Recitation Worksheet Nine

Name: key

MyID:

Textbook:
Chemistry & Chemical Reactivity
by John C. Kotz, Paul M. Treichel, John R. Townsend, David Treichel
11th Edition | Copyright 2024

Instructions:

- This recitation worksheet covers Ch. 16.1-16.3
- Please enter your first and last name as it appears on the eLC roster (do not use a nickname that is not reflected in eLC).
- Your UGA myID is a combination of letters and numbers (example: Dr. Abdelrahman's MyID is ema88805@uga.edu). **Do not use your 81x number**.
- Your completed worksheet has to be submitted to **Gradescope**. You have multiple options for submission:
  - You may use an app to annotate the worksheet by placing your answers in the answer boxes and showing your work when appropriate. Afterward, submit the worksheet to Gradescope. You will not need to upload anything to eLC.
  - You may print out the worksheet, write your answers in the answer boxes, and show your work on it when appropriate. Afterward, convert the worksheet to a PDF and submit to Gradescope. You will not need to upload anything to eLC.
  - If you do not have access to a printer, you may type your answers directly into the worksheet PDF and then submit it to Gradescope. Write your work on separate sheets of paper, convert them to a PDF, and upload to the appropriate dropbox on eLC.
  - There is a Gradescope app available for both iOS and Android devices that allows you to scan and submit your printed work, or you can submit your fillable PDF directly.
- The following criteria **must** be met to be eligible for full credit:
  - You must make sure the pages are in the correct order and have the same layout as the original worksheet when submitting to Gradescope regardless of your submission type.
  - Answers must be written in the corresponding answer boxes.
  - You must show your work when appropriate.
- This worksheet is due no later than **12:00 PM (noon) on the Saturday, October 26th.**
- A periodic table and formula sheet are attached to the end of this worksheet. Please keep these attached to your worksheet in the correct order when submitting to Gradescope.

1. Which of the following is a conjugate acid-base pair? Select all that apply.

$\boxed{CD}$

~~A.~~ H_2CO_3 and CO_3^{2-} two proton difference
~~B.~~ $HClO_4$ and ClO_3^- Both are a different acid & base
C. CH_2FCOOH and CH_2FCOO^-
D. $C_{10}H_7NH_2$ and $C_{10}H_7NH_3^+$
~~E.~~ H_2S and S^{2-} two proton difference

The difference between a conjugate acid-base pair is only one proton

2. The three diagrams below represent three different binary acid solutions with the generic formula HA. Water molecules have been omitted for clarity and H_3O^+ is represented by H^+ instead. Rank the acids in order of decreasing acid strength.

$\boxed{C}$

↳ From strongest to weakest

A strongest B C ↳ weakest

A. B > C > A
B. C > B > A
C. A > B > C
D. C > A > B
E. A > C > B

Strategy:
If the acid is HA then when it is dissociated
$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$
- the stronger the acid the more dissociated (ions in acid solution)
- the weaker the acid ∴ less dissociated (more molecules are found vs. ions)

3. Please refer to the figure in question 2 to answer the following question. Which of the acids is expected to have the smallest K_a value?

