قسم الكيمياء

الكيمياء التحليلية - نظري

المرحلة الأولى

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Safety and Hazardous Chemicals

Hazard :- The hazard is anything that has the potential to cause harm in terms of injury, ill-health or damage to the environment, for example, working with dangerous chemicals or processes which give rise to dusts or fumes.

Identify the Hazards :- This involves identifying the chemicals you have in your workplace and the hazards associated with them.

Hazards chemicals :- Ther are many ways chemicals Can enter the body like

1- By inhalation, where breathing in contaminated air is the most Common way that workplace chemicals enter the body.
2- By Contact with the skin or eye, Some chemicals can damage the skin or eye like irritation or pass through the skin into the body.
3- Ingestion :- workplace chemicals may be swallowed accidentally if food or hands are contaminated.
4- Injections :- Through indirect injection (wrong injection)

Types of chemical health hazards :- Chemicals health hazards are classed as either acute or Chronic.

1- The acute hazards are asphyxiation, acid burns, dizziness, nausea and vomiting.

2- The chronic hazards are issues that may take some time to develop symptoms such as bronchitis, dermatitis, cancer and liver damage.

Classifying hazardous chemicals:- The classification process assigns categories to hazardous chemicals based on agreed hazard classification criteria.

The classification includes, (GHS classification)

1- physical hazard, for example flammability

2- Health hazard, for example toxicity and carcinogenicity

3- Environmental hazard, for example hazardous to the aquatic environment.

Classifying hazardous chemicals according to hazards to

1- Toxic meterials for example mercury, arsenic, Poloni

2- Incendiary meterials like Sulfuric acid, hydrochlor

3- Carcinogens like Uranium, Benzene and Lead

4- Flammable meterials like Carbon disulfide, Alcohol

5- Oxidants meterials like ammonium nitrate, hydrogen p

6- Radioactive meterials like uranium, phosphate

7- Explosive meterials like ammonium nitrate and gas cylinders.

8- Irritating meterials like Solvents e.g acetone, ethanol, and like weak acids e.g acetic, citric. The oxides e.g Ag_2O, Al_2O_3

إجراءات يجب اتباعها قبل مغادرة المختبر

١- تنظيف مكان عملك
٢- غسل جميع الزجاجيات المستخدمة في عملك
٣- تغلق كافة الاجهزه والمعدات (جهاز، كهرباء، وماء، غاز)
٤- ازالة اي مخلفات فيها مواد كيميائية ملقاة على الارض
٥- اطفئ كافة نقاط الاضاءه واترك خزانة شفط الغازات مفتوح ثم اغلق ابواب المختبر

طرق التخلص من نفايات المواد الكيميائية بطرق آمنة

١- يمنع التخلص من المواد ذات السمية العالية مثل الزئبق، الزرنيخ، الكادميوم، مركبات السيانيد والفينول داخل مجاري الصرف المختبري.
٢- يمنع التخلص من المواد الكيميائية الصلبة داخل مجرى الصرف.
٣- يمنع التخلص من الحوامض داخل مجرى الصرف واذا لم يكن هنالك مكان مخصص للتخلص من الحوامض فيجب ان يسكب الماء بصورة مستمرة بعد اتلاف الحوامض داخل المجرى لمنع تراكمها حتى لا تسبب عمليات تآكل للانابيب البلاستيكية او المعدنية.
٤- يجب تخفيف الحوامض القوية والقواعد القوية قبل سكبها

الطرق المتبعة عند حدوث حريق

١- اقرع اجراس الانذار واذا لم توجد اجراس انذار ارفع صوتك لغرض التنبيه وطلب المساعدة.
٢- تأكد من خروج الجميع من المختبر
٣- اتصل برقم الدفاع المدني
٤- حاول قدر المستطاع في منع انتقال الحريق الى مكان آخر لحين وصول فرق الدفاع المدني عن طريق فصل التيار الكهربائي ومصدر الوقود

الوقاية من مخاطر المواد الكيميائية الملتهبة

ذات اللهب المكشوف

1. يجب إطفاء جميع مصادر الاشتعال ذات اللهب المكشوف
2. عدم نقل المواد الملتهبة مع مواد متفجرة أو سامة أو مؤكسدة
3. عدم تخزين المواد الملتهبة مع الاحماض
4. عدم تسخين سوائل هذه المواد على لهب مباشر بل في حمام مائي

طريقة حفظ المواد المشتعلة

تحفظ في مكان مظلم بعيداً عن الشمس
توضع هذه المواد في رمل مندى بالماء وطبقة سميكة من كربونات الصوديوم ، توضع الزجاجات قائمة فوق هذه الوسادة متباعدة قليلاً

طرق التعامل مع المواد السامة

1. الرجوع الى دليل المواد السامة
2. قراءة التحذيرات على كل عبوة قبل الاستخدام
3. تهوية مكان العمل تهوية جيدة
4. غسيل اليدين بعد الاستخدام مباشرةً
5. تطهير الملابس الملوثة .

طرق التعامل مع الكيمياويات داخل مختبرات الكيمياء

1. يجب تقسيم الكيمياويات حسب انواعها ومدى خطورتها
2. التعامل الصحيح مع الكيمياويات كلاً حسب خطورتة
3. التخزين الصحيح للكيمياويات
4. التعامل الصحيح والحذر الشديد مع اسطوانات الغاز

الاسعافات الاولية في حالة بعض الاصابات

١- اذا تعرضت العين لمواد كيميائية توضع تحت تيار مائي لمدة تتراوح من 15 دقيقة الى ٢٠ دقيقة (غسيل)

٢- اذا تعرض الجلد لمواد كيميائية يعرض لتيار مائي لمدة 15 دقيقة (غسيل)

٣- اذا حدث عملية اختناق بأبخرة او غازات فان المصاب يجب ان ينقل الى خارج المختبر فوراً ويعرض الى الهواء النقي لحين عودته الى الحالة الطبيعية واذا اضطر الامر يمكن اجراء عملية التنفس الصناعي ونقله الى المستشفى

٤- اذا تم ابتلاع مواد كيميائية عن طريق الاستعمال الخاطئ فيجب معرفة هوية تلك المادة اولاً فاذا كانت غير حارقة فيجب التقيؤ قدر المستطاع اذا لم يكن فاقد للوعي لهذا ذلك نسقي المصاب ماء او حليباً ثم ننقله الى المستشفى فوراً

٥- في حالة حدوث حروق كيميائية يجب غسل مكان الحرق فوراً بالماء ومن ثم بمحلول مخفف من المادة الحامضية او القلوية المخففة المعادلة للمادة التي تسببت في حدوث الحروق في حالة التعرف على المادة المسببة للحروق.

ادوات السلامة الشخصية

١- القفازات المطاطية الواقية لليدين
٢- النظارات الواقية للعيون
٣- القناع الواقي للوجه.
٤- المعطف المختبري

إشارات الخطر
Hazard signs

Importance of analytical Chemistry

Analytical chemistry is applied in all areas of Science, industry and medicine.
Analytical chemistry is important in the field of medicine because it helps to measure the level of important nutrients in human body like Carbohydrates, lipids, proteins and sugars.
Analytical chemistry also helps in disease diagnosis, for example diseases like diabetes, high levels of cholesterol and other bacterial and viral diseases can be diagnosed by the help of quantitative and qualitative analysis.

Analytical chemistry also help in determining the levels of toxic waste in the body like uric acide, cholesterol, drugs, and some salts, this helps in diagnosis of many diseases.

Analytical Chemistry plays a very important role in biological studies an clinical assays.

Analytical chemistry has wide spread applications from quality control in food industries. It used in analysis of steel during its production for Carbon, nickel and chromium to achieve a desired strength, hardness, and ductility.

Importance of qualitative analysis:- Reveals identify of the elements and compounds in a sample.

Importance of quantitative analysis:- Indicates the amount of each substance in a sample, %, concentration.

Quantitative analytical measurements also play a vital role in biochemistry, biology, geology, physics and the other sciences

The importance of analytical chemistry is the determination of the chemical composition of matter. It is the main goal of analytical chemistry. However, the identification of a substance, the elucidation of its structure and quantitative analysis of its composition are the aspects covered by modern analytical chemistry. The most difficult task for an analytical chemistry is to explain what analytical chemistry is?

The importance of analytical chemistry is of many applications they are as follows.

