions to be answered through chemical measurements.

2. ***Selecting analytical procedures:*** Search the chemical literature to find appropriate procedures or, if necessary, devise new procedures to make the required measurements.

3. ***Sampling*** is the process of selecting representative material to analyze. If you begin with a poorly chosen sample or if the sample changes between the time it is collected and the time it is analyzed, results are meaningless.

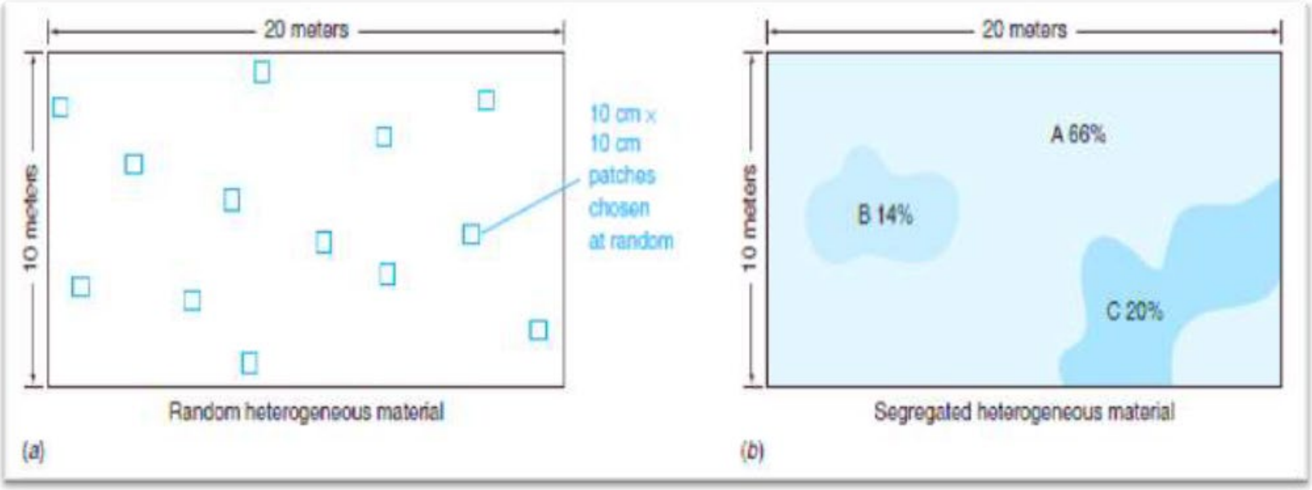


Figure (1) samples distribution

4. ***Sample preparation***

Converting a representative sample into a form suitable for analysis is called *sample preparation,* which usually means dissolving the sample. Samples with a low concentration of analyte may need to be concentrated prior to analysis. It may be necessary to remove or *mask* species that interfere with the chemical analysis. For a chocolate bar, sample preparation consisted of removing fat and dissolving the desired analytes. Fat was removed because it would interfere with chromatography, Figure (2).

5. ***Analysis*****:** Measure the concentration of analyte in several identical **aliquots** (portions). The purpose of replicate measurements (repeated measurements) is to assess the variability (uncertainty) in the analysis and to guard against a gross error in the analysis of a single aliquot, Figure (3).

The uncertainty of a measurement is as important as the measurement itself because it tells us how reliable the measurement is. If necessary, use different analytical methods on similar samples to show that the choice of analytical method is not biasing the result. You may also wish to construct several different samples to see what variations arise from your sampling and sample preparation procedure.

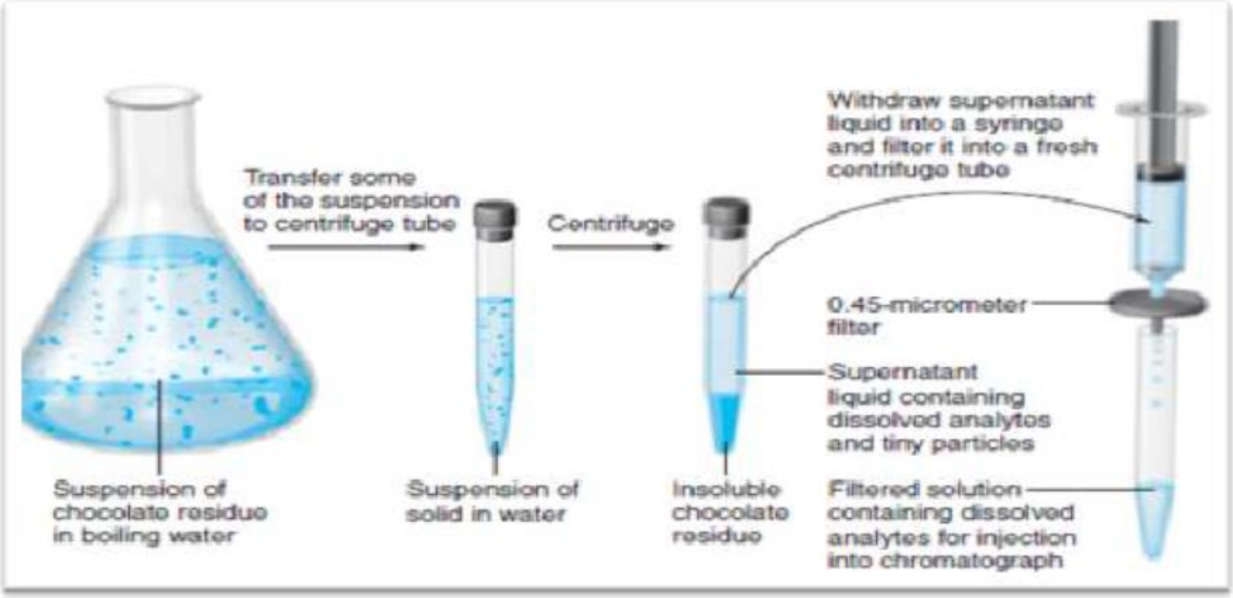


Figure (2) Centrifugation and filtration are used to separate undesired solid residue from the aqueous solution of analytes.

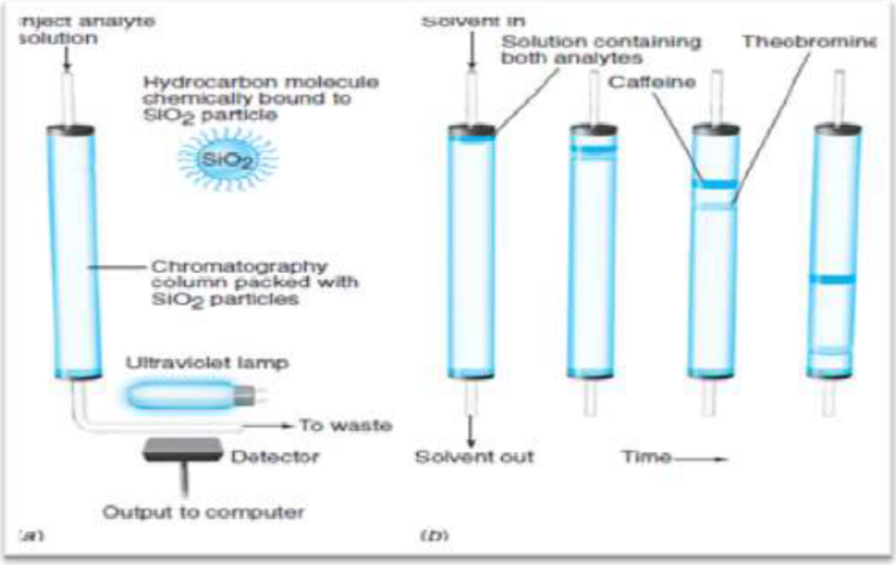


Figure (3) Principle of liquid chromatography. (*a*) Chromatography apparatus with an ultraviolet absorbance monitor to detect analytes at the column outlet. (*b*) Separation of caffeine and theobromine by chromatography. Caffeine has greater affinity than theobromine for the hydrocarbon layer on the particles in the column. Therefore, caffeine is retained more strongly and moves through the column more slowly than theobromine.

6. ***Reporting and interpretation:*** Deliver a clearly written, complete report of your results, highlighting any limitations that you attach to them. Your report might be written to be read only by a specialist (such as your instructor), or it might be written for a general audience (such as a legislator or newspaper reporter). Be sure the report is appropriate for its intended audience, Figure (4).

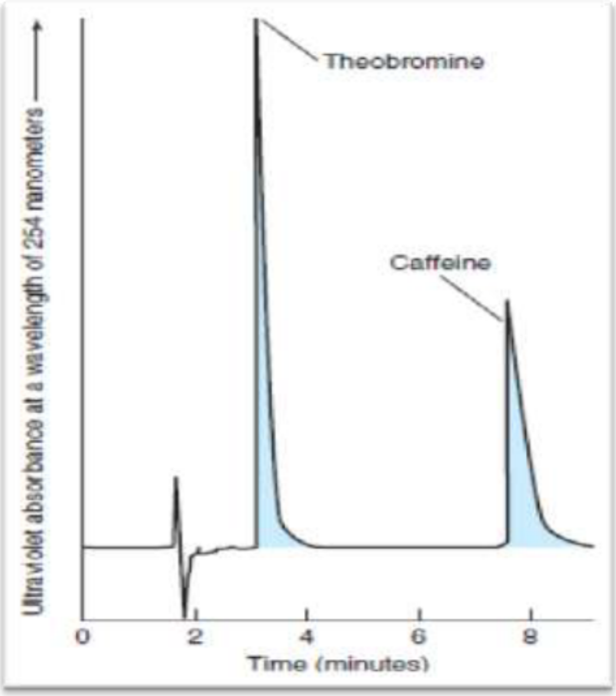


Figure (4) Chromatogram of 20.0 microliters of a standard solution containing 50.0 micrograms of theobromine and 50.0 micrograms of caffeine per gram of solution.

7. ***Drawing conclusions*** once a report is written, the analyst might not be involved in what is done with the information, such as modifying the raw material supply for a factory or creating new laws to regulate food additives. The more clearly a report is written, the less likely it is to be misinterpreted by those who use it.

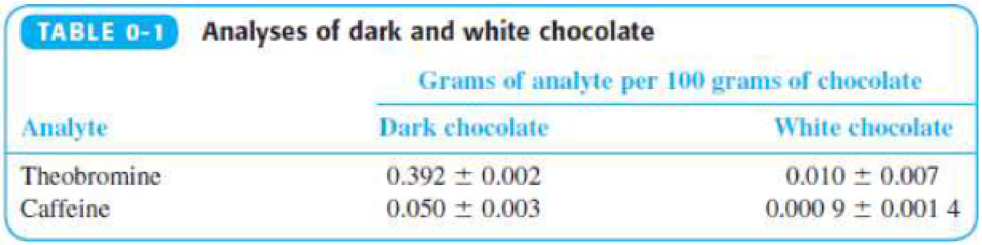
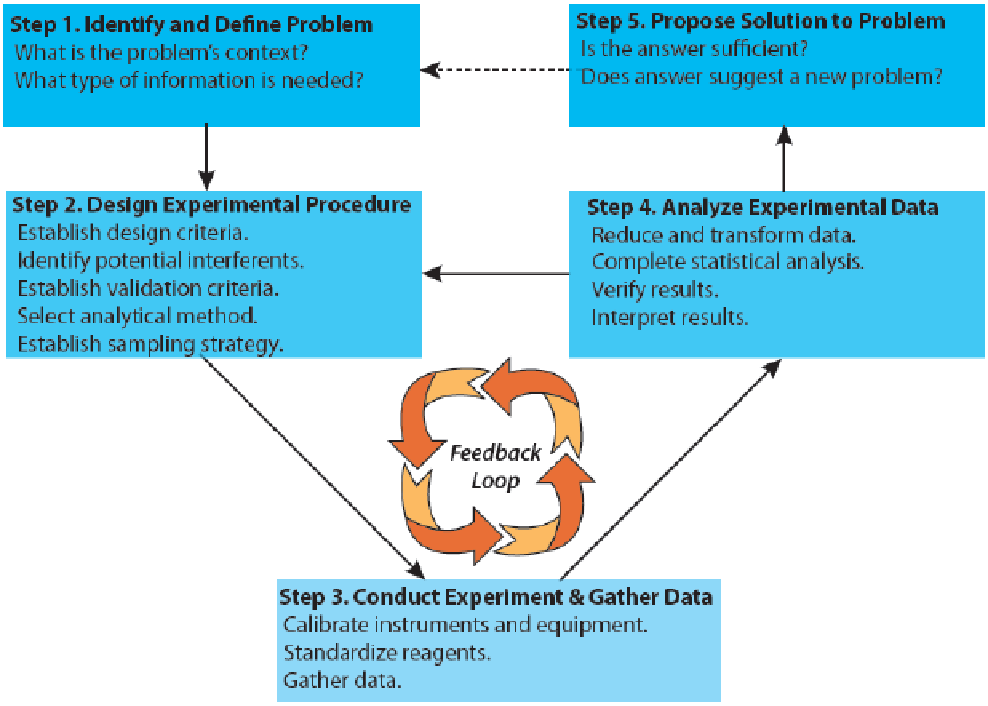


TABLE 0-1 Analyses of dark and white chocolate

Analyte	Grams of analyte per 100 grams of chocolate	
	Dark chocolate	White chocolate
Theobromine	0.392 ± 0.002	0.010 ± 0.007
Caffeine	0.050 ± 0.003	0.000 9 ± 0.001 4



Step 1. Identify and Define Problem
What is the problem's context?
What type of information is needed?

Step 2. Design Experimental Procedure
Establish design criteria.
Identify potential interferents.
Establish validation criteria.
Select analytical method.
Establish sampling strategy.

Step 3. Conduct Experiment & Gather Data
Calibrate instruments and equipment.
Standardize reagents.
Gather data.

Step 4. Analyze Experimental Data
Reduce and transform data.
Complete statistical analysis.
Verify results.
Interpret results.

Step 5. Propose Solution to Problem
Is the answer sufficient?
Does answer suggest a new problem?

Flow diagram showing one view of the analytical approach to solving problems

الوحدة الأولى - المحاضرة الثالثة - الزمن: 90 دقيقة

أهداف المحاضرة الثالثة:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **كيفية التعبير عن تراكيز المحاليل بطرق مختلفة**

موضوعات المحاضرة الثالثة:

النورمالية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
3	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الثالثة

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الأولى	**الثالثة**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Molarity and Molality:

A **mole** (mol) is *Avogadro's number* of particles (atoms, molecules, ions, or anything else). **Molarity** (M) is the number of moles of a substance per liter of solution. A **liter** (L) is the volume of a cube that is 10 cm on each edge. Because 10 cm = 0.1 m, 1 L = $(0.1\ m)^3 = 10^{-3}\ m^3$. Chemical concentrations, denoted with square brackets, are usually expressed in moles per liter (M). Thus "$[H^+]$" means "the concentration of H^+." The **atomic mass** of an element is the number of grams containing Avogadro's number of atoms. The **molecular mass** of a compound is the sum of atomic masses of the atoms in the molecule. It is the number of grams containing Avogadro's number of molecules.

A **homogeneous** substance has a uniform composition. Sugar dissolved in water is homogeneous. A **mixture** that is not the same everywhere (such as orange juice, which has suspended solids) is **heterogeneous**. **Avogadro's number** (number of units in one mole of any substance (defined as its molecular weight in grams) = $6.022*10^{23}$.

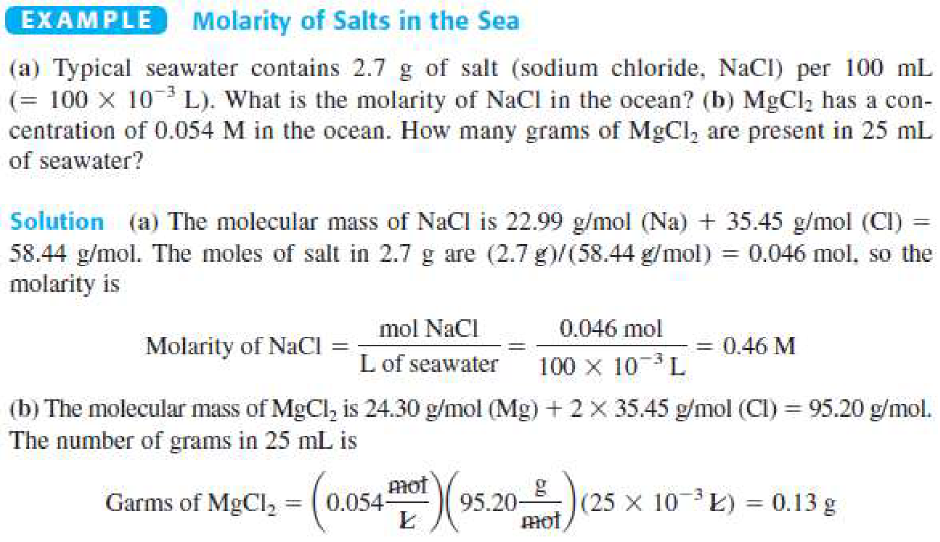
$$Molarity\ (M) = \frac{moles\ of\ solute}{liters\ of\ solution}$$

Atomic masses and physical constants such as Avogadro's number are shown in the periodic table inside the periodic table in last page of lecture.

An **electrolyte** is a substance that dissociates into ions in solution. In general, electrolytes are more dissociated in water than in other solvents. We refer to a compound that is mostly dissociated into ions as a *strong electrolyte*. One that is partially dissociated is called a *weak electrolyte.*

Magnesium chloride is a strong electrolyte. In 0.44 M $MgCl_2$ solution, 70% of the magnesium is free Mg^{2+} and 30% is $MgCl^+$. The concentration of $MgCl_2$ molecules is close to 0. Sometimes the molarity of a strong electrolyte is called the **formal concentration** (F), which is a description of how the solution was made by dissolving F moles per liter, even if the substance is converted into other species in solution. When we say that the "concentration" of $MgCl_2$ is 0.054 M in seawater, we are really speaking of its formal concentration (0.054 F). The "molecular mass" of a strong electrolyte is called the **formula**

mass (FM), because it is the sum of atomic masses of atoms in the formula, even though there are very few molecules with that formula. *We are going to use the abbreviation FM for both formula mass and molecular mass.*



EXAMPLE **Molarity of Salts in the Sea**

(**a**) Typical seawater contains 2.7 g of salt (sodium chloride, NaCl) per 100 mL (= 100 × 10^{-3} L). What is the molarity of NaCl in the ocean? (**b**) $MgCl_2$ has a concentration of 0.054 M in the ocean. How many grams of $MgCl_2$ are present in 25 mL of seawater?

Solution (**a**) The molecular mass of NaCl is 22.99 g/mol (Na) + 35.45 g/mol (Cl) = 58.44 g/mol. The moles of salt in 2.7 g are (2.7 g)/(58.44 g/mol) = 0.046 mol, so the molarity is

$$\text{Molarity of NaCl} = \frac{\text{mol NaCl}}{\text{L of seawater}} = \frac{0.046\ \text{mol}}{100 \times 10^{-3}\ \text{L}} = 0.46\ \text{M}$$

(**b**) The molecular mass of $MgCl_2$ is 24.30 g/mol (Mg) + 2 × 35.45 g/mol (Cl) = 95.20 g/mol. The number of grams in 25 mL is

$$\text{Garms of } MgCl_2 = \left(0.054\frac{\cancel{\text{mol}}}{\cancel{\text{L}}}\right)\left(95.20\frac{\text{g}}{\cancel{\text{mol}}}\right)(25 \times 10^{-3}\ \cancel{\text{L}}) = 0.13\ \text{g}$$

Molality (m) is concentration expressed as moles of substance per kilogram of solvent (not total solution). Molality is independent of temperature. Molarity changes with temperature because the volume of a solution usually increases when it is heated.

$$Molarity\ (M) = \frac{moles\ of\ solute}{liters\ of\ solution} \qquad Molality\ (m) = \frac{moles\ of\ solute}{mass\ of\ solution\ (kg)}$$

Percent Composition

The percentage of a component in a mixture or solution is usually expressed as a **weight percent** (wt%):

$$Weight\ percent = \frac{mass\ of\ solute}{\text{mass of total solution or mixture}} x100$$

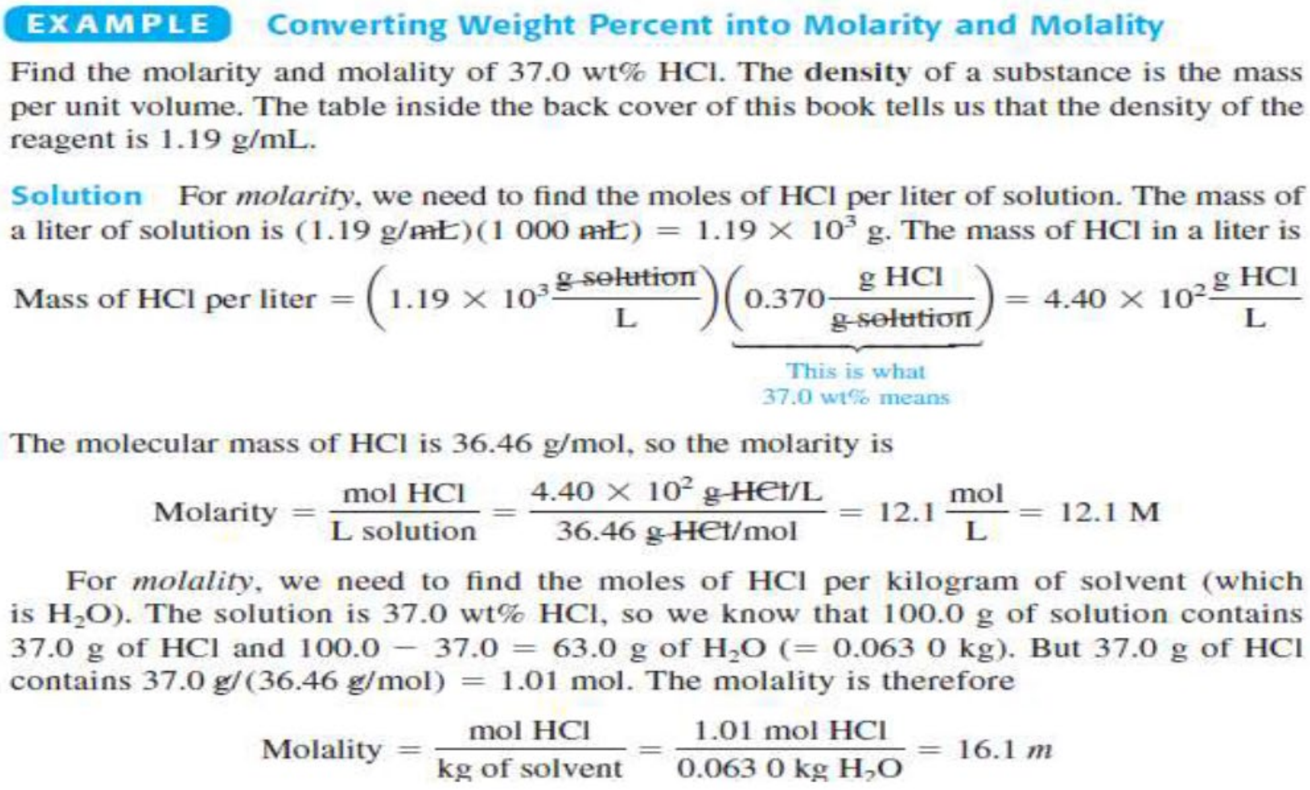
Ethanol (CH_3CH_2OH) is often purchased as a 95 wt% solution containing 95 g of ethanol per 100 g of total solution. The remainder is water. **Volume percent** (vol%) is defined as:

$$Volume\ percent = \frac{Volume\ of\ solute}{\text{volume of total solution}} x100$$

Although units of mass or volume should always be expressed to avoid ambiguity, mass is usually implied when units are absent.

$$Density\ = \frac{mass}{volume} = \frac{g}{mL} \qquad Specific\ gravity\ = \frac{density\ of\ substance}{density\ of\ water\ at\ 4\ C}$$

The density of water at 4^0C is close to 1 g/mL, so specific gravity is nearly the same as density.



EXAMPLE **Converting Weight Percent into Molarity and Molality**

Find the molarity and molality of 37.0 wt% HCl. The **density** of a substance is the mass per unit volume. The table inside the back cover of this book tells us that the density of the reagent is 1.19 g/mL.

Solution For *molarity*, we need to find the moles of HCl per liter of solution. The mass of a liter of solution is $(1.19\ g/\cancel{mL})(1\ 000\ \cancel{mL}) = 1.19 \times 10^3$ g. The mass of HCl in a liter is

$$\text{Mass of HCl per liter} = \left(1.19 \times 10^3 \frac{\cancel{\text{g solution}}}{\text{L}}\right)\underbrace{\left(0.370 \frac{\text{g HCl}}{\cancel{\text{g solution}}}\right)}_{\text{This is what 37.0 wt\% means}} = 4.40 \times 10^2 \frac{\text{g HCl}}{\text{L}}$$

The molecular mass of HCl is 36.46 g/mol, so the molarity is

$$\text{Molarity} = \frac{\text{mol HCl}}{\text{L solution}} = \frac{4.40 \times 10^2\ \cancel{\text{g HCl}}/\text{L}}{36.46\ \cancel{\text{g HCl}}/\text{mol}} = 12.1 \frac{\text{mol}}{\text{L}} = 12.1\ \text{M}$$

For *molality*, we need to find the moles of HCl per kilogram of solvent (which is H_2O). The solution is 37.0 wt% HCl, so we know that 100.0 g of solution contains 37.0 g of HCl and 100.0 − 37.0 = 63.0 g of H_2O (= 0.063 0 kg). But 37.0 g of HCl contains 37.0 g/(36.46 g/mol) = 1.01 mol. The molality is therefore

$$\text{Molality} = \frac{\text{mol HCl}}{\text{kg of solvent}} = \frac{1.01\ \text{mol HCl}}{0.063\ 0\ \text{kg}\ H_2O} = 16.1\ m$$

الوحدة الأولى - المحاضرة الرابعة - الزمن: 90 دقيقة

أهداف المحاضرة الرابعة:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **كيفية التعبير عن تراكيز المحاليل بطرق مختلفة**

موضوعات المحاضرة الرابعة:

الفورمالية
المولارية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
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		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Formality: is a substance's total concentration in solution without regard to its specific chemical form. There is no difference between a substance's molarity and formality if it dissolves without dissociating into ions. The molar concentration of a solution of glucose, for example, is the same as its formality.