$\boxed{C}$

A. A
B. B
C. C
D. All acids have the same K_a value

K_a value ↑ with acid strength ∴ the weakest acid will have the smallest K_a

Percent dissociation (α) = $\frac{[H_3O^+]_{eq}}{[HA]_0} \times 100$

4. What is the percent ionization of a 0.337 M HF solution? K_a of HF is 3.5×10^{-4}.

$\boxed{3.22}$ %

① $HF(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + F^-(aq)$

Initial	0.337	–	0	0
Change	$-x$	–	$+x$	$+x$
Equilibrium	$0.337-x$	–	x	x

② solve for x

$K_a = \frac{[H_3O^+][F^-]}{[HF]}$

$3.5 \times 10^{-4} = \frac{[x][x]}{0.337-\cancel{x}}$

↓ apply the "100 rule" $\frac{0.337}{3.5\times10^{-4}} >> 100$

∴ $3.5 \times 10^{-4} \times 0.337 = x^2$

$x^2 = 1.1795 \times 10^{-4}$

$\therefore x = \sqrt{1.1795 \times 10^{-4}}$

$\therefore x = \pm 1.086047881 \times 10^{-2}$

Negative value is ignored

③ $\alpha = \frac{[H_3O^+]_{eq}}{[HA]_0}$

$= \frac{1.086047881 \times 10^{-2}}{0.337} \times 100$

$= 3.22\%$

5. If benzoic acid is 0.42% ionized in a 0.80 M solution, what is the K_a of benzoic acid?

$\boxed{B}$

A. 1.41×10^{-7}
B. 1.41×10^{-5}
C. 1.77×10^{-5}
D. 6.15×10^{4}
E. None of the above choices is correct.

Percent dissociation (α) = $\frac{[H_3O^+]_{eq}}{[HA]_0} \times 100$

→ using this equation to start the problem

① $\frac{0.42 M [H_3O^+]}{100 M [C_6H_5COOH]} \times 0.80 M [C_6H_5COOH] = 3.36 \times 10^{-3} M \; H_3O^+$

② $C_6H_5COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_6H_5COO^-(aq)$

Initial	0.80	–	0	0
Change	$-x$	–	$+x$	$+x$
Equilibrium	$0.80-x$	–	3.36×10^{-3}	x

③ $[H_3O^+]_{eq} = [C_6H_5COO^-]_{eq} = x$

$= 3.36 \times 10^{-3} M$

$[C_6H_5COOH]_{eq} =$

$0.80 - x = 0.80 - 3.36 \times 10^{-3}$

$= 0.79664$

④ $K_a(C_6H_5COOH) = \frac{[H_3O^+][C_6H_5COO^-]}{[C_6H_5COOH]}$

$= \frac{[3.36 \times 10^{-3}][3.36 \times 10^{-3}]}{0.79664}$

$= 1.417152039 \times 10^{-5}$

6. Calculate the pH of

$\boxed{11.629}$

A. 0.00213 M $Sr(OH)_2$ strong base

$Sr(OH)_2(aq) \longrightarrow Sr^{2+}(aq) + 2OH^-(aq)$

$[OH^-] = 2 \times 0.00213 M = 4.26 \times 10^{-3} M$

$\therefore pOH = -\log[4.26 \times 10^{-3}] = 2.371$

$\therefore pH = 14.000 - 2.371 = 11.629$

$\boxed{3.24}$

B. 5.8×10^{-4} M HI strong acid

$pH = -\log[H_3O^+]$

$= -\log[5.8 \times 10^{-4}] = 3.24$

7. According to the Bronsted-Lowry definition of acids and bases, which of the compounds below is **NOT** a base?

E

A. F^-
B. NO_2^-
C. NH_3
D. OH^-
E. NH_4^+

- According to the Bronsted-Lowry definition a base is a proton acceptor
- In order for a substance to act as a base it should either have a negative charge or a lone pair to accept electrons
- If the substance has a positive charge ∴ it can act as it can donate an electron

8. What is the K_a of fluoroacetic (CH_2FCOOH) acid, if a 0.318 M solution has a pH = 1.56? Report your answer using **scientific notation**.

* or 2.7×10^{-3} can also be accepted

2.6 x 10^{-3}

① $CH_2FCOOH_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_2FCOO^-_{(aq)}$

Initial	0.318	—	0	0
Change	$-x$	—	$+x$	$+x$
Equilibrium	$0.318-x$	—	2.75×10^{-2}	x

$x \rightarrow 2.75 \times 10^{-2}$

0.29045713

$x = 2.75 \times 10^{-2}$

② Determine $[H_3O^+]$ using the pH

$pH = 1.56$

$\therefore [H_3O^+] = 10^{-1.56}$

$= 2.754228703 \times 10^{-2} M$

③ $K_a = \frac{[H_3O^+][CH_2FCOO^-]}{[CH_2FCOOH]} = \frac{[2.75 \times 10^{-2}][2.75 \times 10^{-2}]}{0.29045713}$