1- Inorganic
2- organic
3- physical
4- Biochemistry
5- Enviromental science
6- Agricultural science
7- Biomedical and clinical chemis
8- Solid state research

Classification of methods of analytical Chemistry

- Analytical chemistry
  - Classical method
    - Qualitative analysis
      - chemical test
      - Flam test
    - Quantitative analysis
      - Gravimetric analysis
      - Volumetric analysis
      - Electro analytical method
      - Spectroscopic method
  - Instrumental method
    - spectroscopy analysis
      - Ultra-violet spectroscopy
      - Infrared spectroscopy
      - mass spectroscopy
      - Nuclear magnetic resonance spectroscopy
    - separation analysis
      - Paper chromatography
      - Column chromatography
      - thinlayer chromatography
      - Gas chromatography

Classical methods

Advantages and disadvantages of classical methods

Advantages are

1- Simple method
2- Accurate method دقيقة
3- Based on absolute measurements.
4- The devices and tools used are cheap

Disadvantages are

1- Lack of specificity
2- It takes along time
3- Accuracy decreases with decreasing amounts of analyt
4- Affected by external environmental factors.

Instrumental methods

Advantages and disadvantages of instrumental methods

Advantages are

1- Rapid method سريعة
2- Use small amounts of sample.
3- Complex samples analysis
4- High sensitivity
5- Its measurements possess high reliability موثوقية
6- Not affected by external factors.

Disadvantages are

1- It need a calibration curve.
2- Accuracy and sensitivity depend upon the chemical method used for the calibration process as well as the dev
3- The costs of the devices and their substainabitliy processes are expensive.
4- These devices require technicians.

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Methods of expressing Concentration.

There are many ways to express Concentration, like

1- Molarity M
2- Molality m
3- Normality N
4- Formality F
5- Part per thousand ppt
6- part per million ppm
7- Part per billion ppb
8- weight by weight %(w/w)
9- Weight by Volume % (w/v)
10- Volume by volume % (v/v)

1- Molarity (M): - Is defined as the number of moles of solute per liter of solution, also known as the molar concentration of a solution. The unite of molarity are M or mole/L or mmol/ml

1- $$\text{Molarity (M)} = \frac{\text{moles of solute}}{\text{Volume of Solution (Solute + Solvent)}}$$

2- $$\text{Moles of solute} = \frac{\text{weight of Solute (g)}}{\text{Molecular weight (g/mol)}}$$

3- $$\text{Volume of Solution (L)} = \frac{\text{moles of solute}}{\text{Molarity}}$$

4- Moles of solute = Molarity x volume of Solution (L)

5- mmoles of Solute = Molarity * volume of solution (ml)

6- mmole = mole * 1000

An Easy short_Cut

7- $M(\frac{mol}{L}) = \frac{m(g)}{m.wt \times V(L)}$

8- $M(\frac{mol}{L}) = \frac{m(g)}{m.wt} \times \frac{1000}{V(ml)}$

Question (1)

Find the number of grams of Na_2SO_4 (m.wt = 142 mg/mm required to prepare 500 ml of 0.1 molarity Solution.

$n(mol) = M\frac{mol}{L} * V(L) \rightarrow$

$n(mol) = 0.1 \times 0.5 = 0.05$ mole

$m(g) = n(mole) * m.wt$

$m(g) = 0.05$ mole $\times 142$ g/mole $= 7.1$ g

Short_Cut

$M(\frac{mol}{L}) = \frac{m(g)}{m.wt\ g/mol \times V(L)} \rightarrow$

$m(g) = M \times m.wt \times V \rightarrow$

$m(g) = 0.1$ mol/L $\times 142$ g/mol $\times 0.5$ L $= 7.1$ g

Question 2

Calculate the molarity of a solution resulting from dissolving 1.26 g of $AgNO_3$ (m.wt = 169.9) in a total volume of 250 ml Solution.

$$n(mol) = \frac{m(g)}{m.wt\ g/mol} = \frac{1.26\ g}{169.9\ g/mol} = 7.42 \times 10^{-3}\ mol$$

$$M\left(\frac{mol}{L}\right) = \frac{n(mol)}{V(L)} = \frac{7.42 \times 10^{-3}\ mol}{0.25\ L} = 0.029\ mol/L$$

$$M\left(\frac{mol}{L}\right) = \frac{m(g)}{m.wt\ \frac{g}{mol} \times V(L)} = \frac{1.26\ g}{169.9\ g/mol \times 0.25\ L} = 0.02$$

$$M = \frac{m}{m.wt} \times \frac{1000}{V\,ml} \rightarrow M = \frac{1.26}{169.9} \times \frac{1000}{250} \rightarrow M = 0.029\ \frac{m}{L}$$

Question 3

Find the molarity of potassium ion after mixing 100 ml of 0.25 M KCl with 200 ml of 0.1 M K_2SO_4.

mmol of K^+ = mmol K^+ from KCl + mmol K^+ from K_2SO_4

mmol $K^+ = 0.25\ \frac{mmol}{ml} \times 100\ ml + (2 \times 0.1\ \frac{mmol}{ml}) \times 200\ ml$

mmol of $K^+ = 25 + 40 \rightarrow$

mmol of Potassium ion = 65 mmol

$$Molarity = \frac{n(mol)}{V(L)} = \frac{n(mmol)}{V(ml)} = \frac{65\ mmol}{300\ ml} = 0.2161$$

Question 4 :- what is the Molar concentration of a solution if 0.28 g NaOH is dissolved in 500 ml of water

2- Molality :- Is defined as number of moles of Solute per weight of solvent in Kilogram

$$molality = \frac{\text{moles of solute}}{\text{weight of solvent (Kg)}}$$

Question 1

what is the molality of Solution made by dissolve 25 g of NaCl in to 2 liter of water. Assume the density of water (d = 1.0 g/ml) ((Na = 23)(Cl = 35.5)

Molar mass of NaCl = (1×23) + (1×35.5) = 58.5 g/mol

$$n(mole)\ of\ NaCl = \frac{weight}{m.wt} = \frac{25\ g}{58.5\ g/mol} = 0.427\ mol$$

$$density = \frac{mass}{volume} \rightarrow mass = 2\ L \times 1\ Kg/L = 2\ Kg$$

∴ weigh of water in kg = 2 Kg

$$molality = \frac{\text{moles of solute}}{\text{weigh of Solvent (Kg)}} = \frac{0.427\ mol\ NaCl}{2\ Kg\ water}$$

⇒ molality = 0.213 m of NaCl.

Question (2)

what is the molality of a solution that Contains 8 grams of Sodium hydroxide and 500 grams of water (m.wt) = 40 g/mol (Homework)

3- Normality :- is the number of equivalents (Eq) per unit volume, the unite of Normality are N, eq/L, meq/ml.

Equivalent weight :- is defined as the ratio of a chemical species' formula weight (F.wt) to the number of its equivalents.

$$\text{Normality} = \frac{\text{number of Eq of Solute}}{\text{liter of Solution}}$$

$$\text{Equivalent Weight (EM)} = \frac{\text{Formula weigh (g/ml)}}{n \text{ (eq/mol)}}$$

$$\text{Formula weigh (F.wt)} = \Sigma (\text{no. of atom} \times \text{Atomic weigh})$$

Consequently, the following simple relationship exists between Normality and Molarity.

$$\text{Normality} = n \times \text{Molarity}$$

where (n) is number of reacting units ($\frac{eq}{mol}$).

n is $\overset{+}{H}$ for acid
n is $\overline{OH}$ for base
} Neutralization reactions

n is electrons number for oxidation-reduction reaction
n is ion change × its atoms for precipitation reaction.
n is number of pair electron need to form Complexe

Question (1)

Calculate the Normality of 0.53 g in 100 ml Solution of Na_2CO_3 (F.wt = 106 g/mol) as the following reaction.

$$Na_2CO_3 + 2H^+ \rightarrow H_2CO_3 + 2Na^+$$

Solution:

number of reacting (n) = 2 eq/mol

$$EW\left(\frac{g}{eq}\right) = \frac{F.wt(g/mol)}{n(eq/mol)} = \frac{106\ g/mol}{2\ eq/mol} = 53\ \frac{g}{eq}$$

$$Normality = \frac{no.\ eq}{V(L)} = \frac{\frac{0.53\ g}{53\ g/eq}}{0.1\ L} = 0.1\ \frac{eq}{L}$$ or

$$Normality\left(\frac{eq}{L}\right) = \frac{m(g)}{EW(g/eq)} * \frac{1000}{V(ml)} \rightarrow$$

$$Normality = \frac{0.53\ g}{53\ g/eq} * \frac{1000\ ml/L}{100\ ml} \rightarrow$$

$$Normality = 0.01\ eq * 10\ L = 0.1\ \frac{eq}{L}$$

Question (2)

Calculate the equivalent weight and normality for a solution of 6.0 M H_3PO_4 given the following reaction. (F.wt = 98 g/mol).