Molarity: The number of moles of solute per liter of solution (M).

Formality: The number of moles of solute, regardless of chemical form, per liter of solution (F).

So is formality the same as molarity? *Sometimes yes*.

Formality does not take into account **what happens to a chemical compound once it's dissolved**. That is, it won't matter if the compound is an electrolyte or a non-electrolyte.
If you dissolve sodium chloride, NaCl, in water, you know that it dissociates completely and exists as ions in solution

$$\mathrm{NaCl_{(aq)}} \rightarrow \mathrm{Na^{+}_{(aq)}} + \mathrm{Cl^{-}_{(aq)}}$$

So if you dissolve **one mole** of NaCl in **one liter** of water, you will have

$$F = \frac{\text{moles of solute}}{\text{liters of solution}}$$

$$F = \frac{\text{1 mole NaCl}}{\text{1 L}} = \text{1 formal}$$

The molarity of this solution, on the other hand, is said to be 1 molar in sodium cations and 1 molar in chloride anions, **not** 1 molar in sodium chloride.
And here's the difference between formality and molarity.
Molarity actually takes into account what happens to the solute once it's dissolved. Formality does not.

Name	Units	Symbol
molarity	$\frac{\text{moles solute}}{\text{liters solution}}$	M
formality	$\frac{\text{moles solute}}{\text{liters solution}}$	F
normality	$\frac{\text{equivalents solute}}{\text{liters solution}}$	N
molality	$\frac{\text{moles solute}}{\text{kilograms solvent}}$	m
weight percent	$\frac{\text{grams solute}}{\text{100 grams solution}}$	% w/w
volume percent	$\frac{\text{mL solute}}{\text{100 mL solution}}$	% v/v

Normality

The normality 'N' of a solution is, given by the number of equivalents of solute per liter of solution:

$$N = \frac{Gram\ eq.of\ Solute}{Volume\ of\ sol.in\ litre}$$

$$= \frac{Weight}{Equivalent\ weight} \times \frac{1000}{V\ ml}$$

$$\text{Equivalent Weight} = \frac{Molar\ Mass}{n}$$

The number of **equivalents,** *n,* is based on a reaction unit, which is that part of a chemical species involved in a reaction (Is the amount of a substance that reacts with (or is equivalent to) an arbitrary amount of another substance in a given chemical reaction.)

- By this definition, an equivalent is the number of moles of an ion in a solution, multiplied by the valence of that ion. If 1 mol of NaCl and 1 mol of CaCl2 dissolve in a solution, there is 1 equiv Na, 2 equiv Ca, and 3 equiv Cl in that solution. (The valency of calcium is 2, so for that ion 1 mole is 2 equivalents.)
- Valency is defined as the combining capacity of atoms or molecules. It is obtained from the number of electrons present in the outermost shell of an atom.

In a precipitation reaction, for example, the reaction unit is the charge of the cation or anion involved in the reaction; thus for the reaction

$$Pb^{2+}(aq) + 2I^{-}(aq) \rightleftharpoons PbI_2(s)$$

$n = 2$ for Pb^{2+} and $n = 1$ for I^-.

In an acid–base reaction, the reaction unit is the number of H^+ ions donated by an acid or accepted by a base. For the reaction between sulfuric acid and ammonia

$$H_2SO_4(aq) + 2NH_3(aq) \rightleftharpoons 2NH_4^+(aq) + SO_4^{2-}(aq)$$

It was found that $n = 2$ for H_2SO_4 and $n = 1$ for NH_3. For a complexation reaction, the reaction unit is the number of electron pairs that can be accepted by the metal or donated by the ligand.

In the reaction between Ag^+ and NH_3 ,

$$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq)$$

The value of n for Ag^+ is 2 and that for NH_3 is 1. Finally, in an oxidation–reduction reaction the reaction unit is the number of electrons released by the reducing agent or accepted by the oxidizing agent; thus, for the reaction

$$2Fe^{3+}(aq) + Sn^{2+}(aq) \rightleftharpoons Sn^{4+}(aq) + 2Fe^{2+}(aq)$$

$n = 1$ for Fe3+ and $n = 2$ for Sn2+. Clearly, determining the number of equivalents for a chemical species requires an understanding of how it reacts.

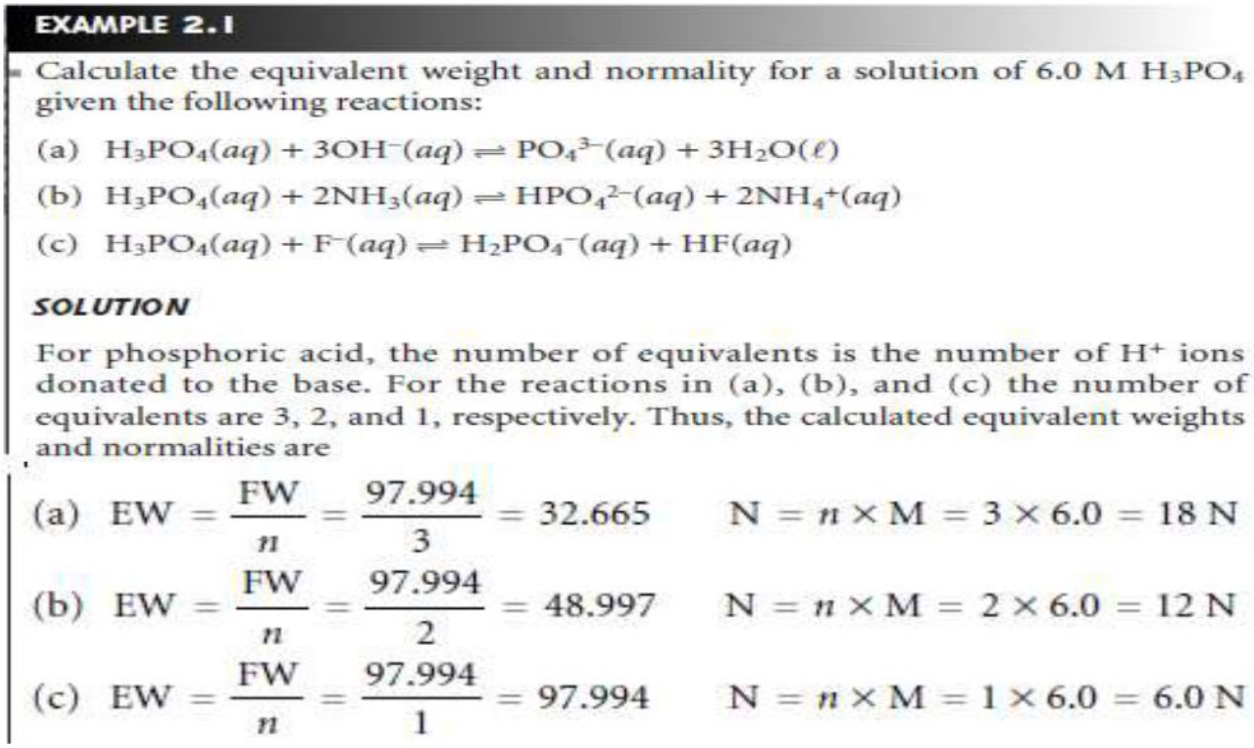
Normality is the number of **equivalent weights** (EW) per unit volume and, like formality, is independent of speciation. An equivalent weight is defined as the ratio of a chemical species' **formula weight** (FW) to the number of its equivalents

$$EW = \frac{FW}{n}$$

Consequently, the following simple relationship exists between normality and molarity.

$$N = n \times M$$

Example 2.1 illustrates the relationship among chemical reactivity, equivalent weight, and normality. .FW for H_3PO_4 [H=1*3, P=30.97, O=15.99*4] = 97.9



EXAMPLE 2.1

Calculate the equivalent weight and normality for a solution of 6.0 M H_3PO_4 given the following reactions:

(a) $H_3PO_4(aq) + 3OH^-(aq) \rightleftharpoons PO_4^{3-}(aq) + 3H_2O(\ell)$

(b) $H_3PO_4(aq) + 2NH_3(aq) \rightleftharpoons HPO_4^{2-}(aq) + 2NH_4^+(aq)$

(c) $H_3PO_4(aq) + F^-(aq) \rightleftharpoons H_2PO_4^-(aq) + HF(aq)$

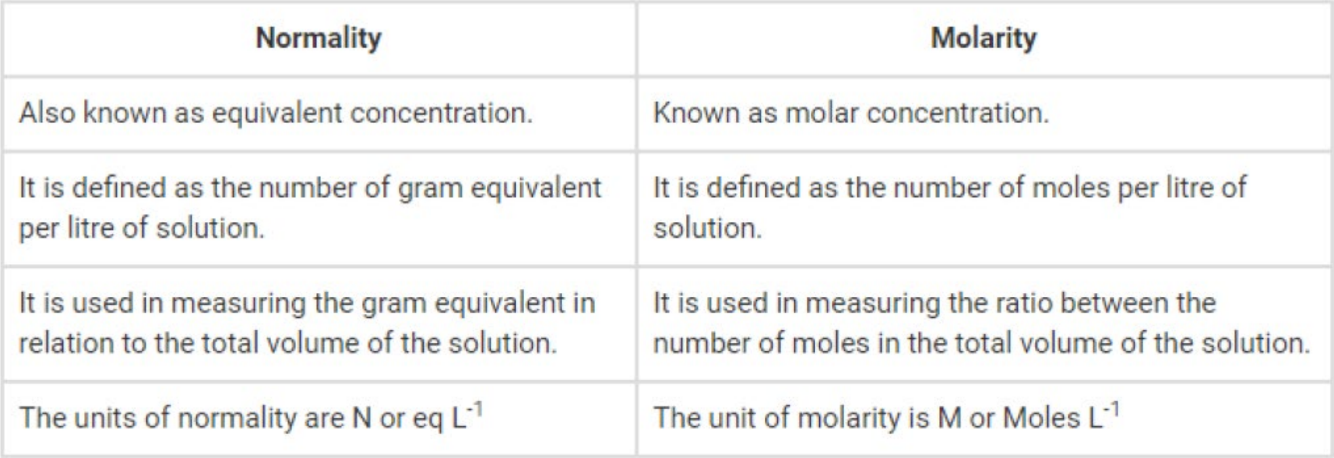
SOLUTION

For phosphoric acid, the number of equivalents is the number of H^+ ions donated to the base. For the reactions in (a), (b), and (c) the number of equivalents are 3, 2, and 1, respectively. Thus, the calculated equivalent weights and normalities are

(a) $EW = \frac{FW}{n} = \frac{97.994}{3} = 32.665 \qquad N = n \times M = 3 \times 6.0 = 18\ N$

(b) $EW = \frac{FW}{n} = \frac{97.994}{2} = 48.997 \qquad N = n \times M = 2 \times 6.0 = 12\ N$

(c) $EW = \frac{FW}{n} = \frac{97.994}{1} = 97.994 \qquad N = n \times M = 1 \times 6.0 = 6.0\ N$



Normality	Molarity
Also known as equivalent concentration.	Known as molar concentration.
It is defined as the number of gram equivalent per litre of solution.	It is defined as the number of moles per litre of solution.
It is used in measuring the gram equivalent in relation to the total volume of the solution.	It is used in measuring the ratio between the number of moles in the total volume of the solution.
The units of normality are N or eq L^{-1}	The unit of molarity is M or Moles L^{-1}

Uses of Normality

Normality is used mostly in three common situations:

- In determining the concentrations in acid-base chemistry. For instance, normality is used to indicate hydronium ions (H_3O^+) or hydroxide ions (OH^-) concentrations in a solution.
- Normality is used in precipitation reactions to measure the number of ions which are likely to precipitate in a specific reaction.
- It is used in redox reactions to determine the number of electrons that a reducing or an oxidizing agent can donate or accept.

Limitations in Using Normality

Many chemists use normality in acid-base chemistry to avoid the mole ratios in the calculations or simply to get more accurate results. While normality is used commonly in precipitation and redox reactions there are some limitations to it. These limitations are as follows:

- It is not a proper unit of concentration in situations apart from the ones that are mentioned above. It is an ambiguous measure and molarity or molality is better options for units.
- Normality requires a defined equivalence factor.
- It is not a specified value for a particular chemical solution. The value can significantly change depending on the chemical reaction. To elucidate further, one solution can actually contain different normalities for different reactions.

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الكسر المولي
المول المكافئ

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
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المادة العلمية:

Mole Fraction (X):- is defined as the number of moles of solute divided by the total numbers of moles of solute and solvent.

Mole Fraction (X)= $\frac{n1}{n1+n2}$

X= mole of some solute/ total moles in solution

When *n1* and *n2* are the numbers of moles of solute and solvent, respectively

Ex: 23.0g of ethanol when molecular weight= 46.0g/mol as a solute CH_3CH_2OH
And 85.0g water when molecular weight= 18.0g/mol as asolvent H_2O and total of 100 ml of ethanol /water find Mole Fraction of ethanol?

Solution:-

Mole Fraction of ethanol = moles of ethanol/ total moles in solution

No. of moles = Wt / M.wt

Mole of ethanol= 23.0 / 46.0= 0.500mole of ethanol

Mole of water= 85.0 / 18.0= 4.72 mole of water

Mole Fraction of ethanol= 0.5/0.500+4.72

=0.096

- .Mole fraction of any component of solution is the number of moles of this substance divided by the total number of moles for all components of solution.

$$\textbf{Mole fraction of solute} = \frac{\textbf{no. of moles of solute}}{\textbf{no. of moles of solute + no. of moles of solvent}}$$

Mole fraction of solvent = $n_2 \backslash n_1 + n_2$

Ex:- A solution contain 2 mole of ether and 6 mole of water. Calculate the mole fraction of each component?

$$\text{Mole fraction of ether} = \frac{\text{no. of moles of ether}}{\text{no. of moles of ether + no. of moles of water}}$$

$$\text{Mole fraction of ether} = \frac{2}{2+6} = 0.25$$

$$\text{Mole fraction of water} = \frac{\text{no. of moles of water}}{\text{no. of moles of water + no. of moles of ether}}$$

$$\text{Mole fraction of water} = \frac{6}{6+2} = 0.75$$

p-Functions

scientists frequently express the concentration of species in term of it is p-value or p-function : is the negative logarithm of molar concentration of that species .

the species X

P x = - log [x]

Example : what is the pH of a solution that 0.10 M H^+ ?

$pH = -\log[H^+] = -\log(0.1) = 1$

Example : what is the pH of 5.0 × 10^{-13} M H^+ ?

$pH = -\log[H+] = -\log(5.0 \times 10^{-13}) = 12.30$

$= -\log5 - \log10^{-13}$

$= -0.7 + 13\log10$ $\log10=1$

$= -0.7+13.0=12.3$

Example : What is p Na for a solution of 1.76×10^{-3} M Na_3PO_4?

Solution:-

Na_3PO_4 contains three moles of Na+,

$[Na+] = 3 \text{ mol } Na^{+} \times 1.76 \times 10^{-3}$

$[Na+] = 5.28 \times 10^{-3}$ M

And $p\,Na^{+}$ is

$P\,Na = -\log [Na+] = -\log (5.28 \times 10^{-3}) = 2.27$

الوحدة الأولى - المحاضرة السادسة - الزمن: 90 دقيقة

أهداف المحاضرة السادسة:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **ما المقصود التحليل الحجمي**

موضوعات المحاضرة السادسة:

مبادئ التحليل الحجمي
المحلول القياسي

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
6	• محاضرة • مناقشة • سؤال وجواب	• جهاز حاسوب • جهاز عرض • سبورة • اوراق واقلام

خطة إجراءات تنفيذ المحاضرة السادسة

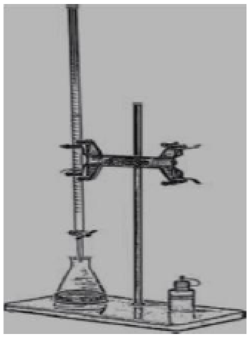
الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الأولى	**السادسة**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Volumetric analysis

- Volumetric analysis is one of the most useful and accurate analytical techniques, especially for millimole amounts of analyte.
- They are rapid and can be manual and automated, and they can be applied to smaller amounts of analyte when combined with a sensitive instrumental technique for detecting the completion of the titration reaction, for example, pH measurement.
- This method based on measured the volume of reagent needed to react with analyte.
- Titration methods are based on determining the quantity of a reagent of known concentration that is required to react completely with the analyte. The reagent may be a standard solution of a chemical or an electric current of known magnitude.

- A volume-based titration is shown in the Figure in which the standard solution is added from a buret, and the reaction occurs in the Erlenmeyer flask. In some titrations, known as coulometric titrations



- In coulometric titrations, the quantity of charge required to complete a reaction with the analyte is the measured quantity.

- A standard solution is a reagent of known concentration. Standard solutions are used in titrations and in many other chemical analyses.

- Back-titration is a process in which the excess of a standard solution used to consume an analyte is determined by titration with a second standard solution. Back-titrations are often required when the rate of reaction between the analyte and reagent is slow or when the standard solution lacks stability.

- **Equivalence point** is the point in a titration when the amount of added standard reagent is equivalent to the amount of analyte.

- **End point** is the point in a titration when a physical change occurs that is associated with the condition of chemical equivalence.

- In volumetric methods, the titration error, Et, is given by

$$\mathbf{Et = V_{ep} - V_{eq}}$$

- Where
- $\mathbf{V_{ep}}$ is the actual volume of reagent required to reach the end point.
- $\mathbf{V_{eq}}$ is the theoretical volume necessary to reach equivalence point.
- **Indicators** are often added to the analyte solution to produce an observable physical change (signaling the end point) at or near the equivalence point. Large changes in the relative concentration of analyte or titrant occur in the equivalence-point region. These concentration changes cause the indicator to change in appearance.
- **Typical indicator changes** include the appearance or disappearance of a color, a change in color, or the appearance or disappearance of turbidity.

- **Primary standard** is a highly purified compound that serves as a reference material in titrations and in other analytical methods. The accuracy of a method critically depends on the properties of the primary standard.
- 1. High purity.
- 2. Atmospheric stability.
- 3. Absence of hydrate water.
- 4. Modest cost.
- 5. Reasonable solubility in the titration medium.
- 6. Reasonably large molar mass.
- **Secondary standard** is a compound whose purity has been determined by chemical analysis. The secondary standard serves as the working standard material for titrations and for many other analyses.

- **Standard solutions** play a central role in all titrations. Therefore, we must consider the desirable properties for such solutions, how they are prepared, and how their concentrations are expressed. The *ideal* standard solution for a titrimetric method will

- 1. Be sufficiently stable so that it is necessary to determine its concentration only once;

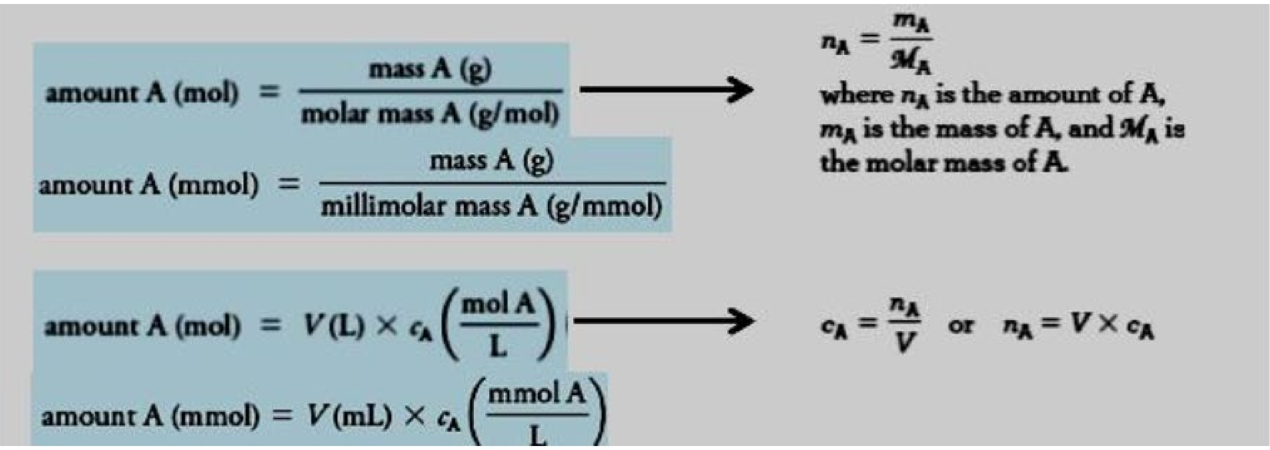
- 2. React rapidly with the analyte so that the time required between additions of reagent is minimized;

- 3. React more or less completely with the analyte so that satisfactory end points are realized;

- 4. Undergo a selective reaction with the analyte that can be described by a balanced equation.
- Two basic methods are used to establish the concentration of such solutions.
- Direct method in which a carefully determined mass of a primary standard is dissolved in a suitable solvent and diluted to a known volume in a volumetric flask.
- 2. Standardization in which the titrant to be standardized is used to titrate
- A) known mass of a primary standard,
- (B) A known mass of a secondary standard,
- C) or a measured volume of another standard solution.

- **In a standardization,** the concentration of a volumetric solution is determined by titrating it against a carefully measured quantity of a primary or secondary standard or an exactly known volume of another standard solution.

Volumetric Calculations



$$\text{amount A (mol)} = \frac{\text{mass A (g)}}{\text{molar mass A (g/mol)}} \longrightarrow n_A = \frac{m_A}{\mathcal{M}_A}$$

$$\text{amount A (mmol)} = \frac{\text{mass A (g)}}{\text{millimolar mass A (g/mmol)}}$$

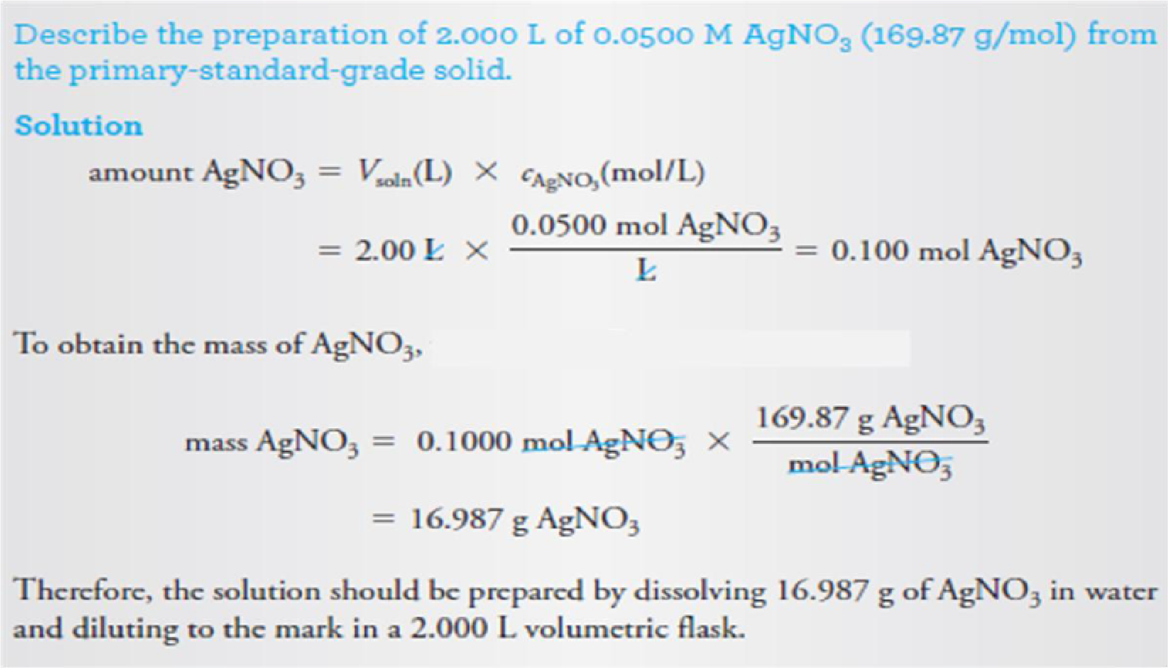
where n_A is the amount of A, m_A is the mass of A, and $\mathcal{M}_A$ is the molar mass of A.

$$\text{amount A (mol)} = V(\text{L}) \times c_A\left(\frac{\text{mol A}}{\text{L}}\right) \longrightarrow c_A = \frac{n_A}{V} \quad \text{or} \quad n_A = V \times c_A$$

$$\text{amount A (mmol)} = V(\text{mL}) \times c_A\left(\frac{\text{mmol A}}{\text{L}}\right)$$

Calculating the Molar Concentration of Standard Solutions

The following three examples illustrate how the concentrations of volumetric reagents are calculated.



Describe the preparation of 2.000 L of 0.0500 M $AgNO_3$ (169.87 g/mol) from the primary-standard-grade solid.