$= 2.6116627 \times 10^{-3}$

9. Which of the following is a strong acid?

E

A. CH_3COOH
B. HF
C. H_3PO_4
D. H_2SO_3
E. H_2SO_4

10. Which of these aqueous solutions has the highest $[H_3O^+]$ at 25 °C?

$\boxed{C}$

A. a solution with a pH of 3.0 $[H_3O^+] = 10^{-3.0} = 1 \times 10^{-3} M$

B. a 1×10^{-4} M solution of HNO_3 strong acid ∴ $[HNO_3] = [H_3O^+] = 1 \times 10^{-4} M$

C. a solution with a pOH of 12.0 $[H_3O^+] = 1 \times 10^{-2} M$

D. pure water $[H_3O^+] = 1 \times 10^{-7}$

E. a 1×10^{-2} M solution of HF weak acid ∴ doesn't fully dissociate ∴ $[H_3O^+] < 1 \times 10^{-2} M$

Strategy:
Change all the choices to $[H_3O^+]$ to be able to make a comparison

C) $pH + pOH = 14.0$
∴ $pH = 14.0 - 12.0 = 2.0$
$[H_3O^+] = 10^{-2.0} = 1 \times 10^{-2} M$ you can use $K_w = 1.0 \times 10^{-14}$

11. Which of these aqueous solutions is(are) considered basic at 25 °C? Select all that apply.

$\boxed{AC}$

A. $[H_3O^+] = 5.4 \times 10^{-8}$

B. pOH = 9.0

C. $[OH^-] = 4.3 \times 10^{-4}$

For a solution to be considered basic $[H_3O^+] < [OH^-]$

A) $K_w = [H_3O^+][OH^-]$
$1.0 \times 10^{-14} = [5.4 \times 10^{-8}][OH^-]$
∴ $[OH^-] = 1.9 \times 10^{-7}$
$[H_3O^+] < [OH^-]$
Basic

B) $pH + pOH = 14.0$
∴ $pH = 14.0 - 9.0 = 5.0$
$[H_3O^+] = 10^{-pH} = 10^{-5.0} = 1 \times 10^{-5} M$
$[OH^-] = 10^{-pOH} = 10^{-9.0} = 1 \times 10^{-9} M$
$[H_3O^+] > [OH^-]$
Acidic

C) $[H_3O^+] = \frac{1.0 \times 10^{-14}}{4.3 \times 10^{-4}} = 2.3 \times 10^{-11}$
$[H_3O^+] < [OH^-]$

12. What are the $[H_3O^+]$, $[OH^-]$, pH, and pOH of 0.55 M HNO_2? K_a of $HClO_2$ is 4.6×10^{-4}. Report your answer using **scientific notation**.

weak acid

A. $[H_3O^+]$ $\boxed{1.6} \times 10^{\boxed{-2}}$

B. $[OH^-]$. $\boxed{6.3} \times 10^{\boxed{-13}}$

C. pH. $\boxed{1.80}$

D. pOH. $\boxed{12.20}$

③ $K_w = [H_3O^+][OH^-]$
$1 \times 10^{-14} = [1.59059 \times 10^{-2}][OH^-]$
∴ $[OH^-] = 6.28694613 \times 10^{-13}$
$\sim 6.3 \times 10^{-13} M$

① $HNO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$

Initial	0.55	–	0	0
Change	$-x$	–	$+x$	$+x$
Equilibrium	$0.55-x$	–	x	x

② $K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2]}$

$4.6 \times 10^{-4} = \frac{[x][x]}{0.55-\cancel{x}}$ Apply the "100 rule"

$\frac{0.55}{4.6 \times 10^{-4}} \gg 100$

∴ $x^2 = 4.6 \times 10^{-4} \times 0.55$
∴ $x = \sqrt{2.53 \times 10^{-4}}$
$\pm 1.590597372 \times 10^{-2}$