1- $H_3PO_4 + 3OH^- \rightarrow PO_4^{-3} + 3H_2O$

2- $H_3PO_4 + 2NH_3 \rightarrow HPO_4^{-2} + 2NH_4^+$

3- $H_3PO_4 + F^- \rightarrow H_2PO_4^- + HF$

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

1- $EW = \frac{F.wt\ (g/mol)}{n\ (eq/mol)} = \frac{98\ g/mol}{3\ eq/mol} = 32.6\ \frac{g}{eq}$

$N = n \times M \rightarrow N = 3\left(\frac{eq}{mol}\right) * 6\left(\frac{mol}{L}\right) = 18\ \frac{eq}{L}$

2- $EW = \frac{F.wt\ (g/mol)}{n\ (eq/mol)} = \frac{98\ g/mol}{2\ eq/mol} = 49\ \frac{g}{eq}$

$N = n \times M \rightarrow N = 2\left(\frac{eq}{mol}\right) * 6\left(\frac{mol}{L}\right) = 12\ \frac{eq}{L}$

3- $EW = \frac{F.wt\ (g/mol)}{n\ (eq/mol)} = \frac{98\ g/mol}{1\ eq/mol} = 98\ \frac{g}{eq}$

$N = n \times M \rightarrow N = 1\left(\frac{eq}{mol}\right) * 6\left(\frac{mol}{L}\right) = 6\ \frac{eq}{L}$

Question (3)

Calculate the normality of 2.35 g in 250 ml solution of $KMnO_4$ (F.wt = 158 g/mol) if Mn^{+7} is reduced to Mn^{+2}

$$KMnO_4 \rightleftharpoons MnO$$

Solution:-

$$\overset{+7}{Mn} + 5\bar{e} \rightarrow \overset{+2}{Mn}$$

($5\bar{e}$)

$n = 5\ eq/mol$

$$EW = \frac{F.wt}{n} = \frac{158 \frac{g}{mol}}{5 \frac{eq}{mol}} = 31.6\ g/eq$$

An Easy short-cut

$$N\left(\frac{eq}{L}\right) = \frac{m(g)}{EW} \times \frac{1000}{V ml} \rightarrow N = \frac{2.35 g}{31.6\ g/eq} \times \frac{1000}{250 ml}$$

$$N = 0.297 \frac{eq}{L}$$

Question (4)

Calculate the normality and molarity of 0.53g in 100ml Solution of Na_2CO_3. F.wt = 106 g/mole.

Number of reacting units of Na_2CO_3 = 2 eq/mole.

$$EW \text{ of } Na_2CO_3 = \frac{F.wt \text{ of } Na_2CO_3}{n \text{ of } Na_2CO_3} = \frac{106 \frac{g}{mol}}{2\ eq/mol} = 53 \frac{g}{eq}$$

$$N = \frac{\frac{m(g)}{EW}}{V(L)} = \frac{\frac{0.53}{53}}{0.1} = 0.1 N$$

$$N = nM \rightarrow 0.1\ eq/L = 2\ eq/mole \times M \rightarrow$$

$$M = \frac{0.1 \frac{eq}{L}}{2 \frac{eq}{mole}} = 0.05\ mole/L$$

The molarity can be calculated first, then Normality as shown

$$M = \frac{\frac{m(g)}{F.wt}}{V(L)} = \frac{\frac{0.53}{106}}{0.1} = 0.05\ mole/L$$

$$N = nM \rightarrow N = 2 * 0.05 = 0.1\ eq/L$$

4- part per thousand ppt (g/L) ①

$$ppt = \frac{\text{mass of Solute (g)}}{\text{volume of Solution (L)}}$$

5- part per million ppm (mg/L)

$$ppm = \frac{\text{mass of Solute (mg)}}{\text{volume of Solution (L)}}$$

6- part per billion ppb (µg/L)

$$ppb = \frac{\text{mass of Solute (µg)}}{\text{volume of Solution (L)}}$$

Question (1)

5.0 gram of Sodium chloride was dissolved in 500 ml of water, express the Concentration of the Solution by ppt, ppm, ppb

$$ppt = \frac{5\,g}{0.5\,L} = 10\ ppt\ (g/L)$$

$$ppm = \frac{5 \times 10^{3}\ mg}{0.5\ L} = 10000\ ppm = 1 \times 10^{4}\ mg/L$$

$$ppb = \frac{5 \times 10^{6}\ \mu g}{0.5\ L} = 1 \times 10^{7}\ \mu g/L = 10^{7}\ ppb$$

Note:- There are relationship between the molarity and each of ppt, ppm, and ppb as shown

1- $ppt = M\left(\frac{mol}{L}\right) \times m.wt\left(\frac{g}{mol}\right)$ (c)

2- $ppm = M\left(\frac{mol}{L}\right) \times m.wt\left(\frac{g}{mol}\right) \times 10^3$

3- $ppb = M\left(\frac{mol}{L}\right) \times m.wt\left(\frac{g}{mol}\right) \times 10^6$

Question (2)

5 gram of Copper metal was dissolved in HCl, then diluted to 200ml with water Calculate the Concentration in ppt, molarity, ppm, and normality (atomic mass of Copper 63.5)

Solution

$$ppt = \frac{5\,g}{0.2\,L} = 25\,ppt\ (25\,g/L)$$

$$Molarity = \frac{ppt}{m.wt} = \frac{25\,g/L}{63.5\,g/mol} = 0.393\,\frac{mol}{L}$$

$$ppm = ppt \times 10^3 \rightarrow ppm = 25 \times 10^3\ mg/L$$

Second method

$$Molarity = \frac{m(g)}{m.wt} * \frac{1000}{v\,ml} \rightarrow$$

$$Molarity = \frac{5}{63.5} \times \frac{1000}{200} = 0.393\,\frac{mol}{L}$$

$$ppt = M\,\frac{mol}{L} * m.wt\,\frac{g}{mol} \rightarrow$$

$$ppt = 0.393\,\frac{mol}{L} * 63.5\,g/mol = 25\,g/L = ppt$$

$$ppm = ppt \times 10^3 \rightarrow ppm = 25 \times 10^3\ ppm$$

Question (3)

A Solution prepared by mixing 50 ml from 0.5 M Orthophosphate (PO_4^{-3}) and 35 ml from 5000 ppm (mg/L) (PO_4^{-3}) Solution then Completed to 250 ml total Volume. what is the final Concentration of phosphate anion PO_4^{-3} in both ppm and molarity

First we calculate number of moles of orthophosphate ion we took from Solution

$$50\,ml \times 0.5 \frac{mmol}{ml} = 25\,mmol = 0.025\ mol\ of\ PO_4^{-3}$$

$$ppm = M\left(\frac{mol}{L}\right) \times M\left(\frac{g}{mol}\right) \times 1000 \rightarrow$$

$$M\frac{mol}{L} = \frac{ppm}{M\left(\frac{g}{mol}\right) * 1000} = \frac{5000}{94.97 \times 1000} = \frac{5000}{94970}$$

$$\Rightarrow M\left(\frac{mol}{L}\right) = 0.052\ M$$

$$M\frac{mol}{L} = \frac{n\,(mole)}{V\,(L)} \rightarrow n\,(mol) = M\frac{mol}{L} \times V\,(L) \rightarrow$$

$$n\,(mol)\ of\ PO_4^{-3} = 0.052 * 0.035\,L = 0.0018\ mol\ of\ P$$

Total number of moles = 0.025 + 0.0018 = 0.0268 m

Calculate Concentration of final Solution in Molarity

$$M\frac{mol}{L} = \frac{0.0268\,mol}{0.25\,L} = 0.1072\ M\ of\ PO_4^{-3}$$

7- weight by weight %(w/w)

$$(\%w/w) = \frac{\text{mass of solute (g)}}{\text{mass of Solution (g)}} \times 100\%$$

Question (1)

A Solution its weight 200g it contains 25g of Sodium Sulphate Na_2SO_4 Calculate the Concentration in weight by weight (%w/w)

$$\%\,w/w = \frac{\text{wt of solute}}{\text{wt of solution}} \rightarrow \%\,w/w = \frac{25\,g}{200\,g} \times 100 = 12.5\%$$

Question (2)

calculate the (%w/w) for a solution prepared from dissolve 5g of $AgNO_3$ in 100ml of H_2O. Density of water is 1g/ml

$$\text{Density} = \frac{\text{mass}}{\text{Volume}} \rightarrow \text{mass of solvent} = 1\,g/ml \times 100\,ml$$

mass of solvent = 100g

wt (g) of Solution = 100g + 5g = 105g

$$(\%\,w/w) = \frac{\text{wt of solute}}{\text{wt of Solution}} \times 100 = \frac{5\,g}{105\,g} \times 100 = 4.76\%$$

Question (Homework)

what is the weight of water required to dissolve 25g of sodium chloride to prepare 8% (w/w) Solution?

