AP CHEMISTRY
REVIEW PACKET

Summer 2024

The following collection of materials is intended to provide students with a general review of concepts and techniques learned during their freshman and sophomore year science classes. Students should complete this packet over the course of the summer and be prepared to submit the completed work on the first day of classes.

The material and assessments found in this packet will be tested the first day of classes to ensure all students are able to perform at a common standard and possess a minimum level of understanding.

Table of Contents

AP CHEMISTRY COURSE CONTENT

The material provided is intended to help students understand concepts and applications. Students should build upon the information provided in this handout with class notes and should **NOT** rely solely on this handout.

1) Atomic Structure and Properties

- Moles and Molar Mass
- Mass Spectroscopy
- Elemental Composition
- Composition of Mixtures
- Atomic Structure and Electron Configuration
- Photoelectron Spectroscopy
- Periodic Trends
- Valence Electrons and Ionic Compounds

2) Molecular and Ionic Compound Structure and Properties

- Types of Chemical Bonds
- Intramolecular Forces and Potential Energy
- Structure of Ionic Solids
- Structure of Metals and Alloys
- Lewis Diagrams
- Resonances
- VSEPR and Bond Hybridization

3) Intermolecular Forces and Properties

- Intermolecular Forces
- Properties of Solids
- Solids, Liquids, and Gases
- Ideal Gas Law
- Kinetic Molecular Theory
- Deviation from Ideal Gas Law
- Solutions and Mixtures
- Representations of Solutions
- Separations of Solutions and Mixtures
- Chromatography
- Solubility
- Spectroscopy and the Electromagnetic Spectrum
- Photoelectric Effect
- Beer-Lambert Law

4) Chemical Reactions

- Introduction to Reactions
- Net Ionic Equations
- Representations of Reactions
- Physical and Chemical Changes
- Stoichiometry
- Introduction to Titration
- Types of Chemical Reactions
- Introduction to Acid-Base Reactions
- Oxidation-Reduction (Redox) Reactions

5) Kinetics

- Reactions Rates
- Introduction to Rate Law
- Concentration Changes Over Time
- Elementary Reactions
- Collision Model
- Reaction Energy Profile
- Introduction to Reaction Mechanisms
- Reaction Mechanism and Rate Law
- Steady-State Approximation
- Multistep Reaction Energy Profile
- Catalysis

6) Thermodynamics

- Endothermic and Exothermic Processes
- Energy Diagrams
- Heat Transfer and Thermal Equilibrium
- Heat Capacity and Calorimetry
- Energy of Phase Changes
- Introduction to Enthalpy of Reaction
- Bond Enthalpies
- Enthalpy of Formation
- Hess's Law

7) Equilibrium

- Introduction to Equilibrium
- Direction of Reversible Reactions
- Reaction Quotient and Equilibrium Constant
- Calculating the Equilibrium Constant
- Magnitude of the Equilibrium Constant
- Properties of the Equilibrium Constant
- Calculating Equilibrium Concentrations
- Representations of Equilibrium
- Introduction to Le Chatelier's Principle
- Reaction Quotient and Le Chatelier's Principle
- Introduction to Solubility Equilibria
- Common-Ion Effect
- pH and Solubility
- Free Energy of Dissolution

8) Acids and Bases

- Introduction to Acids and Bases
- pH and pOH of Strong Acids and Bases
- Weak Acid and Base Equilibria
- Acid-Base Reactions and Buffers
- Acid-Base Titrations
- Molecular Structure of Acids and Bases
- pH and pK_a
- Properties of Buffers
- Henderson-Hasselbalch Equation
- Buffer Capacity

9) Applications of Thermodynamics

- Introduction to Entropy
- Absolute Entropy and Entropy Change
- Gibbs Free Energy and Thermodynamic Favorability
- Thermodynamic and Kinetic Control
- Free Energy and Equilibrium
- Coupled Reactions
- Galvanic(Voltaic) and Electrolytic Cells
- Cell Potential and Free Energy
- Cell Potential Under Nonstandard Conditions
- Electrolysis and Faraday's Law

...all of this in one class...

