SCH4U Formula and Data Sheet · Grade 12 Chemistry

ONTARIO CURRICULUM

Organic Chemistry

ALKANE	$\mathrm{C}_n\mathrm{H}_{2n+2}$ Single bonds only.
ALKENE OR CYCLOALKANE	$\mathrm{C}_n\mathrm{H}_{2n}$ One C=C double bond, or one ring.
ALKYNE	$\mathrm{C}_n\mathrm{H}_{2n-2}$ One C≡C triple bond.
ESTERIFICATION	$\mathrm{RCOOH} + \mathrm{R'OH} \rightleftharpoons \mathrm{RCOOR'} + \mathrm{H_2O}$ Acid catalyst; the reverse is hydrolysis.
COMPLETE COMBUSTION	$\mathrm{C}_x\mathrm{H}_y + \mathrm{O_2} \longrightarrow \mathrm{CO_2} + \mathrm{H_2O}$ Balance C, then H, then O.

Structure and Properties of Matter

SPEED OF LIGHT	$c = \lambda\nu$
PHOTON ENERGY	$E = h\nu = \dfrac{hc}{\lambda}$
HYDROGEN ENERGY LEVELS (BOHR)	$E_n = -\dfrac{2.18 \times 10^{-18}\ \mathrm{J}}{n^2}$
ORBITALS AND ELECTRONS IN LEVEL N	n^2 orbitals, $\quad 2n^2$ electrons
QUANTUM NUMBERS	$l = 0, \ldots, n-1 \qquad m_l = -l, \ldots, +l \qquad m_s = \pm\frac{1}{2}$ $l = 0, 1, 2, 3$ are the s, p, d and f sublevels.

Energy Changes and Rates of Reaction

HEAT	$q = mc\Delta T$
ENTHALPY CHANGE	$\Delta H = n\Delta H_m$ $\Delta H < 0$ is exothermic, $\Delta H > 0$ endothermic.
CALORIMETRY	$q_{\text{system}} = -q_{\text{surroundings}}$
HESS'S LAW	$\Delta H_{\text{target}} = \Delta H_1 + \Delta H_2 + \ldots$ Reverse a step: change its sign. Multiply a step: multiply its ΔH.
ENTHALPIES OF FORMATION	$\Delta H_r^\circ = \sum n\Delta H_f^\circ(\text{products}) - \sum n\Delta H_f^\circ(\text{reactants})$ $\Delta H_f^\circ = 0$ for an element in its standard state.
BOND ENTHALPIES	$\Delta H \approx \sum D(\text{bonds broken}) - \sum D(\text{bonds formed})$
RATE OF REACTION	$\text{rate} = -\dfrac{1}{a}\dfrac{\Delta[\mathrm{A}]}{\Delta t} = \dfrac{1}{c}\dfrac{\Delta[\mathrm{C}]}{\Delta t}$ For $a\mathrm{A} \rightarrow c\mathrm{C}$.
RATE LAW	$\text{rate} = k[\mathrm{A}]^m[\mathrm{B}]^n$ The orders m and n come from experiment, not the coefficients.

Chemical Systems and Equilibrium

EQUILIBRIUM CONSTANT	$K = \dfrac{[\mathrm{C}]^c[\mathrm{D}]^d}{[\mathrm{A}]^a[\mathrm{B}]^b}$ For $a\,\mathrm{A} + b\,\mathrm{B} \rightleftharpoons c\,\mathrm{C} + d\,\mathrm{D}$. Leave out pure solids and liquids.
REACTION QUOTIENT	$Q < K \Rightarrow$ shifts right $\qquad Q > K \Rightarrow$ shifts left Same form as K, any concentrations.
WATER	$K_w = [\mathrm{H_3O^+}][\mathrm{OH^-}] = 1.0 \times 10^{-14}$ At 25 °C.
PH AND POH	$\mathrm{pH} = -\log[\mathrm{H_3O^+}] \qquad \mathrm{pH} + \mathrm{pOH} = 14.00$ $[\mathrm{H_3O^+}] = 10^{-\mathrm{pH}}$, at 25 °C.
ACID IONIZATION	$K_a = \dfrac{[\mathrm{H_3O^+}][\mathrm{A^-}]}{[\mathrm{HA}]}$
CONJUGATE PAIR	$K_a \times K_b = K_w$
PERCENT IONIZATION	$\dfrac{[\mathrm{H_3O^+}]_{\text{eq}}}{[\mathrm{HA}]_0} \times 100\%$
SOLUBILITY PRODUCT	$\mathrm{M}_x\mathrm{A}_y\,(\mathrm{s}) \rightleftharpoons x\,\mathrm{M}^{y+} + y\,\mathrm{A}^{x-} \qquad K_{sp} = [\mathrm{M}^{y+}]^x[\mathrm{A}^{x-}]^y$ A precipitate forms when $Q_{sp} > K_{sp}$.
AMOUNT IN SOLUTION	$n = cV$