Question (3) ②

If we need to prepa a solution of NaOH with concentration of 20% (w/w) with total weight of solution equals to 2Kg how many grams of Sodium hydroxide required.

$$Conc.\%(w/w) = \frac{wt\ of\ NaOH\ (g)}{wt\ of\ solution (g)} \times 100\% \rightarrow$$

$$wt\ of\ Sodium\ hydroxide = \frac{(\%w/w) \times wt\ of\ solution\ (g)}{100\%} \rightarrow$$

$$wt\ of\ NaOH = \frac{20 (\%w/w) \times 2000\,g}{100\%} = 400\,g\ of\ NaOH$$

Question (4)

How many grams of NaCl required to prepare each of the following solutions.

1) 20% (w/w) NaCl in 250 g solution.

2) 2500 ppm NaCl in 250 ml solution

Solution

1) $$wt\ of\ NaCl\ (g) = \frac{(\%w/w) * wt\ of\ solution\ (g)}{100\%}$$

$$wt\ of\ NaCl = \frac{20 (\%w/w) \times 250\,g}{100\%} = 50\,g\ of\ NaCl$$

2) $$Conc.(ppm) = \frac{wt\ of\ solute\ (mg)}{volume\ of\ solution\ (L)} \rightarrow$$

$wt\ of\ NaCl = 2500 \times 0.25\,L = 625\,mg = 0.625\,g$

8 weight by volume %(w/v)

$$\text{Conc. }\%(w/v) = \frac{\text{wt of solute (g)}}{\text{volume of solution (ml)}} \times 100$$

Question (1)

What is the concentration of $MgSO_4$ prepared from dissolve 30 g of $MgSO_4$ in 500 ml distilled water, expressing concentration in (% w/v), ppm, and (% w/w). Assume solution density is 1.06 g/ml

$$\text{Conc. }\%(w/v) = \frac{\text{wt of solute}}{\text{volume of solution}} * 100$$

$$(\% w/v) = \frac{30\,g}{500\,ml} \times 100 = 6\%\ w/v\ MgSO_4$$

$$ppm = \frac{\text{wt of solute (mg)}}{\text{volume of solution (L)}} = \frac{30000\,mg}{0.5\,L} = 60000\,ppm$$

$$\%\, w/v = \%\, w/w \times \text{density of solution} \rightarrow$$

$$(\%\, w/w) = \frac{6\%}{1.06} = 5.66\%\,(w/w)$$

Question (2)

How many grams of sodium persulfate $Na_2S_2O_8$ required to prepare a 1L solution of sodium persulfate with concentration of 10% (w/v).

$$(\%\, w/v) = \frac{\text{wt of solute } Na_2S_2O_8}{\text{volume of solution (ml)}} \times 100\% \rightarrow$$

$$\text{wt of } Na_2S_2O_8 = \frac{(\%\, w/v) \times \text{volume of solution (ml)}}{100\%} \rightarrow$$

wt of $Na_2S_2O_8$ = $\frac{10\% (w/v) \times 1000}{100\%}$. of Solution →

wt of $Na_2S_2O_4$ (g) = 100 g of $Na_2S_2O_8$

Question (3)

10 gram barium chloride $BaCl_2$ is dissolved in 90 g of water, the density of the solution is 1.090 g/ml Calculate the weigh/volume percentage Concentration of the Solution.

weigh of Solution = weigh of solute ($BaCl_2$) + weigh of Solvent (water)

weigh of Solution = 10 g + 90 g = 100 g

Density = $\frac{weigh}{volume}$ → Volume of Solution = $\frac{100 g}{1.09 g/m}$

Volume of Solution = 91.74 ml

$(w/v)\% = \frac{\text{weigh of solute}}{\text{Volume of solution}} \times 100$

$(w/v)\% = \frac{10 g}{91.74 ml} \times 100$ = 10.9 g / 100 ml

Question (4)

2 L of an aqueous solution of potassium chloride Contains 45 g of KCl. What is the weigh/volume percentage Concentration of this Solution in g/100 ml

(Homework)

9) Volume by Volume % (V/V)

$$\%(V/V) = \frac{\text{Volume of Solute (ml)}}{\text{Volume of Solution (ml)}} \times 100$$

Question (1)

Calculate the % (V/V) for solution was prepared by add 50 ml of C_2H_5OH to 450 ml of H_2O.

Volume of Solution = Volume of solute + Volume of solvent

Volume of Solution = 50 ml + 450 ml = 500 ml

$$\%(V/V) = \frac{\text{Volume (ml) of Solute}}{\text{Volume of Solution (ml)}} \times 100$$

$$\%(V/V) = \frac{50\ ml}{500\ ml} \times 100 = 10\%\ (V/V)$$

Note:- There are reationship between the N, M and % (W/W), % (W/V) as shown below

$$M = \frac{\%(W/W) * \text{density of Solution} * 10}{m.wt}$$

$$M = \frac{\%(W/V) * 10}{m.wt}$$

$$N = \frac{\%(W/W) * \text{density of Solution} * 10}{Eq.wt}$$

$$N = \frac{\%(W/V) * 10}{Eq.wt}$$

Question (1)

How would you prepare 500ml of 0.25M NaOH Solution starting from a Concentration of 1.0M

The problem gives initial and final Concentration (M_i and M_f) and final volume (V_f) and asks for the initial volume (V_i) that we need to dilute

$$M_f = M_i * \frac{V_i}{V_f} \rightarrow V_i = \frac{M_f \times V_f}{M_i} \rightarrow$$

$$V_i = \frac{500ml \times 0.25M}{1.0M} = 125 ml$$

This mean to prepare Solution with Concentration of 0.25M NaOH you have to transfer 125ml from initial Solution and Complete with Solvent to 500ml

Question (2)

بنك دمولا

How many milliliters of 5M Copper(II) sulfate solution must be added to 160ml of water to achieve a 0.3M Copper II Sulfate solution?

$$M_i \times V_i = M_f \times V_f \rightarrow (5M * x(ml)) = 0.3M * (160 + x$$

$$x5 = 48 + 0.3x \rightarrow 4.7x = 48 \rightarrow x = 10 ml$$

Question (3): what volume of 4.5M HCl Can be Prep.. by mixing 5.65M HCl with 250ml of 3.55M HCl?

(Homework)

Acid and Base Concepts

Arrhenius Concept :- According to arrhenius concept, Substances which produce H^+ ions when dissolved in water are called acids, while those which ionize in water to produce OH^- ions are called bases. for example the HCl, H_2SO_4, and HNO_3 considered as acids according to Arrhenius, while the $NaOH$ and KOH considered as Bases according to Arrhenius;

Bronsted Lowry Concept :- The acid is a proton donor H^+, while the base is a proton acceptor, for example NH_3 and H_2O are an base and acide respectively according to Bronsted

Lewis Concept :- The acid is electron pair acceptors, while the Base is electron pair donor for example BF_3 and NH_3 are an acide and base respectively according Lewis

Note :- Arrhenius Concept is limited to water Solutions only. While Bronsted Concept is limited to proton transfer reactions only

Examples

① Arrhenius

HNO_3 Considered acid

$$HNO_3 \longrightarrow H^+(aq) + NO_3^-(aq)$$

Dissociates in water to produce hydrogen ions (H^+)

NaOH Considered base

$$NaOH(aq) \longrightarrow Na^+(aq) + OH^-(aq)$$

Dissociates in water to produce hydroxide ions (OH^-)

② Bronsted - Lowry

CH_3COOH Considered acid, is a proton donor, while the base is a proton acceptor as shown

$$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$$

CH_3COOH is acid (H^+ donor)

H_2O is base (H^+ acceptor)

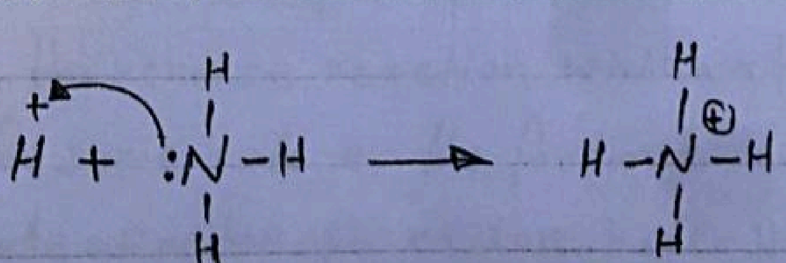
$$NH_3 + H_2O \rightleftharpoons OH^- + NH_4^+$$

NH_3 is base (H^+ acceptor)

H_2O is acid (H^+ donor)

③ Lewis

Acid as an electron pair acceptor and a base as an electron pair donor



Acids :- Acidity is a characteristic property of acids. Acidic substances are usually very sour. Apart from hydrochloric acid, there are many other types of acids around us. Citrus fruits like lemons and oranges contain citric and ascorbic acids, while tamarind paste contains tartaric acid.

In fact, the word "acid" and acidity are derived from the Latin word acidus which means sour. If you dip a blue litmus paper into an acid, it will turn red while a red litmus paper will not change colour.