Omit the negative value

13. What is the concentration of hydroxide ions in pure water at 30.0 °C, if K_w at this temperature is 1.47 x 10^{-14}?

$\boxed{E}$

A. 1.00 × 10^{-7} M
B. 1.30 × 10^{-7} M
C. 1.47 × 10^{-7} M
D. 8.93 × 10^{-8} M
E. 1.21 × 10^{-7} M

① $H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

Initial	–	–	0	0
Change	–	–	+x	+x
Equilibrium	–	–	x	x

② $K_w = [H_3O^+][OH^-]$

$1.47 \times 10^{-14} = [x][x]$ @ 30.0 °C

$\therefore x^2 = 1.47 \times 10^{-14}$

$\therefore x = 1.21243556 \times 10^{-7}$

$\therefore [OH^-] = x = 1.21 \times 10^{-7}$ M

14. What is the pH of a 1.2 M pyridine (C_5H_5N) solution that has K_b = 1.9 × 10^{-9}?

$\boxed{C}$

A. 4.32
B. 8.72
C. 9.68
D. 10.68

weak base

lone pair can accept a proton

① $C_5H_5N(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + C_5H_5NH^+$

Initial	1.2	–	0	0
Change	−x	–	+x	+x
Equilibrium	1.2−x	–	x	x

② $K_b = \dfrac{[OH^-][C_5H_5NH^+]}{[C_5H_5N]}$

$1.9 \times 10^{-9} = \dfrac{[x][x]}{[1.2 - \cancel{x}]}$

$\dfrac{1.2}{1.9 \times 10^{-9}} >> 100$

$\therefore x^2 = 1.9 \times 10^{-9} \times 1.2$

$\therefore x = \sqrt{2.28 \times 10^{-9}} = \pm 4.774934555 \times 10^{-5}$

ignore negative value

③ $[OH^-] = x = 4.774 \times 10^{-5}$ M

$\therefore pOH = -\log[4.774 \times 10^{-5}]$

$= 4.32$

$\therefore pH + pOH = 14.00$

$\therefore pH = 14.00 - 4.32$

$= 9.68$

15. Given the acids and their K_a values:

Hydrocyanic acid, HCN K_a = 4.00 × 10^{-10}
weakest Phenol, C_6H_5OH K_a = 1.00 × 10^{-10}
strongest Benzoic acid, $C_6H_5CO_2H$ K_a = 6.30 × 10^{-5}

What is the order of **increasing base strength** for CN^-, $C_6H_5O^-$, and $C_6H_5CO_2^-$?

$\boxed{D}$

A. $C_6H_5CO_2^-$ < $C_6H_5O^-$ < CN^- weakest to strongest
B. $C_6H_5O^-$ < $C_6H_5CO_2^-$ < CN^-
C. CN^- < $C_6H_5CO_2^-$ < $C_6H_5O^-$
D. $C_6H_5CO_2^-$ < CN^- < $C_6H_5O^-$
E. CN^- < $C_6H_5O^-$ < $C_6H_5CO_2^-$

↑ strength of acid ↑ Ka value

a strong acid will produce a weak conjugate base

& a weak acid will produce a strong base

16. The hydride ion, H^-, is a stronger base than the hydroxide ion, OH^-. The product(s) of the reaction of hydride ion with water is/are

B

A. $H_3O^+(aq)$
B. $OH^-(aq) + H_2(g)$
C. $OH^-(aq) + 2\ H^+(aq)$
D. No reaction occurs
E. $H_2O_2(aq)$

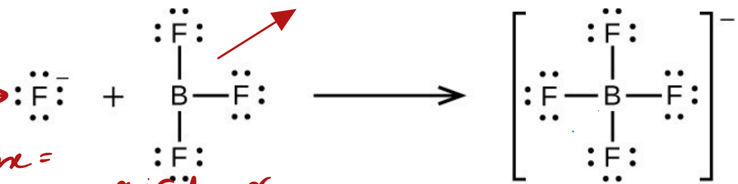
$$H^-(aq) + H_2O(l) \rightleftharpoons H_2(g) + OH^-(aq)$$

Base ∴ proton acceptor

17. In the gas phase reaction below, F^- is acting as a(n)

C

Lewis acid is an electron pair acceptor



Lewis base = electron pair donor

Lewis acid-base complex

A. BrØnsted-Lowry acid
B. BrØnsted-Lowry base
C. Lewis base
D. Lewis acid
E. Arrhenius acid

can act as an acid & a base

18. Which of these species is amphoteric?

A

A. HPO_4^{2-} → has a proton & a negative charge ∴ amphoteric
B. H_3O^+ → can only donate a proton ∴ acid
C. PO_4^{3-} → can only accept a proton
D. Cl^-
E. None of the above are amphoteric.