Solution

$$\text{amount } AgNO_3 = V_{soln}(L) \times c_{AgNO_3}(mol/L)$$

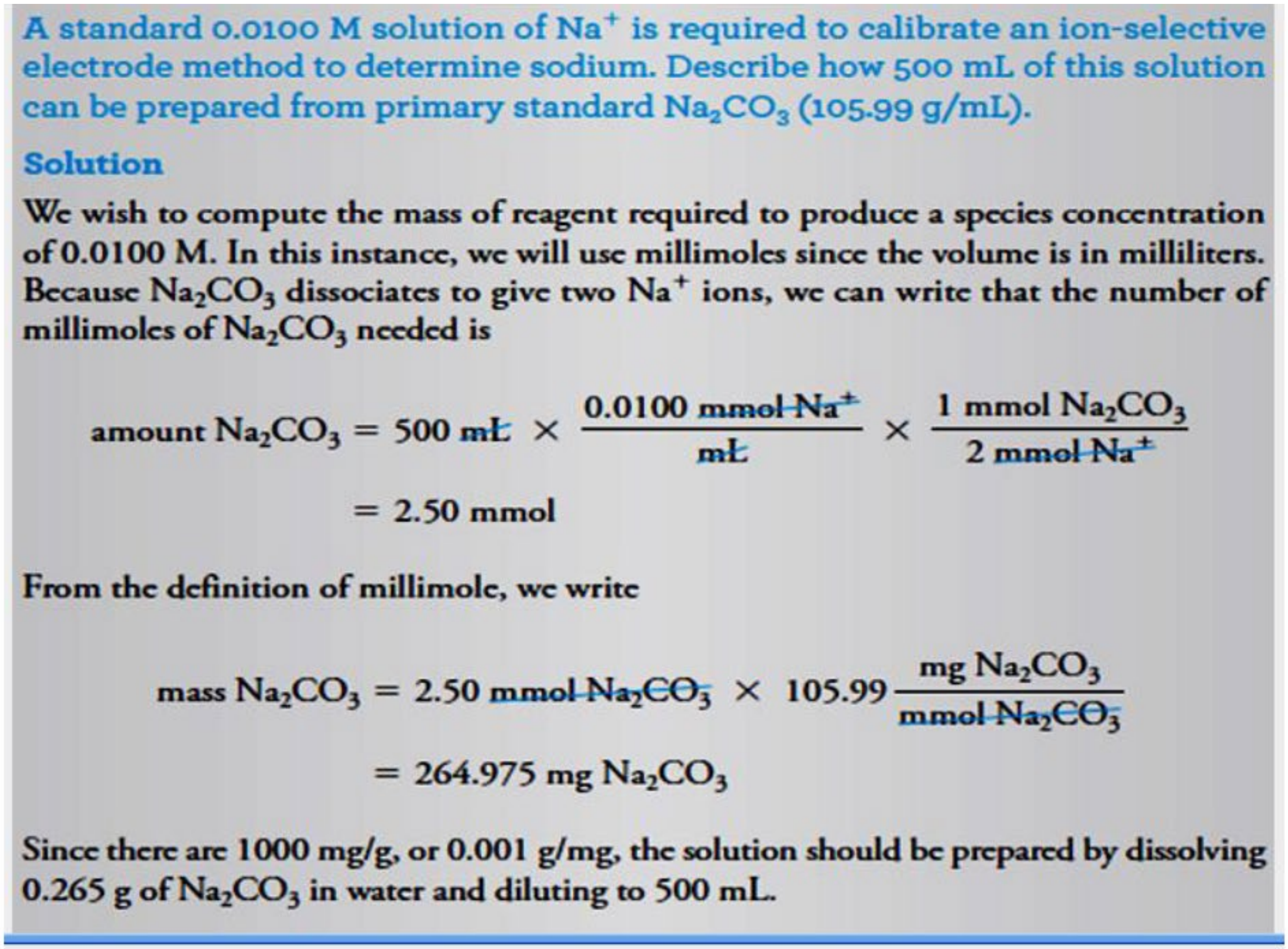
$$= 2.00\ \cancel{L} \times \frac{0.0500\ mol\ AgNO_3}{\cancel{L}} = 0.100\ mol\ AgNO_3$$

To obtain the mass of $AgNO_3$,

$$\text{mass } AgNO_3 = 0.1000\ \cancel{mol\ AgNO_3} \times \frac{169.87\ g\ AgNO_3}{\cancel{mol\ AgNO_3}}$$

$$= 16.987\ g\ AgNO_3$$

Therefore, the solution should be prepared by dissolving 16.987 g of $AgNO_3$ in water and diluting to the mark in a 2.000 L volumetric flask.



A standard 0.0100 M solution of Na^+ is required to calibrate an ion-selective electrode method to determine sodium. Describe how 500 mL of this solution can be prepared from primary standard Na_2CO_3 (105.99 g/mL).

Solution

We wish to compute the mass of reagent required to produce a species concentration of 0.0100 M. In this instance, we will use millimoles since the volume is in milliliters. Because Na_2CO_3 dissociates to give two Na^+ ions, we can write that the number of millimoles of Na_2CO_3 needed is

$$\text{amount } Na_2CO_3 = 500\ \cancel{\text{mL}} \times \frac{0.0100\ \cancel{\text{mmol Na}^+}}{\cancel{\text{mL}}} \times \frac{1\ \text{mmol } Na_2CO_3}{2\ \cancel{\text{mmol Na}^+}}$$

$$= 2.50\ \text{mmol}$$

From the definition of millimole, we write

$$\text{mass } Na_2CO_3 = 2.50\ \cancel{\text{mmol } Na_2CO_3} \times 105.99\ \frac{\text{mg } Na_2CO_3}{\cancel{\text{mmol } Na_2CO_3}}$$

$$= 264.975\ \text{mg } Na_2CO_3$$

Since there are 1000 mg/g, or 0.001 g/mg, the solution should be prepared by dissolving 0.265 g of Na_2CO_3 in water and diluting to 500 mL.

الوحدة الأولى - المحاضرة السابعة - الزمن: 90 دقيقة

أهداف المحاضرة السابعة:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **ما المقصود التحليل الحجمي**

موضوعات المحاضرة السابعة:

تصنيف التحليل الحجمي

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
7	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة السابعة

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الأولى	السابعة	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Classification of volumetric Methods:

1. ***Acid-Base.*** Many compounds, both inorganic and organic, are either acids or bases and can be titrated with a standard solution of a strong base or a strong acid. The end points of these titrations are easy to detect, either by means of an indicator or by following the change in pH with a pH meter here are four general classes of volumetric or titrimetric methods.

$$HCl+NaOH \longrightarrow NaCl+H_2O$$

2. ***Precipitation.*** In the case of precipitation, the titrantforms an insoluble product with the analyte. An example is the titration of chloride ion with silver nitrate solution to form silver chloride precipitate

$$AgNO_3+NaCl \longrightarrow AgCl\downarrow +NaNO_3$$

3. ***Complexometric.*** In complexometrictitrations, the titrantis a reagent that forms a water-soluble complex with the analyte, a metal ion.

$$Ca+EDTA \longrightarrow \text{soluble complex ion}$$

4. ***Reduction-Oxidation.*** These "redox" titrations involve the titration of an oxidizing agent with a reducing agent, or vice versa. An oxidizing agent gains electrons and a reducing agent loses electrons in a reaction between them.

$$2KMnO_4+5Na_2C_2O_4+16HCl \longrightarrow 2Mn(+2) + 10CO_2 + 8H_2O$$

الوحدة الأولى - المحاضرة الثامنة - الزمن: 90 دقيقة

أهداف المحاضرة الثامنة:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **ما المقصود التحليل الحجمي**

موضوعات المحاضرة الثامنة:

كواشف الحوامض و القواعد
المحاليل المنظمة

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
8	• محاضرة • مناقشة • سؤال وجواب	• جهاز حاسوب • جهاز عرض • سبورة • اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الثامنة

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الأولى	الثامنة	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

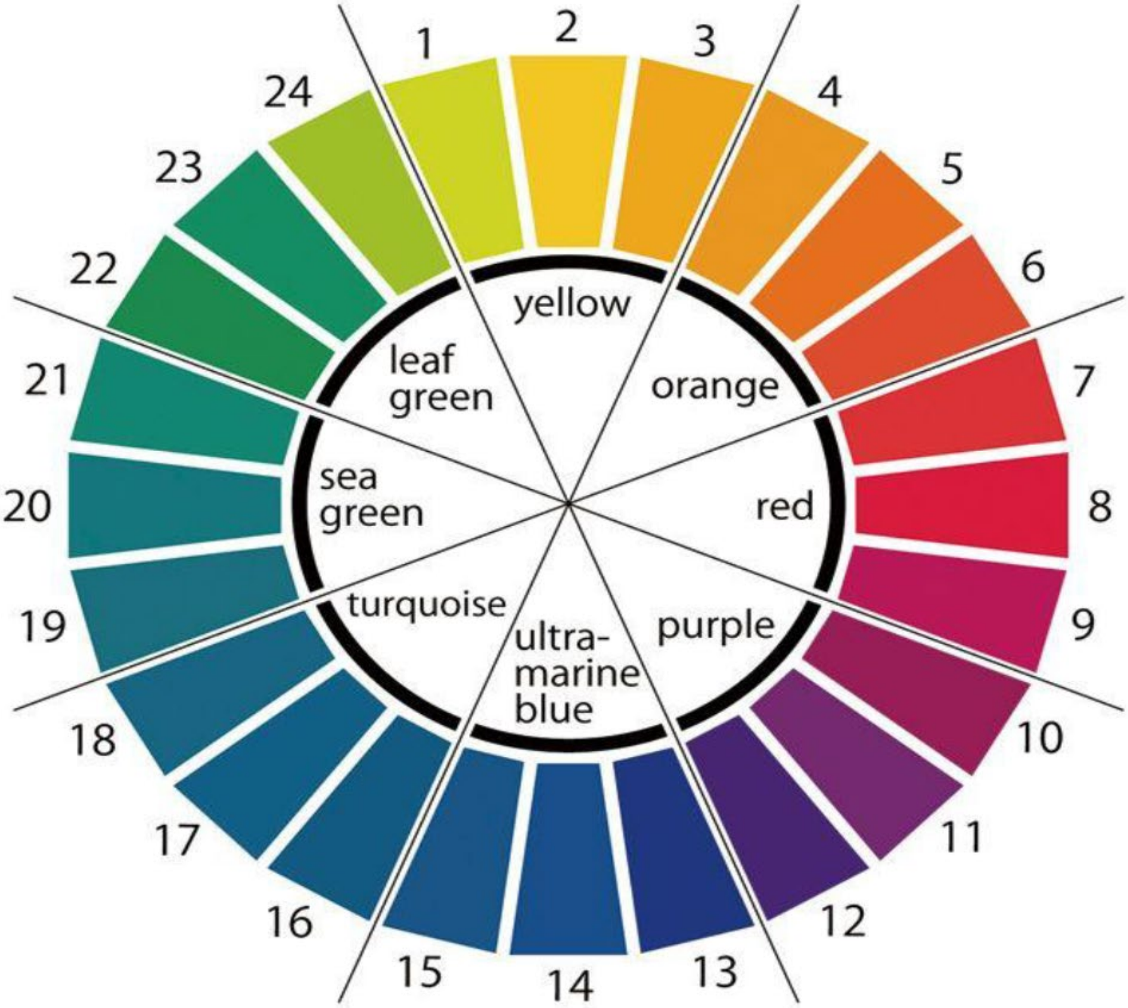
Theories of Acid-base indicators

1. (Ostwald theory)

According to this theory:

(a) The color change is due to ionization of the acid-base indicator. The unionized form has different color than the ionized form.

(b) The ionization of the indicator is largely affected in acids and bases as it is either a weak acid or a weak base. In case, the indicator is a weak acid, its ionization is very much low in acids due to common H+ ions while it is fairly ionized in alkalis. Similarly if the indicator is a weak base, its ionization is large in acids and low in alkalis due to common OH- ions.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20
21
22
23
24
yellow
orange
red
purple
ultra-marine blue
turquoise
sea green
leaf green

2. (Quinonoid theory)

According to this theory:

(a)The acid-base indicators exist in two tautomeric forms having different structures. Two forms are in equilibrium. One form is termed benzenoid form and the other Quinonoid form.

(b) The two forms have different colors. The color change in due to the interconversation of one tautomeric form into other.

(c) One form mainly exists in acidic medium and the other in alkaline medium.

How an Acid-Base Indicator Works

If the indicator is a weak acid, the acid and its conjugate base are different colors. If the indicator is a weak base, the base, and its conjugate acid display different colors.

For a weak acid indicator with the general formula HIn, equilibrium is reached in the solution according to the chemical equation:

$$HIn(aq) + H_2O(l) \leftrightarrow In^-(aq) + H_3O^+(aq)$$

HIn(aq) is the acid, which is a different color from the base $In^-(aq)$. When the pH is low, the concentration of the hydronium ion H_3O^+ is high and equilibrium is toward the left. At high pH, the concentration of H_3O^+ is low, so equilibrium tends toward the right side of the equation.

An example of a weak acid indicator is phenolphthalein, which is colorless as a weak acid but dissociates in water to form a magenta or red-purple anion. In an acidic solution, equilibrium is to the left, so the solution is colorless (too little magenta anion to be visible), but as pH increases, the equilibrium shifts to the right and the magenta color is visible.

The equilibrium constant for the reaction may be determined using the equation:

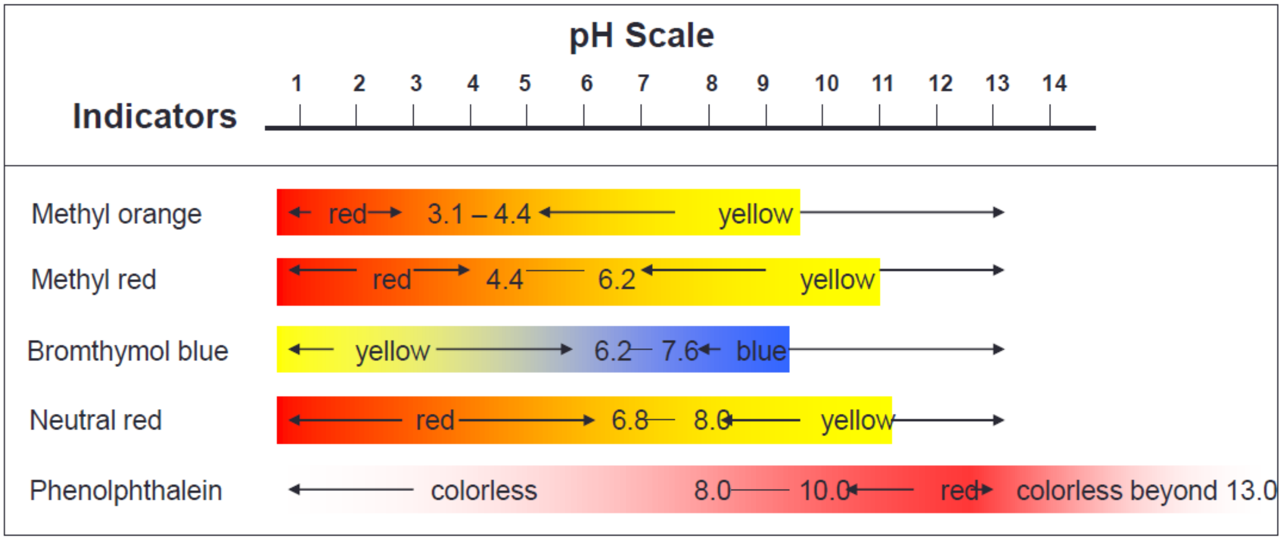
$$K_{In} = [H_3O^+][In^-] / [HIn]$$

where K_{In} is the indicator dissociation constant. The color change occurs at the point where the concentration of the acid and anion base is equal:

$$[HIn] = [In^-]$$

which is the point where half of the indicator is in acid form and the other half is its conjugate base.

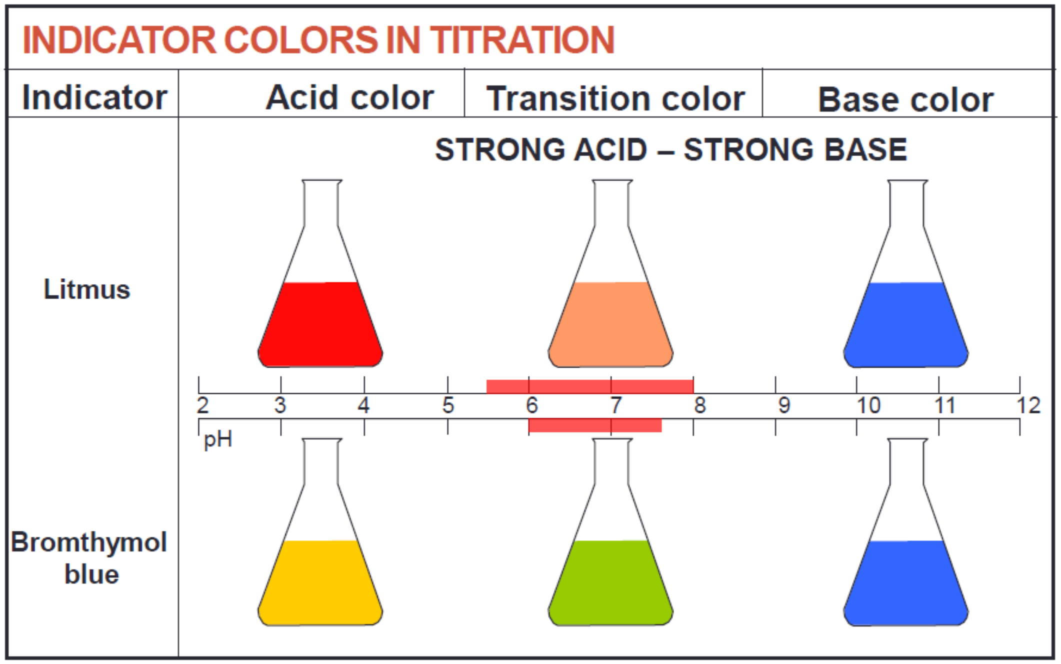
Range and Color Changes of Some Common Acid-Base Indicators



Bromthymol blue indicator would be used in titrating a strong acid with a strong base.

Phenolpthalein indicator would be used in titrating a weak acid with a strong base.

Methyl orange indicator would be used in titrating a strong acid with a weak base.


INDICATOR COLORS IN TITRATION
Indicator
Acid color
Transition color
Base color
STRONG ACID – STRONG BASE
Litmus
2
3
4
5
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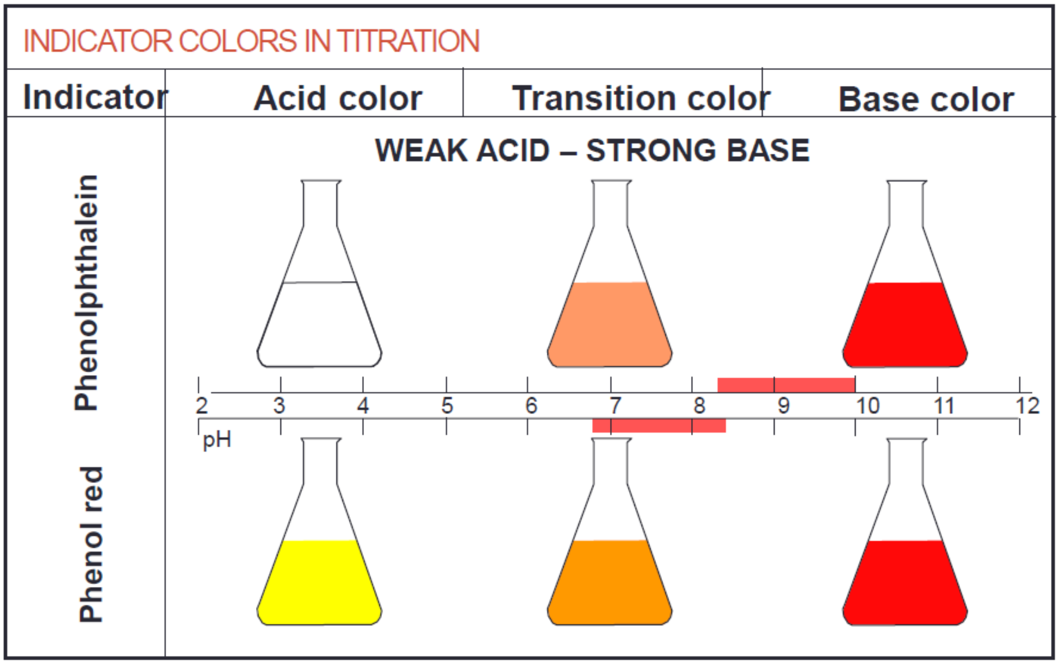
7
8
9
10
11
12
pH
Bromthymol blue


INDICATOR COLORS IN TITRATION
Indicator
Acid color
Transition color
Base color
WEAK ACID – STRONG BASE
Phenolphthalein
Phenol red
2
3
4
5
6
7
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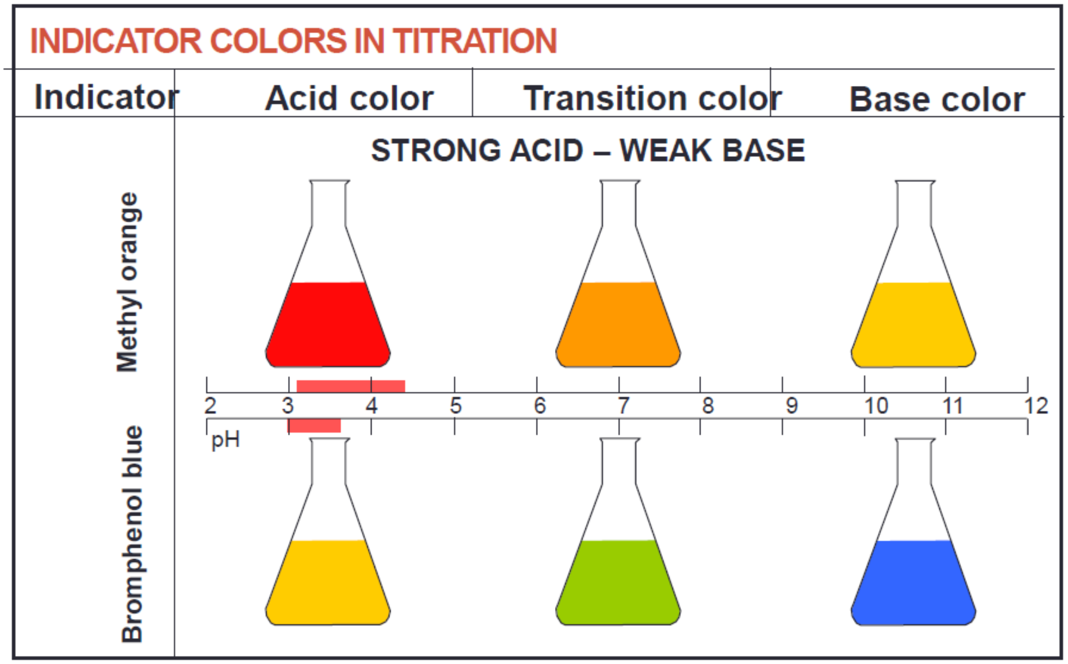
pH


INDICATOR COLORS IN TITRATION
Indicator
Acid color
Transition color
Base color
STRONG ACID – WEAK BASE
Methyl orange
Bromphenol blue
2
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4
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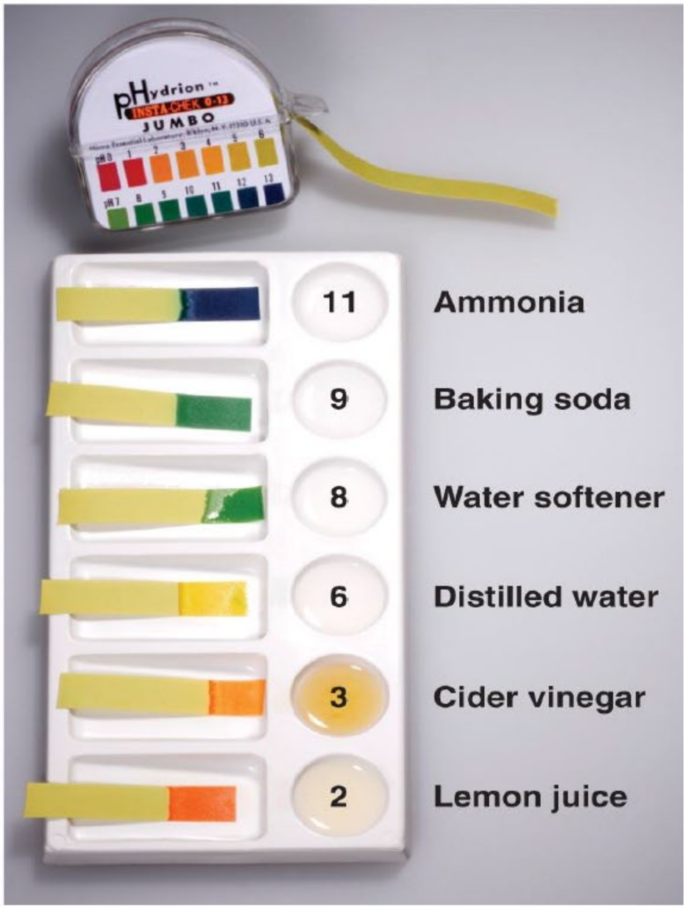
pH

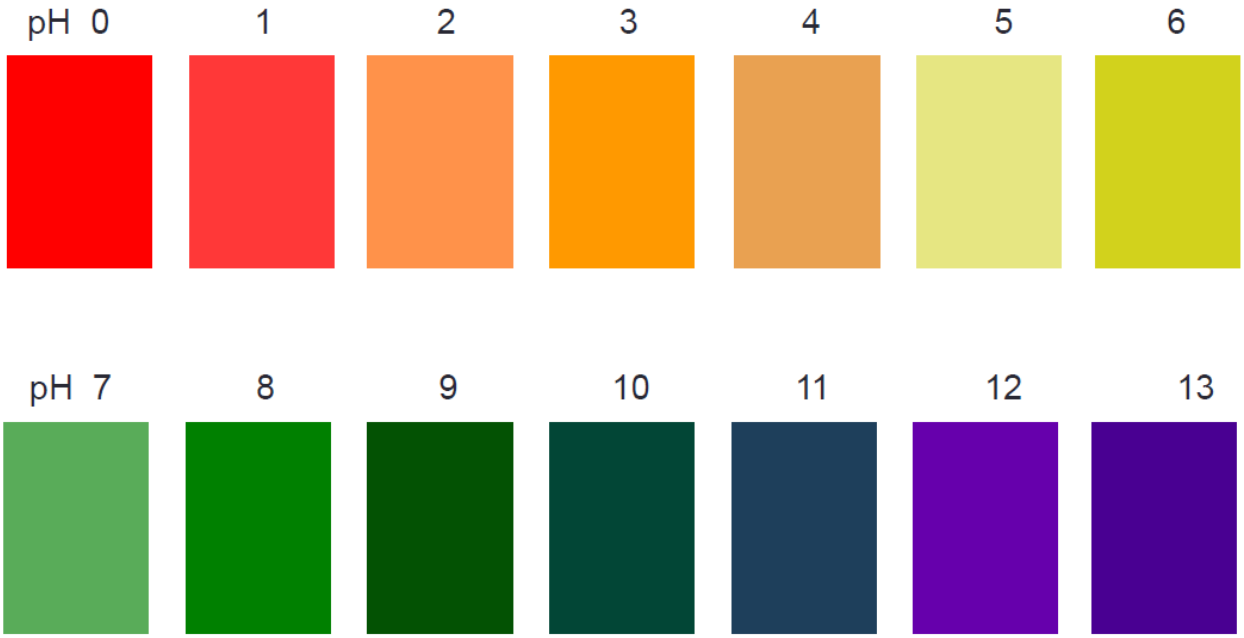
pH indicator

A **pH indicator** is a halochromic chemical compound added in small amounts to a solution so the pH (acidity or basicity) of the solution can be determined visually. Hence, a pH indicator is a chemical detector for hydronium ions (H_3O^+) or hydrogen ions (H^+) in the Arrhenius model. Normally, the indicator causes the color of the solution to change depending on the pH. Indicators can also show change in other physical properties; for example, olfactory indicators show change in their odor. The pH value of a neutral solution is 7.0 at 25°C (standard laboratory conditions).