1 **H** Hydrogen 1.008																	2 **He** Helium 4.003
3 **Li** Lithium 6.94	4 **Be** Beryllium 9.012											5 **B** Boron 10.81	6 **C** Carbon 12.011	7 **N** Nitrogen 14.007	8 **O** Oxygen 15.999	9 **F** Fluorine 18.998	10 **Ne** Neon 20.180
11 **Na** Sodium 22.990	12 **Mg** Magnesium 24.305											13 **Al** Aluminum 26.982	14 **Si** Silicon 28.085	15 **P** Phosphorus 30.974	16 **S** Sulfur 32.06	17 **Cl** Chlorine 35.45	18 **Ar** Argon 39.948
19 **K** Potassium 39.098	20 **Ca** Calcium 40.078		21 **Sc** Scandium 44.956	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.942	24 **Cr** Chromium 51.996	25 **Mn** Manganese 54.938	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933	28 **Ni** Nickel 58.693	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.38	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.630	33 **As** Arsenic 74.922	34 **Se** Selenium 78.97	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.798
37 **Rb** Rubidium 85.468	38 **Sr** Strontium 87.62		39 **Y** Yttrium 88.906	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.906	42 **Mo** Molybdenum 95.95	43 **Tc** Technetium [97]	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.906	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.868	48 **Cd** Cadmium 112.414	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	53 **Te** Tellurium 127.60	53 **I** Iodine 126.904	54 **Xe** Xenon 131.293
55 **Cs** Cesium 132.905	56 **Ba** Barium 137.327	***** 57 - 70	71 **Lu** Lutetium 174.967	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.948	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	78 **Ir** Iridium 192.217	79 **Pt** Platinum 195.084	80 **Au** Gold 196.997	81 **Hg** Mercury 200.592	81 **Tl** Thallium 204.38	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.980	84 **Po** Polonium [209]	85 **At** Astatine [210]	86 **Rn** Radon [222]
87 **Fr** Francium [223]	88 **Ra** Radium [226]	****** 89 - 102	103 **Lr** Lawrencium [262]	104 **Rf** Rutherfordium [267]	105 **Db** Dubnium [270]	106 **Sg** Seaborgium [269]	107 **Bh** Bohrium [270]	108 **Hs** Hassium [270]	109 **Mt** Meitnerium [278]	110 **Ds** Darmstadtium [281]	111 **Rg** Roentgenium [281]	112 **Cn** Copernicium [285]	113 **Nh** Nihonium [286]	114 **Fl** Flerovium [289]	115 **Mc** Moscovium [289]	116 **Lv** Livermorium [293]	117 **Ts** Tennessine [293]	118 **Og** Oganesson [294]

*Lanthanide series	57 **La** Lanthanum 138.905	58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.908	60 **Nd** Neodymium 144.242	61 **Pm** Promethium [145]	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.925	66 **Dy** Dysprosium 162.500	67 **Ho** Holmium 164.930	68 **Er** Erbium 167.259	69 **Tm** Thulium 168.934	70 **Yb** Ytterbium 173.045
**Actinide series	89 **Ac** Actinium [227]	90 **Th** Thorium 232.038	91 **Pa** Protactinium 231.036	92 **U** Uranium 238.029	93 **Np** Neptunium [237]	94 **Pu** Plutonium [244]	95 **Am** Americium [243]	96 **Cm** Curium [247]	97 **Bk** Berkelium [247]	98 **Cf** Californium [251]	99 **Es** Einsteinium [252]	100 **Fm** Fermium [257]	101 **Md** Mendelevium [258]	102 **No** Nobelium [259]

AP® CHEMISTRY EQUATIONS AND CONSTANTS

Throughout the exam the following symbols have the definitions specified unless otherwise noted.