Electrochemistry

CELL POTENTIAL	$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$ Both reduction potentials from the table. Spontaneous when $E^\circ_{\text{cell}} > 0$.
CHARGE	$q = It$
ELECTRONS TRANSFERRED	$n_{e^-} = \dfrac{It}{F}$
OXIDATION AND REDUCTION	oxidation: loss of e^- $\qquad$ reduction: gain of e^- Oxidation at the anode, reduction at the cathode.

Constants

Constant	Value
Avogadro constant	$N_A = 6.022 \times 10^{23}\ \mathrm{mol^{-1}}$
Gas constant	$R = 8.314\ \mathrm{J/(mol{\cdot}K)} = 8.314\ \mathrm{kPa{\cdot}L/(mol{\cdot}K)}$
Speed of light	$c = 3.00 \times 10^8\ \mathrm{m/s}$
Planck constant	$h = 6.626 \times 10^{-34}\ \mathrm{J{\cdot}s}$
Faraday constant	$F = 9.649 \times 10^4\ \mathrm{C/mol}$
Elementary charge	$e = 1.602 \times 10^{-19}\ \mathrm{C}$
Specific heat capacity of water	$c = 4.18\ \mathrm{J/(g{\cdot}^\circ C)}$

Standard Reduction Potentials at 25 °C

Half-reaction	E° (V)
$\mathrm{F_2\,(g) + 2\,e^- \longrightarrow 2\,F^-\,(aq)}$	+2.866
$\mathrm{MnO_4^-\,(aq) + 8\,H^+\,(aq) + 5\,e^- \longrightarrow Mn^{2+}\,(aq) + 4\,H_2O\,(l)}$	+1.507
$\mathrm{Au^{3+}\,(aq) + 3\,e^- \longrightarrow Au\,(s)}$	+1.498
$\mathrm{Cl_2\,(g) + 2\,e^- \longrightarrow 2\,Cl^-\,(aq)}$	+1.35827
$\mathrm{Cr_2O_7^{2-}\,(aq) + 14\,H^+\,(aq) + 6\,e^- \longrightarrow 2\,Cr^{3+}\,(aq) + 7\,H_2O\,(l)}$	+1.232
$\mathrm{O_2\,(g) + 4\,H^+\,(aq) + 4\,e^- \longrightarrow 2\,H_2O\,(l)}$	+1.229
$\mathrm{Br_2\,(aq) + 2\,e^- \longrightarrow 2\,Br^-\,(aq)}$	+1.0873
$\mathrm{Ag^+\,(aq) + e^- \longrightarrow Ag\,(s)}$	+0.7996
$\mathrm{Fe^{3+}\,(aq) + e^- \longrightarrow Fe^{2+}\,(aq)}$	+0.771
$\mathrm{I_2\,(s) + 2\,e^- \longrightarrow 2\,I^-\,(aq)}$	+0.5355
$\mathrm{O_2\,(g) + 2\,H_2O\,(l) + 4\,e^- \longrightarrow 4\,OH^-\,(aq)}$	+0.401
$\mathrm{Cu^{2+}\,(aq) + 2\,e^- \longrightarrow Cu\,(s)}$	+0.337
$\mathrm{2\,H^+\,(aq) + 2\,e^- \longrightarrow H_2\,(g)}$	0.00
$\mathrm{Pb^{2+}\,(aq) + 2\,e^- \longrightarrow Pb\,(s)}$	−0.1262
$\mathrm{Sn^{2+}\,(aq) + 2\,e^- \longrightarrow Sn\,(s)}$	−0.1375
$\mathrm{Ni^{2+}\,(aq) + 2\,e^- \longrightarrow Ni\,(s)}$	−0.257
$\mathrm{Fe^{2+}\,(aq) + 2\,e^- \longrightarrow Fe\,(s)}$	−0.447
$\mathrm{Zn^{2+}\,(aq) + 2\,e^- \longrightarrow Zn\,(s)}$	−0.7618
$\mathrm{2\,H_2O\,(l) + 2\,e^- \longrightarrow H_2\,(g) + 2\,OH^-\,(aq)}$	−0.8277
$\mathrm{Al^{3+}\,(aq) + 3\,e^- \longrightarrow Al\,(s)}$	−1.662
$\mathrm{Mg^{2+}\,(aq) + 2\,e^- \longrightarrow Mg\,(s)}$	−2.372
$\mathrm{Na^+\,(aq) + e^- \longrightarrow Na\,(s)}$	−2.71
$\mathrm{Ca^{2+}\,(aq) + 2\,e^- \longrightarrow Ca\,(s)}$	−2.868
$\mathrm{K^+\,(aq) + e^- \longrightarrow K\,(s)}$	−2.931
$\mathrm{Li^+\,(aq) + e^- \longrightarrow Li\,(s)}$	−3.04