CA= conjugate acid
CB= conjugate base

Extra Practice Questions: these questions will not be graded

1. In the reaction $HSO_4^-(aq)$ + $OH^-(aq)$ ⇋ $SO_4^{2-}(aq)$ + $H_2O(l)$, the conjugate acid-base pairs are

CA CB CB CA

$\boxed{A}$

	pair 1	*pair 2*
Row 1	HSO_4^- and SO_4^{2-};	H_2O and OH^-.
Row 2	HSO_4^- and H_3O^+;	SO_4^{2-} and OH^-.
Row 3	HSO_4^- and OH^-;	SO_4^{2-} and H_2O.
Row 4	HSO_4^- and H_2O;	OH^- and SO_4^{2-}.
Row 5	HSO_4^- and OH^-;	SO_4^{2-} and H_3O^+.

A. Row 1
B. Row 2
C. Row 3
D. Row 4
E. Row 5

2. What is the $[OH^-]$ in pure water at 50 °C? K_w = 5.5 x 10^-14^ at 50 °C?

→ equilibrium constant is temperature dependent

$\boxed{2.3 \times 10^{-7}}$ M

$K_w = [H_3O^+][OH^-]$

if $[H_3O^+] = [OH^-]$ in pure water

we call both x

$5.5 \times 10^{-14} = [x][x]$

$\therefore x^2 = 5.5 \times 10^{-14}$

taking the square root of x

$\therefore x = \pm 2.34520788 \times 10^{-7}$

(negative value is disregarded).

$\therefore x = 2.3 \times 10^{-7}$ M $= [OH^-]$

3. Deuterium oxide, D_2O (deuterium is an isotope of hydrogen) has an ion product constant, $K_w = 8.9 \times 10^{-16}$.

What is the pH of pure D_2O?

$\boxed{7.52}$

① Determine the $[H_3O^+]$ in pure water

$K_w = [H_3O^+][OH^-]$

if $[H_3O^+] = [OH^-]$ in pure water

we call both x

$\therefore 8.9 \times 10^{-16} = [x][x]$

$\therefore x^2 = 8.9 \times 10^{-16}$

taking the square root of x

$\therefore x = \pm 2.983286778 \times 10^{-8}$

(negative value is disregarded).

$\therefore [H_3O^+] = 2.98 \times 10^{-8}$

② $pH = -\log[H_3O^+] = 7.525304997$

~ 7.52

4. At 50 °C the value of Kw is 5.50 × 10^{-14}. A basic solution at 50 °C has

$\boxed{B}$

A. $[H_3O^+] < [OH^-] < 2.35 \times 10^{-7}$ M.
B. $[H_3O^+] < 2.35 \times 10^{-7}$ M $< [OH^-]$.
C. $[H_3O^+] = [OH^-] < 2.35 \times 10^{-7}$ M.
D. $[H_3O^+] > [OH^-] > 2.35 \times 10^{-7}$ M.

in pure water

$[H_3O^+] = [OH^-] = \sqrt{5.50 \times 10^{-14}} = 2.354207 88 \times 10^{-7}$ M

in a basic solution the $[H_3O^+] < [OH^-]$

$\therefore [H_3O^+] < 2.35 \times 10^{-7}$ M $< [OH^-]$
in a basic solution

5. At 25 °C, what is the hydroxide ion concentration and the pH for a hydrochloric acid solution that has a hydronium ion concentration of 1.50 × 10^{-4} M? Kw = 1.00 × 10^{-14} at 25 °C. Use the rules of significant figures to answer this question.

