Chemistry by

Quentin Turkes Chemistry Summary



Mixtimes if miform if nonuniform PSE $\frac{1}{1 + 2}$	homogeneous heterogeneous	Along		1e= 3,11.10	Isotop	ICS (same elemant u	sille difficut # neutrons
if uniform if nonuniform PSE $1 \frac{1}{12} \frac$	homogeneous heterogeneous	·e		ie = 3,11 10	34	_	-1
i f <i>nonuniform</i> PSE 1 $\frac{1}{H}_{2}$ 2 $\frac{1}{H}_{2}$ 3 $\frac{1}{H}_{2}$ 3 $\frac{4}{5}$ 4 $\frac{19}{2}$ 20 $\frac{21}{21}$ 22 $\frac{22}{22}$ 23 $\frac{4}{22}$ 23 $\frac{2}{23}$ 24 $\frac{2}{23}$ 25 $\frac{2}{23}$ 27 $\frac{2}{3}$ 27	heterogeneous	8	★ 1		"9 Mass#- 12	Alomic weight 12	u u x 1,66053 1027
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Metalloids La Ce Pr Nonmetals 89 90 91 Ac Th Pa	Nd Pm Sm Eu Gd Tb 92 93 94 95 96 97 U Np Pu Am Cm Bk	Dy Ho Er 98 99 100 Cf Es Fm	$\begin{array}{c cccc} Tm & Yb \\ \hline 101 & 102 \\ Md & No \end{array} \rightarrow \begin{array}{c} Lall \\ Acti$	inides		~	L = U
					Book	112-122	
Jaming of	Ionic Compa	ucls			1300k p.	1117 1-5	
Cations			Acids	adding H	+		
pos. Charge Fe ²⁺ , Fo	3t iton (\mathbf{I}) ion / iton (\mathbf{II})) ion	Anions who	end ide : h	1ydro ic acid		
normetal molecules Cations:	-ium		CL Chloride	+H ⁺ HCL	Hydrochloric acid		
Laione ()			Anions w	no end ale/	/,tc		
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02- oxide O	H- Hydroxide		4 (CIO3	Chloric acid	HCIOz chic	irous acid	
polyatomic with C	> - ate/-ite : 0>	<i>canions</i>	Amount	of Atoms			
NO3 Nitrate	normale one O fewe status than "ate"	-T	1 mono	$>$ Cl_2O d	ichloride monoxide		
NO2 Witrite	-per / hypo		3 tri	NF3 N.	itingen trifluoride		
C10, chlorale	One more O even les	s O	10 deca	→ P4540 Te	straphosphorous Decasulf.	ide	
Clo- hypochlorite	chan ale than "i-	te '					
per ale > -ate _	s ite shypoite	.	Stochior	netry	242 + 02 2	2H20	
adding H1 - hyd	iogn			/			
2111 - dih	ydrogh				Compand	Elemen	t molecule
•							
Limiting cea	ictant table	- With	$n = \frac{M}{M_{\rm bol}}$				
Gases					for gases o	nly	
$P = \frac{F}{A} = L_{M}^{N}$	$\frac{1}{2} = \left[Pa \right] = \left[\frac{hg}{ms^2} \right]$	S= ~	iass =	上AL	J E MW	$= \frac{SKI}{SKI}$	
	Baroneler	- Va	rume	1 70		Р	
Matm = 760mm	Hg I Marorel	μ. L	0.1			P.	= Pa
= 760 to	μ Ū O O	rgas =	Patr + g	gh	7V =		
= 1,013	25 bar	D				R=	= 8,314
= 101,3	25kPa	rg =	zgn				
= 1013	25 Pa			C	>= 8.2111	J7	h _ L.Bar L.
- Pa	= atm			16	- 013-14 A	ol K moll	K Molk Me

P: V: = Pf Vf if $n, V const:$	$\frac{P_i}{T_i} = \frac{P_P}{T_P} \frac{P_i V_i}{T_i} =$	Pt Vt Tt	1	nv ²	
Portial Pressure: Ptol	$F = \underbrace{\underbrace{n_{1}RT}_{V}}_{V} + \underbrace{\underbrace{n_{2}R}_{V}}_{V}$	$\frac{P}{1}$ + + $\frac{n_i R}{V}$	P Dallons	law of Parlial"	Pressures
mole fraction Pi = ni . Pt	$at = \mathbf{X}_i \equiv \frac{n_i}{n_{tot}}$	= Mole fraction	van des i	waals equal	ion
VØ = Vrms = 3RT Velocity root mean squader MW	average notecular Velocity , deputs on Thuesday	. (9	$P + \frac{n^2 \alpha}{V^2}$	(V-nb) =	nRT
			Correction for Intendions	Corrections for missing Volume	
mol / = pressure / e	X: 00004 md y co.	->			
,	P - o moll alm -	O.OVOSKA			
	$1_{CO_2} = 0,0004 \text{ which } \equiv$	0,0403474			
		Prefix Abbreviation	n Meaning	Example	
		Peta P	10 ¹⁵	1 petawatt (PW) = 1×10^{1}	⁵ watts ^a
		Tera T	10 ¹²	1 terawatt (TW) = 1×10^{11}	² watts
		Giga G Mega M	10 ⁵	1 gigawatt (GW) = 1×10^{9} 1 megawatt (MW) = 1×10^{6}	watts
Elastic Litan) and le cloule las	Kilo k	10 ³	1 kilowatt (kW) = 1×10^3	watts
Electrolytes n	Unerectivitytes	Deci d	10^{-1}	1 deciwatt (dW) = 1×10^{-1}	¹ watt
		Centi c	10 ⁻²	1 centiwatt (cW) = 1×10^{-1} 1 milliwatt (mW) = 1×10^{-1}	² watt
HЪ		Micro u ^b	10 ⁻⁶	1 miniwatt (mW) = 1×10^{-1} 1 microwatt (μW) = 1×10^{-1}	⁶ watt
EC II		Nano n	10 ⁻⁹	1 nanowatt (nW) = 1×10^{-10}	⁹ watt
		Pico p	10^{-12}	1 picowatt (pW) = 1×10^{-1}	¹² watt
HOT		Femto f	10 ⁻¹⁵	1 femtowatt (fW) = 1×10^{-1} 1 attowatt (aW) = 1×10^{-1}	¹⁵ watt
Precipitation Reactions Ax+ By -> Ay+ Bx	->solubility chart	Zepto z	10 ⁻²¹	1 zeptowatt (zW) = 1×10^{-1}	²¹ watt
$A_{a}^{+}(a_{1}) + WO_{2}^{-}(a_{4}) + K^{+}(a_{4}) + (l^{-})$	$(a_1) \rightarrow A_1(l(s) + k^{\dagger}(q_1))$) + NO3-(01)			
)	0:	$- \sim$	
=> kt and NO3 are on both sides -	-> spectator ions		(12		
-> net reaction Ag++ (1> Ag	CL (s)			Min	
Significant Figures					
An one Ordini	41.25 11	Day H	A clinal a	In Via Jacob	ain Rinn
ray non varye	U4,90 4	Komolig: 14 M	ma pocarian	to the lengt	org trys
Any U between Digits	740,0035 7				- Y
O on beginning of Number are not sig.	0,00035 Z				
Out only on Pilling to Aut	2.000	Salubil 1			
o at elu ore sig. it twee is a dec. point	7,000 4	activity			
		Soluble Ionic Compounds	Important Exceptions		
$1 \text{ kcal} = 4,184 \cdot 10^3 \text{ J}$		Compounds containing NO ₃ CH ₃ COO	None D ⁻ None		
		Cl ⁼ Br ⁻	Compounds of Ag ⁺ , Compounds of Ag ⁺ ,	$\mathrm{Hg_2}^{2+},$ and Pb^{2+} $\mathrm{Hg_2}^{2+},$ and Pb^{2+}	
		Г ⁻ SO. ²⁻	Compounds of Ag ⁺ , Compounds of Sr ²⁺	$Hg_2^{2^+}$, and Pb^{2^+} Ba^{2^+} , $Hg_2^{2^+}$, and Pb^{2^+}	
		Insoluble Ionic Compounds Compounds containing c2-	Important Exceptions	the alkali metal eations Co2+ So2+ and the	2+
ST		CO ₃ ²⁻	Compounds of NH ₄	, the anali metal cations, Ca*', Sr*', and Ba	
		PO4 ³⁻ OH ⁻	Compounds of NH Compounds of NH	⁺ and the alkali metal cations ⁺ , the alkali metal cations,Ca ²⁺ , Sr ²⁺ , and Ba	2+
(for the modynamic tables)					
Hermodynamics -> StP = 25°/2	38K				
Pressure -> STP = 04/2	736				
(PH-ORT)					