Solutions with a pH value below 7.0 are considered acidic and solutions with pH value above 7.0 are basic (alkaline). As most naturally occurring organic compounds are weak protolytes, carboxylic acids and amines, pH indicators find many applications in biology and analytical chemistry.



pH Paper



Buffer Solutions

A buffer is defined as a solution that resists change in pH when a small amount of an acid or base is added or when the solution is diluted.

A buffer solution consists of a mixture of a weak acid and its conjugate base, or a weak base, and its conjugate acid at predetermined concentrations or ratios. That is, we have a mixture of a weak acid and its salt or a weak base and its salt.

The equilibrium that governs this system is:

$$\mathrm{HOAc} \rightleftharpoons \mathrm{H}^+ + \mathrm{OAc}^-$$

$$[\mathrm{H}^+] = K_a \frac{[\mathrm{HOAc}]}{[\mathrm{OAc}^-]}$$

Taking the negative logarithm of each side of this equation, we have:

$$-\log[\mathrm{H}^+] = -\log K_a - \log \frac{[\mathrm{HOAc}]}{[\mathrm{OAc}^-]}$$

$$\mathrm{pH} = \mathrm{p}K_a - \log \frac{[\mathrm{HOAc}]}{[\mathrm{OAc}^-]}$$

Upon inverting the last log term, it becomes positive:

$$\mathrm{pH} = \mathrm{p}K_a + \log \frac{[\mathrm{OAc}^-]}{[\mathrm{HOAc}]}$$

This form of the ionization constant equation is called the **Henderson–Hasselbalch equation**. It is useful for calculating the pH of a weak acid solution containing its salt.

Example \\ The normal pH of human blood is about 7.4. The carbonate buffer system in the blood uses the following equilibrium reaction:

$$CO_2(g)+{}_2H_2O(l)\rightleftharpoons H_2CO_3(aq)\rightleftharpoons HCO_3{}^-(aq)+H_3O+(aq)CO_2(g)+{}_2H_2O(l)\rightleftharpoons H_2CO_3(aq)\rightleftharpoons HCO_3{}^-(aq)+H_3O+(aq)$$

The concentration of carbonic acid, H_2CO_3 is approximately 0.0012 *M*, and the concentration of the hydrogen carbonate ion, $HCO_3{}^-$,$HCO_3{}^-$, is around 0.024 *M*. Using the Henderson-Hasselbalch equation and the pK_a of carbonic acid at body temperature, we can calculate the pH of blood:

$$\mathrm{pH} = \mathrm{p}K_a + \log \frac{[\mathrm{base}]}{[\mathrm{acid}]} = 6.4 + \log \frac{0.024}{0.0012} = 7.7$$

Buffers are broadly divided into two types:

– acidic and alkaline buffer solutions.

Acidic buffers are **solutions** that have **a pH below 7** and contain a weak acid and one of its salts. For example, a mixture of acetic acid and sodium acetate acts as a buffer solution with a pH of about 4.75.

Alkaline buffers, on the other hand, have a **pH above 7 and contain a weak base and one of its salts**. For example, a mixture of ammonium chloride and ammonium hydroxide acts as a buffer solution with a pH of about 9.25. Buffer solutions help maintain the pH of many different things as shown in the image below.

- ✓ **Polar solvents can be further divided into protic and aprotic.**

Polar protic solvents are **capable of hydrogen bonding** because they contain at least one hydrogen atom connected directly to an electronegative atom (such as O-H or N-H bonds). They solvate cations and anions effectively. Polar protic solvents are water, ethanol, methanol, acetic acid, and others

polar aprotic solvents contain no hydrogen atoms connected directly to an electronegative atom and they **are not capable** of hydrogen bonding. These are acetone, dimethyl sulfoxide, DMF (N,N-dimethylformamide), acetonitrile and others.

Polyprotic Acids and Their Salts

Many acids or bases are polyfunctional, that is, have more than one ionizable proton or hydroxide ion. These substances ionize stepwise, and an equilibrium constant can be written for each step. Consider, for example, the ionization of phosphoric acid:

$$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^- \qquad K_{a1} = 1.1 \times 10^{-2} = \frac{[H^+][H_2PO_4^-]}{[H_3PO_4]}$$

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-} \qquad K_{a2} = 7.5 \times 10^{-8} = \frac{[H^+][HPO_4^{2-}]}{[H_2PO_4^-]}$$

$$HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-} \qquad K_{a3} = 4.8 \times 10^{-13} = \frac{[H^+][PO_4^{3-}]}{[HPO_4^{2-}]}$$

the overall ionization is the sum of these individual steps and the overall ionization constant is the product of the individual ionization constants:

$$H_3PO_4 \rightleftharpoons 3H^+ + PO_4^{3-}$$

$$K_a = K_{a1}K_{a2}K_{a3} = 4.0 \times 10^{-22} = \frac{[H^+]^3[PO_4^{3-}]}{[H_3PO_4]}$$

Note\\ Buffers do not maintain pH at an absolutely constant value, but changes in pH are relatively small when small amounts of acid or base are added.

Buffer Capacity

The **buffer capacity, β,** of a solution is defined as the number of moles of a strong acid or a strong base that causes 1.00 L of the buffer to undergo a 1.00-unit change in pH. Mathematically, buffer capacity is given by :

$$\beta = \frac{dc_b}{dpH} = -\frac{dc_a}{dpH}$$

Where:

dc_b is the number of moles per liter of strong base added to the buffer.

dc_a is the number of moles per liter of strong acid added to the buffer.

- Since adding strong acid to a buffer causes the pH to decrease, dc_a/dpH is negative, and buffer capacity is always positive.
- Buffer capacity depends not only on the total concentration of the two buffer components but also on their concentration ratio (buffer capacity decreases fairly rapidly as the concentration ratio of acid to conjugate base becomes larger or smaller than 1) .

الوحدة الأولى - المحاضرة التاسعة - الزمن: 90 دقيقة

أهداف المحاضرة التاسعة:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **ما المقصود التحليل الحجمي**

موضوعات المحاضرة التاسعة:

تفاعلات تكوين الراسب
مقياس الرقم الحامضي pH

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
9	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة التاسعة

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الأولى	**التاسعة**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

The pH Scale:

It is more convenient to compress the acidity scale by placing it on a logarithm basis. The **pH** of a solution was defined **by Sorenson** as:

$$pH = -\log[H^+]$$

A similar definition is made for the hydroxide ion concentration:

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

The equation in logarithm form for a more direct calculation of pH or pOH is :

$$-\log Kw = -\log[H^+][OH^-] = -\log[H^+] - \log [OH^-]$$

At 25◦C,

$$pKw = pH + pOH$$

$$14.00 = pH + pOH$$

Example \\ A 1.0×10^{-3} M solution of hydrochloric acid is prepared. What is the hydroxide ion concentration?

Solution

Since hydrochloric acid is a strong electrolyte and is completely ionized, the H^+ concentration is 1.0×10^{-3} M.

Thus,

$$(1.0 \times 10^{-3})\,[OH^-] = 1.0 \times 10^{-14}$$

$$[OH^-] = 1.0 \times 10^{-11}\ M$$

Example

Calculate the pH of a 2.0×10^{-3} *M* solution of HCl.

Solution

HCl is completely ionized, so

$$[H^+] = 2.0 \times 10^{-3}\ M$$

$$pH = -\log(2.0 \times 10^{-3}) = 3 - \log 2.0 = 3 - 0.30 = 2.70$$

Weak Acids and Bases—What Is the pH?

**Example **

Calculate the pH and pOH of a 1.00 × 10–3 *M* solution of acetic acid.

Solution

$$HOAc \rightleftharpoons H^+ + OAc^-$$

The concentrations of the various species in the form of an ICE table are as follows:

	$[HOAc]$	$[H^+]$	$[OAc^-]$
Initial	1.00×10^{-3}	0	0
Change (x = mmol/mL HOAc ionized)	$-x$	$+x$	$+x$
Equilibrium	$1.00 \times 10^{-3} - x$	x	x

$$\frac{(x)(x)}{1.00 \times 10^{-3} - x} = 1.75 \times 10^{-5}$$

$$\frac{x^2}{1.00 \times 10^{-3}} = 1.75 \times 10^{-5}$$

$$x = 1.32 \times 10^{-4}\, M \equiv [\mathrm{H}^+]$$

Therefore,

$$\mathrm{pH} = -\log(1.32 \times 10^{-4}) = 4 - \log 1.32 = 4 - 0.12 = 3.88$$

$$\mathrm{pOH} = 14.00 - 3.88 = 10.12$$

Solubility Equilibrium and solubility produce

Solubility is a very important phenomenon. The fact that substance such as sugar and table salt dissolve in water allows us to flavor food easily. Because calcium carbonate is less soluble in hot water than in cold water it coats tube in boilers, reducing thermal efficiency.

In this section we consider the equilibrium associated with solid dissolving in water to form aqueous solutions. When an ionic solid dissolves in water, we typically assume that it dissociates into separate cations and anions, for example:

$$CaF_{2(s)} \rightarrow Ca^{2+}_{(aq)} + 2F^{-}_{(aq)}$$

When the solid salt is first added to water, no $Ca^{2+} or F^{-}$ are present. However, as the dissolution proceeds, the ions of Ca^{2+}, F^{-}increase, making it more and more likely these ions will collide, and reform the solid phase.

$Ca^{2+}_{(aq)} + 2F^{-}_{(aq)} \rightarrow\ CaF_{2(s)}$

Ultimately, dynamic equilibrium is reached:

$$CaF_{2(s)} \rightleftharpoons Ca^{2+}_{(aq)} + 2F^{-}_{(aq)}$$

Solubility product constant →

$$k_{s.p} = [Ca^{2+}][F^{-}]^2$$

Since CaF_2 is a pure solid, it is not included in the equilibrium expression, it has an activity of 1. The fact that these of excess solid present does not affect the position of solubility equilibrium might seem strange at first, solid means more surface area exposed to solvent, which seem to result in greater solubility. This is not the case, however when the ions of solution reform the solid they does on the surface of the solid. Thus doubling the surface area of the solid not only doubles the rate of dissolving but also doubles the rate of re-formation of the solid the amount of excess solid present therefore has no effect on the equilibrium position.

Ex: Calculate the k_{sp} value for bismuth sulfide Bi_2S_3 which has a solubility of 1×10^{-15}mol/L at 25C°?

Sol: $Bi_2S_{3(s)} \rightleftharpoons 2Bi^{+3} + 3S^{-}$

$$k_{s.p} = [Bi^{+3}]^2[S^{-}]^3 \Rightarrow (2 \times 1 \times 10^{-15})^2(3 \times 1 \times 10^{-15})^3 = 1.1 \times 10^{-73}.$$

Ex: The k_{sp} value for copper (II) iodate,$Cu(IO_3)_2$ is 1.4×10^{-7} at 25C°. Calculate its solubility at 25C°?

Sol: $Cu(IO_3)_{2(s)} \rightleftharpoons Cu^{+2} + 2IO_3^{-}$

$$k_{s.p} = 1.4 \times 10^{-7} = [Cu^{+2}][IO_3^{-}]^2 \Rightarrow (s)(2s)^2 = 4s^3$$

$$1.4 \times 10^{-7} = 4s^3$$

$$\therefore s = 3.3 \times 10^{-3}\text{mol/L}$$

pH and Solubility: The pH of a solution can affect a salt solubility for example:

$$Mg(OH)_2 \rightleftharpoons Mg^{+2} + 2OH^-$$

Addition of OH^- ion (an increase in pH) will, by the common effect. Force equilibrium to the left, decreasing the solubility of $Mg(OH)_2$. On the other hand, an addition of H^+ ions (a decrease in pH) increase the solubility, because of OH^- ion are remain from solution by reacting with the added H^+ions. In response to lower concentration of OH^-, the equilibrium position moves to the right.

الوحدة الأولى - المحاضرة العاشرة - الزمن: 90 دقيقة

أهداف المحاضرة العاشرة:

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1. **ما المقصود تحليل الوزن النوعي**

موضوعات المحاضرة العاشرة:

حسابات تحليل الوزن النوعي

الأساليب والأنشطة والوسائل التعليمية

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المادة العلمية:

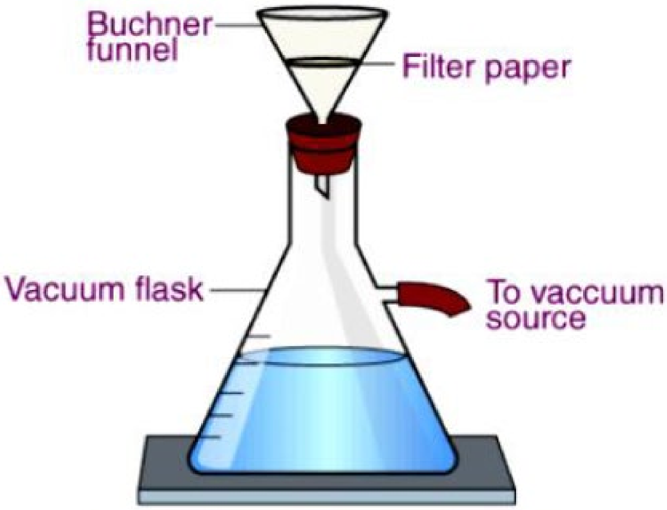
Gravimetric analysis

is one of the most accurate and precise methods of macroquan-titative analysis. In this process the analyte is selectively converted to an insoluble form.

The separated precipitate is dried or ignited, possibly to another form, and is accurately weighed. From the weight of the precipitate and a knowledge of its chemical composition, we can calculate the weight of analyte in the desired form.

The principle of Gravimetric Analysis:

The principle behind the gravimetric analysis is that the mass of an ion in a pure compound and can be determined. Later, used to find the mass percent of the same ion in a known quantity of an impure compound.



Gravimetric Analysis Apparatus

-How to Perform a Successful Gravimetric Analysis

A successful gravimetric analysis consists of a number of important operations designed to obtain a pure and filterable precipitate suitable for weighing.

-WHAT STEPS ARE NEEDED?

The steps required in a gravimetric analysis, after the sample has been dissolved, can be summarized as follows:

1. Preparation of the solution
2. Precipitation
3. Digestion
4. Filtration
5. Washing
6. Drying
7. Weighing
8. Calculation

Types of Gravimetric Analysis:

There are 4 fundamental types of gravimetric analysis. Of which, there are 2 common types involving changes in the phase of the analyte to separate it from the rest of a mixture, resulting in a change in mass.

1-Volatilization gravimetry

Volatilization Gravimetry involves separating components of our mixture by heating or chemically decomposing the sample.

2-Precipitation gravimetry

Precipitation Gravimetry uses a precipitation reaction to separate one or more parts of a solution by incorporating it into a solid.

3-Electrogravimetry

Electrogravimetry is a method used to separate and quantify ions of a substance, usually a metal.

4-Thermogravimetric

Thermogravimetric is a method of thermal analysis in which changes in physical and chemical properties of materials are measured as a function of increasing temperature or as a function of time.

-Advantages of Gravimetric Analysis:

If the methods are followed carefully, it provides exceedingly precise analysis. It is used to determine the atomic masses of many elements to six-figure accuracy. It provides a little room for instrumental error and does not require a series of standards for calculation of an unknown.

-Disadvantages of Gravimetric Analysis:

It usually provides only for the analysis of a single element, or a limited group of elements, at a time. Comparing modern dynamic flash combustion coupled with gas chromatography with traditional combustion analysis.

الوحدة الأولى - المحاضرة الحادية عشر - الزمن: 90 دقيقة

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المادة العلمية:

Example:

Precipitation method for determining calcium in water.

In this technique.

1. An excess of oxalic acid, H2C2O4, is added to an aqueous solution of the sample.
2. Ammonia is then added, which neutralizes the acid and causes essentially all of the calcium in the sample to precipitate as calcium oxalate.

The reactions are :

$$2NH_3 + H_2C_2O_4 \rightarrow 2NH_4^{+} + C_2O_4^{2-}$$

$$Ca^{2+}(aq) + C_2O_4^{2-}(aq) \rightarrow CaC_2O_4\,(s)$$

3. The CaC2O4 precipitate is filtered using a weighed filtering crucible, then dried and ignited. This process converts the precipitate entirely to calcium oxide.

The reaction is

$$\mathrm{CaC_2O_4}(s) \xrightarrow{\Delta} \mathrm{CaO}(s) + \mathrm{CO}(g) + \mathrm{CO_2}(g)$$

4. After cooling, the crucible and precipitate are weighed, and the mass of calcium oxide is determined by subtracting the known mass of the crucible.

Gravimetric Calculations—How Much Analyte Is There?

The **gravimetric factor** (GF) which represents the weight of analyte per unit weight of precipitate. It is obtained from the ratio of the formula weight of the analyte to that of the precipitate, multiplied by the moles of analyte per mole of precipitate obtained from each mole of analyte,

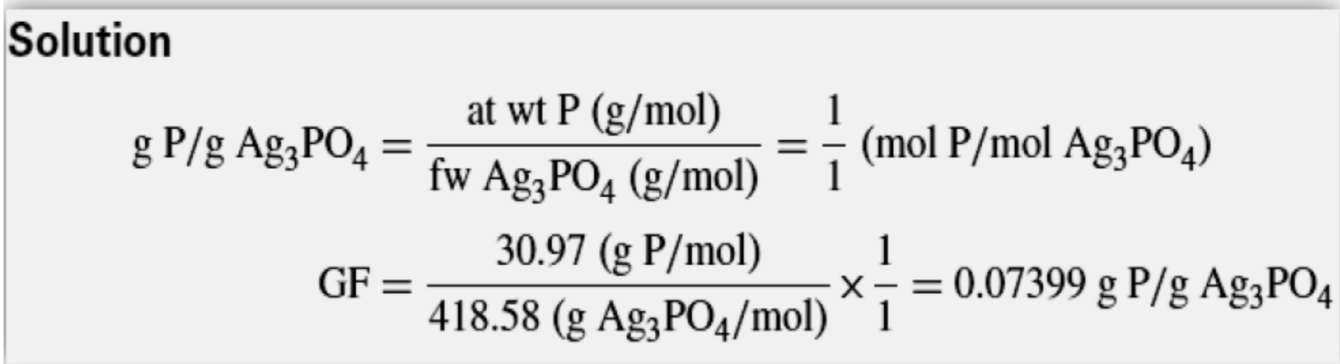
$$\mathrm{GF} = \frac{\text{fw analyte (g/mol)}}{\text{fw precipitate (g/mol)}} \times \frac{a}{b}\text{(mol analyte/mol precipitate)}$$

$$= \text{g analyte/g precipitate}$$

that is,

Example \\ Calculate the grams of analyte per gram of precipitate for the following conversions:

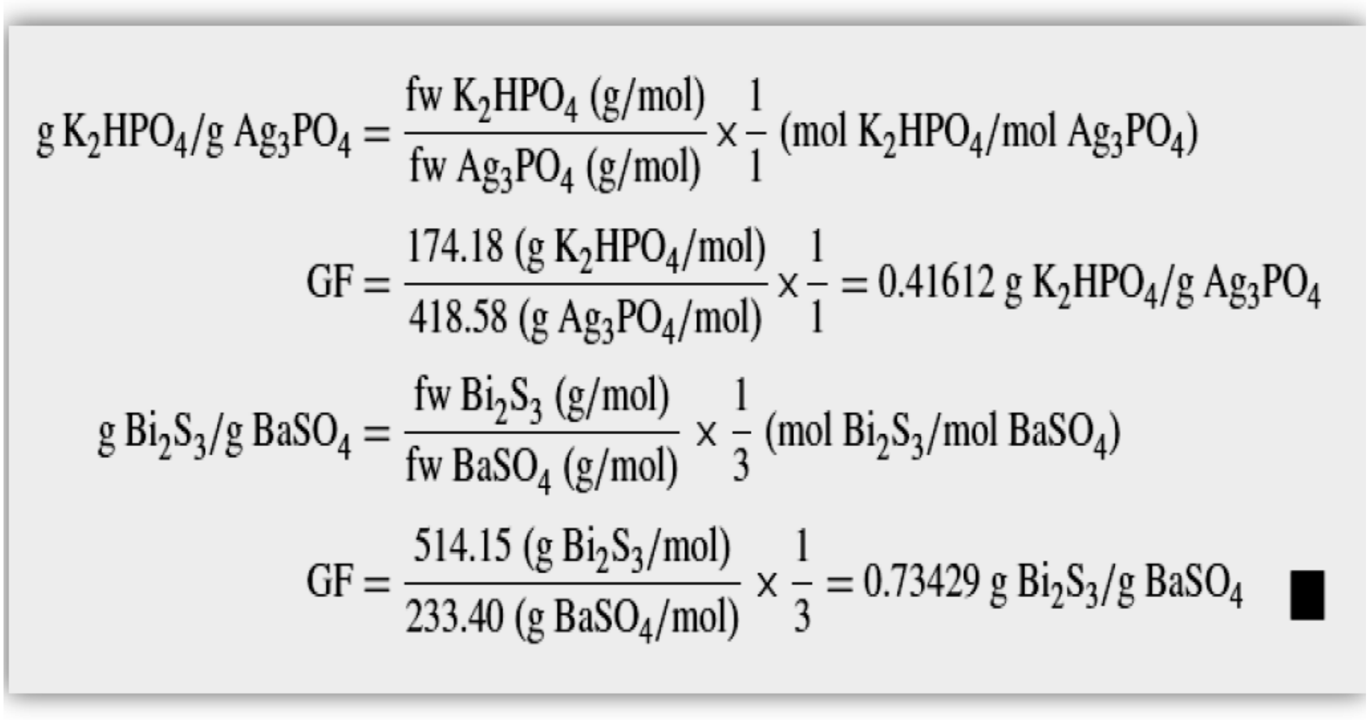
Analyte	Precipitate
P	Ag_3PO_4
K_2HPO_4	Ag_3PO_4
Bi_2S_3	$BaSO_4$



Solution

$$\text{g P/g } Ag_3PO_4 = \frac{\text{at wt P (g/mol)}}{\text{fw } Ag_3PO_4 \text{ (g/mol)}} = \frac{1}{1}\,(\text{mol P/mol } Ag_3PO_4)$$

$$GF = \frac{30.97 \text{ (g P/mol)}}{418.58 \text{ (g } Ag_3PO_4\text{/mol)}} \times \frac{1}{1} = 0.07399 \text{ g P/g } Ag_3PO_4$$



$$\text{g } K_2HPO_4/\text{g } Ag_3PO_4 = \frac{\text{fw } K_2HPO_4 \text{ (g/mol)}}{\text{fw } Ag_3PO_4 \text{ (g/mol)}} \times \frac{1}{1} \text{ (mol } K_2HPO_4/\text{mol } Ag_3PO_4)$$

$$GF = \frac{174.18 \text{ (g } K_2HPO_4/\text{mol)}}{418.58 \text{ (g } Ag_3PO_4/\text{mol)}} \times \frac{1}{1} = 0.41612 \text{ g } K_2HPO_4/\text{g } Ag_3PO_4$$

$$\text{g } Bi_2S_3/\text{g } BaSO_4 = \frac{\text{fw } Bi_2S_3 \text{ (g/mol)}}{\text{fw } BaSO_4 \text{ (g/mol)}} \times \frac{1}{3} \text{ (mol } Bi_2S_3/\text{mol } BaSO_4)$$

$$GF = \frac{514.15 \text{ (g } Bi_2S_3/\text{mol)}}{233.40 \text{ (g } BaSO_4/\text{mol)}} \times \frac{1}{3} = 0.73429 \text{ g } Bi_2S_3/\text{g } BaSO_4 \quad ■$$

In gravimetric analysis, we are generally interested in the percent composition by weight of the analyte in the sample, that is,

$$\%\text{ substance sought} = \frac{\text{weight of substance sought (g)}}{\text{weight of sample (g)}} \times 100\%$$

الوحدة الأولى - المحاضرة الثانية عشر - الزمن: 90 دقيقة

أهداف المحاضرة الثانية عشر:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **ما المقصود الذوبانية**

موضوعات المحاضرة الثانية عشر:

حسابات الذوبانية للرواسب

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
12	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الثانية عشر

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الأولى	**الثانية عشر**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
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المادة العلمية:

Precipitation Equilibria: The Solubility Product

When substances have limited solubility and their solubility is exceeded, the ions of the dissolved portion exist in equilibrium with the solid material. So-called insoluble compounds generally exhibit this property.