$[OH^-]$ = $\boxed{6.67 \times 10^{-11}}$ M

pH = $\boxed{3.824}$

① $Kw = [H_3O^+][OH^-]$

$1.00 \times 10^{-14} = [1.50 \times 10^{-4}][OH^-]$

$\therefore [OH^-] = 6.666667 \times 10^{-11}$

$\sim 6.67 \times 10^{-11}$ M

② $pH = -\log[1.50 \times 10^{-4}]$

$= 3.823908741$

3 sig figs

$\sim 3.\underline{824}$ 3 decimal places

6. What is the pH of a 0.020 M $Sr(OH)_2$ solution?

pH = $\boxed{12.60}$

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

0.020M 0.020M 2(0.020M)
0.040M

$\therefore pOH = -\log[OH^-] = -\log[0.040]$
$= 1.397940009$

$\therefore pH = 14.00 - 1.397940009$
$= 12.60205999$
≈ 12.60

7. Which of the following is a Brønsted-Lowry acid?

$\boxed{A}$

A. NH_4^+
B. Cl_2
C. BF_3
D. I_2

↓ proton donor

8. What would happen to the K_w and pH of neutral water if the water was warmed to 37°C? The K_w would __________ and the pH would __________.

$\boxed{D}$

A. Decrease, increase
B. Decrease, decrease
C. Increase, increase
D. Increase, decrease
E. The K_w and pH would stay the same

heat + $H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$
↳ autoionization of water is endothermic
∴ if water is warmed the equilibrium shifts to the right & K_w would increase & $[H_3O^+]\uparrow$
∴ pH ↓

9. Which statement is true about the conjugate bases and their conjugated acids?

$\boxed{D}$

Conjugate base	pK_b
F^-	10.85
$CH_3CO_2^-$	9.25
NH_3	4.75
PO_4^{3-}	1.55

↓pK_b strongest base
→ weakest conjugate base
→ strongest conjugate base

A. The ~~strongest~~ weakest conjugated acid would be HPO_4^{2-} because PO_4^{3-} is the strongest base
B. NH_4^+ would be a ~~stronger~~ weaker acid than CH_3CO_2H because NH_3 has a lower pK_b than $CH_3CO_2^-$
C. The ~~weakest~~ strongest conjugated acid would be HF because F^- is the strongest base
D. The strongest parent acid would be HF because F^- is the weakest base

Formula Sheet

Length
1 kilometer = 0.62137 mile
1 inch = 2.54 centimeters (exactly)
1 Ångstrom = 1×10^{-10} meter

Energy
1 joule = 1 $kg{\cdot}m^2/s^2$
1 calorie = 4.184 joules
1 Calorie = 1 kilocalorie = 1000 calories
1 L·atm = 101.325 joules

Pressure
1 pascal = 1 N/m^3 = 1 $kg/m{\cdot}s^2$
1 atmosphere = 101.325 kilopascals = 760 mm Hg = 760 torr = 14.70 lb/in^2
1 bar = 1×10^5 Pa (exactly)

Temperature
0 K = −273.15°C
K = °C + 273.15
°C = (5/9)(°F − 32)

Mass
1 kg = 2.205 lbs

Volume
1 mL = 1 cm^3 = 1 cc

Constants
$c = 2.998 \times 10^8$ m/sec
$h = 6.626 \times 10^{-34}$ $J{\cdot}sec^{-1}$
R = 0.08206 L·atm/mol·K = 8.314 J/mol·K
Specific heat of water = 4.184 J/g·K
Mass of an electron: 9.109×10^{-31} kg
Mass of a proton: 1.673×10^{-27} kg
RH = 2.18×10^{-18} J
Specific heat of water = 4.184 J/g·K
STP = 273.15 K and 1 atm
Avogadro's number: 6.022×10^{23}

Equations
d (density) = m/V
$P_1V_1=P_2V_2$
$V_1/T_1=V_2/T_2$
$P_1V_1/n_1T_1=P_2V_2/n_2T_2$
$PV=nRT$
$(P + a(n^2/V^2))\cdot(V - nb) = nRT$
molar mass (M) = mRT/PV
density (d) = MP/RT
$x_A = n_A/n_{tot} = P_A/P_{tot} = V_A/V_{tot}$
$P_{tot} = P_A + P_B + \ldots$
$n_{tot} = n_A + n_B + \ldots$