Bases :- Bases turn red litmus paper blue while the blue litmus paper stays blue. They taste bitter and also feel soapy. Some other common examples of bases include sodium bicarbonate that is used in cooking and household bleach.

Conjugate Acid-Base Pairs

Consider a reaction

$$Acid(1) + Base(2) \rightarrow Acid(2) + Base(1)$$

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

In this reaction, HCl donates a proton to H_2O therefore is acid. The water accepts a proton from HCl therefor is a base. In the reverse reaction which at equilibrium proceeds at the same rate as the forward reaction, the H_3O^+ ions donate a proton to Cl^- ion, hence H_3O^+ is acid.

تفكك

Dissociation of Water

when water dissociates, one of the hydrogen nuclei leaves its electron behind with the oxygen atom to become a hydrogen ion, while the oxygen and other hydrogen atoms become a hydroxide ion. Since the hydrogen ion has no electron to neutralize the positive change on its proton, it has a full unit of positive change and is symbolized as $\overset{+}{H}$. The hydroxide ion retains the electron left behind and thus has a full unit of negative charge, symbolized by $\overline{O}H$. The hydrogen ion (proton) does not wander long by itself before it attaches to the oxygen atom of a second un-ionized water molecule to form a hydronium ion ($H_3\overset{+}{O}$)

$$\underset{(L)}{H_2O} + \underset{(L)}{H_2O} \rightleftharpoons \underset{(aq)}{H_3\overset{+}{O}} + \underset{(aq)}{\overline{O}H}$$

water molecules dissociate into equal amounts of $H_3\overset{+}{O}$ and $\overline{O}H$, so their concentration are equal to 1×10^{-7} mol/L at 25 °C

$$[\overset{+}{H}] = [\overline{O}H] = 1\times10^{-7}\ M$$

The Ion-Product of water:- The self-ionization of water, the process in which water ionizes to hydronium ions and hydroxide ions to a very limited extent. When two molecules of water collide, there can be a transfer of a hydrogen ion from one molecule to the other. The products are a positively charged hydronium ion and a negatively charged hydroxide ion.

$$H_2O_{(L)} + H_2O_{(L)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

we often use the simplified form of the reaction

$$H_2O_{(L)} + H_2O_{(L)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$$

The equilibrium Constant for the self-ionization of water is referred to as the ion-product for water and is given the symbol K_w, where

$$K_w = [H^+][OH^-]$$

The ion-product of water K_w is the mathematical product of the Concentration of hydrogen ions and hydroxide ions. The value of K_w is very Small, in accordance with a reaction that favors the reactants. At 25°c, the experimentally determined value of K_w in pure water is 1.0×10^{-14}.

$$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$$

In pure water, the concentrations of hydrogen and hydroxide ions are equal to one another. pure water or any other aqueous Solution in which this ration holds is said to be neutral. To find the molarity of each ion, the square root of K_w is taken

$[H^+] = [OH^-] = 1.0 \times 10^{-7}$ mole/L

An Acidic Solution, is a solution in which the Concentration of hydrogen ions is greater than the Concentration of hydroxide ions. For example, hydrogen chloride ionizes to produce H^+ and Cl^- ions upon dissolving in water

$$HCl \rightarrow H^+ + Cl^-$$

This increases the concentration of H^+ ions in the solution, according to Le chateliers principle, the equilibrium represented by

$$H_2O_{(L)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$$

is forced to the left, towards the reactant. As a result the Concentration of the hydrogen ion decreases.

$$[H^+] > [OH^-] \quad , \quad [H^+] > 1.0 \times 10^{-7}\ M$$

A basic Solution, is the solution in which the Concentration of hydroxide ions is greater than the Concentration of hydrogen ion. Solid potassium hydroxide dissociates in water to yield (تنتج) potassium ions and hydroxide ions.

$$KOH_{(S)} \rightarrow K^+_{(aq)} + OH^-_{(aq)}$$

The increase in Concentration of the OH^- ions Causes a decrease in the Concentration of the H^+ ions, therefore the ion-product of $[H^+][OH^-]$ remains Constant

$[\bar{O}H] > [\overset{+}{H}]$, $[\bar{O}H] > 1.0 \times 10^{-7}$ M

Question (1)

Calculate the Concentrations each of hydrogen ion and hydroxide ions of hydrochloric acid solution its Concentration 2.0×10^{-3} M.

Hydrochloric acid is a strong acid therefore HCl is 100% ionized

$$HCl \rightarrow \overset{+}{H} + \bar{Cl}$$

$[HCl] = [\overset{+}{H}] = 2 \times 10^{-3}$ M

$K_w = 1 \times 10^{-14}$ M

$[\overset{+}{H}][\bar{O}H] = 1 \times 10^{-14} \rightarrow [\bar{O}H] = \frac{1 \times 10^{-14}}{2 \times 10^{-3}} = 5 \times 10^{-12}$ M

$\therefore [\overset{+}{H}] > [\bar{O}H]$, $2 \times 10^{-3} > 5 \times 10^{-12}$

Acidic Solution.

Question (2)

Calculate the $[\overset{+}{H}]$ and $[\bar{O}H]$ for potassium hydroxid solution its 2×10^{-3} M.

potassium hydroxide is strong base therefor KOH is 100% ionized

$$KOH \rightarrow \overset{+}{K} + \bar{O}H$$

$[KOH] = [\bar{O}H] = 2 \times 10^{-3}$ M

$K_w = 1 \times 10^{-14}$

$[\overset{+}{H}][\bar{O}H] = K_w \rightarrow [\overset{+}{H}] = \frac{1 \times 10^{-14}}{2 \times 10^{-3}} = 5 \times 10^{-12}$ M

$[\bar{O}H] > [\overset{+}{H}]$, $2 \times 10^{-3} > 5 \times 10^{-12}$

pH and pOH scale

pH is defined as the negative logarithm of hydrogen ion concentration

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

pOH is defined as the negative logarithm of hydroxyl ion concentration

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

pH value of an acid having $[H^+]$ concentration more than 10^{-7} M, while the pH value of base having $[H^+]$ less than 10^{-7} M

$[H^+] > [OH]$
$[H^+] > 10^{-7}$ M
$[OH^-] < 10^{-7}$ M
$pH < pOH$
$pH < 7$
$pOH > 7$

} Acidic Solution

$[H^+] < [OH^-]$
$[H^+] < 10^{-7}$ M
$[OH^-] > 10^{-7}$ M
$pH > pOH$
$pH > 7$
$pOH < 7$

} Alkaline Solution

Ionization and Dissociation

Dissociation is the separation of ions from an ionic crystal when a solid ionic compound dissolves in water. On the other hand, ionization is the process where a neutral molecule breaks into charged ions when dissolved in a solution.

The extent of ionization depends on the strength of the bonds between ions and the extent of solvation of ions.

Question (3)

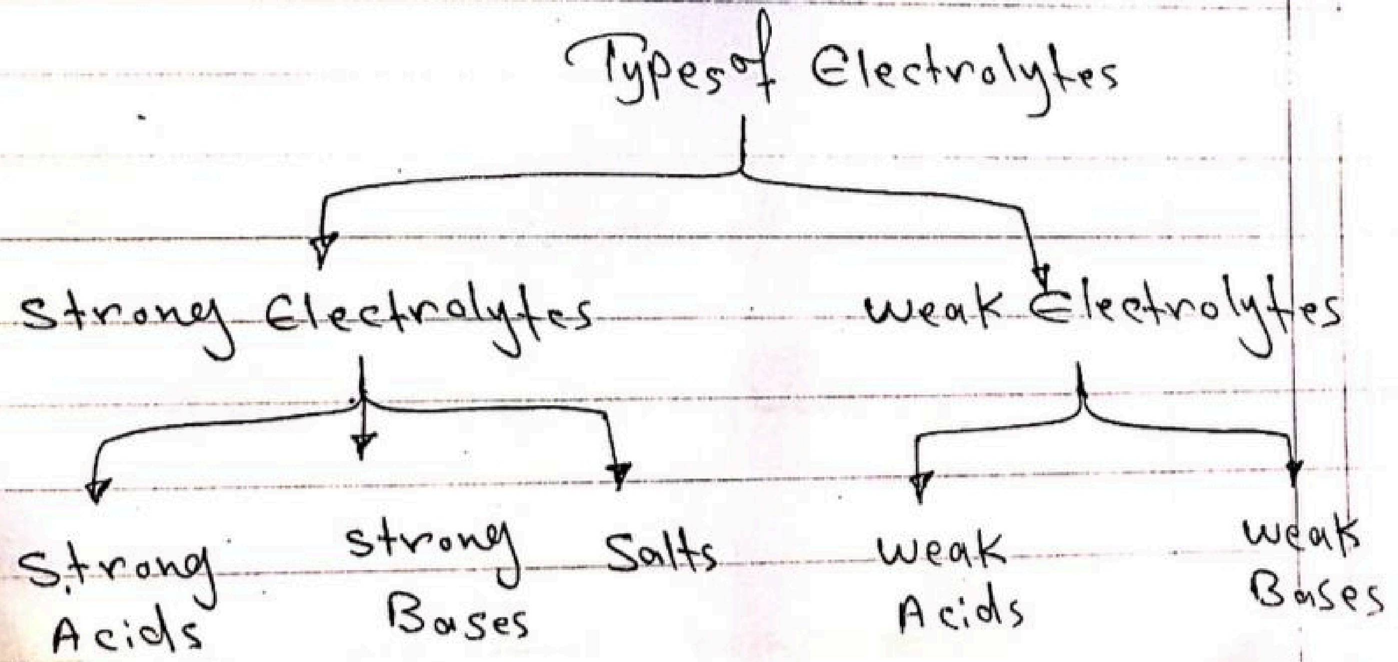
what is the difference between ionization and dissociation