L, mL	=	liter(s), milliliter(s)	mm Hg	=	millimeters of mercury
g	=	gram(s)	J, kJ	=	joule(s), kilojoule(s)
nm	=	nanometer(s)	V	=	volt(s)
atm	=	atmosphere(s)	mol	=	mole(s)

ATOMIC STRUCTURE

$E = h\nu$

$c = \lambda\nu$

E = energy
ν = frequency
λ = wavelength

Planck's constant, $h = 6.626 \times 10^{-34}$ J s
Speed of light, $c = 2.998 \times 10^{8}$ m s^{-1}
Avogadro's number = 6.022×10^{23} mol^{-1}
Electron charge, $e = -1.602 \times 10^{-19}$ coulomb

EQUILIBRIUM

$K_c = \dfrac{[C]^c[D]^d}{[A]^a[B]^b}$, where $a\ A + b\ B \rightleftarrows c\ C + d\ D$

$K_p = \dfrac{(P_C)^c(P_D)^d}{(P_A)^a(P_B)^b}$

$K_a = \dfrac{[H^+][A^-]}{[HA]}$

$K_b = \dfrac{[OH^-][HB^+]}{[B]}$

$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$ at 25°C

$= K_a \times K_b$

$pH = -\log[H^+]$, $pOH = -\log[OH^-]$

$14 = pH + pOH$

$pH = pK_a + \log\dfrac{[A^-]}{[HA]}$

$pK_a = -\log K_a$, $pK_b = -\log K_b$

Equilibrium Constants

K_c (molar concentrations)
K_p (gas pressures)
K_a (weak acid)
K_b (weak base)
K_w (water)

KINETICS

$\ln[A]_t - \ln[A]_0 = -kt$

$\dfrac{1}{[A]_t} - \dfrac{1}{[A]_0} = kt$

$t_{1/2} = \dfrac{0.693}{k}$

k = rate constant
t = time
$t_{1/2}$ = half-life

GASES, LIQUIDS, AND SOLUTIONS

$$PV = nRT$$

$$P_A = P_{\text{total}} \times X_A, \text{ where } X_A = \frac{\text{moles A}}{\text{total moles}}$$

$$P_{total} = P_A + P_B + P_C + \ldots$$

$$n = \frac{m}{\boldsymbol{M}}$$

$$\text{K} = \text{°C} + 273$$

$$D = \frac{m}{V}$$

$$KE \text{ per molecule} = \frac{1}{2}mv^2$$

Molarity, M = moles of solute per liter of solution

$$A = abc$$

P = pressure
V = volume
T = temperature
n = number of moles
m = mass
$\boldsymbol{M}$ = molar mass
D = density
KE = kinetic energy
v = velocity
A = absorbance
a = molar absorptivity
b = path length
c = concentration

Gas constant, R = 8.314 J $\text{mol}^{-1}\text{K}^{-1}$
= 0.08206 L atm $\text{mol}^{-1}\text{K}^{-1}$
= 62.36 L torr $\text{mol}^{-1}\text{K}^{-1}$

1 atm = 760 mm Hg = 760 torr

STP = 273.15 K and 1.0 atm

Ideal gas at STP = 22.4 L mol^{-1}

THERMODYNAMICS / ELECTROCHEMISTRY

$$q = mc\Delta T$$

$$\Delta S^\circ = \sum S^\circ \text{ products} - \sum S^\circ \text{ reactants}$$

$$\Delta H^\circ = \sum \Delta H_f^\circ \text{ products} - \sum \Delta H_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \sum \Delta G_f^\circ \text{ products} - \sum \Delta G_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$
$$= -RT \ln K$$
$$= -nFE^\circ$$

$$I = \frac{q}{t}$$

q = heat
m = mass
c = specific heat capacity
T = temperature
S° = standard entropy
H° = standard enthalpy
G° = standard Gibbs free energy
n = number of moles
E° = standard reduction potential
I = current (amperes)
q = charge (coulombs)
t = time (seconds)

Faraday's constant, F = 96,485 coulombs per mole of electrons

$$1 \text{ volt} = \frac{1 \text{ joule}}{1 \text{ coulomb}}$$

AP CHEMISTRY – GENERAL ASSESSMENT

The following is an assessment to help students identify strengths and weaknesses in their knowledge prior to engaging with the entirety of the material contained in this packet. Students should complete all questions to the best of their abilities and should only reference the periodic table and formula sheets included in this packet.