$\mathrm{H^+}$ stands for $\mathrm{H_3O^+}$. The higher the half-reaction, the stronger the oxidizing agent on its left.

Functional Groups

Group	Structure	Name ending	Example
Alkene	$\mathrm{C{=}C}$	-ene	ethene
Alkyne	$\mathrm{C{\equiv}C}$	-yne	ethyne
Haloalkane	$\mathrm{R{-}X}$	fluoro-, chloro-, bromo-, iodo-	chloromethane
Alcohol	$\mathrm{R{-}OH}$	-ol	ethanol
Ether	$\mathrm{R{-}O{-}R'}$	alkoxy- (methoxy-)	methoxyethane
Aldehyde	$\mathrm{R{-}CHO}$	-al	ethanal
Ketone	$\mathrm{R{-}CO{-}R'}$	-one	propanone
Carboxylic acid	$\mathrm{R{-}COOH}$	-oic acid	ethanoic acid
Ester	$\mathrm{R{-}COO{-}R'}$	alkyl -oate	methyl ethanoate
Amine	$\mathrm{R{-}NH_2}$	-amine	ethanamine
Amide	$\mathrm{R{-}CONH_2}$	-amide	ethanamide
Aromatic	benzene ring	phenyl-, -benzene	methylbenzene

Carbon Chain Prefixes

C	Prefix	C	Prefix
1	meth-	6	hex-
2	eth-	7	hept-
3	prop-	8	oct-
4	but-	9	non-
5	pent-	10	dec-

Multipliers: di- 2, tri- 3, tetra- 4.

VSEPR Shapes

Bonding groups	Lone pairs	Shape	Angle	Example
2	0	linear	180°	$\mathrm{CO_2}$
3	0	trigonal planar	120°	$\mathrm{BF_3}$
2	1	bent	< 120°	$\mathrm{SO_2}$
4	0	tetrahedral	109.5°	$\mathrm{CH_4}$
3	1	trigonal pyramidal	about 107°	$\mathrm{NH_3}$
2	2	bent	about 104.5°	$\mathrm{H_2O}$
5	0	trigonal bipyramidal	90°, 120°	$\mathrm{PCl_5}$
4	1	seesaw	< 90°, < 120°	$\mathrm{SF_4}$
3	2	T-shaped	< 90°	$\mathrm{ClF_3}$
2	3	linear	180°	$\mathrm{XeF_2}$
6	0	octahedral	90°	$\mathrm{SF_6}$
5	1	square pyramidal	< 90°	$\mathrm{BrF_5}$
4	2	square planar	90°	$\mathrm{XeF_4}$

Molar Masses (g/mol)

Element	M	Element	M	Element	M
H	1.0080	Si	28.085	Ni	58.693
Li	6.94	P	30.974	Cu	63.546
C	12.011	S	32.06	Zn	65.38
N	14.007	Cl	35.45	Br	79.904
O	15.999	K	39.098	Ag	107.87
F	18.998	Ca	40.078	Sn	118.71
Na	22.990	Cr	51.996	I	126.90
Mg	24.305	Mn	54.938	Au	196.97
Al	26.982	Fe	55.845	Pb	207.2

Sources, read November 24, 2026: OpenStax, Chemistry 2e, Appendix L: Standard Electrode (Half-Cell) Potentials; CIAAW, Abridged Standard Atomic Weights 2024; NIST, CODATA Fundamental Physical Constants.