Ionization	Dissociation
1- Is the process which produces new charged particles	1- Is the separation of charged particles which already exist in a Compound
2- Involves polar Covalent Compounds or metals	2- Involves ionic Compound
3- Always produces charged particles	3- produces either charged particles or electrically neutral particles
4- process is irreversible	4- Is reversible
5- Involves covalent bonds between atoms	5- Involves ionic bonds in Compound.

Classifying Electrolytes

Electrolytes are substances which when dissolved in water break up into cations (plus-charged ions) and anions (minus-charged ions). we say they ionize.

Strong electrolytes ionize completely (100%), while weak electrolytes ionize only partially (usually on the order of 1–10%). That is, the principal species in solution for strong electrolytes is the un-ionized compound itself. Strong electrolytes fall into three categories:- strong acids, strong bases, and salts. The salts are sometimes also called ionic compounds, but really strong bases are ionic compounds as well. The weak electrolytes include weak acids and weak bases.



Examples of strong and weak electrolytes are given

(1) strong electrolytes are an acids, bases, and salts

strong acids:- HCl, HBr, HI, HNO_3, $HClO_3$, $HClO_4$, and H_2SO_4

strong bases:- NaOH, KOH, LiOH, $Ba(OH)_2$, and $Ca(OH)_2$

Salts:- NaCl, KBr, $MgCl_2$, K_2SO_4, and KNO_3 and many, many more

② weak electrolytes are acids and Bases

weak acids:- HF, acetic acid ($HC_2H_3O_2$), H_2CO_3, H_3PO_4, HCN, H_2CO_2 and many more

weak bases:- NH_3, pyridine (C_5H_5N), CH_3NH_2, C_6H_7N, and several more

Question (1)
Define and give examples of electrolytes.
Question (2)
Explain what happens when electrolytes dissolve in Wate
Question (3)
what difference between strong electrolytes and weak electrolytes, with examples.
what difference between electrolytes and nonelectrolytes

* Solutions of nonelectrolytes:- Substances that not give ions when dissolved in water are called nonelectrolytes, such as ethanol and sucrose (Cannot Conduct electric

Pure Water

pure water is a very weak electrolyte. The ionization or autoionization of pure water can be represented by the ionization equation

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

and the equilibrium constant is

$$K = \frac{[H^+][OH^-]}{[H_2O]}$$

for pure water, $[H_2O]$ is a constant (55.55M), and we often use the ion product (K_w) for water

$$K_w = [H^+][OH^-] = 10^{-14} M$$

where, the constant K_w depends on temperature, at 298K.

Skills to Develop

1- what is the meaning of the statement ion product for water

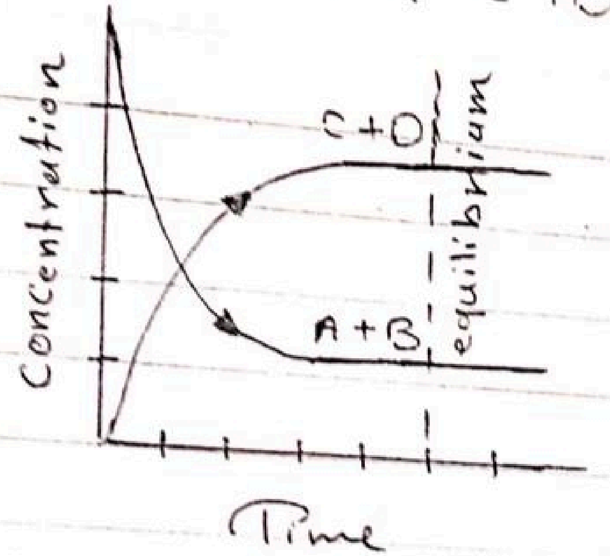
2- what is the meaning of the statement equilibrium constant for water.

 ④

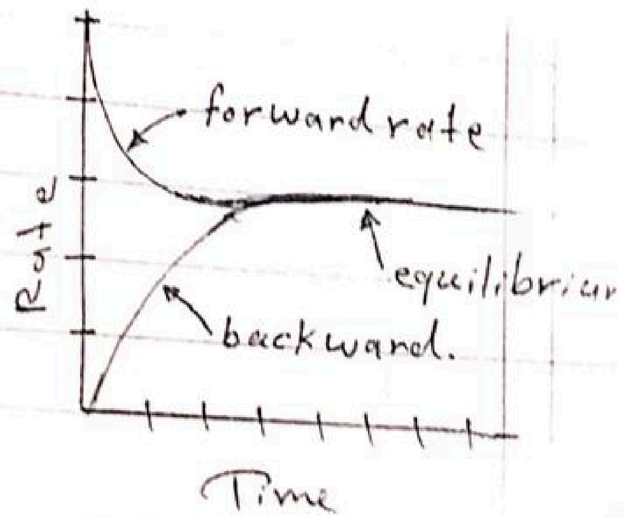
Chemical equilibrium:- is the state of a chemical reaction when the concentration of the products and reactants are unchanged over time, in other words, the forward rate of reaction equals the backward rate of reaction. Chemical equilibrium is also known as dynamic equilibrium.

In chemical equilibrium, the concentration of reactants and products are constant, and forward rate, backward rate are equal as shown below

$$A + B \rightleftharpoons C + D$$



The concentrations are constant



The rates are equal

Types of chemical equilibrium

① Homogeneous Equilibrium
② Hetrogeneous Equilibrium

Homogeneous equilibrium :- in this type, the reactants and the products of chemical equilibrium are all in the same phases for example

$$\underset{(g)}{H_2} + \underset{(g)}{I_2} \rightleftharpoons \underset{(g)}{2HI} \qquad K = \frac{[HI]^2}{[H_2][I_2]}$$

$$\underset{(g)}{N_2} + \underset{(g)}{O_2} \rightleftharpoons \underset{(g)}{2NO} \qquad K = \frac{[NO]^2}{[N_2][O_2]}$$

Heterogeneous equilibrium, in this type of chemical equilibrium, the reactants and the products are present in different phases for example

$$\underset{(g)}{CO_2} + \underset{(s)}{C} \rightleftharpoons \underset{(g)}{2CO} \qquad K = \frac{[CO]^2}{[CO_2]}$$

$$\underset{(s)}{CaCO_3} \rightleftharpoons \underset{(s)}{CaO} + \underset{(g)}{CO_2} \qquad K = \frac{[CO_2]}{1} = [CO_2]$$

where the constant K is called the equilibrium constant. This formulation of a chemical equilibrium is termed the law of mass action, or sometimes the law of Guldberg and Waage.

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Question (1) A chemical system is Known to react according to the balanced reaction $2A + B \rightleftharpoons 2C$. When an equilibrium reaction mixture was analyzed, the following concentrations were found $[A] = 1 \times 10^{-2}\,M$, $[B] = 4 \times 10^{-9}\,M$ and $[C] = 2 \times 10^{-5}\,M$, what is the value of the equilibrium constant ?.