P l= 2 y Grbitals Orbitels 1=1 ML-1 *p* orbital $H_{Ml} = \{3, +3\}$ >M2 = Orientation -> depends on l $Ml = \{l \}$ -> Ms = Spin up or down Ms = ± 1/2 1/2 how electrons are in arbital. Energy depends on n -> 2s, 2p 3s, 3d, 3p =) have the some Energy l orbital Fill from bottom up, then go again, two e in one ber 11111 11 11 11 (spio) No e can have some set of n, l, Me, Ms Pauli Exclusion Arine ple: Not two electrons can have the some set of Quantum Dumbers S=2 p=6 d=10 f=14TABLE 6.3 Electron Configurations of Several Lighter Elements Total Electrons Λ Element Box = orbital 1s 2s 2p 3s $1s^22s^1$ Li Noble-10 1-1 3 Be 4 11 $1s^2 2s^2$ gas core $4p^4$ Se 11 1 $1s^2 2s^2 2p^1$ -d-PL. С 6 11 1 1 1 $1s^2 2s^2 2p^2$ 7 11 11 1 1 1 $1s^2 2s^2 2p^3$ 1-2 10 11 11 11 11 11 $1s^2 2s^2 2p^6$ Ne 11 11 11 11 11 1 $1s^2 2s^2 2p^6 3s^1$ 11 = D Hands rule: fill up orbital box first, then and spin Elektronenkonfiguration place electron spins paralell first in whole subshell then add second spin Edelgas von reibe dur nehmen, dans reibe durchgeben bis in Element, and jeweils Schale, orbital "scheeber," Screening Zeff increases across row in PSE Schole des d'arbitale -1, & schole f arbitale -2, (warun? Ka) e Attraction Bsp: Se [Ar] 4523d104p4 Zeff = attraction VE to Mucleus(?) Bsp: P6 [Xe] 652 4414 50/10 6p2 A-2 A-1 Jonic Radius Atomic size Ð Estimate radius from Bond Leghts in ionic solids Cations @ smaller radius then povent neutral atom Anions @ bigger radius then povent neutral atom Bonding allomic radius = d Atomic radius ted to increase down in colourn PSE (n shell is getting bigger) & decrease across period => because Leff occases. Trends Ions will some charge -> bigger down group (colourn) Ions with some # = -> smaller with increasing Zeff (row) Ionisation Energy A Election Affinity eignilich regalive Zahl Energy to remove e^{-} $N_a \rightarrow No^{+} \cdot 1e^{-}(I_a)$ first $No^{-} \rightarrow No^{2+} \cdot 1e^{-}(I_a)$ second Ionisation Energies -D Energy change when add extra e to Alom I >0 add Enery to System to remou Trends I2 > Typically Exothermic: EA < O Pse I increases from left to right PSE I decreases down colourn PSE EA <0 1 Trends Halozens EA << 0, Noble goses EA > 0 (full shell)