When a compound is referred to as insoluble, it is actually not completely insoluble but is **slightly soluble**. For example, if solid AgCl is added to water, a small portion of it will dissolve:

$$\underline{\mathrm{AgCl}} \rightleftharpoons (\mathrm{AgCl})_{aq} \rightleftharpoons \mathrm{Ag}^+ + \mathrm{Cl}^-$$

The precipitate will have a definite solubility (i.e., a definite amount that will dissolve) in g/L, or mol/L.

We can write an overall equilibrium constant for the above stepwise equilibrium, called the **solubility product** K_{sp}. $(\mathrm{AgCl})_{aq}$ cancels when the two stepwise equilibrium constants are multiplied together.

$$K_{sp} = [\mathrm{Ag}^+][\mathrm{Cl}^-]$$

The “concentration” of any solid such as AgCl is constant and is combined in the equilibrium constant to give Ksp. The above relationship holds regardless of the presence of any undissociated intermediate; that is, the concentrations of free ions are rigorously defined by Equation above.

The amount of a slightly soluble salt that dissolves does *not* depend on the amount of the solid in equilibrium with the solution, so long as some solid is present. Instead, the amount that dissolves depends on the *volume* of the solvent. A nonsymmetric salt (one in which the cation and anion are not in the same ratio) such as Ag_2CrO_4 would have a K_{sp} as follows:

$$Ag_2CrO_4 \rightleftharpoons 2\ Ag^+ + CrO_4{}^{2-}$$

$$K_{sp} = [Ag^+]^2[CrO_4{}^{2-}]$$

Such electrolytes do not dissolve or dissociate in steps because they are really strong electrolytes. That portion that dissolves ionizes completely. *Therefore, we do not have stepwise* K_{sp} *values*. As with any equilibrium constant, the K_{sp} product holds under all equilibrium conditions at the specified temperature. Since we are dealing with heterogeneous equilibria, the equilibrium state is achieved more slowly than with homogeneous solution equilibria.

-THE SATURATED SOLUTION

Example

The K_{sp} of AgCl at 25°C is 1.0×10^{-10}. Calculate the concentrations of Ag^+ and Cl^- in a saturated solution of AgCl, and the molar solubility of AgCl.

Solution

When AgCl ionizes, equal amounts of Ag^+ and Cl^- are formed; $AgCl \rightleftharpoons Ag^+ + Cl^-$ and $K_{sp} = [Ag^+][Cl^-]$. Let s represent the molar solubility of AgCl. Since each mole of AgCl that dissolves gives one mole of either Ag^+ or Cl^-, then

$$[Ag^+] = [Cl^-] = s$$

$$s^2 = 1.0 \times 10^{-10}$$

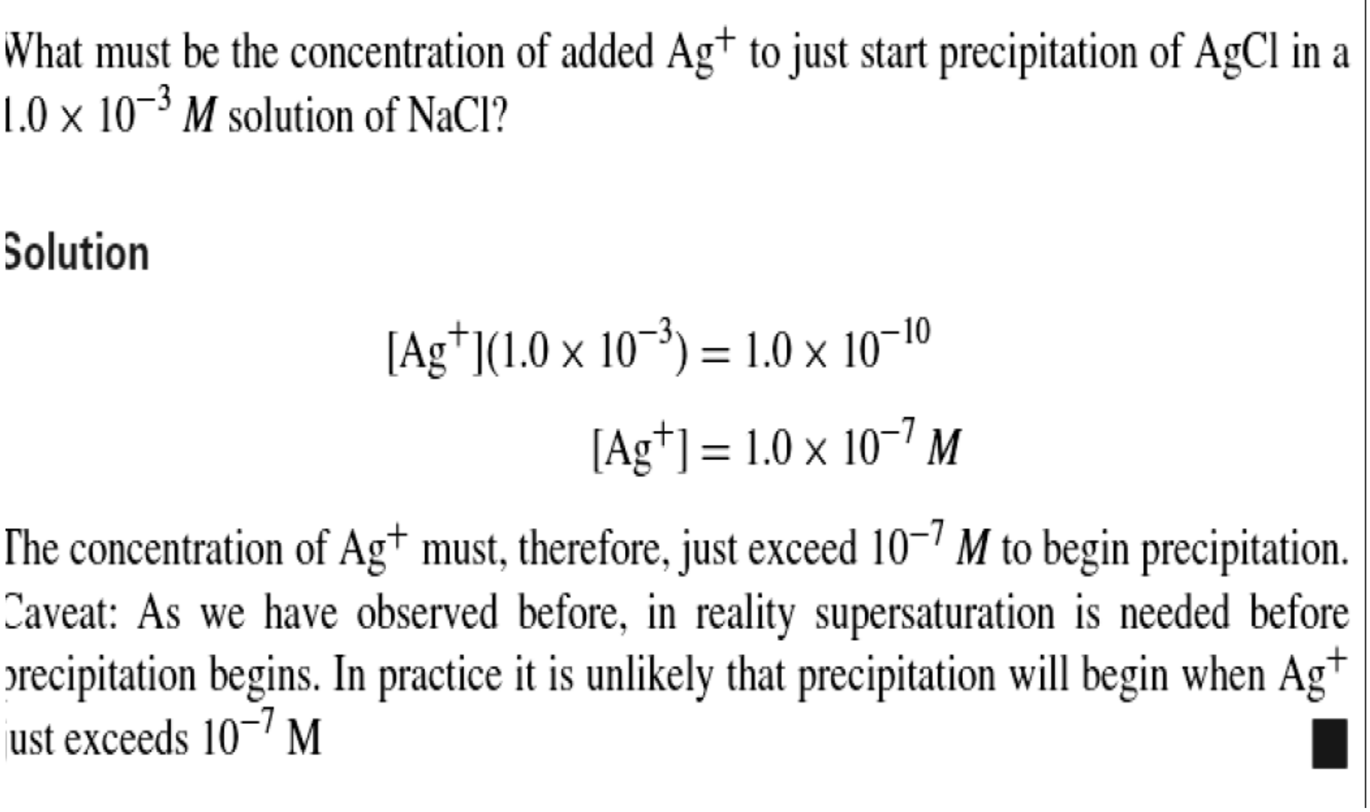
$$s = 1.0 \times 10^{-5}\ M$$

The solubility of AgCl is $1.0 \times 10^{-5}\ M$. ■

-DECREASING THE SOLUBILITY—THE COMMON ION EFFECT

If there is an excess of one ion over the other, the concentration of the other is suppressed (**common ion effect**), and the solubility of the precipitate is decreased. We can still calculate the concentration from the solubility product.

**Example **



What must be the concentration of added Ag^+ to just start precipitation of AgCl in a 1.0×10^{-3} *M* solution of NaCl?

Solution

$$[Ag^+](1.0 \times 10^{-3}) = 1.0 \times 10^{-10}$$

$$[Ag^+] = 1.0 \times 10^{-7}\ M$$

The concentration of Ag^+ must, therefore, just exceed 10^{-7} *M* to begin precipitation. Caveat: As we have observed before, in reality supersaturation is needed before precipitation begins. In practice it is unlikely that precipitation will begin when Ag^+ just exceeds 10^{-7} M ■

Factors affecting the solubility of precipitates

1 - Nature of the precipitate: If the attraction between solvent molecules and solute ions is higher than that between solute ions in the crystal then the salt is soluble.

2 - Nature of solvent: Two properties of the solvent affecting the solubility of the solute, these are polarity and dielectric value . Solvent of more polarity means more attraction between solute ions and solvent molecules. The attraction at crystal surface decreases with higher electric constant of the solvent. Water as with high polarity and dielectric constant value is a good solvent for nearly all inorganic

ionic salts .Organic solvents such as chloroform, alcohols are good solvents for organic salts (non polar compounds) .

3 - Temperature : Higher temperature means higher solubility ; in water this solubility process in endothermic.

4 - Common ion effect: The ion that forms the precipitate is the common ion if the solvent contain these common ions. The solubility of the salts decreases compared with pure solvents. Other un common ions increases the solubility.

5 - pH value :The concentration of hydrogen ion and hydroxide ions affect the acidity of the solution and hence the solubility of sparingly soluble solute.

الوحدة الأولى - المحاضرة الثالثة عشر- الزمن: 90 دقيقة

أهداف المحاضرة الثالثة عشر:

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1. **نسبة الخطاء في بيانات التحليل الكمي و كفية التعامل مع مسببات نسبة الخطاء**

موضوعات المحاضرة الثالثة عشر:

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متوسط و مدى الخطاء

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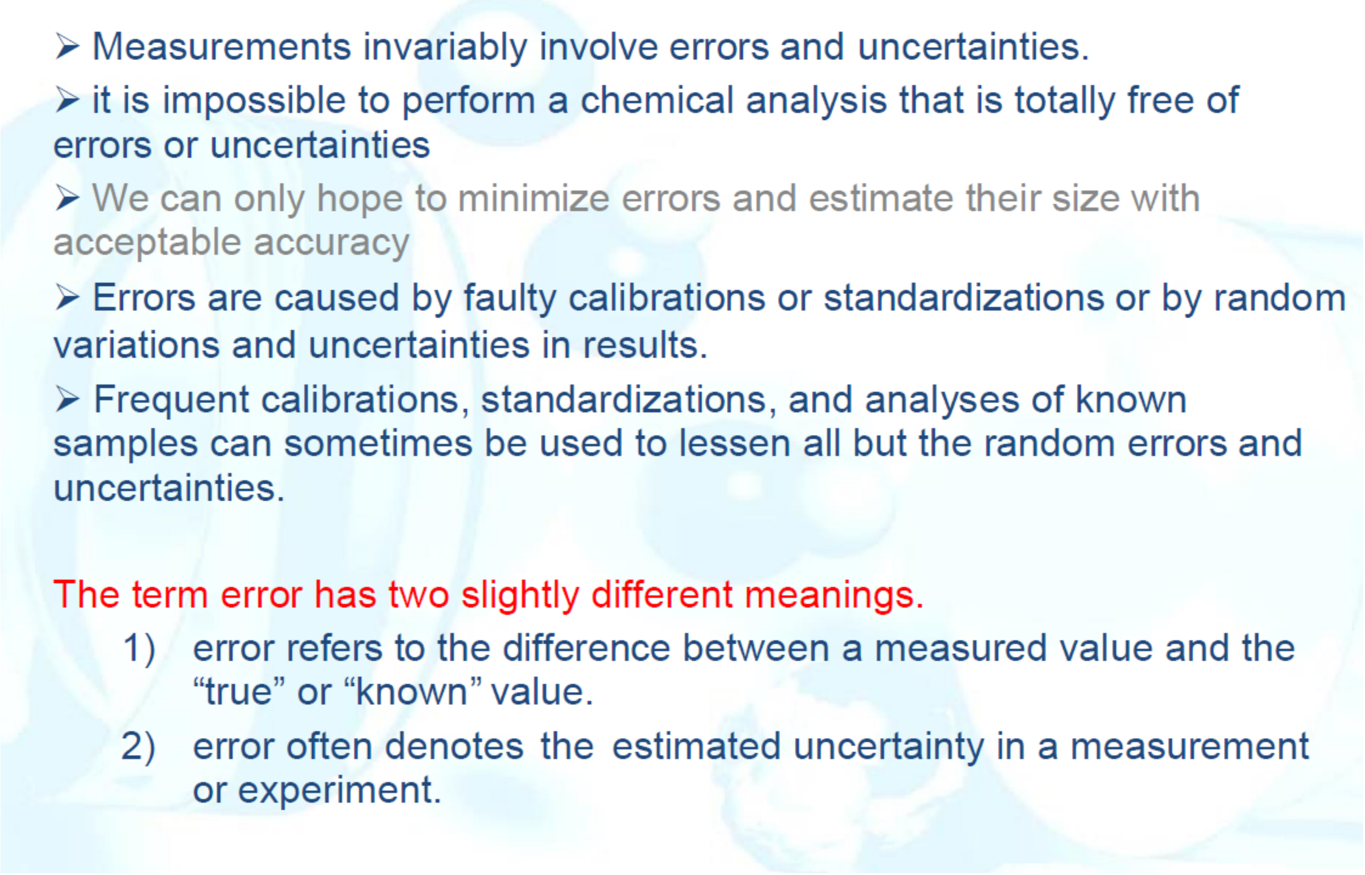
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:



- Measurements invariably involve errors and uncertainties.
- it is impossible to perform a chemical analysis that is totally free of errors or uncertainties
- We can only hope to minimize errors and estimate their size with acceptable accuracy
- Errors are caused by faulty calibrations or standardizations or by random variations and uncertainties in results.
- Frequent calibrations, standardizations, and analyses of known samples can sometimes be used to lessen all but the random errors and uncertainties.

The term error has two slightly different meanings.

1) error refers to the difference between a measured value and the "true" or "known" value.
2) error often denotes the estimated uncertainty in a measurement or experiment.

Every measurement is influenced by many uncertainties, which combine to produce a scatter of results.

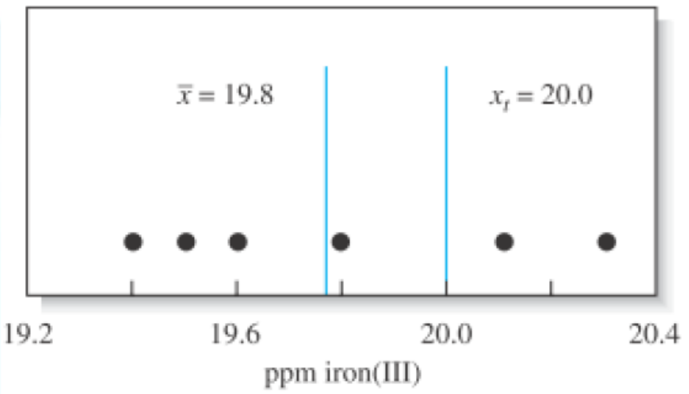
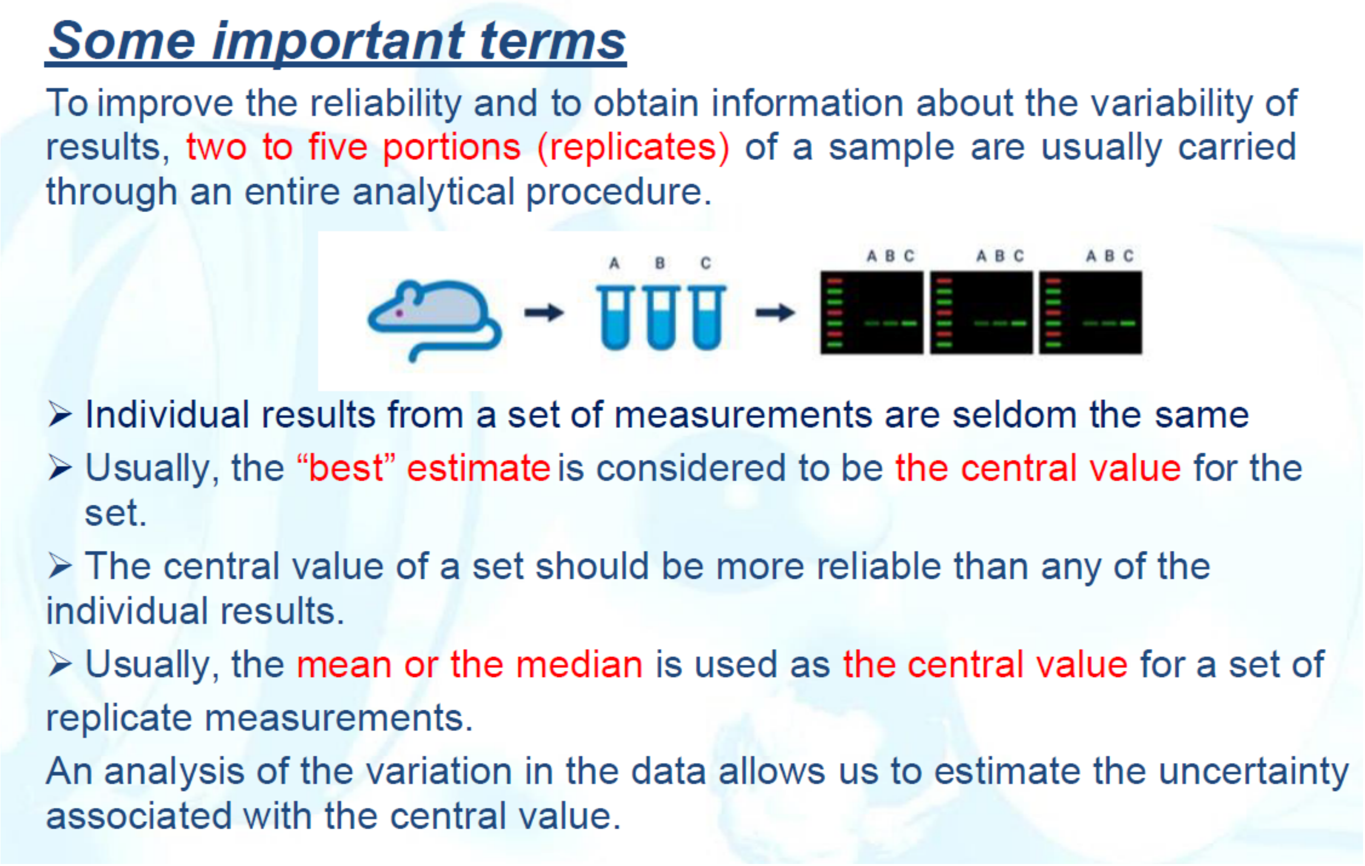


Figure 5-1 Results from six replicate determinations of iron in aqueous samples of a standard solution containing 20.0 ppm iron(III). Note that the results range from a low of 19.4 ppm to a high of 20.3 ppm of iron. The average, or mean value, *x, of the data is 19.78 ppm, which rounds to 19.8 ppm*

Because measurement uncertainties can never be completely eliminated, *measurement data can only give us an estimate of the "true" value.*

However, the probable magnitude of the error in a measurement can often be evaluated. It is then possible to define limits within which the true value of a measured quantity lies with a given level of probability.

Before beginning an analysis ask, "What maximum error can be tolerated in the result?" The answer to this question often determines the method chosen and the time required to complete the analysis.



Some important terms

To improve the reliability and to obtain information about the variability of results, two to five portions (replicates) of a sample are usually carried through an entire analytical procedure.

- ➢ Individual results from a set of measurements are seldom the same
- ➢ Usually, the "best" estimate is considered to be the central value for the set.
- ➢ The central value of a set should be more reliable than any of the individual results.
- ➢ Usually, the mean or the median is used as the central value for a set of replicate measurements.

An analysis of the variation in the data allows us to estimate the uncertainty associated with the central value.

The Mean and the Median

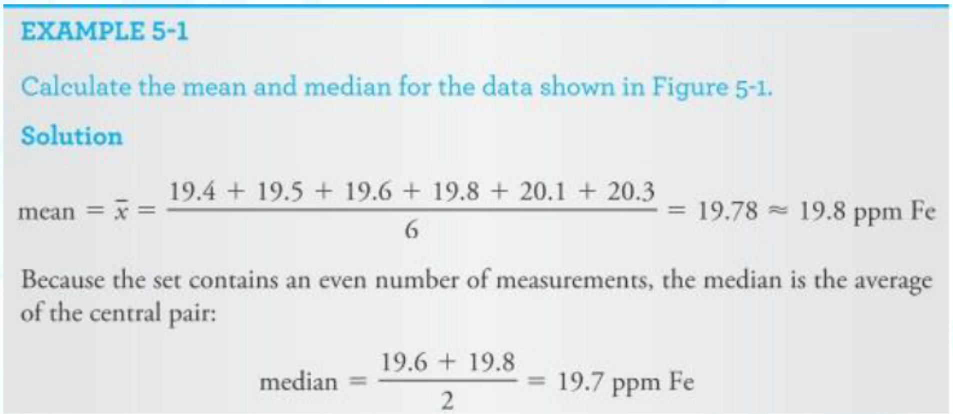
$$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N}$$

The mean, also called the arithmetic mean or the average, is obtained by dividing the sum of replicate measurements by the number of measurements in the set:

- ➢ The symbol Σx_i means to add all of the values x_i for the replicates; x_i represents the individual values of x making up the set of N replicate measurements.
- ➢ The median is the middle value in a set of data that has been arranged in numerical order.

- ➢ The median is used advantageously when a set of data contain an outlier. An outlier is a result that differs significantly from others in the set.

- ➢ An outlier can have a significant effect on the mean of the set but has no effect on the median.



EXAMPLE 5-1

Calculate the mean and median for the data shown in Figure 5-1.

Solution

$$\text{mean} = \bar{x} = \frac{19.4 + 19.5 + 19.6 + 19.8 + 20.1 + 20.3}{6} = 19.78 \approx 19.8 \text{ ppm Fe}$$

Because the set contains an even number of measurements, the median is the average of the central pair:

$$\text{median} = \frac{19.6 + 19.8}{2} = 19.7 \text{ ppm Fe}$$

الوحدة الأولى – المحاضرة الرابعة عشر- الزمن: 90 دقيقة

أهداف المحاضرة الرابعة عشر:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **نسبة الخطاء في بيانات التحليل الكمي و كفية التعامل مع مسببات نسبة الخطاء**

موضوعات المحاضرة الرابعة عشر:

متوسط الانحراف
الانحراف المعياري
التباين
طرق التعبير عن الدقة

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
14	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الرابعة عشر

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الأولى	الرابعة عشر	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Sample Standard Deviation, s

The equation for σ must be modified for small samples of data, i.e. small *N*

$$s = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \overline{x})^2}{N-1}}$$

Two differences cf. to equation for σ:

1. Use sample mean instead of population mean.

2. Use ***degrees of freedom***, *N* - 1, instead of *N*.
   Reason is that in working out the mean, the sum of the differences from the mean must be zero. If *N* - 1 values are known, the last value is defined. Thus only *N* - 1 degrees of freedom. For large values of *N*, used in calculating σ, *N* and *N* - 1 are effectively equal.

Alternative Expression for s (suitable for calculators)

$$s = \sqrt{\frac{\left(\sum_{i=1}^{N} x_i^{\,2}\right) - \dfrac{\left(\sum_{i=1}^{N} x_i\right)^2}{N}}{N-1}}$$

Note: NEVER round off figures before the end of the calculation

Standard Deviation of a Sample

Reproducibility of a method for determining the % of selenium in foods. 9 measurements were made on a single batch of brown rice.

Sample	Selenium content (µg/g) (x_I)	x_i^2
1	0.07	0.0049
2	0.07	0.0049
3	0.08	0.0064
4	0.07	0.0049
5	0.07	0.0049
6	0.08	0.0064
7	0.08	0.0064
8	0.09	0.0081
9	0.08	0.0064

$\Sigma x_i = 0.69$ $\Sigma x_i^2 = 0.0533$

Mean $= \Sigma x_i/N = 0.077\mu g/g$ $(\Sigma x_i)^2/N = 0.4761/9 = 0.0529$

Standard deviation: $$s = \sqrt{\frac{0.0533 - 0.0529}{9-1}} = 0.00707106 = 0.007$$

Coefficient of variance = 9.2% Concentration = 0.077 ± 0.007 µg/g

Two alternative methods for measuring the precision of a set of results:

VARIANCE: This is the square of the standard deviation:

$$s^2 = \frac{\sum_{i=1}^{N}(x_i^2 - \bar{x})^2}{N-1}$$

COEFFICIENT OF VARIANCE (CV) (or RELATIVE STANDARD DEVIATION):

Divide the standard deviation by the mean value and express as a percentage:

$$CV = (\frac{s}{\bar{x}}) \times 100\%$$

Precision

Relates to *reproducibility* of results..
How similar are values obtained in exactly the same way?

Useful for measuring this:
Deviation from the mean:

$$d_i = \left| x_i - \bar{x} \right|$$

Accuracy

Measurement of agreement between experimental mean and true value (which may not be known!).
Measures of accuracy:

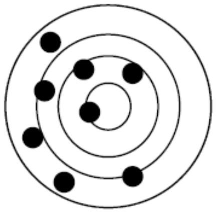
Absolute error: $E = x_i - x_t$ (where x_t = true or accepted value)

Relative error:

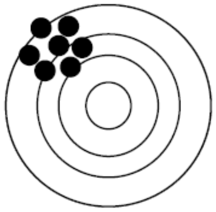
$$E_r = \frac{x_i - x_t}{x_t} \times 100\%$$

(latter is more useful in practice)

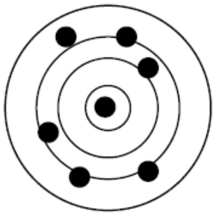
Illustrating the difference between "accuracy" and "precision"



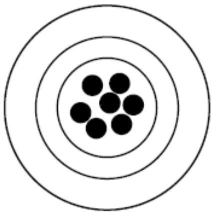
Low accuracy, low precision



Low accuracy, high precision

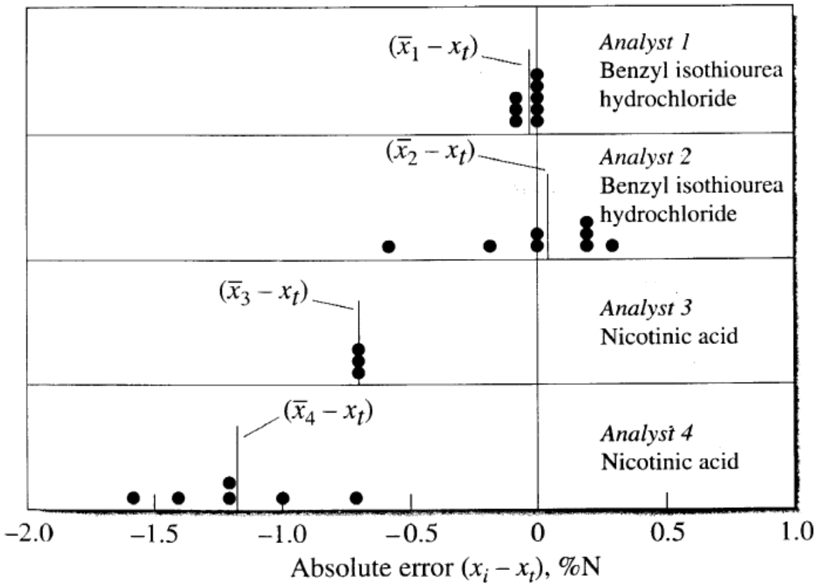


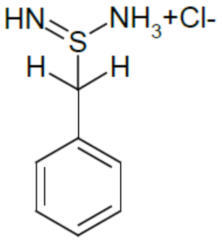
High accuracy, low precision



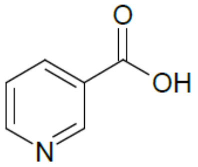
High accuracy, high precision

Some analytical data illustrating "accuracy" and "precision"





Benzyl isothiourea hydrochloride



Nicotinic acid

Analyst 4: imprecise, inaccurate
Analyst 3: precise, inaccurate
Analyst 2: imprecise, accurate
Analyst 1: precise, accurate

الوحدة الأولى – المحاضرة الخامسة عشر- الزمن: 90 دقيقة

أهداف المحاضرة الخامسة عشر:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **نسبة الخطاء في بيانات التحليل الكمي و كفية التعامل مع مسببات نسبة الخطاء**

موضوعات المحاضرة الخامسة عشر:

الخطاء المطلق
الخطاء النسبي
رفض البيانات التجريبية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
15	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الخامسة عشر

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الأولى	الخامسة عشر	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
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		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Types of Error in Experimental Data

Three types:

(1) **Random (indeterminate) Error**

Data scattered approx. symmetrically about a mean value. Affects precision - dealt with statistically (see later).