②

$$K = \frac{[C]^2}{[A]^2[B]} = \frac{(2\times10^{-5}\ \text{mole/liter})^2}{(1\times10^{-2}\ \text{mole/liter})^2 \times (4\times10^{-9}\ \text{mole/liter})}$$

$K = 1\times10^{3}$ liters/mole

Question (2)

The partial pressure each of Cl_2 and CO are 0.46 atm and 0.45 atm respectively, the total pressure for a mixture of gases at equilibrium is 0.58 atm calculate K_p for reaction $CO + Cl_2 \rightleftharpoons COCl_2$

$$CO + Cl_2 \rightleftharpoons COCl_2$$

0.45	0.46	0	
$0.45-x$	$0.46-x$	x	at equilibrium

Total pressure $= P_{CO} + P_{Cl_2} + P_{COCl_2}$ at equilibrium

$$0.58\ \text{atm} = (0.45-x)+(0.46-x)+x$$

$$x = P_{COCl_2} = 0.33\ \text{atm}$$

$P_{CO} = 0.45 - 0.33 = 0.12$ atm at equilibrium

$P_{Cl_2} = 0.46 - 0.33 = 0.13$ atm at equilibrium

$$K_p = \frac{P_{COCl_2}}{P_{CO}\times P_{Cl_2}} = \frac{0.33}{(0.13)(0.12)} = 21.15$$

and to calculate K_c at 395 °C

$\Delta n = \sum n_P - \sum n_R$ for gases only

$\Delta n = 1 - 2 = -1$

$K_c = K_p (RT)^{-\Delta n} \rightarrow K_c = 21.15 \times (0.082 * 668)$

$K_c = 21.15 \times 54.77 = 1.15 \times 10^3$

Effect of Conditions on Chemical Equilibrium

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Some of the factors that influence either the position of a chemical equilibrium or the value of the equilibrium Constant, or both.

1- Nature of the reaction system
2- Concentration
3- Acitivity
4- Temperature
5- Catalysis.

The principle of Le Chatelier

If a stress is applied to a system at equilibrium, the equilibrium will be displaced in the direction which tends to diminish the effect of the stress. The factors of Chateliver are Concentnation change, a change in temperature and change in pressure.

Question (3) what is the meaning of the statement A chemical equilibrium (Homework)

Ionic Equilibrium

Ionic equilibrium is the equilibrium established between the unionized molecules and the ions in a solution of weak electrolytes. اتشاق

Weak electrolytes:- Electrolytes that ionizes to a small extent or ionizer incompletely in its solution form is said to be weak electrolytes. for example HCN, CH_3COOH, NH_4OH, H_2CO_2, H_2CO_3, CH_3NH_2, HF, C_6H_5OH, C_6H_7N.

① Ionization of weak acid

$$HA(aq) + H_2O(L) \rightleftharpoons H_3O^+(aq) + A^-$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

$$H_2S \rightleftharpoons H^+ + HS^- \qquad K_a = \frac{[H^+][HS^-]}{[H_2S]}$$

$$HS^- \rightleftharpoons H^+ + S^- \qquad K_a = \frac{[H^+][S^-]}{[HS^-]}$$

$$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$$

$$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$$

$$HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$$

$$K_a = \frac{[H_3O^+][CN^-]}{[HCN]}$$

2- Ionization of Weak Base

$$A + H_2O_{(L)} \rightleftharpoons \bar{O}H_{(aq)} + H\overset{+}{A} \qquad K_b = \frac{[\bar{O}H][H\overset{+}{A}]}{[A]}$$

$$NH_3 + H_2O \rightleftharpoons \overset{+}{N}H_4 + \bar{O}H \qquad K_b = \frac{[\overset{+}{N}H_4][\bar{O}H]}{[NH_3]}$$

3- Solubility and Solubility Product.

A saturated solution is one containing the maximum amount of solute soluble in the solvent under equilibrium conditions.

Solubility :- The amount of a substance that can be
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dissolved in a given amount of solvent.

Expression of Solubility product (K_{sp})

$$M_mA_a \rightleftharpoons mM + aA$$

The solubility-product expression then takes the form

$$K_{sp} = [M]^m[A]^a$$

K_{sp} = Solubility product Constant

M and A are molar solubility of ions

$$AgCl_{(S)} \rightleftharpoons \overset{+}{Ag}_{(aq)} + \bar{Cl}_{(aq)} \qquad K_{sp} = [\overset{+}{Ag}][\bar{Cl}]$$

$$Ba(IO_3)_2 \rightleftharpoons \overset{+2}{Ba} + 2\bar{IO_3} \qquad K_{sp} = [\overset{+2}{Ba}][\bar{IO_3}]^2$$

Solubility Product:- It is defined as the product of the Concentrations of the ions of the salt in its saturated solution at a given temperature raised to the power of the ions produced by the dissociation of one mole of the Salt.

Application of Solubility

The Concept product of K_{sp} helps in predicting the formation of precipitate. In general if

Ionic product (I.P) $>$ K_{sp} precipitate is formed

Ionic product (I.P) $<$ K_{sp} precipitate is not formed

Ionic Product (I.P) $=$ K_{sp} saturated Solution

Factors that affect Solubility of precipitates.

There are several factors can effect the Solubility like

1- Temperature effect
2- Common-Ion effect
3- Nature of solvent effect
4- Nature of precipitates
5- Complex formation effect
6- ph effect.

Question (1)

The solubility product of silver chloride in water is about 1×10^{-10}. Calculate the formal solubility of salt.

Since the solution contains one silver ion for every chloride ion, the molar concentration of these two ions are identical and equal the formal solubility of the salt.

$$[Ag^{+}] = [Cl^{-}] = S$$

$$AgCl_{(s)} \rightleftharpoons Ag^{+1}_{(aq)} + Cl^{-}_{(aq)}$$

$$K_{sp} = [Ag^{+}][Cl^{-}] \rightarrow 1 \times 10^{-10} = S^{2} \rightarrow S = 10^{-5}$$

Question (2)

Calculate the formal solubility of silver chromate Ag_2CrO_4 when its solubility product has the value 2×10^{-12}

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

$$\quad\quad\quad\quad 2S \quad\quad S$$

$$[CrO_4^{=}] = S$$

$$[Ag^{+}] = 2[CrO_4^{=}] = 2S$$

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

$$K_{sp} = (2S)^{2}(S) \rightarrow 2 \times 10^{-12} = 4S^{3}$$

$$S^{3} = \frac{2 \times 10^{-12}}{4} \rightarrow S = 8 \times 10^{-5} \text{ mol/L}$$

The Solubility in gram per liter is molar solubility multiplied by molecular weigh as shown

$$Solubility\,(g/L) = Solubility\,(mol/L) \times m.wt\,(g/mol)$$

$$Solubility\,(mol/L) = \frac{Solubility\,(g/L)}{m.wt\,(g/mol)}$$

Question (3)

The solubility of AB_2 salt (105) is 0.4 g per 1000 ml Calculate the Solubility Constant.

$$Solubility\left(\frac{mol}{L}\right) = \frac{0.4\ g/L}{105\ g/mol} = 3.8 \times 10^{-3}\ mol/L$$

$$AB_2 \rightleftharpoons A + 2B$$

$$\quad\quad\quad S \quad 2S$$

$$K_{sp} = [A][B]^2 \rightarrow K_{sp} = (S)(2S)^2 \rightarrow$$

$$K_{sp} = 4S^3 \rightarrow K_{sp} = 4(3.8 \times 10^{-3})^3 \Rightarrow K_{sp} = 2.2 \times 10^{-7}$$

Question (4)

The solubility of AB_2 salt (100) is 0.6 g per 100 ml Calculate the Solubility Constant. (Homework)

قوانين لحساب الدالة الحامضية PH

1) Solution of strong acid and weak base, if the [weak base] > [strong acid]

2) Solution of weak base and its salt

3) Solution of weak acid and weak base if the [weak base] > [weak acid]

$$POH = PK_b + \log \frac{[Salt]}{[Base]}$$ or

$$[\bar{O}H] = K_b \times \frac{[Base]}{[salt]}$$

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1) Solution of strong base and weak acid if the [weak acid] > [strong base]

2) Solution of weak acid and its Salt

3) Solution of weak acid and weak base if the [weak acid] > [weak base]

$$PH = PK_a + \log \frac{[Salt]}{[acid]}$$

or

$$[\overset{+}{H}] = K_a \times \frac{[acid]}{[salt]}$$

1) Solution of strong acid and weak base if the [strong acid] = [weak base]

2) Solution of acidic salts

$$pH = \frac{1}{2}(pK_w - pK_b - \log C_s)$$

or

$$[H^+] = \sqrt{C_s \times \frac{K_w}{K_b}}$$

1) Solution of strong base and weak acid if the [strong base] = [weak acid]

2) Solution of baseic salts

$$pH = \frac{1}{2}(pK_w + pK_a + \log C_s)$$

or

$$[H^+] = \sqrt{\frac{K_w \times K_a}{C_s}}$$

1) Solution of weak acid and weak base if the [weak acid] = [weak base]

$$pH = \frac{1}{2}(pK_w + pK_a - pK_b)$$

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$pH + pOH = 14$

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

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

$pK_a = -\log K_a$ ، $K_a = 10^{-pK_a}$

$pK_b = -\log K_b$ ، $K_b = 10^{-pK_b}$

$[H^+][OH^-] = 1 \times 10^{-14}$

PH Calculations

① Solution of strong acid and strong base

$$HCl \rightarrow H^+ + Cl^-$$

0.1	0	0	
0	0.1	0.1	

$[HCl] = [H^+]$

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{=}$$

0.1	0	0	
0	0.2	0.1	

$[H_2SO_4] = \frac{[H^+]}{\text{no. of mole}}$

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

0.1	0	0	
0	0.1	0.1	

$[NaOH] = [OH^-]$

$$Ca(OH)_2 \rightarrow Ca^{+2} + 2OH^-$$

0.1	0	0	
0	0.1	0.2	

$[Ca(OH)_2] = \frac{[OH^-]}{\text{no. of mole}}$

Question (1)

calculate the pH of solution after mixing 10 ml of 0.1 M HCl with 15 ml of 0.1 M NaOH.

For HCl

$M_1V_1 = M_2V_2 \rightarrow 0.1 \times 10 = M_2 \times 25\ ml \rightarrow M_2 = \frac{1}{25} \rightarrow$

$[HCl] = 0.04\ M$

$HCl \rightarrow H^+ + Cl^-$ $[H^+] = 0.04\,M$

0.04 0 0

0 0.04 0.04

For NaoH

$M_1V_1 = M_2V_2 \rightarrow 0.1 \times 15\,ml = M_2 \times 25\,ml \rightarrow M_2 = \frac{1.5}{25}$

$[NaoH] = 0.06\,M$

$NaoH \rightarrow Na^+ + OH^-$

0.06 0 0 $[OH^-] = 0.06\,M$

0 0.06 0.06

$[OH^-]$ remaining $= 0.06 - 0.04 = 0.02\,M$

$[OH^-] = 0.02\,M$

$pOH = -\log[OH^-] \rightarrow pOH = -\log 0.02 = 1.7$

$pH + pOH = 14 \rightarrow pH = 14 - pOH \rightarrow pH = 14 - 1.7 = 12.3$

Question(2)

Calculate the pH of solution after mixing 10ml of 0.1M HCl with 10ml of 0.1M NaoH (Homework)

Another method to answer :- the first question as shown mmol of HCl $= 0.1 \frac{mmol}{ml} \times 10 ml = 1$ mmole

mmol of NaOH $= 0.1 \frac{mmol}{ml} \times 15 ml = 1.5$ mmole.

mmol of NaOH remaining $= 1.5$ mmole $- 1$ mmol $= 0.5$ mmole

$[NaOH] = \frac{mmole}{ml} \rightarrow [NaOH] = \frac{0.5 \, mmole}{25 \, ml} = 0.02 \, M$

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

0.02   0   0

0   0.02   0.02

$[OH^-] = 0.02 M \rightarrow pOH = -\log[OH^-] \rightarrow pOH = -\log 0.02$

$pOH = 1.7$

$pH + pOH = 14 \rightarrow pH = 14 - pOH \rightarrow pH = 14 - 1.7 = 12.3$

② Solution of strong acid and weak base or Solution of strong base and weak acid.

Question (1)

Calculate the pH of solution after mixing 20 ml of 0.2 M Sodium hydroxide with 50 ml of 0.1 M acetic acid ($Ka = 1.8 \times 10^{-5}$)

For NaOH

mmole of NaOH $= M \frac{mmol}{ml} * V(ml) = 0.2 \frac{mmol}{ml} * 20 ml$

mmole of NaOH $= 4$ mmole.

الحالة ٤ الرابعة: [illegible] حامض + قاعدة

Question (2)

Calculate the pH of solution after mixing 10ml of 0.1M HCl with 10ml of 0.1M NH_3 ($K_b = 1.8 \times 10^{-5}$)

- For HCl

$$\text{mmole of HCl} = M \frac{mmol}{ml} * v(ml) = 0.1 \frac{mmol}{ml} * 10ml = 1mmol$$

For NH_3

$$\text{mmole of } NH_3 = M \frac{mmole}{ml} * v(ml) = 0.1 \frac{mmole}{ml} * 10ml = 1mmole$$

$$HCl + NH_3 \rightarrow NH_4Cl$$

HCl	NH_3	NH_4Cl
1mmole	1mmol	0
−1	−1	1mmole
0	0	1mmole

$$[NH_4Cl] = \frac{1mmole}{20ml} \rightarrow$$

$$[NH_4Cl] = 0.05 \frac{mol}{L}$$

$$[H^+] = \sqrt{C_s * \frac{K_w}{K_b}} \rightarrow [H^+] = \sqrt{0.05 * \frac{1 \times 10^{-14}}{1.8 \times 10^{-5}}}$$

$$[H^+] = \sqrt{27 \times 10^{-12}} \rightarrow [H^+] = 5.2 \times 10^{-6}$$

$$pH = -\log[H^+] \rightarrow pH = -\log 5.2 \times 10^{-6} = 5.28$$

(or) $pH = \frac{1}{2}[pK_w - pK_b - \log C_s]$

$$pK_b = -\log K_b \rightarrow pK_b = -\log 1.8 \times 10^{-5} = 4.74$$

$$pK_w = -\log K_w \rightarrow pK_w = -\log 1 \times 10^{-14} = 14$$

$$pH = \frac{1}{2}(14 - 4.74 - \log 0.05)$$

$$pH = \frac{1}{2}(10.56) \rightarrow pH = 5.28$$

3) Solution of weak acid and weak base.

Question (1)

Calculate the pH of solution prepared by mixing 100ml of 0.1 HCN with 100ml of 0.2M NH_3 ($Kb = 1.8 \times 10^{-5}$)

mmole of HCN = M * v(ml)

mmole of HCN = $0.1 \frac{mmole}{ml} \times 100ml = 10$ mmole

mmole of NH_3 = M * v(ml)

mmole of $NH_3 = 0.2 \frac{mmole}{ml} * 100ml = 20$ mmole

HCN +	NH_3 →	NH_4CN
10 mmole	20 mmole	0
- 10 mmole	- 10 mmole	10 mmole
0	10 mmole	10 mmole

$[NH_4CN] = \frac{10\ mmole}{200ml} = 0.05\ mol/L$

$[NH_3] = \frac{10\ mmole}{200ml} = 0.05\ mol/L$

$[OH^-] = Kb \times \frac{[Base]}{[Salt]} \rightarrow [OH^-] = 1.8 \times 10^{-5} * \frac{0.05}{0.05}$

$[OH^-] = 1.8 \times 10^{-5}$ $\quad pOH = -\log[OH^-] \rightarrow pOH = -\log 1.8 \times 10^{-5}$

$pOH = 4.74$

$pH + pOH = 14 \rightarrow pH = 14 - 4.74 = 9.26$

Question

What is the pH of Solution 0.05 M Sodium acetate and 0.025 M acetic acid ($K_a = 1.8 \times 10^{-5}$)

$$HAC \rightleftharpoons H^+ + AC^-$$

$$NaAC \rightarrow Na^+ + AC^-$$

$[H^+] = K_a \times \frac{[Acid]}{[Salt]} \rightarrow [H^+] = 1.8 \times 10^{-5} \times \frac{0.025}{0.05}$

$[H^+] = 9 \times 10^{-6}$ M , $pH = -\log[H^+] \rightarrow pH = -\log 9 \times 10^{-6} = 5.05$

Second method

$pH = pK_a + \log \frac{[Salt]}{[Acid]}$, $pK_a = -\log K_a$

$pK_a = -\log 1.8 \times 10^{-5}$

$pK_a = 4.74$

$pH = 4.74 + \log \frac{0.05}{0.025}$

$pH = 4.74 + \log 2 \rightarrow pH = 4.74 + 0.3 \simeq 5.05$

Question:- Calculate the pH of solution after mixing 10 ml of 0.1 M HCl with 10 ml of 0.2 M NH_3 ($K_b = 1.8 \times 10^{-5}$). Homework

Question:- Calculate the pH of solution after mixing 100 ml of 0.2 M HCN with 100 ml of 0.1 M NH_3 ($K_a = 4.9 \times 10^{-10}$) Homework

Buffer Solutions

Buffer Solutions:- A solution that resists changes in pH value, even on the addition of a small amount of strong acid or base.

Characteristics (properties) of buffer Solutions

1- It has a definite pH value
2- Its pH does not change on keeping for a long time
3- Its pH does not change on dilution.
4- Its pH is slightly changed by the addition of a small amount of a strong acid or strong base.

Types of buffer Solutions.

1- **Acidic Buffer:-** A mixture of a weak acid and its salt of a strong base in water.
2- **Basic Buffer:-** A mixture of a weak base and its salt of a strong acid in a water medium.

Buffer Capacity:- Is defined as the number of moles of acid or base added in one litre of solution as to change the pH by unity, and depends on the type and concentration of the buffe

Examples for Acidic Buffer are CH_3COOH and CH_3COONa, HCN and $NaCN$
Examples for Basic Buffer are NH_4OH and NH_4Cl, NH_4OH and NH_4NO_3.