Octet rule: Atom would "	8 Ve : Xe :
1) Ionic	$Na^+(g) + e^- + Cl(g)$ $Na^+(g) + e^- + Cl(g)$
11.+ CO- Strench qualitied by Lat	ice Energy EA(CI)
chand while Every to separate two every	$I_1(Na)$ $I_1(Na)$ $I_2(Na^+(g) + Cl^-(g)$ $Ionise$
Vacl Atlat Not + (1- 14+788 KT, two	ions and istne aport
Not + Cl No Cl &H - 788 min	$\Delta H^{\circ}_{f}[\operatorname{Na}(g)] \xrightarrow{\operatorname{Na}(g) + \frac{1}{2}\operatorname{Cl}_{2}(g)}_{J^{\circ}} \qquad $
Ionusation Energy	$-\Delta H^{o}_{f}[\text{NaCl}(s)] \qquad \qquad$
$(A \tan x \# - 1)^2$. 13,6 = V	
	alles aufsummers, (-Hf, - Elat),=0, nach l
2) Covalent	Electronegativity Electronegative Atoms
H2O (H(:)H) Each atom	How sligning on Allom pulls e Large negative EA
sharing Ve concern has Noble gos	s Use to estimate Bond polarity JF J Large Ionisation Every
CKOLCO CONTA	Trend Increases across row PSEAN (want Electrons and resist g
Multiple Bonds	decreases down colomn lincr.
0=0 (->=>≡)	SElectroney
N=N	NEN > 2 Ionic Bond
Trend Bond length decreases with # shared e-	AS OX Number of Metal (
	DEN < 0,4 Apolar => More covalent
Dipole Moments	
Dipole moneyat I OFH - F OF	Victor Processing of the the
	VEED FILMENT TO JUSS O=C=O apolar be linear symmetry
$ M = (2 \cdot \Gamma) D Debye = 3$	134×10-50 CM
$ \mathcal{M} = Q \cdot \Gamma [D] Debye = S_1$ C = obstace	,34×10 ⁵⁰ CM
M = Q. C LD Debye = 3, r= distace Q = Chare M = Magnilide	Alternative Lewis Structures:
M = Q. [] Debye = 3, r= distace G = Chane M = Magnitude 2) Mp fall & Roadl	734×10 ⁻⁵⁰ Cm Alternative Lewis Structures:
Im = Q. [] Debye = 3, r= distance G = Charle M = Magnitude 3) Metallic Bonds Fer	$\frac{34 \times 10^{-50} \text{ Cm}}{\text{Alternative Lewis Structures:}}$
1 M = Q. C L D Debye = 3, c= distance G= Charle M= Majnishde 3) Metall & Bonds Fe Ve shared with whole solved	Alternative Lewis Structures: $\ddot{\bigcirc} = C = \ddot{\bigcirc}$ $\dot{\bigcirc} = C = \dot{\bigcirc}$ $\dot{ = C = \dot{\bigcirc}$ $ = C = \dot{ = C = \dot{ = C = = C = \dot{ = C = c = c = c = c = c = c = c = c = c$
Image: A construction Image: A construction Image: A constred Image: A construction	$\begin{array}{c} 34 \times 10^{-50} \text{ Cm} \\ \hline \\ \text{Alternative Lewis Structures:} \\ \hline \\ \hline \\ \\ \text{Valence electrons:} \\ -(\text{Electrons assigned to atom):} \\ \hline \\ \text{Formal charge:} \\ \hline \\ 0 \\ 0 \\ 0 \\ \hline \end{array} \\ \begin{array}{c} \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \hline \\ \hline \\ \end{array} \\ \begin{array}{c} \vdots \\ \hline \\ \hline \\ \end{array} \\ \begin{array}{c} \vdots \\ \vdots $
Image: A construction Image: A construction Image: A constred Image: A construction	Alternative Lewis Structures: $ \begin{array}{c} & & & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & & \\ & & & \\ & & & & & \\ & & & & \\ & & & & \\ & & & &$
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1) Sum of all Ve ⁻ 1) Sum of all Ve ⁻	Alternative Lewis Structures: Valence electrons: -(Electrons assigned to atom): Formal charge: 0 0 0 0 0 -1 0 +1 0 0 0 -1 0 +1 0 0 0 0 -1 0 +1
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1) Sum of all Ve ⁻ 2) Distribute, complete Oclet for Noncentral A 3) Multiple Bords if Central Atom downth hume	Alternative Lewis Structures: $\begin{array}{c} & & \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ $
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IM = Q. T LD Debye = S, r= distance G = Chane M = Maynibble 3) Metall & Bonds Fe Ve shared With whole solid Lew's Structures 1) Sum of all Ve ⁻ 2) Distribute, complete Octet for Ubneentral A 3) Multiple Bonds if Central Atom oberth have exeptions to octet rule: odd e	$\frac{34 \times 10^{-50} \text{ Cm}}{\text{Alternative Lewis Structures:}}$ $\frac{34 \times 10^{-50} \text{ Cm}}{\text{Alternative Lewis Structures:}}$ $\frac{34 \times 10^{-50} \text{ Cm}}{(\text{Electrons assigned to atom):}}$ $\frac{34 \times 10^{-50} \text{ Cm}}{6 + 4 + 6}$ 34×10^{-50
IM = Q. C LD Debye = S, r= distace G = Change M = Maynible 3) Metall & Bonds Fe Ve shared with whole solid Lewis Structures 1) Sum of all Ve ⁻ 2) Distribute, complete Octet for Noncentral A 3) Multiple Bonds if Cedual A tom dost have exeptions to octed rule: odd e V= d Kess them Ve ⁻ on count atom More than Ve ⁻ on count atom Multiple Bossible Lewis Structures (0=0-01 4-2 10-0=0) Shapes: VSEPR (valence distinguist between:	$\frac{34 \times 10^{-50} \text{ Cm}}{\text{Alternative Lewis Structures:}}$ $\frac{34 \times 10^{-50} \text{ Cm}}{(\text{Electrons assigned to atom):}}$ $\frac{34 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ $\frac{36 \times 10^{-50} \text{ Cm}}{(\text{Electrons function for a cm})}$ 36
IM = Q. T LD Debye = S, r= distance G = Chane M = Magnitude 3) Metall & Bonds Fe Ve shared With whole solid Lewis Structures Sum of all Ve⁻ Distribute, complete Octet for Iborcentral A Multiple Bonds if Certral Atom obesit have exeptions to octet rule: odd e Ve⁻ on count atom more than Te⁻ on count atom more than Te⁻ on count atom Multiple Dossible Lewis Structures () = 0 - 01 4-b 10 - 0 = 0) Shapes: USEPR (volence distinguist between: 	$\frac{34 \times 10^{-50} \text{ Cm}}{\text{Alternative Lewis Structures:}}$ $\frac{34 \times 10^{-50} \text{ Cm}}{\text{Alternative Lewis Structures:}}$ $\frac{34 \times 10^{-50} \text{ Cm}}{(100000000000000000000000000000000000$
IM = Q. C LD Debye = S, r= distance G = Chane M = Maynible 3) Metall & Bonds Fe Ve shared With whole solid Lewis Structures 1) Sum of all Ve ⁻ 2) Distribute, complete Octet for Abancentral A 3) Multiple Bonds if Cedual Atom obsyst have exeptions to octel rule: odd e V=0, N=0 kess time Y = on count atom more than Y = on count atom Multiple Dossible Lewis Structures (D= D-DI A-D ID-D=0) Shapes: USEPR (valuace distinguist between: Election domain Geored	$\frac{34 \times 10^{-50} \text{ Cm}}{\text{Alternative Lewis Structures:}}$ $\frac{34 \times 10^{-50} \text{ Cm}}{\text{Alternative Lewis Structures:}}$ $\frac{34 \times 10^{-50} \text{ Cm}}{(-(\text{Electrons assigned to atom):}}$ $\frac{34 \times 10^{-50} \text{ Cm}}{(-100 \text{ Cm})}$ $\frac{34 \times 10^{-50} \text{ Cm}}{(-(-100 \text{ Cm}))}$