(2) **Systematic (determinate) Error**

Several possible sources - later. Readings all too high or too low. Affects accuracy.

(3) **Gross Errors**

Usually obvious - give "*outlier*" readings. Detectable by carrying out sufficient replicate measurements.

Sources of Systematic Error

1. **Instrument Error**

   Need frequent calibration - both for apparatus such as volumetric flasks, burettes etc., but also for electronic devices such as spectrometers.

2. **Method Error**

   Due to inadequacies in physical or chemical behaviour of reagents or reactions (e.g. slow or incomplete reactions) Example from earlier overhead - nicotinic acid does not react completely under normal Kjeldahl conditions for nitrogen determination.

3. **Personal Error**

   e.g. insensitivity to colour changes; tendency to estimate scale readings to improve precision; preconceived idea of “true” value.

Systematic errors can be

constant (e.g. error in burette reading - less important for larger values of reading) or **proportional** (e.g. presence of given proportion of interfering impurity in sample; equally significant for all values of measurement)

Minimise instrument errors by careful recalibration and good maintenance of equipment.

Minimise personal errors by care and self-discipline

Method errors - most difficult. "True" value may not be known. Three approaches to minimise:

- analysis of certified standards
- use 2 or more independent methods
- analysis of blanks

Absolute Error

* The absolute error of a measurement is the difference between the measured value and the true value. If the measurement result is low, the sign is negative; if the measurement result is high, the sign is positive.

$$\boxed{E = x_i - x_t}$$

Relative Error

The relative error of a measurement is the absolute error divided by the true value.

Relative error may be expressed in percent, parts per thousand, or parts per million, depending on the magnitude of the result.

$$\boxed{E_r = \frac{x_i - x_t}{x_t} \times 100\%}$$

Testing a Hypothesis

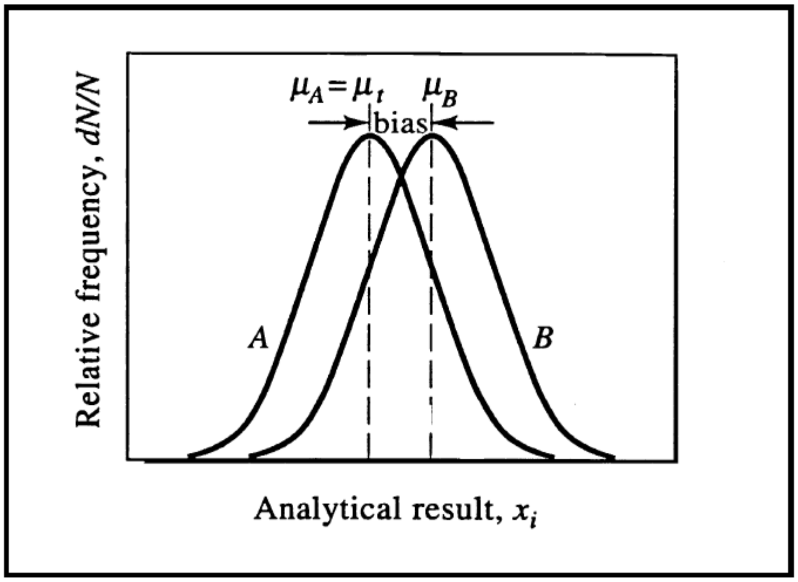
Carry out measurements on an accurately known standard.

Experimental value is different from the true value.

Is the difference due to a systematic error (bias) in the method - or simply to random error?

Assume that there is *no* bias (**NULL HYPOTHESIS**), and calculate the probability that the experimental error is due to random errors.

Figure shows (A) the curve for the true value ($\mu_A = \mu_t$) and (B) the experimental curve (μ_B)



Bias = $\mu_B - \mu_A = \mu_B - x_t$.

Test for bias by comparing $\bar{x} - x_t$ with the difference caused by random error

Remember confidence limit for μ (assumed to be x_t, i.e. *assume no bias*) is given by:

$$\text{CL for } \mu = \bar{x} \pm \frac{ts}{\sqrt{N}}$$

∴ at desired confidence level, random errors can lead to:

$$\bar{x} - x_t = \pm \frac{ts}{\sqrt{N}}$$

∴ if $\bar{x} - x_t > \left| \frac{ts}{\sqrt{N}} \right|$, then at the desired confidence level bias (systematic error) is likely (and vice versa).

Detection of Systematic Error (Bias)

A standard material known to contain 38.9% Hg was analysed by atomic absorption spectroscopy. The results were 38.9%, 37.4% and 37.1%. At the 95% confidence level, is there any evidence for a systematic error in the method?

$$\bar{x} = 37.8\% \qquad \therefore \bar{x} - x_t = -1.1\%$$

$$\sum x_i = 113.4 \qquad \sum x_i^2 = 4208.30$$

$$\therefore s = \sqrt{\frac{4208.30 - (113.4)^2/3}{2}} = 0.943\%$$

Assume null hypothesis (no bias). Only reject this if

$$\bar{x} - x_t > \pm ts/\sqrt{N}$$

But t (from Table) = 4.30, s (calc. above) = 0.943% and N = 3

$$ts/\sqrt{N} = 4.30 \times 0.943/\sqrt{3} = 2.342\%$$

$$\therefore \bar{x} - x_t < \pm ts/\sqrt{N}$$

Therefore the null hypothesis is maintained, and there is **no** evidence for systematic error at the 95% confidence level.

الوحدة الثانية – المحاضرة السادسة عشر- الزمن: 90 دقيقة

أهداف المحاضرة السادسة عشر:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **ما المقصود بالديناميكية الحرارية و اهميتها و تطبيقاتها**

موضوعات المحاضرة السادسة عشر:

القانون الاول للديناميكية الحرارية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
16	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة السادسة عشر

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الثانية	**السادسة عشر**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

The study of the flow of heat or any other form of energy into or out of a system as it undergoes a physical or chemical transformation, is called **Thermodynamics**.

The first law of thermodynamics is a version of the law of conservation of energy, adapted for thermodynamic processes, distinguishing two kinds of transfer of energy, as heat and as thermodynamic work, and relating them to a function of a body's state, called Internal energy. The law of conservation of energy states that the total energy of an isolated system is constant; energy can be transformed from one form to another, but can be neither created nor destroyed. For a thermodynamic process without transfer of matter, the first law is often formulated.

where **ΔU** denotes the change in the internal energy of a closed system, **Q** denotes the quantity of energy supplied to the system as heat, and **W** denotes the amount of thermodynamic work done by the system on its surroundings. An equivalent statement is that perpetual motion machines of the first kind are impossible.

For processes that include transfer of matter, a further statement is needed: 'With due account of the respective reference states of the systems, when two systems, which may be of different chemical compositions, initially separated only by an impermeable wall, and otherwise isolated, are combined into a new system by the thermodynamic operation of removal of the wall, then where U0 denotes the internal energy of the combined system, and U1 and U2 denote the internal energies of the respective separated systems.'

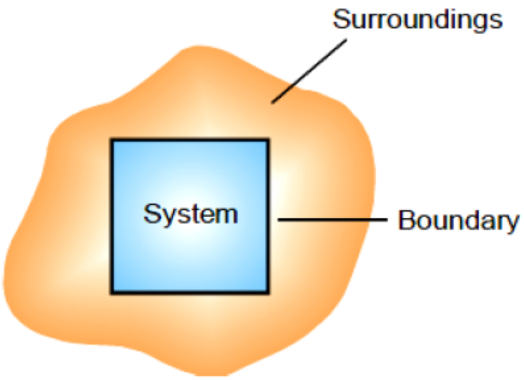
Limitations of Thermodynamics

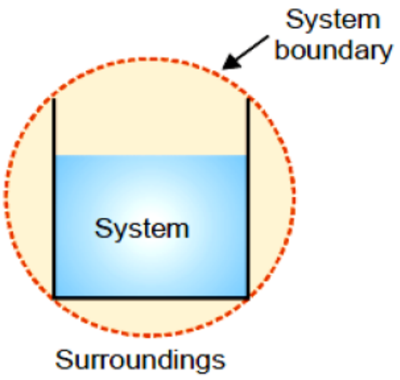
(1) **Thermodynamics is applicable to macroscopic systems** consisting of matter in bulk and not to microscopic systems of individual atoms or molecules. **It ignores the internal structure of atoms and molecules.**

(2) Thermodynamics does not bother about the time factor. That is, it does not tell anything regarding the rate of a physical change or a chemical reaction. **It is concerned only with the initial and the final states of the system.**

SYSTEM, BOUNDARY, SURROUNDINGS

A system is that part of the universe which is under thermodynamic study and the rest of the universe is **surroundings**.
The real or imaginary surface separating the system from the boundary surroundings is called the **boundary**.





TYPES OF THERMODYNAMIC SYSTEMS

(1) Isolated System

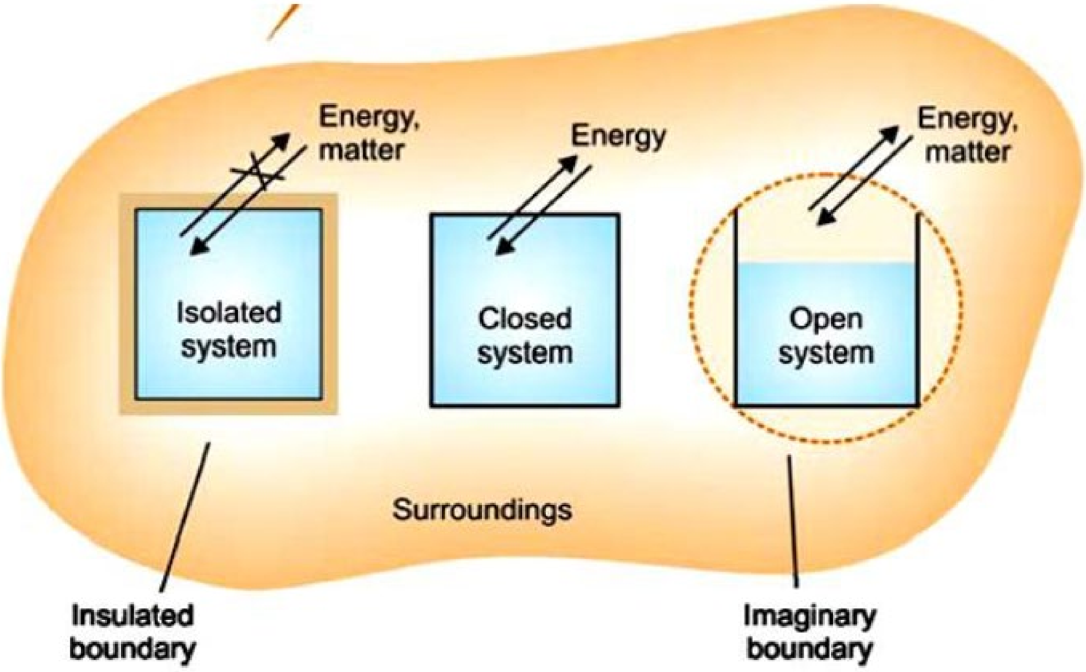
When the boundary is both sealed and insulated, no interaction is possible with the surroundings. Therefore, **an isolated system is one that can transfer neither matter nor energy to and from its surroundings.**

(2) Closed System

Here the boundary is sealed but not insulated. Therefore, **a closed system is one which cannot transfer matter but can transfer energy in the form of heat, work and radiation to and from its surroundings.**

(3) Open System

In such a system the boundary is open and un-insulated. Therefore, **an open system is one which can transfer both energy and matter to and from its surroundings.**


Energy, matter
Energy
Energy, matter
Isolated system
Closed system
Open system
Surroundings
Insulated boundary
Imaginary boundary

THERMODYNAMIC PROCESSES

When a thermodynamic system changes from one state to another, the operation is called a Process. These processes involve the change of conditions (temperature, pressure and volume). The various types of thermodynamic processes are :

(1) Isothermal Processes

Those processes in which the temperature remains fixed, are termed isothermal processes. This is often achieved by placing the system in a thermostat (a constant temperature bath).

For an isothermal process $dT = 0$

(2) Adiabatic Processes

Those processes in which no heat can flow into or out of the system, are called adiabatic processes. Adiabatic conditions can be approached by carrying the process in an insulated container such as 'thermos' bottle. High vacuum and highly polished surfaces help to achieve thermal insulation. For an adiabatic process $dq = 0$

(3) Isobaric Processes

Those processes which take place at constant pressure are called isobaric processes. For example, heating of water to its boiling point and its vaporisation take place at the same atmospheric pressure. These changes are, therefore, designated as isobaric processes and are said to take place isobarically. For an isobaric process $dp = 0$

(4) Isochoric Processes

Those processes in which the volume remains constant are known as isochoric processes. The heating of a substance in a non-expanding chamber is an example of isochoric process.

For isochoric processes $dV = 0$.

(5) Cyclic Process

When a system in a given state goes through a number of different processes and finally returns to its initial state, the overall process is called a cycle or cyclic process.

For a cyclic process $dE = 0$, $dH = 0$.

الوحدة الثانية – المحاضرة السابعة عشر - الزمن: 90 دقيقة

أهداف المحاضرة السابعة عشر:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **تطبيقات القانون الاول للديناميكية الحرارية**

موضوعات المحاضرة السابعة عشر:

التغير الحجمي العكسي و التغير الحجمي اللاعكسي

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
17	• محاضرة • مناقشة • سؤال وجواب	• جهاز حاسوب • جهاز عرض • سبورة • اوراق واقلام

خطة إجراءات تنفيذ المحاضرة السابعة عشر

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الثانية	**السابعة عشر**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

REVERSIBLE AND IRREVERSIBLE PROCESSES

A thermodynamic reverse process is one that takes place infinitesimally slowly and its direction at any point can be reversed by an infinitesimal change in the state of the system.
When a process goes from the initial to the final state in a single step and cannot be carried in the reverse order, it is said to be an irreversible process.

DIFFERENCES BETWEEN REVERSIBLE AND IRREVERSIBLE PROCESSES

Reversible Process	Irreversible Process
1. It takes place in infinite number of infinitesimally small steps and it would take *infinite time* to occur.	1. It takes place *infinite time*.
2. It is *imaginary* as it assumes the presence of frictionless and weightless piston.	2. It is *real* and can be performed actually.
3. It is in equilibrium state at *all stages* of the operation.	3. It is in equilibrium state only at the *initial and final stages* of the operation.
4. All changes are *reversed* when the process is carried out in reversible direction.	4. After this type of process has occurred all changes *do not return* to the initial state by themselves.
5. It is extremely slow.	5. It proceeds at *measureable speed*.
6. Work done by a reversible process is *greater* than the corresponding irreversible process.	6. Work done by a irreversible process is *smaller* than the corresponding reversible process.

Process and path

- Initial state(T1,P1,V1) final state (T2,P2,T2).
- Path 1: T1,P1,V1→T1,P2,Va (Constant-temperature process) →T2,P2,V2 (Constant-pressure process) .
- Path2: T1,P1,V1→Tb,P2,V1 (Constant-volume process)→T2,P2,V2 (Constant-pressure process).
- Path3:T1,P1,V1→T2,P1,Vc (Constant-pressure process) →T2,P2,V2 (Constanttemperature process).

State and path functions

- State properties: temperature, pressure, volume, density, viscosity .
- Extensive properties: dependent on amount .
- Intensive properties: independent on amount.

-**State function** is a property that is independent of how a sample is prepared, **completely differential ,single valued**

-Properties that relate to the preparation of the state are called **path functions**

Question: T, P, V, ρ, Vm…… Extensive or intensive?
W, Q State function or path function?

Thermodynamic equilibrium

• Thermal equilibrium Temperature	is equal everywhere.
• Mechanical equilibrium	No work.
• Phase equilibrium	No phase transition .
• Chemical equilibrium	No component change.

Mathematical Expression:

E (total energy)= U (internal energy) + KE (kinetic energy/energy of motion) + V (potential energy)

In equalibrium state: KE=0, V=0, E=U

$\Delta U = Q + W$ closed system
$dU = \delta Q + \delta W$ closed system

U--- Internal energy of the system
Q--- Heat
W--- Work by the system,

الوحدة الثانية – المحاضرة الثامنة عشر - الزمن: 90 دقيقة

أهداف المحاضرة الثامنة عشر:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **تطبيقات القانون الاول للديناميكية الحرارية**

موضوعات المحاضرة الثامنة عشر:

التغير الحجمي ثابت الحرارة
السعة الحرارية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
18	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الثامنة عشر

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الثانية	الثامنة عشر	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Adiabatic process

An adiabatic process is one in which no heat flows out of the system.

Therefore $Q = 0$

$\Delta U = Q - W \Longrightarrow \Delta U = -W$

When a system expands adiabatically, W is negative (the system does work) so ΔU is positive.

When a system compresses adiabatically, W is positive (work is done on

Isothermal Process

- An isothermal process is a constant temperature process. Any heat flow out of the system must be slow enough to maintain thermal equilibrium
- For ideal gases, if ΔT is zero, $\Delta U = 0$
- Therefore, $Q = W$

Any energy entering the system (Q) must leave as work (W)

Heat Capacity

- The **heat capacity** is **the amount** of heat required to raise the system's temperature by one degree

$$\mathbf{Q = mc_x\Delta T}$$

Where

- **m:** mass of substance.
- The constant $\mathbf{c_x}$ is called the specific heat of substance x, (SI units is J/kg·K).
- **ΔT:** Change in temperature.

الوحدة الثانية – المحاضرة التاسعة عشر - الزمن: 90 دقيقة

أهداف المحاضرة التاسعة عشر:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **القانون الثاني للديناميكية الحرارية**

موضوعات المحاضرة التاسعة عشر:

القانون الثاني للديناميكية الحرارية و اهميته

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
19	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة التاسعة عشر

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الثانية	**التاسعة عشر**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

The Second Law of Thermodynamics

- The second law of thermodynamics states that processes occur in a certain direction, not in just any direction.
- Physical processes in nature can proceed toward equilibrium spontaneously.

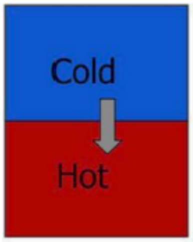
Can We Take Advantage of These Processes?

- Yes!! We can use them to produce work
- Or… we can just let them happen and lose the opportunity.

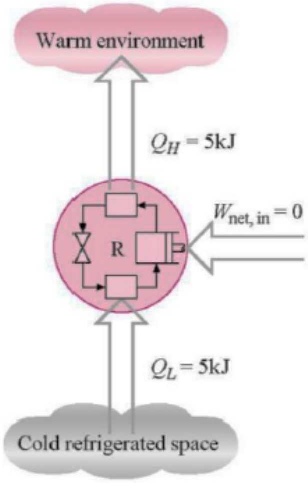
Can we reverse these processes?

- It requires the expenditure of work
- The first law gives us no information about the direction in which a process occurs – it only tells us that energy must balance
- The second law tells us what direction processes occur

It is impossible to construct a device that operates in a cycle and produces no effect other than the transfer of heat from a lower-temperature body to a higher-temperature body.



In order to accomplish heat transfer from cold to hot – you need a device, like a heat pump or refrigerator, that consumes work.



Energy from the surroundings in the form of work or heat has to be expended to force heat to flow from a low-temperature media to a high-temperature media. Thus, the COP of a refrigerator or heat pump must be less than infinity.

So What is the Best You Can Do?

- We know that Coefficients of Performance for refrigerators and heat pumps must be less than infinity, but how much less?
- We know that thermal efficiencies for heat engines must be less than 100%, but how much less?

It Depends on… Irreversibility

الوحدة الثانية – المحاضرة العشرون - الزمن: 90 دقيقة

أهداف المحاضرة العشرون:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. تطبيقات القانون الثاني للديناميكية الحرارية

موضوعات المحاضرة العشرون:

العمليات التلقائية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
20	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

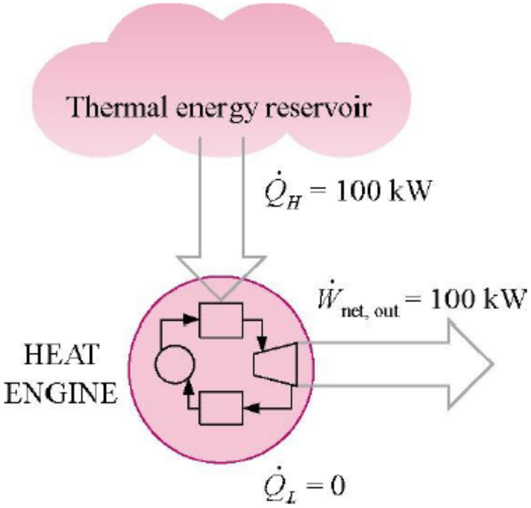
خطة إجراءات تنفيذ المحاضرة العشرون

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الثانية	**العشرون**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Kelvin-Planck Statement of the Second Law

It is impossible for any device that operates on a cycle, to receive heat from a single reservoir and produce a net amount of work.



The Kelvin-Planck statement of the second law of thermodynamics states that no heat engine can produce a net amount of work while exchanging heat with a single reservoir only. In other words, the maximum possible efficiency is less than 100%.

Reversible Process

- A process is reversible if both the system and its environment can be returned to their states before the process.
- Only ideal situations are ever reversible. Example: a frictionless roller coaster.
- Any process that happens spontaneously is irreversible. Examples: friction turning mechanical energy into heat; a drop of ink spreading out when it falls into a bucket of water.
- Heat pumps, refrigerators and heat engines all work best reversibly
- Reversible processes don't have any losses such as

– Friction

– Unrestrained expansion of gases

– Heat transfer through a finite temperature difference

– Mixing of two different substances

– Any deviation from a quasi-static process

- The internally reversible process is a quasi-equilibrium process, which once having taken place, can be reversed without any changes in the system. This says nothing about what happens to the surroundings around the system.
- The externally reversible process is a quasi-equilibrium process, **which once having taken place, can be reversed without any changes in the system or surroundings.**

الوحدة الثانية – المحاضرة الحادية و العشرون - الزمن: 90 دقيقة

أهداف المحاضرة الحادية و العشرون:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **تطبيقات القانون الثاني للديناميكية الحرارية**

موضوعات المحاضرة الحادية و العشرون:

دورة كارنوت

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
21	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الحادية و العشرون

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الثانية	**الحادية و العشرون**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Carnot Cycle

- Named for French engineer Nicolas Sadi Carnot (1769-1832).
- One example of a reversible cycle.
- Composed of four reversible processes .

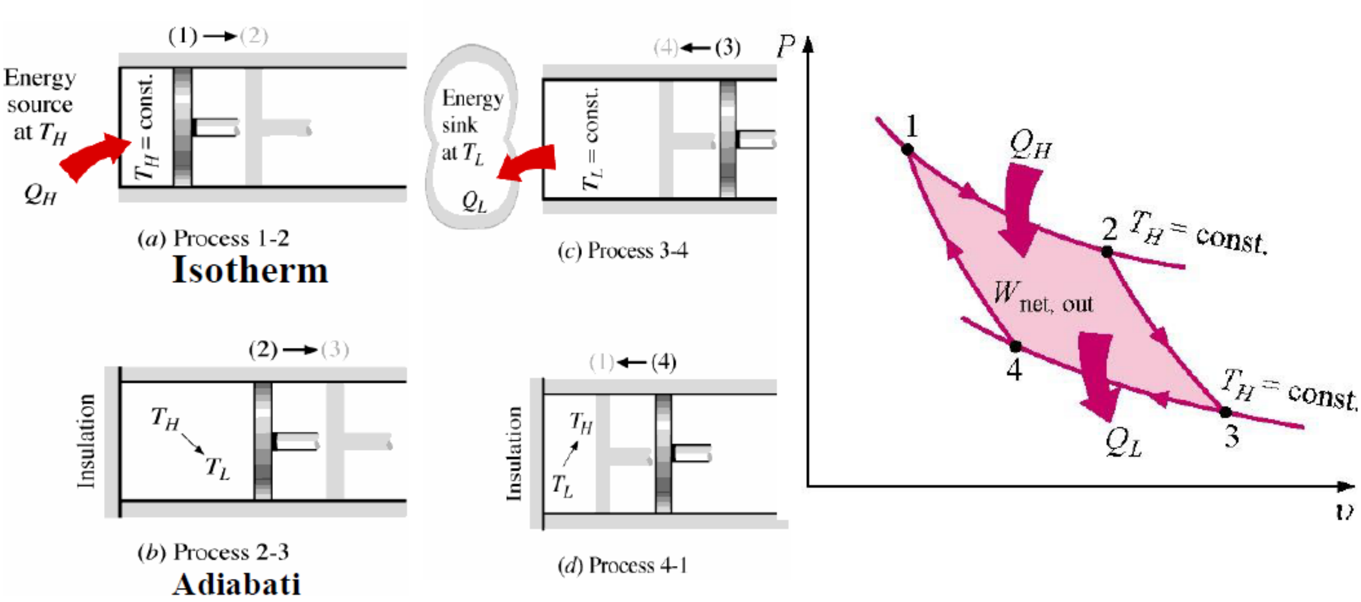
– 2 adiabatic heat transfer .