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{Rate\ of\ effusion\ A}{Rate\ of\ effusion\ B} = \sqrt{\frac{MW_B}{MW_A}}$$

$Q = C \times \Delta T = c_{specific} \times m \times \Delta T$
$Q = n \times \Delta H$ (kJ/mol) $= m \times \Delta H$ (kJ/g)
$w = -P\Delta V$
$\Delta E = q + w$
$\Delta H° = \Sigma n\Delta Hf°(\text{products}) - \Sigma n\Delta Hf°(\text{reactants})$
$\Delta H° = \Sigma n\Delta H°(\text{bonds broken}) - \Sigma n\Delta H°(\text{bonds formed})$
$E=h\nu$
$c=\lambda\nu$
$\lambda = h/mv$

$$\Delta E = -2.18 \times 10^{-18} J\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$C_g = kP_g$
$P_{solution}=P_{solvent}\,X_{solvent}$
$P_{solution}=\sum P_j=\sum P_jX_j$
$\Delta T_b = K_b m i$
$\Delta T_f = K_f m i$
$\pi = MRTi$

Thermodynamic and Electrochemistry

$S = k_b \times \ln(W)$
$k_b = 1.381 \times 10^{-23}$ J/K
$\Delta S = q_{rev}/T$
$\Delta S_{surr} = q_{surr}/T = -q_{rev}/T$
$\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr}$
$\Delta S°_{rxn} = \Sigma v S°_{products} - \Sigma v S°_{reactants}$
$\Delta H°_{rxn} = \Sigma v H°_{products} - \Sigma v H°_{reactants}$
$\Delta G°_{rxn} = \Sigma v G°_{products} - \Sigma v G°_{reactants}$
$\Delta G = \Delta H - T\Delta S$
$\Delta G = \Delta G° + RT\cdot\ln Q$
R=8.314 J/mol.K
$\Delta G° = -RT\cdot\ln K$
$\Delta G= -nFE_{cell}$
$F = 96485$ J/(V·mol e^-)
$E°_{cell} = RT/nF \ln K$
$E°_{cell} = (0.0257/n) \ln K = (0.0592/n) \log K$
$E_{cell} = E°_{cell} - (RT/nF) \ln Q$
$E_{cell} =E°_{cell} - (0.0257/n) \ln Q$
Electrolysis: Q (total charge) = I × t = n × F

Integrated Rate Laws & half-life

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

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

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

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

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$ln\frac{k_2}{k_1} = -\frac{\mathrm{E_a}}{\mathrm{R}}\left(\frac{1}{\mathrm{T_2}} - \frac{1}{\mathrm{T_1}}\right)$$

Equilibrium and Acid / Base

$K_P = K_c \times (RT)^{\Delta n}$

$pH = -\log[H_3O^+]$

$K_w = 1.0 \times 10^{-14}$ at 25 °C

$K_w = [H_3O^+] \times [OH^-]$

$K_w = K_a \times K_b$

$pK_a = -\log[K_a]$

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

$$ln\frac{K_2}{K_1} = \frac{\Delta H^{\circ}_{rxn}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01																	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.97	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.95	43 **Tc** [97]	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
37 **Cs** 132.91	56 **Ba** 137.33		72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** [209]	85 **At** [210]	86 **Rn** [222]
87 **Fr** [223]	88 **Ra** [226]		104 **Rf** [267]	105 **Db** [268]	106 **Sg** [269]	107 **Bh** [270]	108 **Hs** [269]	109 **Mt** [277]	110 **Ds** [281]	111 **Rg** [282]	112 **Cn** [285]	113 **Nh** [286]	114 **Fl** [290]	115 **Mc** [290]	116 **Lv** [293]	117 **Ts** [294]	118 **Og** [294]

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** [145]	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
89 **Ac** [227]	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** [237]	94 **Pu** [244]	95 **Am** [243]	96 **Cm** [247]	97 **Bk** [247]	98 **Cf** [251]	99 **Es** [252]	100 **Fm** [257]	101 **Md** [258]	102 **No** [259]	103 **Lr** [262]