Number of Electron-Electron Domain Bonding Domains Geometry Domains Number of Electron-Electron Domain Bonding Domains Geometry Domains 5 Domains Domains Domains 5 5 Trigonal bipyramidal 4 1 Example Remember: Linear 2 ö=c=ö **ب**ا -Lone pairs will fake PCl₅ Trigonal planar 3 0 More space then bondy Trigonal bipyramidal H US H N H 2 1 2 2 3 - double /triple Bonds take more spacethan Single Londs 4 **1015** Totrahofeal 0 H^HH_HH а с-о; ц 3 Trigonal pyramidal SF₆ H H 2 2 5 1 BrF3 4 2 XeF4 Intermolecular Forces (ZMK) (no Bonds) Eint = Energy of Inkonetion between Notecules (Anziehry) Eint set by RT, depends from separation Dislace d Ekin := Kinedic Energy of Molecules (Berveymy) If Temp increases → IEhial > IEiatl X 3 Types of Interactions (I) Induced Dipole / Dispersion (I), (I) VdWK -salways possible very short Range, but Muye notes the differce 9) (JF @ J-) (JF @ J-) (G very allocative, but only on short distances. This + -> All Atoms, always present -> depends on polarisability Temporary Dipol (present for polar molecules) (I.5) Dipole - Induced Dipole (II) Dipel- Dipol Interaction (permanent), strongest Permanent Dipole is needed for this Interaction I and I mixed together Polar bonds -> Molecule with dipole moment I Polar molecules have $\mu_{1cl} \neq 0$ $|\overline{\mu}| = q \cdot d \quad \textcircled{Q} = \underbrace{G}_{q^+} \underbrace{G}_{q^-} \underbrace{G}_{q^-} - H \overset{T}{J} = \underbrace{H}_{q^+} \underbrace{H}_{q^-} \underbrace{G}_{q^+} \underbrace{G$ vector sum of all land Dipole Moments H - H (III) Hydrogen Bonding / H-Brüchen That's why Liquid water is more dense than ice, because in (frozen)? state it forms fings H H-OIH H-OIH only F, O, N + H Bonds (they are very electronegative NO Are noted to match the second seco Il can attatch to other lone e pars of IFI, or, J Atoms Active Hallbrücke wenn molekül mit anderen gleicher Sorte HBrüchen mehn han Passive Kulbbrücke: wenn es eine andere Mokeking sonte braucht (IV) lon - Dipole HEHHH Naton SCL-H-H-SNAton SHH Dispersion Dipole-dipole Hydrogen forces only forces bonding Examples: Examples: Examples: CH4, Br2 CH3F, HBr NH4, CH3OH in H3O Strength Bonds > Ion - Dipole > H-Bonds > Dipole - Dipole > Induced Dipole -> solubility



Endothim Exothern All sola can be (f) or (-) and s	Shre LG= LH-TIS	Entelpy changes during soluction
		Solute Solvent
if Sthsoln < O IF.	<u>stlsoh >0</u>	broken broken intermolecular intermo
Typically Solution forms -TA	Ssoin must be sufficiently neg	
for any solute concentration make	le AGisch < 0 ridlet	Manual and Andrew Andre
pure pure Othe	unuise solule will not dissolve ⁵	
solvent Solute Prov	cess will depend on T, more .	we celer to every - Exclusion Himal
Miscible "mixable" But	if still is very pos. the still may not mongh to compensate -> will not discolve	
	solutie	
S - duliilidu S [2] - dilule	L = Wassrh T	Ealors albertin solubility
May As a 1 P		actors affecting solutility
Max. Amount of solute in solut	ut at given I	In Romole called interaction for and
=> Saturated Soln = solute + sol	went associate solution	sting some - somet intervention forbour
Lo Dynamic equilibrium above solu	billy concentration	invide: solar limite die agent in solar (invite
supersaturated soln -> contains more than	n max ancent of capable	Acto-oder Liquide gree immissible will, oder (in
(ii) Pressure	6	uneral : if smaller Takander Takander on soluble
Solute of (a) in a (1) dependent	i on Pa	
Sq = qas solubility -	moles concentration? (III) Ter	
Dg = K. Bg Pg=gas partial pre	ssure: P. Vulatinis Ion	solubility in HoD rif Tr as an >0
Henrys Law State and Tenand	each time for Gas	solubility in 1/20 3 if T/ Assum <0
/ · · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·	
Concentration		
and males s		
× fraction = total m	cles useful for gas mix	mass / = mass x100
moles s	dute, Depuds on Volume	mass solute, 6
M Molwity = Litres s	solution = C of solution	Ppm parts per milling = total mass × 10°
Multility = moles s	solute Depends on Mass	mass solute as
M Molality kg solve	M OF Solvent	PPD ports pur billion = total mass \$10
	with T	
Colligative Properties	solule affects properties of	-liquids dilution C= concentrated, d= diluted
If depute only on amount of solule -	- colligative	formula Mc. Vc = Md. Vc
(A) Boiling Point J	(B	b) Prop > Liquid boils when Prop = P
	$m = m \alpha t a t i t v$	bsp volatile solvent + non-volatile solute
$\Delta T_{bp} = T_{bp} - T_{bp} = ib$	6 Kb= mda bp	
	elevation vorst	For ideal Soln
i = 1 for non-electrolytes.	1 - Vour nor the tacket	
ex: Nacl i= 2, MgClz i=	=3	Yop = X solvent Yuop X= mole fraction of solvent
Water: it we add Nacl Top 7		
	.0	Solv-Solv Dsoln, ectual Ser Bacult
Ideal Gas: No Intermolec. Interaction	ons =0 HV= ART if	- solule - solvent < { solu - solu - trep bigger the ideal case
		(solv-solv Dool, ectual SchReault
Ideal Sola All Internolec. In ide	HKal it	- Solute - Solut - [Solu-solu Trep < Frep less the Ideal case
source - source = source - so	wat = 301 WR - 301 WA	