– 2 reversible isothermal heat transfer.

- Process 1-2 Reversible isothermal heat addition at high temperature, $T_H > T_L$ to the working fluid in a piston--cylinder device which does some boundary work.
- Process 2-3 Reversible adiabatic expansion during which the system does work as the working fluid temperature decreases from T_H to T_L.
- Process 3-4 The system is brought in contact with a heat reservoir at $T_L < T_H$ and a reversible isothermal heat exchange takes place while work of compression is doneon the system.

Process 4-1 A reversible adiabatic compression processincreases the working fluid temperature from T_L to T_H

The Carnot cycle is a reversible heat engine



(*a*) Process 1-2
Isotherm

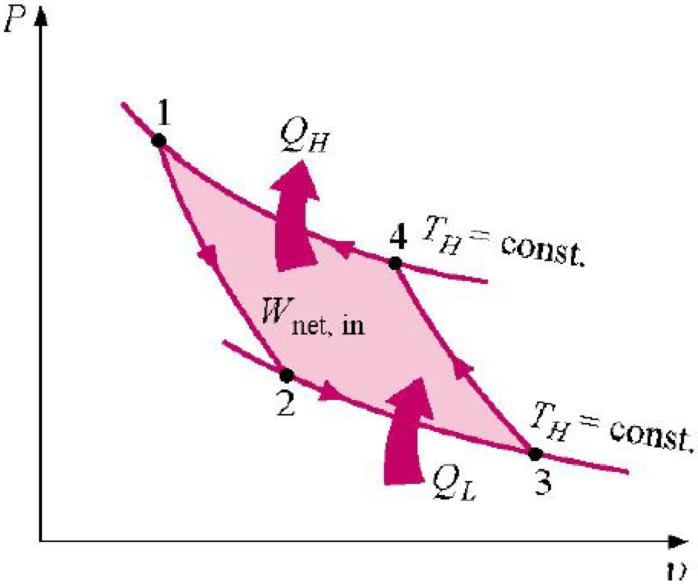
(*c*) Process 3-4

(*b*) Process 2-3
Adiabati

(*d*) Process 4-1

A reversed Carnot Cycle is a refrigerator ora heat pump

The area inside these figures represent the work



The *Carnot principles* state that the thermal efficiencies of all reversible heat engines operating between the same two reservoirs are the same, and that no heat engine is more efficient than a reversible one operatingbetween the same two reservoirs.

- These statements form the basis for establishing a *thermodynamic temperature scale* related to the heat transfers between a reversibledevice and the high- and low-temperature reservoirs by

$$\left(\frac{Q_H}{Q_L}\right)_{rev} = \frac{T_H}{T_L}$$

- Therefore, the Q_H/Q_L ratio can be replaced by T_H/T_L for reversibledevices, where T_H and T_L are the absolute temperatures of the high- and low-temperature reservoirs, respectively.

Efficiency of a Carnot Engine

For a reversible cycle the amount of heat transferred is proportional to the temperature of the reservoir.

الوحدة الثانية – المحاضرة الثانية و العشرون - الزمن: 90 دقيقة

أهداف المحاضرة الثانية و العشرون:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **تطبيقات القانون الثاني للديناميكية الحرارية**

موضوعات المحاضرة الثانية و العشرون:

العشوائية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
22	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الثانية و العشرون

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الثانية	الثانية و العشرون	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
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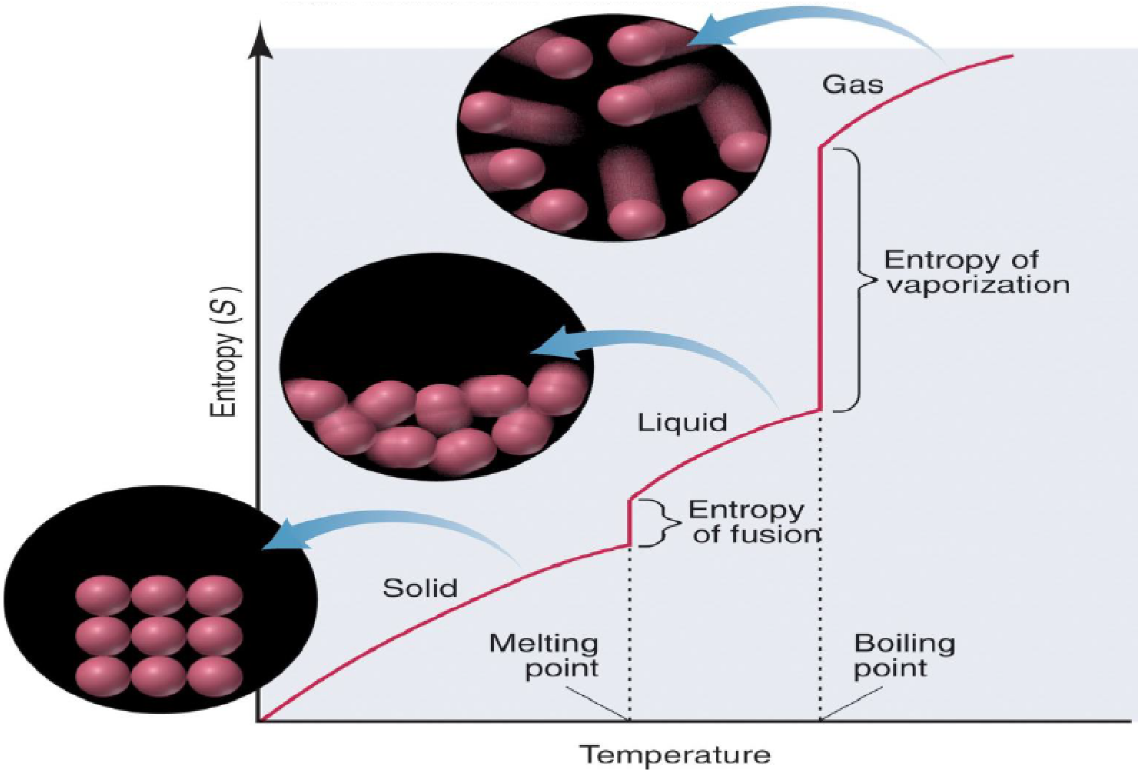
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

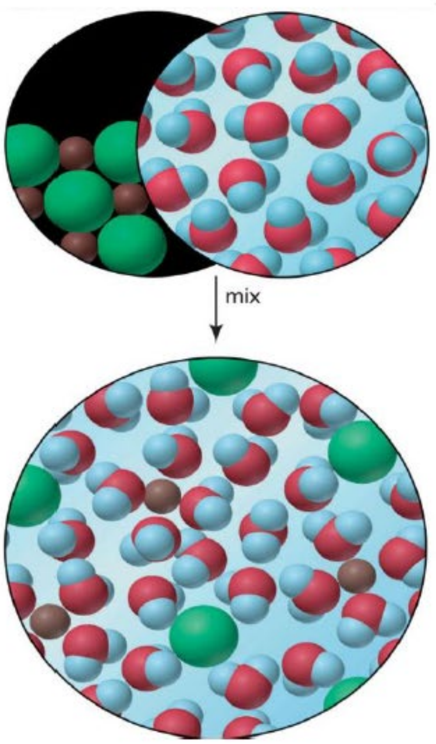
المادة العلمية:

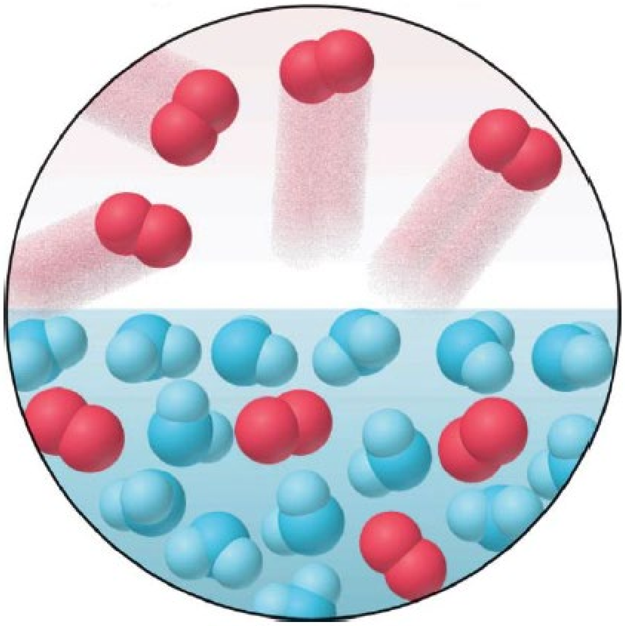
Entropy

Gases Have More Entropy Than Liquids Which Have More Than Solids



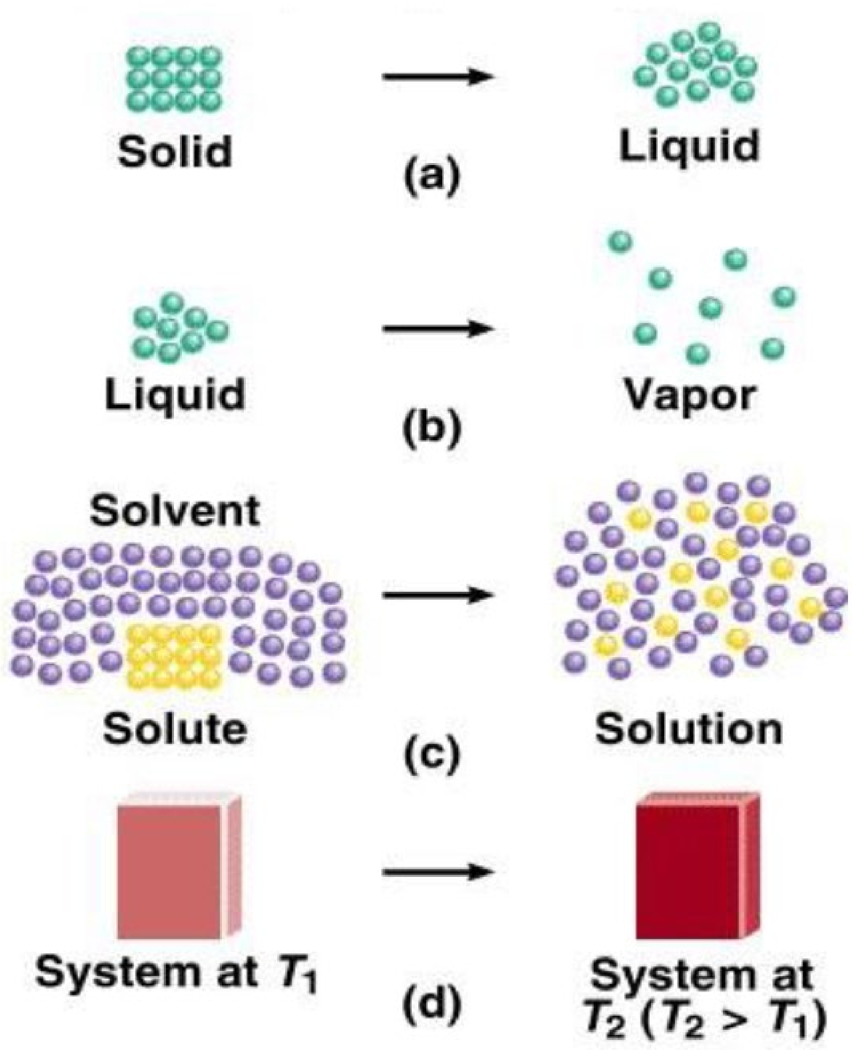
Entropy always favors making solutions because there are more possible arrangements of the atoms or molecules





Entropy decreases when a gas dissolves in a liquid.

Entropy increases during these processes



الوحدة الثالثة – المحاضرة الثالثة و العشرون - الزمن: 90 دقيقة

أهداف المحاضرة الثالثة و العشرون:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **ما المقصود بالكيمياء الكهربائية**
2. **فهم اجزاء الخلية الكهربائية و طريقة عملها**

موضوعات المحاضرة الثالثة و العشرون:

الكيمياء الكهربائية
الخلية الكهربائية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
23	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الثالثة و العشرون

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الثالثة	**الثالثة و العشرون**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
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المادة العلمية:

Electroanalytical Chemistry:

group of analytical methods based upon electrical properties of analytes when it is made part of an electrochemical cell

Types of Electroanalytical Methods:

- ✓ **Potentiometry:** measure the potential of electrochemical cells without drawing substantial current Examples: pH measurements, ion-selective electrodes ,titrations .
- ✓ **Coulometry**: measures the electricity required to drive an electrolytic oxidation/reduction to completion Examples: titrations, "chloride meters" (AgCl).
- ✓ **Voltammetry:** measures current as a function of applied potential under conditions that keep a working electrode polarized Examples: cyclic voltammetry, many biosensors.

Electrochemical Cell:

An electrochemical cell is a device that can generate electrical energy from the chemical reactions occurring in it, or use the electrical energy supplied to it to facilitate chemical reactions in it. These devices are capable of converting chemical energy into electrical energy, or vice versa. A common example of an electrochemical cell is a standard .

Such cells capable of generating an electric current from the chemical reactions occurring in them care called **Galvanic cells** or **Voltaic cells**. Alternatively, the cells which cause chemical reactions to occur in them when an electric current is passed through them are called electrolytic cells.

Electrochemical cells generally consist of a cathode and an anode. The key features of the cathode and the anode are tabulated below.

Cathode	**Anode**
Denoted by a positive sign since electrons are consumed here	Denoted by a negative sign since electrons are liberated here
A reduction reaction occurs in the cathode of an electrochemical cell	An oxidation reaction occurs here
Electrons move into the cathode	Electrons move out of the anode

half-Cells and Cell Potential

- Electrochemical Cells are made up of two half-cells, each consisting of an electrode which is dipped in an electrolyte. The same electrolyte can be used for both half cells.
- These half cells are connected by a salt bridge which provides the platform for ionic contact between them without allowing them to mix with each other. An example of a salt bridge is a filter paper which is dipped in a potassium nitrate or sodium chloride solution.
- One of the half cells of the electrochemical cell loses electrons due to oxidation and the other gains electrons in a reduction process. It can be noted that an equilibrium reaction occurs in both the half cells, and once the equilibrium is reached, the net voltage becomes 0 and the cell stops producing electricity.

- The tendency of an electrode which is in contact with an electrolyte to lose or gain electrons is described by its electrode potential. The values of these potentials can be used to predict the overall cell potential. Generally, the electrode potentials are measured with the help of the standard hydrogen electrode as a reference electrode (an electrode of known potential).

Types of Electrochemical Cells

The two primary types of electrochemical cells are

1. Galvanic cells (also known as Voltaic cells)
2. Electrolytic cells

The key differences between Galvanic cells and electrolytic cells are tabulated below.

Galvanic Cell / Voltaic Cell	**Electrolytic Cell**
Chemical energy is transformed into electrical energy in these electrochemical cells.	Electrical energy is transformed into chemical energy in these cells.
The redox reactions that take place in these cells are spontaneous in nature.	An input of energy is required for the redox reactions to proceed in these cells, i.e. the reactions are non-spontaneous.
In these electrochemical cells, the anode is negatively charged and the cathode is positively charged.	These cells feature a positively charged anode and a negatively charged cathode.
The electrons originate from the species that undergoes oxidation.	Electrons originate from an external source (such as a battery).

الوحدة الثالثة – المحاضرة الرابعة و العشرون - الزمن: 90 دقيقة

أهداف المحاضرة الرابعة و العشرون:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **التعرف الى انواع الاقطاب الكهربائية**
2. **التعرف على المحاليل الالكترولتية**

موضوعات المحاضرة الرابعة و العشرون:

انواع الاقطاب الكهربائية
المحاليل الكهربائية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
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خطة إجراءات تنفيذ المحاضرة الرابعة و العشرون

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الثالثة	**الرابعة و العشرون**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
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		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Types of Cells:

1. Metal Electrodes for Measuring the Metal Cation.
2. Metal–Metal Salt Electrodes for Measuring the Salt Anion.
3. Redox Electrodes—Inert Metals.
4. Voltaic Cells without Liquid Junction—For Maximum Accuracy.
5. Voltaic Cells with Liquid Junction—The Practical Kind.
6. Reference Electrodes: The Saturated Calomel Electrode.

Reference Electrodes: The Saturated Calomel Electrode:

A requirement of a reference electrode is that its potential be fixed and stable, unaffected by the passage of small amounts of current required in making potentiometric measurements (ideally, the current in the measurement is zero, but in practice some small current must be passed—see below). Metal–metal salt electrodes generally possess the needed properties.

Reference electrodes are usually metal–metal salt types. The two most common are the Hg/Hg_2Cl_2 (calomel) and the Ag/AgCl electrodes.

A commonly used reference electrode is the saturated calomel electrode (SCE). The term "saturated" refers to the concentration of potassium chloride; and at 25° C, the potential of the SCE is 0.242 V versus NHE. An SCE consists of a small amount of mercury mixed with some solid Hg_2Cl_2 (calomel), solid KCl, and enough saturated KCl solution to moisten the mixture. This is contacted with a saturated KCl solution containing some solid KCl to maintain saturation. A platinum electrode is immersed in the paste to make contact with the small mercury pool formed, and the connecting wire from that goes to one terminal of the potential measuring device. A salt bridge serves as the contact between the KCl solution and the test solution and is usually a fiber or porous glass frit wetted with the saturated KCl solution. If a different salt bridge is needed to prevent contamination of the test solution (you can't use the SCE for chloride measurements!), then a double-junction reference electrode is used in which the KCl junction contacts a different salt solution that in turn contacts the test solution. This, of course, creates a second liquid-junction potential, but it is constant.

Glass pH Electrode—Workhorse of Chemists The glass electrode because of its convenience, is used almost universally for pH measurements today. Its potential is essentially not affected by the presence of oxidizing or reducing agents, and it is operative over a wide pH range. It is fast responding and functions well in physiological systems. No other pH-measuring electrode possesses all these properties.

الوحدة الثالثة – المحاضرة الخامسة و العشرون - الزمن: 90 دقيقة

أهداف المحاضرة الخامسة و العشرون:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **فهم القوة الدافعة الكهربائية**

موضوعات المحاضرة الخامسة و العشرون:

القوة الدافعة الكهربائية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
25	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الخامسة و العشرون

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الثالثة	الخامسة و العشرون	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

1.Metal Electrodes for Measuring the Metal Cation.

An electrode of this type is a metal in contact with a solution containing the cation of the same metal. An example is a silver metal electrode dipping in a solution of silver nitrate. For all electrode systems, an electrode half-reaction can be written from which the potential of the electrode is described. The electrode system can be represented by **M/Mn+,** in which the line represents an electrode–solution interface. For the silver electrode, we have

$$\mathrm{Ag}|\mathrm{Ag}^+$$

and the half-reaction is

$$\mathrm{Ag}^+ + \mathrm{e}^- \rightleftharpoons \mathrm{Ag}$$

The potential of the electrode is described by the Nernst equation:

$$\boxed{E = E^0_{\mathrm{Ag}^+,\mathrm{Ag}} - \frac{2.303RT}{nF}\log\frac{1}{a_{\mathrm{Ag}^+}}}$$

2.Metal–Metal Salt Electrodes for Measuring the Salt Anion

The general form of this type of electrode is **M|MX|Xn−**, where MX is a slightly soluble salt. An example is the silver–silver chloride electrode:

$$Ag \mid AgCl_{(s)} \mid Cl^-$$

The (s) indicates a solid, (g) is used to indicate a gas, and (l) is used to indicate a pure liquid. A vertical line denotes a phase boundary between two different solids or a solid and a solution. The half-reaction is:

$$\underline{AgCl} + e^- \rightleftharpoons \underline{Ag} + Cl^-$$

where the underline indicates a solid phase and the potential is defined by

$$\boxed{E = E^0_{AgCl,Ag} - \frac{2.303RT}{F} \log a_{Cl^-}}$$

3.Redox Electrodes— Inert Metals

In the redox electrode, an inert metal is in contact with a solution containing the soluble oxidized and reduced forms of the redox half-reaction. The inert metal used is usually platinum. The potential of such an inert electrode is determined by the ratio at the electrode surface of the reduced and oxidized species in the half-reaction:

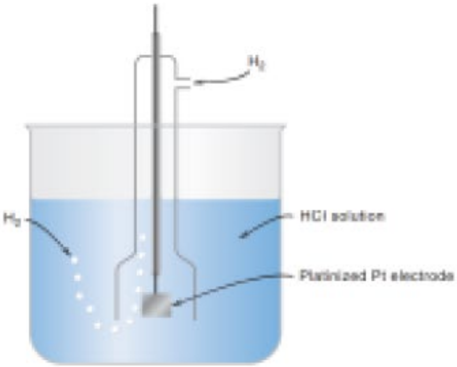
$$\mathrm{M}^{a+} + ne^- \rightleftharpoons \mathrm{M}^{(a-n)+}$$

$$E = E^0_{\mathrm{M}^{a+},\mathrm{M}^{(a-n)+}} - \frac{2.303RT}{nF}\log\frac{a_{\mathrm{M}^{(a-n)+}}}{a_{\mathrm{M}^{a+}}}$$

An example is the measurement of the ratio of $\mathrm{MnO_4}^-/\mathrm{Mn}^{2+}$:

$$\mathrm{MnO_4}^- + 8\mathrm{H}^+ + 5\mathrm{e}^- \rightleftharpoons \mathrm{Mn}^{2+} + 4\mathrm{H_2O}$$

$$E = E^0_{\mathrm{MnO_4}^-,\mathrm{Mn}^{2+}} - \frac{2.303RT}{5F}\log\frac{a_{\mathrm{Mn}^{2+}}}{a_{\mathrm{MnO_4}^-}\cdot(a_{\mathrm{H}^+})^8}$$



الوحدة الثالثة – المحاضرة السادسة و العشرون - الزمن: 90 دقيقة

أهداف المحاضرة السادسة و العشرون:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **فهم معادلة نرنست و طريقة تطبيقها**
2. **فهم ما المقصود بجهد الخلية**

موضوعات المحاضرة السادسة و العشرون:

معادلة نرنست
جهد الخلية

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
26	• محاضرة • مناقشة • سؤال وجواب	• جهاز حاسوب • جهاز عرض • سبورة • اوراق واقلام

خطة إجراءات تنفيذ المحاضرة السادسة و العشرون

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الثالثة	**السادسة و العشرون**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Nernst equation

The Nernst equation provides a relation between the cell potential of an electrochemical cell, the standard cell potential, temperature, and the reaction quotient. Even under non-standard conditions, the cell potentials of electrochemical cells can be determined with the help of the Nernst equation.

The Nernst equation is often used to calculate the cell potential of an electrochemical cell at any given temperature, pressure, and reactant concentration. The equation was introduced by a German chemist named Walther Hermann Nernst.

Expression of Nernst Equation

Nernst equation is an equation relating the capacity of an atom/ion to take up one or more electrons (reduction potential) measured at any conditions to that measured at standard conditions (standard reduction potentials) of 298K and one molar or one atmospheric pressure.

Nernst Equation for Single Electrode Potential

$$E_{cell} = E^0 - [RT/nF] \ln Q$$

Where,

- E_{cell} = cell potential of the cell
- E^0 = cell potential under standard conditions
- R = universal gas constant
- T = temperature
- n = number of electrons transferred in the redox reaction
- F = Faraday constant
- Q = reaction quotient

The calculation of single electrode reduction potential (E_{red}) from the standard single electrode reduction potential (E°_{red}) for an atom/ion is given by the Nernst equation.

For a reduction reaction, Nernst equation for a single electrode reduction potential for a reduction reaction

$M^{n+} + ne^{-} \rightarrow nM$ is;

$E_{red} = EM^{n+}/M = E^{o}M^{n+}/M - [2.303RT/nF] \log [1/[M^{n+}]]$

Where,

- R is the gas constant = 8.314 J/K Mole
- T = absolute temperature,
- n = number of mole of electron involved,
- F = 96487 (≈96500) coulomb/mole = charged carried by one mole of electrons.
- $[M^{n+}]$ = active mass of the ions. For simplicity, it may be taken as equal to the molar concentration of the salt.

Nernst Equation at 25ºC

For measurements carried out 298K, the Nernst equation can be expressed as follows.

$E = E^{0} - 0.0592/n \log_{10} Q$

Therefore, as per the Nernst equation, the overall potential of an electrochemical cell is dependent on the reaction quotient.

Nernst Equation Applications

The Nernst equation can be used to calculate:

- Single electrode reduction or oxidation potential at any conditions
- Standard electrode potentials
- Comparing the relative ability as a reductive or oxidative agent.
- Finding the feasibility of the combination of such single electrodes to produce electric potential.
- Emf of an electrochemical cell

- Unknown ionic concentrations
- The pH of solutions and solubility of sparingly soluble salts can be measured with the help of the Nernst equation.

Limitations of Nernst Equation

The activity of an ion in a very dilute solution is close to infinity and can, therefore, be expressed in terms of the ion concentration. However, for solutions having very high concentrations, the ion concentration is not equal to the ion activity. In order to use the Nernst equation in such cases, experimental measurements must be conducted to obtain the true activity of the ion.

Another shortcoming of this equation is that it cannot be used to measure cell potential when there is a current flowing through the electrode. This is because the flow of current affects the activity of the ions on the surface of the electrode. Also, additional factors such as resistive loss and over potential must be considered when there is a current flowing through the electrode.