When finished, students should check their answers against the solution key provided at the end. Students should then make note of the concepts and topics involved in missed questions and carefully review the relevant material using any and all resources at their disposal.

AP CHEMISTRY – General Assessment

Various Topics (Estimated Time: 25 minutes)

All multiple choice questions will have only one correct option. All free response questions must be written inside the adjacent box and use correct significant figures, charge, and units when applicable.

Question 1: Which of the following measurements contains only four significant figures?

(A) 14.00 g (B) 3.45×10^4 J (C) 6,000 lbs (D) 12,031 kg

Question 2: Which of the following measurements contains only three significant figures?

(A) 153.0 m (B) 0.0100 kg (C) 7.2×10^2 (D) 007 cm

Question 3: Which of the following measurements contains only five significant figures?

(A) 0.6000 mg (B) 809.00 L (C) 0.0005 nm (D) 13,000 g

Question 4: Which of the following is the correct answer to the following calculation?

$2.50 \times 2.00 =$ _____

(A) 5 (B) 5.0 (C) 5.00 (D) 5.00000

Question 5: Which of the following is the correct answer to the following calculation?

$100 \times 3.00 =$ _____

(A) 300 (B) 300. (C) 300.0 (D) 300.00

Question 6: Which of the following is the correct answer to the following calculation?

$(2.0 \times 10^2)(3.00 \times 10^5) =$ _____

(A) 6×10^7 (B) 6.0×10^7 (C) 6.00×10^7 (D) 6.0000×10^7

Question 7: Which of the following is the correct answer to the following calculation?

$20.0 - 15.00 =$ _____

(A) 5 (B) 5.0 (C) 5.00 (D) 5.000

AP CHEMISTRY – General Assessment

Various Topics (Estimated Time: 25 minutes)

All multiple choice questions will have only one correct option. All free response questions must be written inside the adjacent box and use correct significant figures, charge, and units when applicable.

Question 8: How many centimeters are in 2.50 meters?

(A) 0.25 (B) 2.5 (C) 25 (D) 250.

Question 9: How many milliliters are in 0.45 liters?

(A) 450 (B) 45 (C) 0.045 (D) 0.0045

Question 10: How many kilometers are in 14,560 meters?

(A) 1.456 (B) 14.56 (C) 145.6 (D) 1,456

Question 11: How many centimeters are in 10.00 inches, given that 1 inch is exactly equal to 2.54 cm?

(A) 254.0 (B) 25.40 (C) 0.2540 (D) 3.937

Question 12: How many kilometers are in 250 miles, given that 1 kilometer is equal to 0.621 miles?

(A) 160 (B) 402.58 (C) 6210 (D) 0.403

Question 13: Assuming standard conditions, which of the following temperatures would ice form?

(A) 128°C (B) 865 K (C) 98.6°F (D) 213 K

Question 14: Which of the following amounts is the heaviest?

(A) 1.67 kg (B) 456 mg (C) 92.6 g (D) 12,456 g

Question 15: Which of the following amounts would be comparable to the volume of a bathtub?

(A) 275,456 mL (B) 128,456 L (C) 567 kL (D) 807 hL

AP CHEMISTRY – General Assessment

Various Topics (Estimated Time: 25 minutes)

All multiple choice questions will have only one correct option. All free response questions must be written inside the adjacent box and use correct significant figures, charge, and units when applicable.

Question 16: Which of the following elements would be considered a metal?

(A) Carbon (B) Oxygen (C) Sodium (D) Fluorine

Question 17: Which of the following elements would be considered a transition metal?

(A) Aluminum (B) Potassium (C) Selenium (D) Manganese

Question 18: Which of the following elements would be considered a noble gas?

(A) Hydrogen (B) Oxygen (C) Argon (D) Nitrogen

Question 19: Which of the following elements would have the heaviest atom?

(A) Lithium (B) Sulfur (C) Argon (D) Gold

Question 20: Which of the following ions contains the highest number of electrons?

(A) N^{3-} (B) O^{2-} (C) Na^{+} (D) Mg^{+}

Question 21: Which of the following elements is most likely to form an ionic bond with chlorine?

(A) Lithium (B) Carbon (C) Nitrogen (D) Oxygen

Question 22: Which of the following elements is most likely to form a covalent bond with nitrogen?

(A) Sodium (B) Magnesium (C) Phosphorous (D) Argon

Question 23: Which of the following elements is the least reactive?

(A) Nitrogen (B) Sulfur (C) Bromine (D) Xenon

AP CHEMISTRY – General Assessment

Various Topics (Estimated Time: 25 minutes)

All multiple choice questions will have only one correct option. All free response questions must be written inside the adjacent box and use correct significant figures, charge, and units when applicable.

Question 24: For each of the chemical reactions shown below, balance the equation by writing the correct coefficients in the spaces provided. Coefficients of "1" do not need to be written.

_____ $AgNO_3(aq)$ + _____ $MgCl_2(aq)$ → _____ $AgCl(s)$ + _____ $Mg(NO_3)_2$

_____ $C_2H_4(g)$ + _____ $O_2(g)$ → _____ $CO_2(g)$ + _____ $H_2O(g)$

_____ $MgSO_4\ (aq)$ + _____ $KNO_3\ (aq)$ → _____ $Mg(NO_3)_2\ (aq)$ + _____ $K_2SO_4\ (aq)$

Question 25: Given 2.0 moles of $H_2(g)$ and excess $O_2(g)$, how many moles of $H_2O(g)$ can be produced from the reaction shown below?

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

(A) 0.50 (B) 1.0 (C) 2.0 (D) 4.0

Question 26: Given 0.30 moles of $O_2(g)$ and excess $H_2(g)$, how many moles of $H_2O(g)$ can be produced from the reaction shown below?

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

(A) 0.15 (B) 0.30 (C) 0.45 (D) 0.60

Question 27: Given 16.00g of $O_2(g)$ and excess $H_2(g)$, how many moles of $H_2O(g)$ can be produced from the reaction shown below?

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

(A) 0.50 (B) 1.0 (C) 1.8 (D) 3.6

END OF ASSESSMENT

AP CHEMISTRY – GENERAL ASSESSMENT

SOLUTIONS

Students should compare their responses from the assessment against the solutions shown here. Students should review the associated concepts for all missed questions thoroughly and are encouraged to practice similar questions.

Question 1:	A	Significant Figures
Question 2:	B	Significant Figures
Question 3:	B	Significant Figures
Question 4:	C	Significant Figures
Question 5:	A	Significant Figures
Question 6:	B	Significant Figures, Scientific Notation
Question 7:	B	Significant Figures(Addition/Subtraction)
Question 8:	D	Metric Conversions
Question 9:	A	Metric Conversions
Question 10:	B	Metric Conversions
Question 11:	B	Dimensional Analysis
Question 12:	A	Dimensional Analysis, Significant Figures
Question 13:	D	Metric System, Kelvin Scale
Question 14:	D	Metric System, Metric Conversions
Question 15:	A	Metric System, Measurement Estimation
Question 16:	C	Periodic Table, Metals and Nonmetals
Question 17:	D	Periodic Table, Groups
Question 18:	C	Periodic Table, Noble Gases
Question 19:	D	Periodic Table, Atomic Mass
Question 20:	D	Periodic Table, Ionic Charge
Question 21:	A	Periodic Table, Ionic Compounds
Question 22:	C	Periodic Table, Covalent Compounds
Question 23:	D	Periodic Table, Reactivity
Question 24:	2,1,2,1 1,3,2,2 1,2,1,1	Balancing Chemical Equations
Question 25:	C	Stoichiometry
Question 26:	D	Stoichiometry
Question 27:	B	Stoichiometry