	(C) Frazina	Point Ju		(D) Menneie		
				Sani-Optimicalia	Menthrane only Oc	sees solveel not white
	AT - Tooh	Tome ile	m = molality	· Ocnobic florities	to actualize con	seal to light -
	$S_{1}f_{p} = f_{p}$	- ifp in	$k_{f} = mdal fp$	-s Oscilla Line F	acateril la contenal	ma flaus
	-1.01	· C/.	Capital Capita	-s USMULLE pressure. F	- Meeded to countrate	Long Fills Completer
	ex. retizo = 1,00		= # electiclyles	r		ways equilibrium
	equation is for d.	the solg that are raced	1			
	Af uight concern	ation typically / contolea		Initially	At aquilibrium	
	Osmotic Press	we_		Pure Solution		Pressure applied to equalize fluid levels in both arms
		TV= in BT) n=MV	Concuse IT to	- solvent		equals osmotic pressure, T.
	TT= iMRT	M = Molarity	dolarmine. Mus	Solvent Solute particle particle		
		i = Voutboff Factor	T = iMRT M = A	Semipermeable membrane		
		# electroly es	mass II.			-
	This Sola TT=TT	- isolonic	mole = MW	• + + +		
				Net movement of H ₂ O is from pure water side to solution side.	At equilibrium, the flow of H_2O is the same in both directions, so there is no net movement of H_2O .	
		thyperonic by an local				
		ypotonic				
Lecture 10 -	reaction k	<u>Late</u>				
	TXN rate =	change of co	oncentration LC	J M Mola	rity or Moles	
		st			rales always positive	2_
	example: rxn rate	e = rale of appearance	e = rate of dissopeanance		$A \rightarrow B$	
		$\Delta [B] = -4$	S[A] - [c] concertantion in Molarity	[c] halo	whomeens [C]	C-3D
				4	Average rale	
	Aurie CXA	rate 1	nstataneous rx	n rate	U	Instantaneous rale
	$\Delta \underline{IB^{1}} = \underline{IB}$	$\int_{t_2} - L IS \int_{t_1} \int_{t_2} \int_{t_2} \int_{t_1} \int_{t_2} \int_{t_1} \int_{t_2} \int_{t_1} \int_{t_2} \int_{t_$	$\Delta[3] = d$	LISJ Ableitry		
	st .	tz-t1	st	dt	>t [>t
		· ·			her	e avery = Instalaeous role rxn rale cloes not
					depuis -> Black	l on [C]! Box Cookie Factory Analogy
	Kale = Instan	toneous Rate at giv	ut, [s]		city or	e Machine
	Tailalanta	1				α,β,μ,δ
	Latin Fore	- Instantaneous Kate	t = 0	A-10		stochiometric Coeff.
	Kale Laws	find out by experimen.	Kale:=	$-\frac{1}{\alpha}\frac{dL^{A}}{dL^{A}}=-\frac{1}{\beta}$	$\frac{\lambda[S]}{TL} = \frac{\lambda}{T} \frac{\alpha[C]}{TL} = \frac{\lambda}{T} \frac{\alpha}{T} \frac{\alpha}$	1 dLU
		FAT MEAT	n K= rate low constan	A ON P	ort p ort	0 dt
	kale law = v		M, n, = readion o	prodeus $e[0, \frac{1}{2}, 1, 2]$		
	L		<u>14</u> ≠ α,β,γ	A A . M D		
	if more reactants	only reactants	•	Units of	K -> depend a	n rxn order!
		····		1.7	M M= -	$\frac{1}{k} = \frac{M}{c}$
	Uverall exa on	der = M+1+p.	Sum of exponents	[K] = -	M+0+p+.	_ / 5
				u_{n} its $= (u_{n}$ its).	CXA O	rder unit of k
	how to find ou	k/				M S
	Exp [A](M) [B]	KM) Initial rale law (Ms)	Rale 2 = 4.10 =	1 rale= k. [A] ^M [B] ^N	4	$\frac{m^{\frac{1}{2}}}{S}$
	1 0,1 0,	1 4.105	1 10°		1	1
	2 0,1 0,1	2 4.105	() (=	$\frac{1}{10000000000000000000000000000000000$		1
	3 012 01	1 16.105	1- 7		in order	Mis
			·(= 2		3	$\frac{\Lambda}{M^2 S}$
or:	$\frac{rale 3}{rale 1} = \frac{16.10}{4.10^{-5}}$	$= 4 \int_{k}^{k} 4 = k$	$O_{12}^{(2)} \cdot O_{14}^{(1)} = \frac{O_{12}^{(2)}}{O_{14}^{(1)}} = Z^{(1)}$	=4 => Order M=2		

 $-\frac{d[A]}{dt} = rate = k[A]^{M} | ME u, 1, 2$ Oth order 1st Order 2nd order



$$\begin{aligned} \mathbf{rate} = k \left[A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \longrightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \rightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \rightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{M} \left[B \right]^{N} \left[B \right]^{N} \rightarrow \operatorname{ck} kondul a \operatorname{distant}^{N} \left\{ A \right]^{N} \left[B \right]^{N$$

Process to d	retermine cxn	Mechanism	Slochiometric coeff J bc. assumed elere	nleng
		rale law	y^{2} rates = $k_{1} [A]^{2}$, ratez = k	2 [I][B]
->Experiment	Example: Proposed	Nechanism	Lo system of equations to be s	colvect.
-> Picpose idea	slow 24 they	I+C 7	one rxn will be rate l	limiting
->Creck	Consumua_	(C×A	-> one slep is so slow, it se	f rxn order
	fast I+B ->	A+D J	for the Global rxn rate	
	2Å+I+B ->	A+D+I+C -A,-I	if rate, is limiting: k, <<	tost
	A+B>	C+D { Global CXN	$-ate_{overall} = K_1 \cdot [A]^2$	Ľßſ
			-> check with experiments if cc	insisted or not
Catalysts		CIII (CIII		
Substances that incl	rease (Xn rate	Catalysts affect k		
get consumed but rep	produced in sub-step	11- A ava (-Ea) 1 Louis	Es => better orient includes =	er (Xr)
so abut show up in	n Glodal CXA	N= A-exp(=pt/ (www	Lg => lower every of reast	ion state
			Types of cataly	નેડ
$E_a = E_a^{catalyst} <$	Ea	mostly lowers Ea	Homogeneous : reactants	, products &
	-uncatalyzed rxn		u catalysts a	are in the same
		· catalysts can lead to multis	dep phase	
Echlapt		rxns -> mulliple peaks	ex enzyme	s
	\ _	· slowest step has highest p	eak fleterogeneous : reactands,	, products R
Catalyzed Multi-slep process		in curve (hardest to get or	ver) catalysts	are in difficut
rxn coordine	ale		phases	
Equilibriu	Mid-Bace sta	Kfwd	$k_{\rm c} \equiv equilibrium constant los m$	planity conception tions
System reaches stead	dy state		kr [unill	<i>ess</i>]
equilibrium if rate	fund = rate bud	Nowal if elementary rat	n: slochioneltic coeff. is not const	$m = k_c(\mathbf{T})!$
assume elementary rkn		k. J [C] [D]	[Products]	
$kfund [A]^{4} [B]^{4} = b$	(bud [C] [D] E	$\Rightarrow \frac{4}{100} = \frac{2}{100} $	= = = KC	= equilibrium Constant
				junitless!
equilibrium requires closed	d system (products f reacto	ule contescope) Use [T] [A]		
Reactions in both direction	ons slill occurring, but at t	he save rale	requilibrium [D]	equilibrium
so concertation doesn't	chaye			
Locs not Matter if h	le start with pure rea	actalis or pure products		
s all CXAS behave li	he elementary rans nea	r equilibrium -> so when rate we dont nee	e laws, d to know the mechanism	
$(Pe)^{k}(Po)^{s}$	portial Pressure		of gaseous pratures)	
$^{n}P (P_{\lambda})^{*} (P_{\lambda})^{*}$	$P_{i} = \frac{1}{V} [K_{i} = 1]$	$\frac{1}{2} \left[K \right] K p = K \left(\left[K \right] \right) \left[\left(\# n o \right] \right] $	f gascous reactands) NCFNP	
	concertantion			
Lot	o calculate use bas			
Kc & Kp unitless	De cause:			
(ACHINY for substance	ce in) Ratio at	Pressure or concentration	$a_i = \frac{[i]}{1}$	
(ideal mixture) -> to refere	nce concentration of pressure	Activity of 1 1M	
			$a_i = \frac{P_i}{P_i}$	
Kc = <u>litoduc</u>	tsj canl	grore pure liquids & p	owe solids nor	
- Scenda	ale)			

ifK	>1 E	Equil. to c	ight mixture	e is mostly pr	duets Q= Moment	over zustand
ił K	< 1 E	Equil to l	eft mixtu	re is mostly r	actants $\mathbf{Q} = \frac{\mathbf{j}\mathbf{C}}{\mathbf{j}\mathbf{A}}$	$\frac{\int^{N} [D]^{\delta}}{\int^{\Omega} [B]^{\beta}} \qquad \text{to more tourseds} \\ equil. Q= kc$
rate	= rate	@ equil	. but [re	actants]7=[$\frac{\text{concentration}}{\text{products}} \qquad Q < K = \\ Q > K = \\ Q = \\ Q = K = \\ Q =$	fund rxn forms more products bund rxn forms more reactants
reverse	A≓B	Kı	B≓A	$k_2 = \frac{\Lambda}{k_1}$	K≡ equil. C	onstant
Limes . n	AZB	k o	3A ≓ 3B	$k_2 = (k_0)^3$	homogeneous ea	uil. all substances some phase
multislep	A≥B B	k1 Κ2	A≠ C	:K3=K1·K2	helesogneous eq	uil. substances differt phose
			l			

Pue solids & pure liquids

In velesogneous equilibria = exclude pure liquids & pure solids: $PbU_{z}(s) \rightleftharpoons Pb^{2+}(aq) + 2U^{-}(aq)$ Lo because concentration of pure (l) or (s) is constant, have activity of 1 $h_{c} = [Pb^{24}][(l^{-}]^{2}]$ Product of concentrations of dissolved Ions at equilibrium given in For saturated solutions of low-solubility ionic solids kc = Ksp = solubility Product Brown book

		4421 MARANI CALINO	
if sys. @ equil is disturbed by	Change in Concentration	$E_{X}\colon A^{+}B\rightleftharpoonsD = D_{constraining}$ Initially	at equilibrium
change in T , P , concentration	[A]	$Q = \frac{[D]}{[A][B]} = \frac{n_{A}}{n_{A}} \frac{n_{B}}{n_{B}} = K_{e}$	Q in terms of moles of each species. (Volumes Cancel in concentration
con ignore pure solids & owne l	$\begin{bmatrix} A \\ B \\ D \end{bmatrix} \xrightarrow{J} \longrightarrow \begin{bmatrix} A \\ J \\$	$Q = \frac{n_{p}}{n_{A} (n_{B} + \Delta)} < K_{c} $	forward IXN forms more products See p. 9
Change in T	[A] Re-establishes equilibrium [6] JIII IIII [D] IIII IIII	$Q = \frac{n_{p+x}}{(n_{A}-x)(n_{B}+\Delta-x)} = K_{e}$	equilibrium again
Treat heat (T) as product/reoclant			
Endothermic $A + T = B$ Exothermic $A = T + B$	Change in	Pressure Ex: Na	$(q) + 3H_2(q) \rightleftharpoons 2NH_3(q)$
TA: TXA moves right TT CXA moves left	Side O let	with the constraint has	= = 2 half Descence a shelle

System shifts equil to countract Ty: rxn moves left right T & TXA moves right P7 equil to side with less moles equil to side with more moles $k_p = \frac{(P_{WH_3})^2}{(P_{W_2})(P_{H_2})^3}$ because Ea is in $exp\left(-\frac{Ea}{RT}\right) \rightarrow larger Ea is more$ Ъ strongly affected by chaye in Temp. $\widehat{Q} = \frac{2(P_{WH3})^2}{(2P_{V_2})(2P_{V_2})^3} = \frac{4}{4} k_p \quad Q < K$

Catalyst effects on equilibria

catalysed rxn reach equilibrium faster but K does not change due to cat KENd > KENd , KENd > KENd



 $SG^{\circ} = -RT ln(k)$ $k = exp\left(\frac{-\Delta G}{RT}\right)$

Gibbs SGP = Free energy to form substance from elements T=absolute T $\Delta G = \Delta G^{\circ} + RT \ln(Q)$ R=Gas const. SG° = Free every chase for any rxn Q= rxn quotient at equilibrium Q=K 3G < 0, K>1 equil ->produdcts rxn spontaneous: DG<0 $\Delta G > O, K < 1$ at equilibrium DG=0 equil. -> reactants

Sample Problem given: [Hz];, [Iz];, [HI]equil. search: hc

	H2 ·	t Iz z	≥2HI	
initial concentration	1.10-3	Z.10-3	0	1) Change in [CH] $1,87 \cdot 10^{-3} - 0 = 1,87^{-3}$
				2) relate chang to other rxn participants
Change in Concertantion	1-0,335-10 ⁻³	1-0,935-10 ⁻³	+ 1,87 10-3	(1,87-10 ³ mot HI) (<u>1mol Hz</u>) = 0,935-10 ³ mol Hz L) (<u>2 mol HI</u>) = 0
equil. concentration	01065-10 ⁻³	1,065-10-3	1,87.10-3	$ \begin{pmatrix} (1,8) & 60^3 & \text{mol}\text{H} \\ L \end{pmatrix} \begin{pmatrix} 1\text{mol}\text{I}_2 \\ 2\text{mol}\text{H} \end{pmatrix} = 0,335 \cdot 10^3 & \text{mol}\text{I}_2 \\ L \\ 3 \end{pmatrix} \text{fill out equal modulo (Ha) = 1,40^3 - 0,935 \cdot 10^3 = 0.045 \cdot 10^3 \text{mol}\text{H} \\ 3 \end{pmatrix} $
$k_{C} = \begin{bmatrix} 1 \\ \Gamma + 2 \end{bmatrix}^{T} \int_{0}^{T} \int_{0}^{T$	1 Ι] ² Τ.] ¹			$[I_2] = 2 \cdot 10^3 - 0,935 \cdot 10^{-3} = 1,065 \cdot 1$

Sample Roblem given $[H_2]$, $[I_2]$, $k_c = 50,5$ (at given T)

Iz ZHI H2 + initial 1) Use Stochiometry to determine the range for each amount of 0 2 concentration ィ Hz that reacts, one mol Iz is consumed and two mol HI produced Change in concertuation 2) use initial [c] and change in [c] by dockionedry – X – X + 2x for equil. concentration 3) $k_{c} = \frac{[HI]^{2}}{[H_{2}][I_{z}]} = \frac{2x^{2}}{(t-x)(2-x)} - sche x = 0,935$ equil. concertration 1- x 2-X 0+2x

Acid-Base Equilibria (S-B Reaktionen) always SB pair, never alone $HCl + H_2O \neq Cl^{\ominus} + H_3O^{\oplus}$ Acid = gives H+ in water increases [H30^D] concertuation NH3+ H20 ₹ NH4 + OH $Base \equiv takes H^{\oplus}$ in Water increases [OHO] concertation Autoionisation of water $HCl(g) + NH_3(g) \rightleftharpoons NH_4 Cl(s)$ $H_{2O} + H_{2O} \rightleftharpoons H_{3O} \oplus OH^{\odot} | k_{c} = [H_{3O}^{-1}]^{1} [OH^{-1}]^{1}$ $k_{\rm W} = 1,0.10^{-14}(25^{\circ}{\rm C}) = [01^{\circ}][H_3O^{\circ}]$ [ignore pue (SE1)] When [Hz0] = [OH9] solution is neutral Shrony acid : gives up all H^+ to form H_30^+ , fully ionized 1 weak acid : partially ionized , mr of HA & Aif 1430+ 1 increases, [049] decreases for bases (HA without ocididy conjugate Base is Stronger, accepts more H so ggw is left [H30'] > [OH-] "acidic" ? always [H30] [OH-]= 1.10-14 [H207 < INH-7 "basic" [H30] < [OH-] "basic" generic acid "H+acid" GGW regel (Bircher) $\begin{array}{c} HA_{(aq)} + H_{2O}(\ell) \rightleftharpoons A^{-}(aq) + H_{3O}^{+}(aq) \\ \hline Acid \\ Base \\ \hline conjugate \\ \hline conjugat$ search reactants on SB-Chart [HA] H50 kH owny be pure draw immaginary line gives Ht away S GGW right 🖵 gueric Base 🖌 GGW left ڂ $k_{Base} = \frac{[HB^{\dagger}][OH]}{[B]}$ $B_{(eq)} + H_2O(R) \neq HB_{(eq)}^+ + OH^-(eq)$ each Base has a conjugate acid Acid has a conjugate base takes HT the stronger the acid, the weaker the conjugate base 55



only relative concentration of products & recordants

solution

Electrochemistry (Pedox) LEO the Lion says GER

Ox Numbers Alon with higher EN takes.	e = o sum of Ox Numbers equals rel charge
Atoms in elemental form: O	-I +I Ox Number
Monoatemic loss: ionic charge	+I J Reduction lokes e
Nonnetals in ionic/noteenlar compands negative a	* Number 21-II 7 Oxidation, gives e-
O - I exept O2I	
H + I exept banded to metal -I	$M_q(s) + 2HCl(q_g) \rightarrow M_qCl(q_g) + H_2(q_g)$
F -I always	
Cl, Br, I - I exept banded to Hydrogen	My oxidized My reduces H; My 13 reductant
	H ceduzed Havidizes Mg His axidizes
Procedure for aqueous solo	pernanganate ion + oxalate ion We just wrote down "stateton quation"
1) Divide an inter addation half reaction	$\mathbf{Sn} \qquad \qquad$
and reduction half reaction	$\begin{array}{ccc} & & & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & & \\ & & & \\ &$
2) Baimce Elements other than H and C	$\begin{array}{c} & & & & \\ & & & & \\ \end{array}$
Balance O atoms by adding AzO as	needed
Balance H alons by adding H' as	$\frac{neecled}{neecled} \rightarrow \frac{Balance}{neecled} \rightarrow \frac{Balance}{neecled} \rightarrow \frac{M_n O_4^+ \rightarrow M_n^{24} + 4H_2 O}{M_n O_4^+ \rightarrow 2CO_2}$
Dalace charge by adding ve as	$\begin{array}{ccc} ne \ edlad \\ \hline \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ &$
3) Multiply two half ren by Inlegers	
equate e lost & Gared to out the	$\begin{array}{cccc} & & & \\ & & & & \\ & & & \\ & & $
- 1 Had half I XI and if passible C	$\frac{(m(le))}{(m_{less})} = \frac{1}{2} \frac{(m_{less})}{(m_{less})} = 1$
5) Charles appearing on both sides ?	list adjards - ULLINE E's at 1104 - 1011 - 102 - at 10 - 5120 - 50204 - 10002 - 102 existing all-ress lost gained
Of Children to have sure along and	Ald helf-runs. Combine $2M_n D_4^- + 5C_2 Q_4^{2-} + 16H^+ \rightarrow 2M_n^{2+} + 10CO_2 + 8H_2 O_2$
chings the Dulinder.	sides of earlier and the state
	and charges balance loc / 16 H / -2-10+16 = +4 / +4
What if solo is basin?	
1) Balance half exas as it they	Again. His reaction is not balanced yet. We just wrote down "Skeleton equation" Cyanote ion
Occur in acidir sola	Proceed as if Example Balance $CN^- + M_n O_{4}^- \rightarrow CNO^- + M_n O_2(s)$ in basic H_2O
2) Count Number of Ht in each	acidic solution $M_{n}O_{4} \longrightarrow M_{n}O_{2} $ $CN^{-} \longrightarrow CNO^{-}$
half (xn, and add some number	$\begin{array}{ccc} & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & &$
of OH- to each side	
-> neutralize H+ with OH-	Balance O $M_nO_4^- \rightarrow M_nO_2 + 2H_2O$ $CN^- + H_2O \rightarrow CNO^-$
-> equal H+ and OH on some	$\blacksquare \qquad \qquad$
side form HzO	
-> concel out any the that is on boll sides	$B_{3} \text{ adding e:} Balance \qquad M_{n}O_{4}^{-} + 4H^{+} + 3e^{-} \rightarrow M_{n}O_{2} + 2H_{2}O$
3) Multiply two half rin by Integers	$Charge \qquad CN^{-} + H_{2}O \rightarrow CNO^{-} + 2H^{+} + 2e^{-}$
equale e lost & Gained to align the 0	Side on the last \rightarrow Add $OH^ M_NO_4 + 4H^+ + 3e^- + 4OH^- \rightarrow M_NO_4 + 2H_2O + 4OH^-$ to networks H^+ $ON^- + H_3O + 2OH^- \rightarrow ONO^- + 2H^+ + 2e^- + 2OH^-$
4) "Add half rxn and if possible c	$2 \text{ mel}_{H^+ \circ H^- \to H_0} \text{ Neutralize } M_n O_4^- + 4H_2 O + 3e^- \rightarrow M_n O_2 + 2H_2 O + 4OH^-$
species appearing on both sides (by adding 11+	$H^+ \qquad CN^- + H_2O + 2OH^- \rightarrow CNO^- + 2H_2O + 2e^-$
5) Check to rake sure alons and	$ \begin{array}{c} \underset{\text{bits sides}}{\overset{\text{Cancel}}{\longrightarrow}} & M_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2 + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2 + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2 + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2 + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2 + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2 + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2 + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2 + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2 + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2^- + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2^- + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2^- + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2^- + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2^- + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2^- + 4OH^- \\ & H_n O_1^- + 2H_2 O + 3e^- \rightarrow & M_n O_2^- + 2H_2 O + 2$
charges are balanced.	$CN + 2OH \rightarrow CNU + H_{2}U + 2e^{-1}$
	Then proceed as in acidic case
	$\begin{array}{c} M_{u}h_{p} _{h}h_{h}rest}{h_{p}} \\ = b_{u} : rest_{e} : c_{e} : s_{d} \\ = b_{u} : rest_{e} : c_{d} : s_{d} \\ = b_{u} : rest_{e} : c_{d} \\ = b_{u} : rest_{e} : c_{d} \\ = b_{u} : rest_{d} : c_{d} \\ = b_{u} : c_{d} : c_{d} \\ = b_{u} : c_{d} : c_{d} \\ = b_{u} : c_{d} : c_{d} \\ = b_{d} : c_{d} : c_{d} : c_{d} \\ = b_{d} : c_{d} : c_{d} : c_{d} \\ = c_{d} : c_{d} : c_{d} \\ = c_{d} : c_{d} : c_{d} : c_{d} \\ = c_{d} : c_{d} : c_{d} : c_{d} \\ = c_{d} : c : c_{d} : c_{d} : c_{d} : c : c : c_{d} : c_{d} : c : c : c : c_{d} : c_{d} : c : c : c : c : c : c $
	$\frac{1}{2} \frac{1}{2} \frac{1}$
	Add half-rows, Combine $2MnO_4^+ + H_2O + 3CN^- \rightarrow 2MnO_2 + 3CNO^- + 20H^-$
	- Sides of equilian Balanced!
	Are atoms - Check Atoms - 2714 7 oxygen Charge: left-hand side right-hand side and charges - Dalance 3CV 2HV -2-3=-5 -3-2=-5
	balanced?



Cherry and Bayeres	
$1V = \frac{1, 6 \cdot 10^{-19} \text{ J}}{1, 6 \cdot 10^{-19} \text{ J}} \left[\frac{e_{\text{AU}}}{c_{\text{have}}} \right] 1_{\text{U}}$	1= 1王 C

Vollage is a potential Early difference per charge when we compare two points in a Circuit. Here we are comparing cathode to made on a one volt battery

Cell Potentials

Cell Potential: Ecell = E[°]red (cathode) - E[°]red (anode)

reduction is reverse of oxidation. Minus because oxidation actually occurs at anode

Ecell = Voltage of cell at STP

- to be useful Ecell > O (by convention)
- Useful means e flow sponteneously from hade to Cathode to do work +0.40 +0.34
- Elections have higher Potential at Anode and flow to Cathcole O[defined] (SHE)
 E'call is 'inlusive" quantity does not depend on size of system -0.28

Ered = Potential Energy available if reduced

- Half cell potential cannot be measured directly, because we need full cell to measure something
- But can Determine Ered for any half reaction by measuring with SHE (standard Hydrogen Electrocke)

TABL

E° re

+2 +1 +1

+1

+1+0

+0

+0 +0

+0

-0-0

-0 -1

-2

- All helf-cell potentials Listed as reducing potentials, but half-rxns are reversible, depending an what half-cell it is connected to. More positive Ered means greater tendency for reduction

ETHzürich

Chemistry HS22

Determining Cell Potentials





E 20.1	Standard Reduction Potentials in Water at 25°C
d(V)	Reduction Half-Reaction
.87	$F_2(g) + 2e^- \longrightarrow 2F^-(aq)$
.51	$MnO_4^-(aq) + 8 H^+(aq) + 5 e^- \longrightarrow Mn^{2+}(aq) + 4 H_2O(l)$
.36	$\operatorname{Cl}_2(g) + 2 \operatorname{e}^- \longrightarrow 2 \operatorname{Cl}^-(aq)$
.33	$Cr_2O_7^{2-}(aq) + 14 H^+(aq) + 6 e^- \longrightarrow 2 Cr^{3+}(aq) + 7 H_2O(l)$
.23	$O_2(g) + 4 H^+(aq) + 4 e^- \longrightarrow 2 H_2O(l)$
.06	$\operatorname{Br}_2(l) + 2 \operatorname{e}^- \longrightarrow 2 \operatorname{Br}^-(aq)$
.96	$NO_3^-(aq) + 4 H^+(aq) + 3 e^- \longrightarrow NO(g) + 2 H_2O(l)$
.80	$\operatorname{Ag}^+(aq) + e^- \longrightarrow \operatorname{Ag}(s)$
.77	$\operatorname{Fe}^{3+}(aq) + e^{-} \longrightarrow \operatorname{Fe}^{2+}(aq)$
.68	$O_2(g) + 2 H^+(aq) + 2 e^- \longrightarrow H_2O_2(aq)$
.59	$MnO_4^-(aq) + 2H_2O(l) + 3e^- \longrightarrow MnO_2(s) + 4OH^-(aq)$
.54	$I_2(s) + 2 e^- \longrightarrow 2 I^-(aq)$
.40	$O_2(g) + 2 H_2O(l) + 4 e^- \longrightarrow 4 OH^-(aq)$
.34	$\operatorname{Cu}^{2+}(aq) + 2 \operatorname{e}^{-} \longrightarrow \operatorname{Cu}(s)$
defined]	$(SHE) \qquad 2 \operatorname{H}^+(aq) + 2 \operatorname{e}^- \longrightarrow \operatorname{H}_2(g)$
.28	$\operatorname{Ni}^{2+}(aq) + 2e^{-} \longrightarrow \operatorname{Ni}(s)$
.44	$\operatorname{Fe}^{2+}(aq) + 2 e^{-} \longrightarrow \operatorname{Fe}(s)$
.76	$\operatorname{Zn}^{2+}(aq) + 2 e^{-} \longrightarrow \operatorname{Zn}(s)$
.83	$2 \operatorname{H}_2 \operatorname{O}(l) + 2 \operatorname{e}^- \longrightarrow \operatorname{H}_2(g) + 2 \operatorname{OH}^-(aq)$
.66	$Al^{3+}(aq) + 3e^- \longrightarrow Al(s)$
.71	$\operatorname{Na}^{+}(aq) + e^{-} \longrightarrow \operatorname{Na}(s)$
.05	$\operatorname{Li}^+(aq) + e^- \longrightarrow \operatorname{Li}(s)$