الوحدة الثالثة – المحاضرة السابعة و العشرون - الزمن: 90 دقيقة

أهداف المحاضرة السابعة و العشرون:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **فهم ما المقصود بالكيمياء الضوئية و اهميتها و تطبيقاتها**

موضوعات المحاضرة السابعة و العشرون:

الكيمياء الضوئية
تحليل الطيف الظوئي
منطقة الطيف الكهرومغناطيسي

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
27	• محاضرة • مناقشة • سؤال وجواب	• جهاز حاسوب • جهاز عرض • سبورة • اوراق واقلام

خطة إجراءات تنفيذ المحاضرة السابعة و العشرون

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الرابعة	**السابعة و العشرون**	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
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المادة العلمية:

Photochemistry (spectrophotometer analysis)

The study of chemical reactions, isomerization and physical behavior that may occur under the influence of visible and/or ultraviolet light is called **Photochemistry**. Two fundamental principles are the foundation for understanding photochemical transformations:

- **The first law of photochemistry**, the Grotthuss-Draper law, states that light must be absorbed by a compound in order for a photochemical reaction to take place.
- **The second law of photochemistry**, the Stark-Einstein law, states that for each photon of light absorbed by a chemical system, only one molecule is activated for subsequent reaction. This "photo equivalence law" was derived by Albert Einstein during his development of the quantum (photon) theory of light.

The efficiency with which a given photochemical process occurs is given by its **Quantum Yield (Φ)**. Since many photochemical reactions are complex, and may compete with unproductive energy loss, the quantum yield is usually specified for a particular event. Thus, we may define quantum yield as "the number of moles of a stated reactant disappearing, or the number of moles of a stated product produced, per einstein of monochromatic light absorbed.", where an Einstein is one mole of photons. For example, irradiation of acetone with 313 nm light (3130 Å) gives a complex mixture of products, as shown in the following diagram. The quantum yield of these products is less than 0.2, indicating there are radiative (fluorescence & phosphorescence) and non-radiative return pathways (green arrow). The primary photochemical reaction is the homolytic cleavage of a carbon-carbon bond shown in the top equation. Here the asterisk represents an electronic excited state, the nature of which will be defined later.

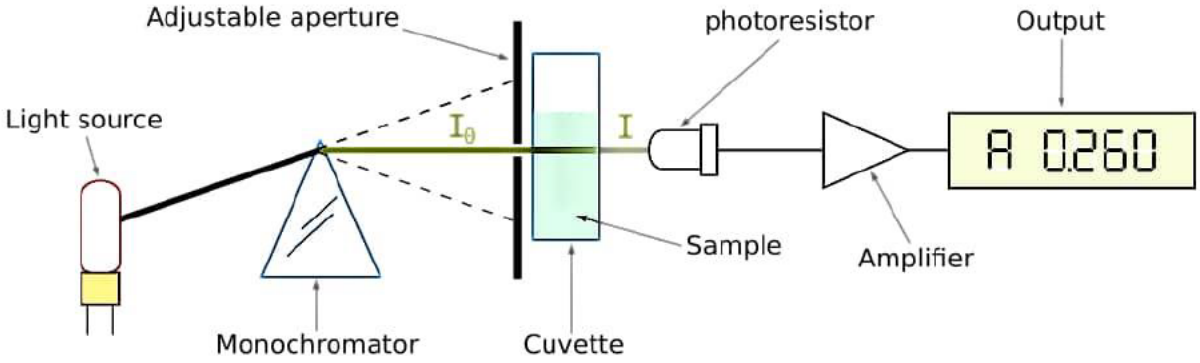
How does a Spectrophotometer work?

Spectrophotometry is a standard and inexpensive technique to measure light absorption or the amount of chemicals in a solution. It uses a light beam which passes through the sample, and each compound in the solution absorbs or transmits light over a certain wavelength. The instrument used is called a spectrophotometer. It measures the number of photons absorbed and is made up of two instruments: a spectrometer and a photometer. The spectrometer produces the light of the wavelength and the photometer measures the intensity of light by measuring the amount of light that passes through the sample.

There are two types: a single beam, and double beam. Single beam spectrophotometers are generally more compact and have a higher dynamic range but the optics in a double beam can permit higher levels of automation, better precision and can correct for background absorption of the solvent. With the double beam spectrophotometer, one beam passes through the sample, and the other through a reference solution or the solvent.

Spectrophotometers consist of a ***light source***, ***a monochromator*** (which separates the polychromatic radiation of the light source into all its wavelength), ***a sample chamber containing a cuvette***, a ***detector*** (such as a photomultiplier tube or photodiode) to detect the transmitted light***, a digital display*** and a ***data analysis software package***.

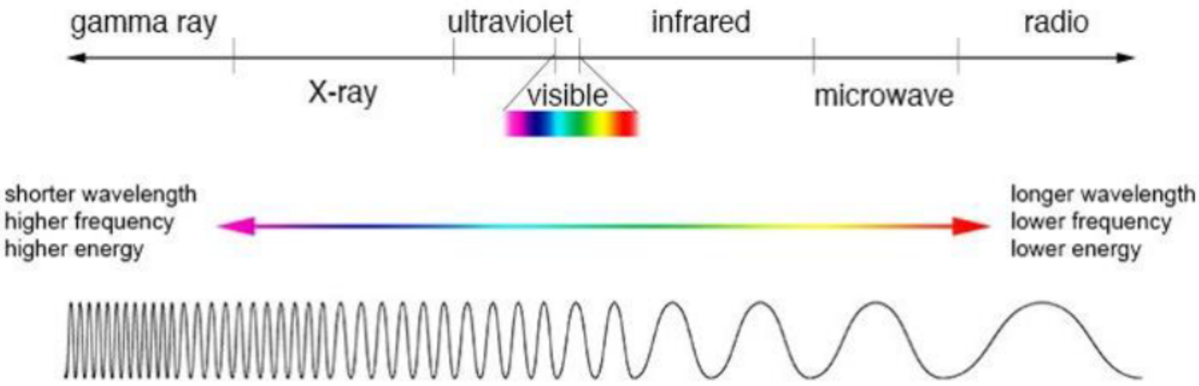
The monochromator (such as a prism or grating) inside the machine refracts the light into a single spectrum and disperses polychromatic light into the essential wavelengths. A grating divides the light available into different segments. Gratings are common in spectrophotometers that use UV, visible and infrared regions.



In the spectrophotometer, the number of photons absorbed by a solution is called the absorbance readout. The longer the path-length that the light must travel through a solution prior to it reaching the detector, the greater the chance of a photon being absorbed.

Regions of electromagnetic spectrum

The entire range of electromagnetic waves is known as the electromagnetic spectrum. This includes electromagnetic energy ranging from gamma rays to radio waves.



Regions of the Electromagnetic Spectrum

The electromagnetic spectrum is broadly classified into different named categories based on the wavelength and characteristics of the energy. The names like "microwave" or "infrared" were developed for convenience to describe electromagnetic radiation with similar characteristics, but there are no definitive dividing lines between one spectral region or the next. The only region in the electromagnetic spectrum that is relatively consistent in the wavelength definition is the visible spectrum, as it corresponds directly with to wavelengths that human eyes are sensitive to. The visible spectrum is a small window of the entire electromagnetic spectrum.

Gamma Rays (Wavelength $< 10^{-12}$ meters)

Gamma rays have the shortest wavelengths (< 0.01 nanometers) and the most energy of any region of the electromagnetic spectrum. Gamma rays are produces by the hottest objects in the universe, including neutron stars, pulsars, supernova explosions. Gamma rays can also be created by nuclear explosions. the majority of gamma rays generated in space are blocked by the Earth's atmosphere. This is a good thing as gamma rays are biologically hazardous.

X-Rays (Wavelength 10^{-8} to 10^{-12} meters)

X-Rays range in wavelength from 0.01 – 10 nm and are primarily generated from by super-heated gas from exploding stars and quasars. X-rays are able to pass through many different types of materials. X-rays are commonly used for medical imaging and for inspecting cargo and luggage. Similar to gamma rays, the Earth's atmosphere blocks x-ray radiation.

Ultraviolet (UV) (Wavelength 10^{-7} - 10^{-8} meters)

Ultraviolet (UV) light has wavelengths of approximately 1 – 380 nm. The Sun is a source of ultraviolet energy. The UV portion of the spectrum is subdivided into UV-A, UV-B, and UV-C. UV-C rays are the most harmful and are almost completely absorbed by our atmosphere. UV-B rays are the harmful rays that cause sunburn. Although UV waves are invisible to the human eye, some insects, such as bumblebees, can see them.

Visible (Wavelength ~ 10^{-7} meters*)*

Color	Wavelength
violet	380–450 nm
blue	450–495 nm
green	495–570 nm
yellow	570–590 nm
orange	590–620 nm
red	620–750 nm

Visible light covers the range of wavelengths from 400 – 750 nm or 0.4 to 0.75 micrometers. This is the only region in spectrum that human eyes are sensitive to. The Sun emits the most radiation in the visible portion of the spectrum. Each individual wavelength within the spectrum of visible light wavelengths is representative of a particular color. Light at the lower end of the visible spectrum, having a longer wavelength, about 750 nm, is seen as red; light in the middle of the spectrum is seen as green; and light at the upper end of the spectrum, with a wavelength of about 380 nm, is seen as violet. When all the wavelengths of the visible light spectrum strike your eye at the same time, the color white is perceived. The visible portion of the spectrum is used extensively in remote sensing and is the energy that is recorded using photography.

Infrared (Wavelength ~ 10^{-6} to 10^{-3} meters*)*

The infrared portion of the spectrum ranges from approximately 0.75 μm to 100 μm (750 nm - 10,000 nm) in wavelength. It is divided up into three main regions, **Near Infrared (NIR):** 0.7 – 1.3μm, **Shortwave Infrared (SWIR):** from 1.3 – 3 μm and the **Far or Thermal Infrared** from 3 - 100 μm. Infrared radiation is used extensively in remote sensing. Objects reflect, transmit, and absorb the Sun's near-infrared and shortwave radiation in unique ways and this can use to observe the health of vegetation, soil composition and moisture content. The region from 8 to 15 μm is referred to as thermal infrared since these wavelengths are best for studying the longwave thermal energy radiating from the Earth.

Microwaves (Wavelength ~ 10^{-3} to 10^{-1} meters*)*

Microwaves are essentially high frequency radio waves and have wavelengths that range 1mm to 1m. Different wavelengths or bands of microwaves are used for different applications. Mid-wavelength microwaves can penetrate haze, light rain and snow, clouds, and smoke are beneficial for satellite communication and studying the Earth from space. Radar technology sends pulses of microwave energy and senses the energy reflected back.

*Radio Waves ((*Wavelength >10^{-1}meters*)*

Radio waves have the longest wavelengths in the electromagnetic spectrum with wavelengths ranging from approximately 1mm to several hundred meters. Radio waves are used to transmit a variety of data. Wireless networking, television and amateur radio all use radio waves. The use of radio frequencies are usually regulated by governments.

الوحدة الثالثة – المحاضرة الثامنة و العشرون - الزمن: 90 دقيقة

أهداف المحاضرة الثامنة و العشرون:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **فهم ما المقصود بالكيمياء الضوئية و اهميتها و تطبيقاتها**

موضوعات المحاضرة الثامنة و العشرون:

الامتزاز و انبعاث الطيف الكهرومغناطيسي

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
28	● محاضرة ● مناقشة ● سؤال وجواب	● جهاز حاسوب ● جهاز عرض ● سبورة ● اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الثامنة و العشرون

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الرابعة	الثامنة و العشرون	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
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		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Absorption and emission of electromagnetic spectrum

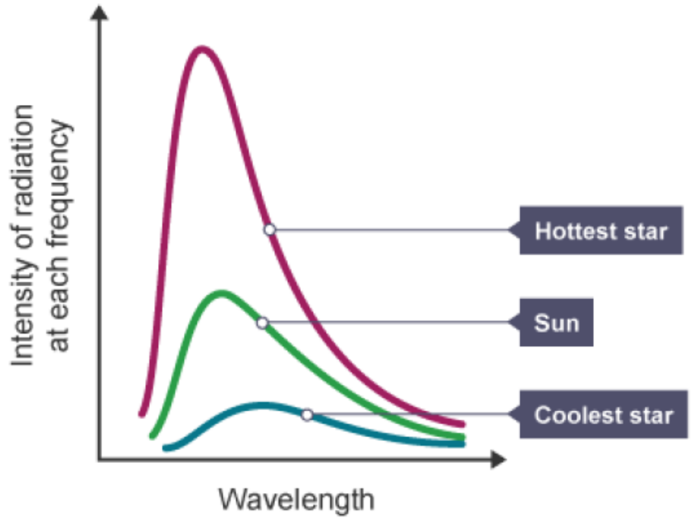
All bodies (objects) emit electromagnetic radiation, no matter what their temperature is. The type of radiation emitted depends on the temperature of the body.

Hot bodies emit a continuous range of electromagnetic radiation at different energy values – this means that the radiation that is emitted is spread out over a range of different frequencies and wavelengths.

As a body gets hotter, it emits more high frequency electromagnetic radiation than low frequency. The higher the frequency, the shorter the wavelength. This means that the intensity of the radiation emitted is greater for a hotter body.

As the surface temperature of a hot body, such as a star, increases:

- the intensity of radiation it emits increases
- the wavelength that corresponds to the peak intensity gets shorter



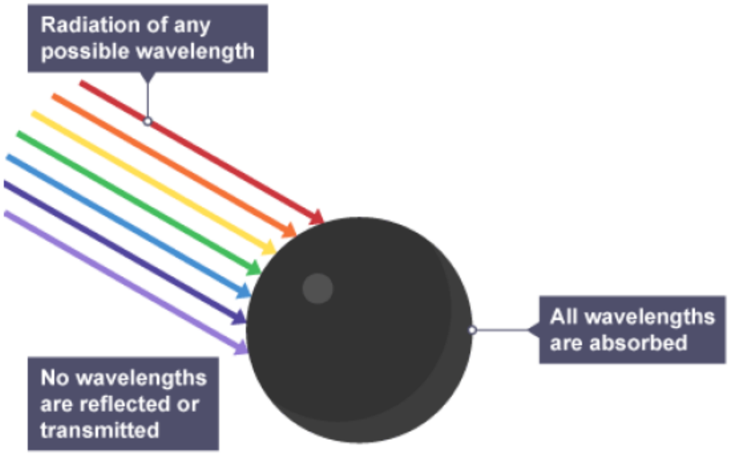
The graph for a hot star (such as a blue supergiant) peaks over a shorter wavelength than a cooler star (such as a red giant). The intensity of radiation for each frequency is higher for a very hot star than for a cooler one.

A perfect black body is a theoretical object. It would have these properties:

- it would absorb all the radiation that falls on it
- it would not reflect or transmit any radiation

An object that is good at absorbing radiation is also a good emitter, so a perfect black body would be the best possible emitter of radiation.

There are no known objects that are perfect at absorbing or emitting all the radiation, of every possible frequency, that may be directed at them. Some objects do, however, come close to this and these are referred to as black bodies.



Features of a perfect black body

Stars are considered to be black bodies because they are very good emitters of most wavelengths in the electromagnetic spectrum. This suggests that stars also absorb most wavelengths. Whilst there are a few wavelengths that stars do not absorb or emit, this figure is very low, so they can be treated as black bodies. Planets and black holes are also treated as nearly perfect black bodies.

الوحدة الثالثة – المحاضرة التاسعة و العشرون - الزمن: 90 دقيقة

أهداف المحاضرة التاسعة و العشرون:

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1. **فهم ما المقصود بالكيمياء الضوئية و اهميتها و تطبيقاتها**

موضوعات المحاضرة التاسعة و العشرون:

تطبيق قانون بير لامبير

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
29	• محاضرة • مناقشة • سؤال وجواب	• جهاز حاسوب • جهاز عرض • سبورة • اوراق واقلام

خطة إجراءات تنفيذ المحاضرة التاسعة و العشرون

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الرابعة	التاسعة و العشرون	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
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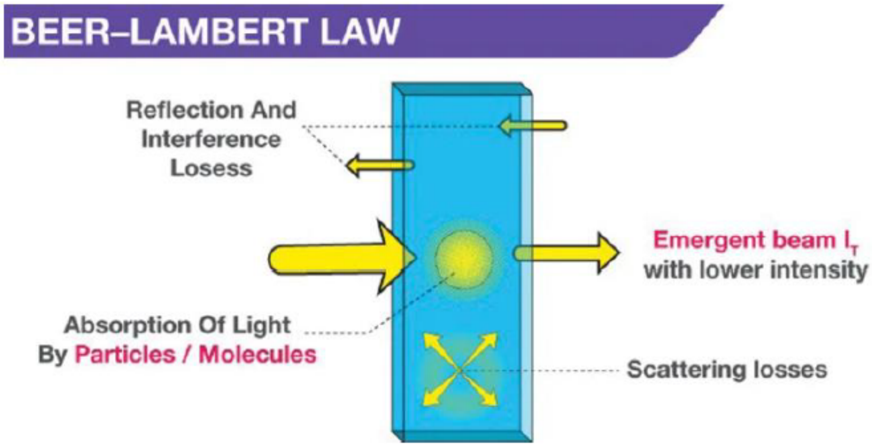
المادة العلمية:

Beer, Lambert law instrumentation.

- When a monochromatic light of initial intensity Io passes through a solution in a transparent vessel, some of the light is absorbed so that the intensity of the transmitted light I is less than Io.
- There is some loss of light intensity from scattering by particles in the solution and reflection at the interfaces, but mainly from absorption by the solution.
- The relationship between I and Io depends on the path length of the absorbing medium, l, and the concentration of the absorbing solution, c. These factors are related in the laws of Lambert and Beer.



The **Beer-Lambert law (or Beer's law)** is the linear relationship between absorbance and concentration of an absorbing species. The general Beer-Lambert law is usually written as:

$$A = a(\lambda) * b * c$$

where A is the measured absorbance, $a(\lambda)$ is a wavelength-dependent absorptivity coefficient, **b** is the path length, and **c** is the analyte concentration. When working in concentration units of molarity, the *Beer-Lambert law* is written as:

$$A = \varepsilon * b * c$$

where ε is the wavelength-dependent molar absorptivity coefficient with units of M^{-1} cm^{-1}. Data are frequently reported in percent transmission (I/I_0 * 100) or in absorbance [$A = \log (I/I_0)$]. The latter is particularly convenient. Sometimes the extinction coefficient is given in other units; for example,

$$A = E^{1\%} * b * c$$

where the concentration C is in gram per 100 ml of solution. This useful when the molecular weight of the solute is unknown or uncertain.

الوحدة الثالثة – المحاضرة الثلاثون - الزمن: 90 دقيقة

أهداف المحاضرة الثلاثون:

يتوقع في نهاية الجلسة أن يكون الطالب قادراً على:

1. **فهم ما المقصود بالكيمياء الضوئية و اهميتها و تطبيقاتها**

موضوعات المحاضرة الثلاثون:

مكونات جهاز المطياف الظوئي
التحليل باستخدام جهاز المطياف الظوئي

الأساليب والأنشطة والوسائل التعليمية

م	الأساليب والأنشطة التدريبية	الوسائل التدريبية
30	• محاضرة • مناقشة • سؤال وجواب	• جهاز حاسوب • جهاز عرض • سبورة • اوراق واقلام

خطة إجراءات تنفيذ المحاضرة الثلاثون

الوحدة	المحاضرة	الإجراءات	الزمن بالدقيقة
الرابعة	الثلاثون	التعريف بالبرنامج وأهدافه وأهميته	90 دقيقة
		القاء المحاضرة مستخدما جهاز العرض و السبورة	
		طرح بعض الاسئلة خلال القاء المحاضرة	
		اجراء اختبار سريع للطلبة في نهاية المحاضرة يتضن تمرين متعدد الخيارات	

المادة العلمية:

Instrumentation

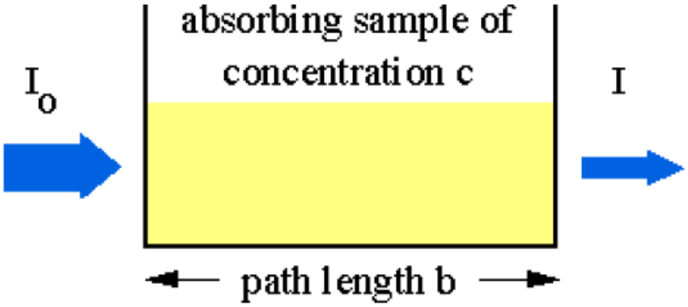
Experimental measurements are usually made in terms of **transmittance** (T), which is defined as:

$$T = I / I_o$$

where I is the **light intensity** after it passes through the sample and I_o is the **initial light intensity**. The relation between A and T is:

$$A = -\log T = -\log (I / I_o).$$

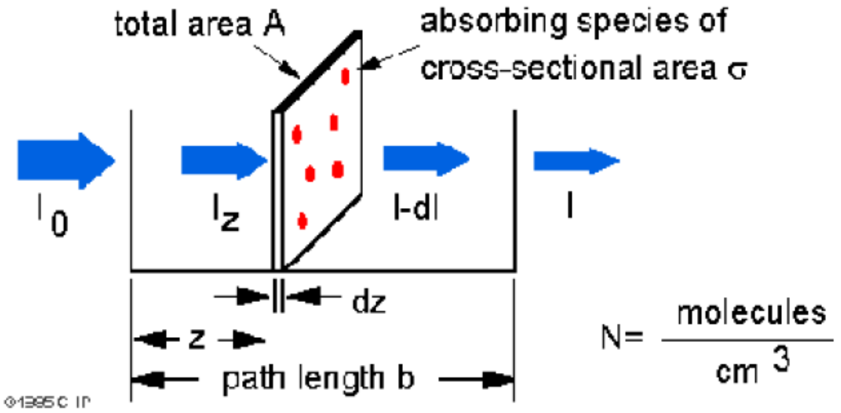
Absorption of light by a sample



Modern absorption instruments can usually display the data as either transmittance, %-transmittance, or absorbance. An unknown concentration of an analyte can be determined by measuring the amount of light that a sample absorbs and applying Beer's law. If the absorptivity coefficient is not known, the unknown concentration can be determined using a working curve of absorbance versus concentration derived from standards.

Derivation of the Beer-Lambert law

The Beer-Lambert law can be derived from an approximation for the absorption coefficient for a molecule by approximating the molecule by an opaque disk whose cross-sectional area, σ, represents the effective area seen by a photon of frequency *w*. If the frequency of the light is far from resonance, the area is approximately 0, and if *w* is close to resonance the area is a maximum. Taking an infinitesimal slab, dz, of sample:



I_o is the intensity entering the sample at z=0, I_z is the intensity entering the infinitesimal slab at z, dI is the intensity absorbed in the slab, and I is the intensity of light leaving the sample. Then, the total opaque area on the slab due to the absorbers is σ * N * A * dz. Then, the fraction of photons absorbed will be σ * N * A * dz / A so,

$$dI / I_z = - \sigma * N * dz$$

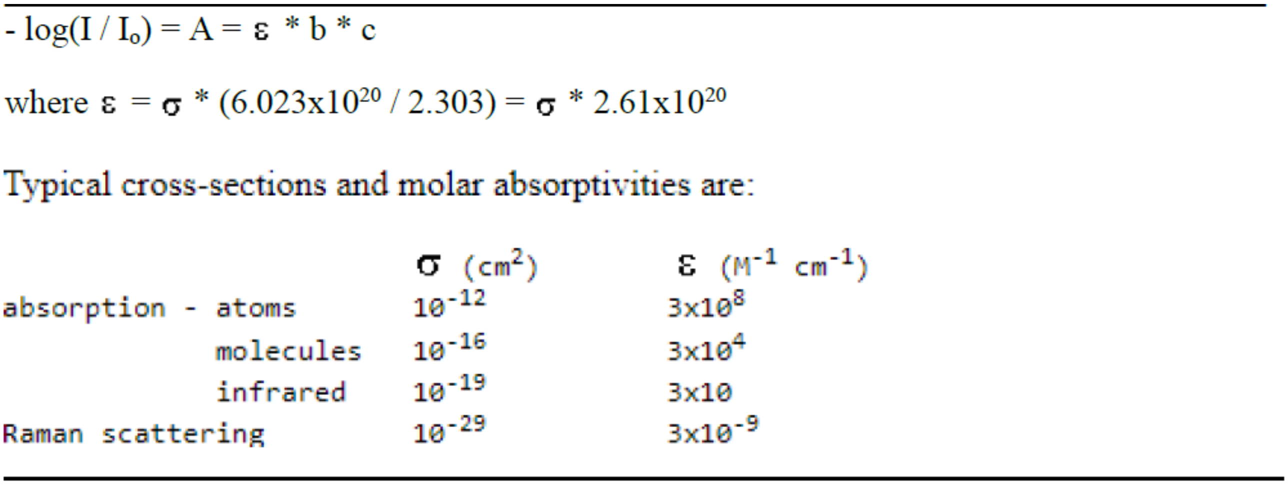
Integrating this equation from z = 0 to z = b gives:

$$\ln(I) - \ln(I_o) = - \sigma * N * b$$

or $- \ln(I / I_o) = \sigma * N * b$.

Since N (molecules/cm^3) * (1 mole / 6.023x10^{23} molecules) * 1000 cm^3 / liter = c (moles/liter) and 2.303 * log(x) = ln(x) then

$$- \log(I / I_o) = \sigma * (6.023x10^{20} / 2.303) * c * b$$



$- \log(I / I_o) = A = \varepsilon * b * c$

where $\varepsilon = \sigma * (6.023\text{x}10^{20} / 2.303) = \sigma * 2.61\text{x}10^{20}$

Typical cross-sections and molar absorptivities are:

	σ (cm^2)	ε (M^{-1} cm^{-1})
absorption - atoms	10^{-12}	$3\text{x}10^{8}$
molecules	10^{-16}	$3\text{x}10^{4}$
infrared	10^{-19}	3x10
Raman scattering	10^{-29}	$3\text{x}10^{-9}$

Limitations of the Beer-Lambert law

The linearity of the Beer-Lambert law is limited by chemical and instrumental factors. Causes of nonlinearity include: